TALLINN UNIVERSITY OF TECHNOLOGY

TUT RESEARCH AND DEVELOPMENT 2014

TALLINN UNIVERSITY OF TECHNOLOGY

TALLINN UNIVERSITY OF TECHNOLOGY

Founded in 1918, university status in 1936

8 FACULTIES

- Civil Engineering
- Power Engineering
- Information Technology
- Chemical and Materials Technology
- School of Economics and Business Administration
- Science
- Mechanical Engineering
- Social Sciences

4 AFFILIATED

R&D institutions

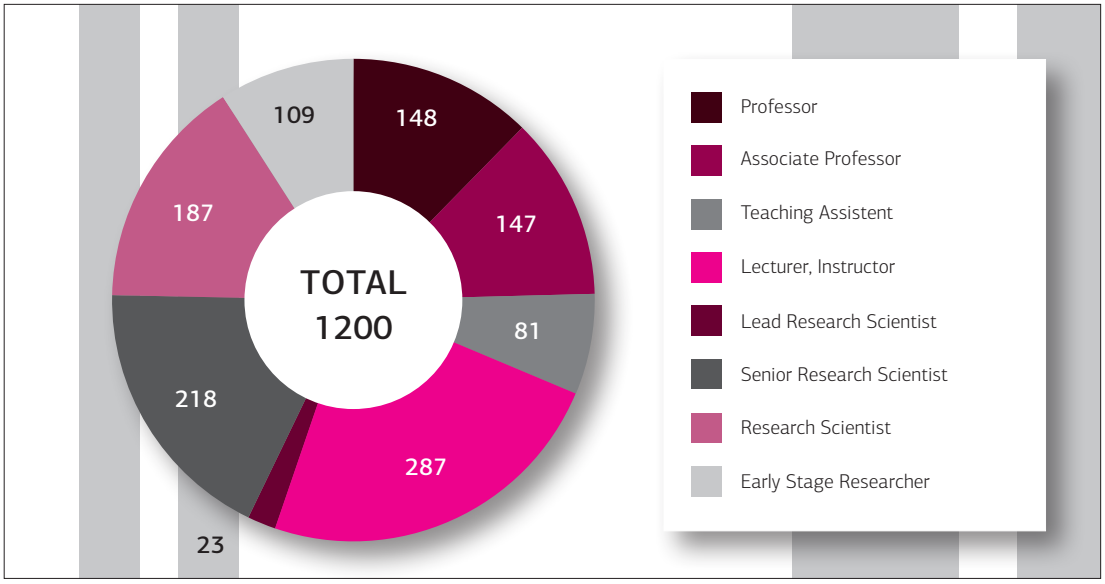
- Institute of Cybernetics
- Institute of Geology
- Institute of Marine Systems
- Technomedicum of TUT

5 COLLEGES

- Estonian Maritime Academy
- Kuressaare College
- Tallinn College
- Tartu College
- Virumaa College

MAIN FIGURES 2014

- Academic staff, total 1157
  - Incl. 148 professors, 537 researchers
- Doctoral students, total 750 (as of Dec. 31, 2014)
- Scientific publications, total 1817
- Defended doctoral dissertations, total 57
- Post-doctoral positions, total 13
- R&D funding, total 36,4 Mill. Euros



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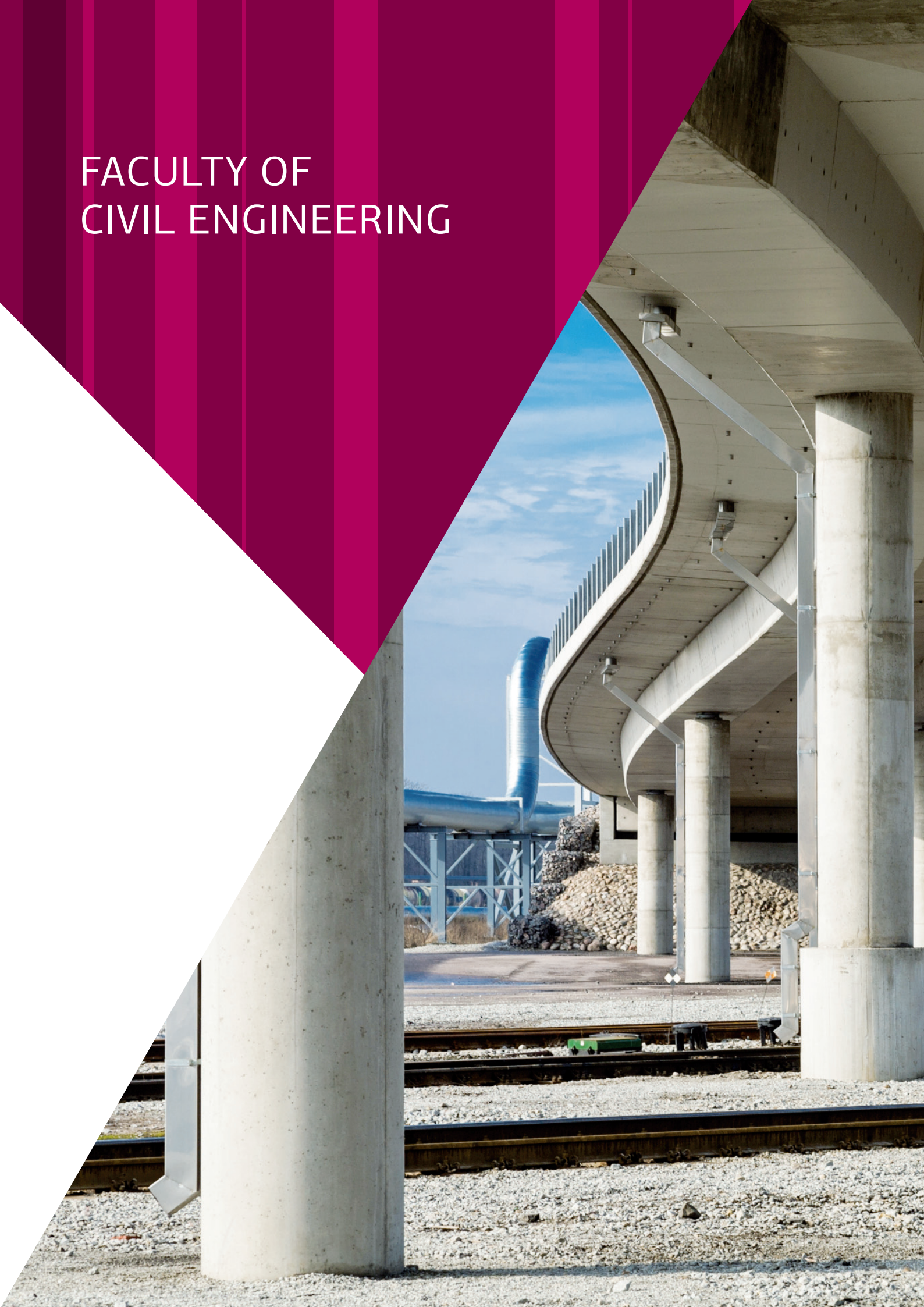
FACULTY OF CIVIL ENGINEERING



FACULTY OF CIVIL ENGINEERING

Dean: ROODE LIIAS, Professor

Phone: +372 620 2456
e-mail: roode.liias@ttu.ee

Vice-Dean for Research and Development: TEET-ANDRUS KÕIV, Visiting Professor

Phone: +372 620 2505
e-mail: teet.koiv@ttu.ee

DEPARTMENTS, RESEARCH CENTRES, LABORATORIES:

- Department of Building Production
  - Research and Testing Laboratory of Building Materials
- Department of Environmental Engineering
  - Laboratory of Water Quality
- Department of Logistics and Transport
- Department of Mechanics
  - Laboratory of Fluid Mechanics
  - Laboratory of Strength of Materials
- Department of Road Engineering
  - Laboratory of Roads and Traffic
- Department of Structural Design
  - Laboratory of Structures
- Department of Architecture and Urban Studies
  - Unit of Engineering Graphics

The Faculty of Civil Engineering is currently employing 23 professors.

The total number of academic staff is 109. 2 doctoral dissertations were defended in 2014.

DEPARTMENT OF STRUCTURAL DESIGN

DEPARTMENT OF STRUCTURAL DESIGN,
Director: Professor Jarek Kurnitski, jarek.kurnitski@ttu.ee, +372 620 2406

CHAIR OF BUILDING PHYSICS AND ENERGY EFFICIENCY,
Professor Jarek Kurnitski, jarek.kurnitski@ttu.ee, +372 620 2406

CHAIR OF STRUCTURAL ENGINEERING,
Visiting Associate Professor Ivar Talvik, ivar.talvik@ttu.ee, +372 620 2410

LABORATORY OF STRUCTURES,
Laboratory Manager Elmar-Jaan Just, elmar.just@ttu.ee, +372 620 2407

MAIN LINES OF RESEARCH

NEARLY ZERO ENERGY nZEB RESEARCH GROUP

This multi- and interdisciplinary nZEB research group represents a strong networking effort within TUT among four different disciplines: Energy performance of buildings, Building Service Systems, Building Physics and Construction Economics and Management.

In 2014 research has been generally focused on technical solutions for nZEB most urgently needed in Estonia: looking for the new heating and ventilation solutions suitable for specific operation conditions in nZEB; new external wall assembly solutions were studied with computational analyses and climate chamber tests; office building solar shading and facade analyses were performed with use of energy simulations and measurements at TUT technological facility; energy simulations combined with economic and cost optimal analyses were carried out.

The research group has contributed to Estonian energy action plan ENMAK 2030+ preparation and on European level through chairing REHVA nZEB Task Force.

CONTACT: Prof. Jarek Kurnitski, jarek.kurnitski@ttu.ee

SELECTED PUBLICATIONS:

Kurnitski, J.; Kuusk, K.; Tark, T.; Uutar, A.; Kalamees, T.; Pikas, E. (2014). Energy and investment intensity of integrated renovation and 2030 cost optimal savings. Energy and Buildings, 75, 51–59.

Seinre, E.; Kurnitski, J.; Voll, H. (2014). Building sustainability objective assessment in Estonian context and a comparative evaluation with LEED and BREEAM. Building and Environment, 82, 110–120.

Pikas, E.; Thalfeldt, M.; Kurnitski, J. (2014). Cost optimal and nearly zero energy building solutions for office buildings. Energy and Buildings, 74, 30–42.

Seinre, E.; Kurnitski, J.; Voll, H. (2014). Quantification of environmental and economic impacts for main categories of building labeling schemes. Energy and Buildings, 70, 145–158.

Arumägi, E.; Kalamees, T. (2014). Analysis of energy economic renovation for historic wooden apartment buildings in cold climates. Applied Energy, 115, 540–548.

STRUCTURAL FIRE DESIGN

Main task of the research is to develop methods for fire design of steel and timber structures. The work group has good co-operation with SP Technical Research Institute of Sweden, Estonian Academy of Security Sciences and Estonian Rescue Board.

In 2014 research was concentrated on following topics: (1) alternative approach to buckling of square hollow section steel columns in fire; (2) fire design of timber structures related to protection provided by claddings and mineral wool as well as influence of elevated temperatures to the strength properties of timber elements; (3) studies with effect of zero-strength layers of timber members and protection properties by claddings and insulations.

CONTACT: Assoc. Prof. Ivar Talvik, ivar.talvik@ttu.ee

SELECTED PUBLICATIONS:

Kervalishvili, A.; Talvik, I. (2014). Alternative approach to buckling of square hollow section steel columns in fire. Journal of Constructional Steel Research, 96 (May), 140–150.

Just, A.; Schmid, J.; Werther, N.; Frangi, A. (2014). Fire Protection of the timber members – determination of the fire protection system characteristics for the verification of the load-bearing resistance by means of calculation models. In: Structures in Fire – Proceedings of the 8th International Conference on Structures in Fire: Structures in Fire, Shanghai, June 9–12, 2014. (2014) Tongji: Tongji University Press, 557–566.

Schmid, J.; Klippel, M.; Just, A.; Frangi, A. (2014). Review and analysis of fire resistance tests of timber members in bending, tension and compression with respect to the Reduced Cross-Section Method. Fire Safety Journal, 68, 81–99.

Schmid, J.; Just, A.; Klippel, M.; Fragiacomo, M. (2014). The Reduced Cross-Section Method for Evaluation of the Fire Resistance of Timber Members: Discussion and Determination of the Zero-Strength Layer. Fire Technology, 50(5), 1043–1326.

DEPARTMENT OF ENVIROMENTAL ENGINEERING

DEPARTMENT OF ENVIROMENTAL ENGINEERING,
Director: Professor Enn Loigu, enn.loigu@ttu.ee, +372 620 2502

CHAIR OF ENVIRONMENTAL PROTECTION,
Professor Enn Loigu, enn.loigu@ttu.ee, +372 620 2502

CHAIR OF HEATING AND VENTILATION,
Professor Hendrik Voll, hendrik.voll@ttu.ee, +372 620 2510

CHAIR OF WATER ENGINEERING,
Visiting Professor Karin Pachel, karin.pachel@ttu.ee, +372 620 2504

LABORATOTY OF WATER QUALITY,
Research Scientist Kati Roosalu, kati.roosalu@ttu.ee, +372 620 2508

MAIN LINES OF RESEARCH

CHAIR OF ENVIRONMENTAL PROTECTION

Research focus is primarily on: (1) formation and assessment of surface water quality; (2) self-purification processes in surface water bodies; (3) long-term trends in river run-off and water quality and impact of climate change on runoff dynamics, water quality and pollution load; 4) development of methods and techniques to adopt climate change and extreme runoff-events.

IN 2014:

BONUS project „Microalgae – Cost efficient algal cultivation systems – a source of emission control and industrial development" first year tasks were completed. As a result, comprehensive reports were compiled on the selection of wastewaters, and on local runoff sources and wastewaters in the Baltic Sea Area.

The Project „Assessment of possible changes of Estonian climate and environmental status on the basis of dynamical modeling of atmosphere, ocean and river runoff (EstKliima)" under KESTA program was completed and the results published.

Pollution load of selected compounds to the Baltic Sea was estimated for the period of 1992–2013. Phosphorus loads were modelled under different climate change scenarios.

A study on nitrogen and phosphorus content and trends in agricultural catchments in Estonia was completed and the results published.

A survey was conducted to assess the physical-chemical status of running waters in comparison to the international and national legal requirements.

Methodological guidance for hydro-chemical monitoring was compiled for the laboratories participating in the national monitoring program.

CONTACT: Prof. Enn Loigu, enn.loigu@ttu.ee

SELECTED PUBLICATIONS:

Iital, A.; Klõga, M.; Pihlak, M.; Pachel, K.; Zahharov, A.; Loigu, E. (2014). Nitrogen content and trends in agricultural catchments in Estonia. Agriculture, Ecosystems and Environment, 198, 44–53.

Kuusik, A.; Pachel, K.; Kuusik, A.; Loigu, E.; Tang, W. Z (2014). Reverse osmosis and nanofiltration of biologically treated leachate. Environmental Technology, 1–11.

Sarauskiene, D.; Kriauciuniene, J.; Reihan, A.; Klavins, M. (2014): Flood pattern changes in the rivers of the Baltic countries, Journal of Environmental Engineering and Landscape Management, 1–11 (Published on-line). DOI:10.3846/16486897.2014.937438

CHAIR OF HEATING AND VENTILATION

Chair of heating and ventilation mainly focuses on the research in HVAC systems, indoor climate of the buildings, energy efficient and sustainable buildings, passive cooling systems and heat supply systems (heat pumps).

IN 2014:

KESTA project "Development of efficient technologies for air exchange and ventilation necessary for the increase of energy efficiency of buildings" was completed. The study was carried out to analyse the work conditions of room-based ventilation units with heat recovery in renovated multi-storey apartment building and to define the characteristics of two units with different operating principles. The main finding was that the pressure difference between the indoor and outdoor air in the bottom floor apartment depends heavily on the outdoor temperature, indicating the influence of the stack effect, whereas on the top floor, due to the smaller height of the exhaust ventilation shaft, the dependence is weak.

CONTACT: Prof. Hendrik Voll, hendrik.voll@ttu.ee

SELECTED PUBLICATIONS:

Voll, H.; Seinre, E. (2014). A Method of Optimizing Fenestration Design for Daylighting to Reduce Heating and Cooling Loads in Offices. Journal of Civil Engineering and Management, 1–10.

Koiv, T.-A.; Mikola, A.; Palmiste, Ü. (2014). The New Dimensioning Method of the District Heating Network. Applied Thermal Engineering, 71, 78–82.

Seinre, E.; Kurnitski, J.; Voll, H. (2014). Quantification of environmental and economic impacts for main categories of building labeling schemes. Energy and Buildings, 70, 145–158.

CHAIR OF WATER ENGINEERING

The broad lines of research are: (1) Technological and technical solutions of small-size equipment for wastewater treatment suitable for Estonian conditions; (2) Establishing preconditions to produce biogas as a result of treatment the sludge and other biodegradable waste in a process of anaerobic fermentation and to reduce significantly the amount of landfilled biodegradable waste; (3) Technologies and technical solutions for treatment of landfills leachates; (4) Engineering solutions for treatment of stormwater.

IN 2014:

In cooperation with Turku University the INTERREG project SUSBIO „Sustainable utilization of waste and industrial non-core materials" was completed. Data of biodegradable waste quantities was collected and the waste treatment investigated. Estimation of the qualities and quantities of biodegradable waste in Estonia and its potential for biogas production have been done. Separate collection of municipal solid waste in Tallinn, changes in collection system waste composition have been analysed. The database model for evaluation of biogas production perspectives in Estonia was created and preliminary optimization method for biomaterial utilization for biofuel was carried out. The research for optimal parameters in biogas production was carried out. The technical manual of biogas production was drafted. The substrates used in laboratory experiments were sludge from wastewater treatment plant, glycerol, food industry wastes.

Tallinn stormwater monitoring was carried out with a view to assess storm waters runoff and quality involving local citizens and to develop suitable measures for improving the state of the sea. The study was conducted under the FP-7 project „Monitoring and management of flowing rainwater in Baltic Sea catchment areas".

CONTACT: Prof. Karin Pachel, karin.pachel@ttu.ee

SELECTED PUBLICATIONS:

Kuusik, Aare.; Pachel, K.; Kuusik, Argo; Loigu, E.; Tang, W. Z (2014). Reverse osmosis and nanofiltration of biologically treated leachate. Environmental Technology, 1–11.

Kuusik, Argo; Pachel, K; Kuusik, Aare; Loigu, E. (2014). Anaerobic co-digestion of sewage sludge with fish farming waste. 9th International Conference on Environmental Engineering: Water Engineering (1–8). Vilnius, Lithuania: VGTU Press „Technika".

Kuusik, Aare; Pachel, K.; Kuusik, Argo; Loigu, E. (2014). Landfill runoff water and landfill leachate discharge and treatment. 9th International Conference Environmental Engineering:Water Engineering:Selected Papers (1–6). Vilnius, Lithuania: VGTU Press „Technika".

DEPARTMENT OF LOGISTICS AND TRANSPORT

DEPARTMENT OF LOGISTICS AND TRANSPORT,
Acting Director: Visiting Professor Alari Purju, alari.purju@ttu.ee, +372 620 2611

CHAIR OF TRANSPORTATIONAL LOGISTICS,
Visiting Professor Ott Koppel, ott.koppel@ttu.ee, +372 620 2605

CHAIR OF TRANSPORT PLANNING,
Professor Dago Antov, dago.antov@ttu.ee, +372 620 2609

CHAIR OF SUPPLY CHAIN ENGINEERING,
Visiting Associate Professor Hele Hammer, hele.hammer@ttu.ee, +372 620 2608

MAIN LINES OF RESEARCH

Research is focused on: (1) production and transportation logistics; (2) traffic safety and transport planning; (3) ICT in road engineering and transport; (4) supply chain management.

IN 2014:

The systemic approach was proposed and cost-benefit analysis of economic regulation issues of network industries was performed.

Ericsson Global Supply chain analysis for manufacturing testing equipment was carried out. Analysis include: (1) VSM Map current state by product categories with cycle times; (2) Replacement strategy description for fixtures; (3) Statistical Analysis of inbound supply data by product categories and suppliers.

The analysis of proportion of oil sale based production in Estonia´s GDP was carried out. Forecaste up to 2030 based on scenarios was compiled.

Analysis of the existing public transport network in Tallinn was carried out and recommendations were drafted for development and optimization in a mid and long term perspectives.

CONTACT: Visiting Prof. Alari Purju, alari.purju@ttu.ee

SELECTED PUBLICATIONS:

Uukkivi, R.; Ots, M.; Koppel, O. (2014). „Systemic approach to economic regulation of network industries in Estonia", Trames: Journal of the Humanities and Social Sciences, 18 (3), 221–241.

Leppiman, A.; Kõrbe Kaare, K.; Koppel, O. (2014). „Improving security of gas supply in Eastern Baltic regioon: LNG terminal alternatives". International Journal of Energy, 8(1), 1–7.

Pruunsild, R.; Mäe, R.; Antov, D. (2014). „Applicability of ITS solutions in the field of winter maintenance in Estonia". Acta Technica Napocensis: Civil Engineering and Architecture, 57(1), 84–94.

Hurt, U.; Otto, T.; Kõrbe Kaare, K.; Koppel, O. (2014). „New approach to knowledge transfer environment development". In: Procedia Engineering, 69, 273–281.

Branten, E.; Purju, A. (2014). „Estonia's maritime sector stakeholders and their reaction patterns. In: Procedia: Social and Behavioral Sciences, Elsevier, 156, 227–230.

DEPARTMENT OF MECHANICS

DEPARTMENT OF MECHANICS,
Director: Professor Aleksander Klauson, aleksander.klauson@ttu.ee, +372 620 2554

CHAIR OF ENGINEERING MECHANICS,
Professor Aleksander Klauson, aleksander.klauson@ttu.ee, +372 620 2554

CHAIR OF FLUID AND AEROMECHANICS,
Senior Research Scientist Ivar Annus, ivar.annus@ttu.ee, +372 620 2559

CHAIR OF APPLIED MECHANICS,
Professor Andrus Salupere, andrus.salupere@ttu.ee, +372 620 2560

LABORATORY OF FLUID MECHANICS,
Senior Research Scientist Ivar Annus, ivar.annus@ttu.ee, +372 620 2559

LABORATORY OF STRENGTH OF MATERIALS,
Associate Professor Hendrik Naar, hendrik.naar@ttu.ee, +372 620 2552

MAIN LINES OF RESEARCH

DYNAMIC PROCESSES IN WATER SYSTEMS

The research is focused on water dynamics and boundary interactions in the hydraulic systems: unsteady flow, transient flow, stratified flow, two-phase flow, etc. Engineering applications are focused on energy efficiency analysis and optimization of hydraulic systems including the development of optimal pumping schedule and comparative studies of various calibration algorithms' performance on real network data.

In 2014 studies were carried out in the following areas:

REDUCTION OF RISKS AND ENERGY CONSUMPTION IN HYDRAULIC SYSTEMS

The aim of the investigation was to elaborate new methods to reduce energy consumption in water distribution systems (WDS). It was shown that a novel procedure can be used to optimize the operation of pumps with the same and with different characteristics. An algorithm to regulate the pumps switching on/off in a pumping station in order to save energy was developed. It was found that a simple tool to evaluate optimal pumping schedules can be a first trigger to find optimal solutions for energy use.

A water distribution system in service was analysed to demonstrate the surplus power factor values under different demand conditions. In order to calculate the factor for WDNs, a network resistance coefficient C was determined. A theoretical approach to determine the coefficient C through matrix equations was introduced. This approach was found to be the most accurate in estimating the networks hydraulic capacity in a real water network case study.

UNSTEADY AND STRATIFIED FLOW IN HYDRAULIC SYSTEMS

Stratified flow mixing in the hydraulic systems, where the water originates from different sources was experimentally investigated. The gravity current propagation and the critical flow conditions due to the effects of boundary friction and interfacial shear were studied.

Two-phase unsteady flow in pipes where liquid flows along the bottom and gas flows above was experimentally investigated. It was determined that during the pipeline filling and emptying two-phase flow can reveal different dynamics due instability and mixing.

It was found that in the case of relatively steeply inclined submerged channel, the dense-water bottom current can be frictionally-controlled. For the mildly sloped channel, the dense water outflow can be hydraulically-controlled, with internal flow dynamics characterised by increasing isopycnal separation in the along-channel direction. Analysis of the gradient Richardson number Ri_g of the flow confirmed that hydraulically-controlled flows dilute the active bottom water due to interfacial mixing.

It was found that the pipeline emptying dynamics is similar to the filling dynamics in respect of the two-phase flow front dynamics. It was demonstrated that the water-air front that enters into the large-scale pipeline splits into two water-fronts during the filling process. The along-flow pressure gradient in the case of filling corresponds to the rigid-column motion. Thus the pressure changes are different in the pipeline emptying and filling processes.

CONTACT: Senior Research Scientist Ivar Annus, ivar.annus@ttu.ee

SELECTED PUBLICATIONS:

Laanearu, J.; Cuthbertson, A. J. S.; Davies, P. A. (2014). Dynamics of dense gravity currents and mixing in an up-sloping and converging vee-shaped channel. IAHR Journal of Hydraulic Research, 52(1), 67–80.

Hou, Q.; Tijsseling, A. S.; Laanearu, J.; Annus, I.; Koppel, T.; Bergant, A.; Vučković, S.; Anderson, A.; van't Westende, J. M. C. (2014). Experimental Investigation on Rapid Filling of a Large-Scale Pipeline. ASCE Journal of Hydraulic Engineering, 140(11), 1–14.

Puust, R.; Vassiljev, A. (2014). Real Water Network Comparative Calibration Studies Considering the Whole Process from Engineer's Perspective. Procedia Engineering, 89, 702–709.

MARITIME ENGINEERING RESEARCH GROUP

Collision analysis model was developed further by including the effects of the level ice on the collision dynamics. The ice load model is based on the Crossdale 2D model that allows to evaluate the ice interaction as a linear load. Ice load module was added to the time domain collision simulation model. Additionally a simplified version of the model was developed based on the conservation of the liner momentum.

Accidental Damage Assessment Model combining structural damage assessment model, oil spill model and ultimate strength model was developed further to allow more logical structure for the input parameters.

CONTACT: Senior Research Scientist Kristjan Tabri, kristjan.tabri@ttu.ee

SELECTED PUBLICATIONS:

Montewka, J.; Ehlers, S.; Goerlandt, F.; Hinz, T.; Tabri, K.; Kujala, P. (2014). A framework for risk assessment for maritime transportation systems – a case study for open sea collisions involving RoPax vessels. Reliability Engineering & System Safety, 124, 142–157.

Kõrgesaar, M.; Tabri, K.; Reinhold, E.; Naar, H. (2014). Ship Collision Simulations Using Different Fracture Criteria and Mesh Size. In: ASME (American Society of Mechanical Engineers) Proceedings of 33rd International Conference on Ocean, Offshore and Arctic Engineering (OMAE2014). Volume 4A: Structures, Safety and Reliability. San Francisco, California, USA, June 8–13, 2014, V04AT02A045; 9 pages.

NON-DESTRUCTIVE EVALUATION (NDE) AND ACOUSTICS RESEARCH GROUP

NON-DESTRUCTIVE EVALUATION

A numerical and experimental procedure based on the Lamb mode orthogonality to separate various modes at a plate edge in a plane strain condition has been developed for non-destructive evaluation of plate-like structures. Overlapping wavepackets of S0 and A0 Lamb modes arriving at a plate edge were simulated by using the FE model and generated in the experiment of an incident S0 mode in a plate with a notch. The required wave field displacement components for the experimental procedure were measured with a 3D SLDV. It was demonstrated that it is possible to extract the signals of several propagating and non-propagating modes in time-domain. The proposed approach is attractive for NDT research because it provides new ways of analysing the signals and is much faster than the classical spatial two-dimensional Fast Fourier transform for mode separation.

UNDERWATER ACOUSTICS

The evaluation of sound pressure levels (SPL) produced by shipping in the Baltic Sea was performed in frames of EU project Baltic Sea Information on Acoustic Soundscape (BIAS).

In 2014 acoustic recordings have been obtained within the project. The analysis of the preliminary results showed that that apart from general signal processing, additional tools are necessary for ef-

fective SPL analysis, such as AIS and acoustical data synchronisation, sound propagation modelling nearby the recorder.

CONTACT: Prof. Aleksander Klauson, aleksander.klauson@ttu.ee

SELECTED PUBLICATIONS:

Echtermeyer, A. T.; Lasn, K. (2014). Safety approach for composite pressure vessels for road transport of hydrogen. Part 2: Safety factors and test requirements. International Journal of Hydrogen Energy, 39(26), 14142–14152.

Lasn, K.; Echtermeyer, A. T. (2014). Safety approach for composite pressure vessels for road transport of hydrogen. Part 1: Acceptable probability of failure and hydrogen mass. International Journal of Hydrogen Energy, 39(26), 14132–14141.

DEPARTMENT OF BUILDING PRODUCTION

DEPARTMENT OF BUILDING PRODUCTION,
Director: Professor Irene Lill, irene.lill@ttu.ee, 372 620 2465

CHAIR OF BUILDING MATERIALS,
Emeritus Lembi-Merike Raado, lembi.raado@ttu.ee, +372 620 2452

CHAIR OF BUILDING TECHNOLOGY,
Professor Irene Lill, irene.lill@ttu.ee, +372 620 2465

CHAIR OF CONSTRUCTION ECONOMICS AND MANAGEMENT,
Professor Roode Liias, roode.liias@ttu.ee, +372 620 2456

RESEARCH AND TESTING LABORATORY OF BUILDING MATERIALS,
Technology Engineer Margit Rosenberg, margit.rosenberg@ttu.ee, +372 620 2460

MAIN LINES OF RESEARCH

BUILDING LIFECYCLE RESEARCH GROUP

The research reflects the building lifecycle as a whole, integrating the construction process and its outcomes with management strategies, technologies and materials used and also with economics and facilities management. Recent research studies have included: (1) Multi-attribute decision making methods for the assessment of different management strategies; (2) Comparing risk transfers under different procurement arrangements; (3) Different aspects of construction economics and management in the major fields of civil engineering (building construction, road engineering, engineering services, etc.); (4) Developing and providing BIM-related know-how; (5) Process management strategies in construction; (6) Surveys of the technical condition of housing; (7) Regulation of construction activities and creation of normative materials and standards for the Estonian construction industry; (8) Construction-related disaster resilience etc.

IN 2014:

Two ERASMUS projects were completed:

Sustainable Real Estate Development (SuReEsDe). The study was focused on integrating sustainable real estate development and construction market skills and increasing cooperation between higher education and real estate and construction/building companies in EU. The outputs: a new international multidisciplinary approach for studying real estate development process in the field of sustainable development has been proposed. Students, as well as teachers and practitioners involved in the project learned numerous aspects that must be considered in making economic, business, provisional, technological, technical, organizational, managerial and legal/regulatory decisions. They learned how to apply theoretical models with a creative consideration of the external factors in the developmental area as well as the needs of the market and of society.

Academic Network for Disaster Resilience to Optimise Educational Development (ANDROID). An academic network was set off to promote co-operation and innovation among European higher education institutions to increase society's resilience to disasters.

An international project GreenEuroHub (GEEE) was started in 2014. The project intends to increase awareness in energy efficiency and „green" competencies for greater energy efficiency in retrofitting of existing build and new construction.

CONTACT: Prof. Irene Lill, irene.lill@ttu.ee;
Prof. Roode Liias, roode.liias@ttu.ee

SELECTED PUBLICATIONS:

Nuuter, T.; Lill, I.; Tupenaite, L. (2014). Comparison of housing market sustainability in European countries based on multiple criteria assessment. Land Use Policy, 42, 642–651.

Pikas, E.; Kurnitski, J.; Liias, R.; Thalfeldt, M. (2014). Quantification of economic benefits of renovation of apartment buildings as a basis for cost optimal 2030 energy efficiency strategies. Energy and Buildings, 86, 151–160.

Sulakatko, I.; Lill, I.; Soekov, E.; Arhipova, R.; Liisma, E. (2014). Towards Nearly Zero-energy Buildings through Analyzing Reasons for Degradation of Facades. In: Procedia Economics and Finance: 4th International Conference on Building Resilience, Incorporating the 3rd Annual Conference of the ANDROID Disaster Resilience Network, September 8–11, 2014, Salford Quays, United Kingdom. Elsevier, 2014, 592–600.

Sulakatko, V.; Lill, I.; Soekov,E.; Arhipova, R.; Witt, E.; Liisma, E. (2014). Towards Nearly Zero-energy Buildings through Analyzing Reasons for Degradation of Facades. Procedia Economics and Finance (592–600). Elsevier.

BUILDING MATERIALS RESEARCH GROUP

Main activities are connected with the utilization of oil shale ash in the production of building materials and the renovation of buildings.

Research involves the following studies: (1) Main characteristics of binders or binder constituents based on oil shale ashes from electrostatic precipitator systems; (2) Basics of new utilization processes for oil shale combustion solid wastes; (3) Sustainable management of historic rural churches in the Baltic Sea Region; (4) Low strength backfilling concrete based on the residues of oil shale processing; (5) Frost resistance of various concretes; (6) Building properties of chemically treated timber; (7) Durability characteristics (vapour and water migration) of facade systems, thermal insulation and external facade coverings.

The Research and Testing Laboratory of Building Materials has certified testing personnel, standards, methods and equipment for the evaluation of conformity for various building products: cement, mortar, grout and concrete products and also for natural and artefact stones and insulation products.

IN 2014:

Research was carried out on the possibilities for utilization of fluidized bed combustion oil shale ashes and ashes from gas purification systems as a Portland cement second constituent contracted by Kunda Nordic Cement and Eesti Energia and OY VKG.

Main characteristics of binders or binder constituents in Portland cements based on oil shale ashes from electrostatic precipitator systems were determined.

Properties and durability of various low strength backfilling concretes based on oil shale ash as a binder modified with other mineral bindings and mining residue as aggregate were studied with the aim to determine compositions of oil shale ash binders able to harden and durable in underground conditions.

CONTACT: Emeritus Lembi-Merike Raado, lembi.raado@ttu.ee

SELECTED PUBLICATIONS:

Raado, L.; Hain, T.; Liisma, E.; Kuusik, R. (2014). Composition and Properties of Oil Shale Ash Concrete. Oil Shale, 31(2), 147–160.

Irha, N.; Uibu, M.; Jefimova, J.; Raado, L.-M.; Hain, T.; Kuusik, R. (2014). Leaching behaviour of estonian oil shale ash-based construction mortars. Oil Shale, 31(4), 394–411.

Raado, L.; Kuusik, R.; Hain, T.; Uibu, M.; Somelar, P. (2014). Oil shale ash based stone formation – hydration, hardening dynamics and phase transformations. Oil Shale, 31(1), 91–101.

Liisma, E.; Raado, L-M.; Lumi, S.; Lill, I.; Sulakatko, V. (2014). The Effect of Moisture Content of Insulation Boards on the Adhesion Strength of ETICS. Recent Advances in Civil Engineering and Mechanics (103–108). WSEAS.

DEPARTMENT OF ROAD ENGINEERING

DEPARTMENT OF ROAD ENGINEERING,
Director: Professor Andrus Aavik, andrus.aavik@ttu.ee, +372 620 2600

CHAIR OF GEODESY,
Professor Artu Ellmann, artu.ellmann@ttu.ee, +372 620 2603

CHAIR OF BRIDGE ENGINEERING,
Professor Siim Idnurm, siim.idnurm@ttu.ee, +372 620 2610

CHAIR OF ROAD ENGINEERING,
Professor Andrus Aavik, andrus.aavik@ttu.ee, +372 620 2600

LABORATORY OF ROADS AND TRAFFIC,
Kristjan Lill, kristjan.lill@ttu.ee, +372 620 2607

MAIN LINES OF RESEARCH

ROAD CONSTRUCTION TECHNOLOGIES AND MATERIALS

Research is concentrated on studies of deformation, wearing and other expluatational properties of pavement structures of Tallinn city streets and roads. The main objectives are to expand the use of local building materials in road construction, get information about the various pavement materials and their working properties under heavy traffic load, specification of requirements for road construction materials, extend the service life of asphalt pavements and optimization of road maintenance costs, develop alternative solutions to asphalt pavements in junction areas.

In 2014 the Standard pavement structures for asphalt concrete pavements based on the traffic load and geological and hydrological conditions of the Tallinn have been developed. Alternative solutions to asphalt pavements in junction areas are developed. Alternative cement concrete pavement type solutions to public transportation stops instead of asphalt concrete pavement types and recommendations for concrete pavement (including composite pavement) standard solutions for use in public transportation stops are developed.

An Estonian temperature map of the roads has been developed, which is the basis for the determination of PG-grade.

New ways of quality determination of bituminous binders were used taking into account specific conditions of bitumen use site and pavement service life.

TRANSPORT PLANNING AND TRANSPORT IMPACTS

The main research topics have been related to analysis of transport growth and its impact. An important traditional research area is traffic safety, where TUT has strong position at research and training areas (road safety auditing and inspection, road network impact analysis, safety analysis, etc).

VALIDATION OF MARINE GEOID MODELS BY ALS TECHNOLOGY

The main aim of the research is to validate accuracy of gravimetric geoid models (GRAV-GEIOID2011 in particular) over marine areas. In this respect the nadir-range airborne laser scanning data seem to be very promising. However, issues related to ALS data acquisition methodology, elimination of possible systematic errors, data processing, analysis and accuracy estimations need a very throughout investigations.

IMPLEMENTATION OF THE AIRBORNE LIDAR AND TERRESTRIAL LASER SCANNER TECHNOLOGY

The research is carried out on applicability airborne LIDAR data-series for monitoring coastal processes, detecting of ground surface in areas of complicated relief, etc.

In 2014 the terrestrial laser scanning (TLS) technology was primarily investigated for enhancing acquirement spatial data of man-made and natural targets. Of particular interest were monitoring of 3D deformations of different construction types. Methods of incorporating the TLS-data into Building

information modeling (BIM) were studied as well. Both the airborne LIDAR and TLS technologies have been applied for geoinformatic development of biodiversity, soil and Earth data systems.

GRAVITY FIELD AND GEOID MODELING IN THE NORDIC-BALTIC REGION

The Geodesy Chair is acting as a computing centre in a Nordic Geodetic Commission co-operation project for developing a new regional high-resolution geoid model for the Nordic and Baltic countries and over the entire Baltic Sea.

CONTACT: Prof. Andrus Aavik, andrus.aavik@ttu.ee

SELECTED PUBLICATIONS:

Mill, T.; Ellmann, A.; Aavik, A.; Horemuz, M.; Sillamäe, S. (2014). Determining ranges and spatial distribution of road frost heave by terrestrial laser scanning. The Baltic Journal of Road and Bridge Engineering, 9(3), 227–236.

Julge, K.; Ellmann, A.; Gruno, A. (2014). Performance analysis of freeware filtering algorithms for determining ground surface from airborne laser scanning data. Journal of Applied Remote Sensing, 8(1), 083573-1 – 083573-15.

Talvik, S. (2014). Precise levelling data processing near terraced landforms. Geodesy and Cartography, 40(2), 51–57.

Julge, K.; Gruno, A.; Ellmann, A.; Liibusk, A.; Oja, T. (2014). Exploring sea surface heights by using Airborne Laser Scanning. In: IEEE/OES Baltic 2014 International Symposium: 2014 IEEE/OES Baltic International Symposium „Measuring and Modeling of Multi-Scale Interactions in the Marine Environment": Tallinn, Estonia, May 26–29, 2014. IEEE, 2014, (IEEE Conference Proceedings), 1–8.

DEPARTMENT OF ARCHITECTURE AND URBAN STUDIES

DEPARTMENT OF ARCHITECTURE AND URBAN STUDIES,
Director: Visiting Professor Irina Raud, irina.raud@ttu.ee, +372 5854 1909

CHAIR OF ARCHITECTURE,
Visiting Professor Rein Murula, rein.murula@ttu.ee, +372 648 4013

CHAIR OF ART AND ARCHITECTURE HISTORY,
Professor Karin Hallas Murula, karin.hallas-murula@ttu.ee, +372 553 4860

CHAIR OF TOWN PLANNING,
Visiting Professor Irina Raud, irina.raud@ttu.ee, +372 5854 1909

CHAIR OF VISUAL ART,
Professor Anu Juurak, anu.juurak@ttu.ee, +372 5668 2455

MAIN LINES OF RESEARCH

The studies are focused on investigation and analysis of trends and mechanisms of actions taking place in architecture and urbanization.

Contact: Visiting Prof. Irina Raud, irina.raud@ttu.ee

SELECTED PUBLICATIONS:

Hallas-Murula, K. (2014). Tallinna Kunstihoone 1934–1940. Ehitamine ja arhitektuur (Tallinn Art Hall 1934–1940. Construction and Architecture). Tallinn: SA Tallinna Kunstihoone Fond, 2014. Monograph. 160 lk.

К. Халлас-Мурула (2014). Международный контекст градостроительного конкурса «Большой Таллин» (1913) – АРХИТЕКТУРА ЭПОХИ МОДЕРНА В СТРАНАХ БАЛТИЙСКОГО РЕГИОНА. Российская академия архитектуры и строительных наук Научно-исследовательский институт теории и истории архитектуры и градостроительства. / РААСН НИИТИАГ, Науч. ред. С. С. Левошко. Санкт-Петербург: Коло, 87–104.

FACULTY OF POWER ENGINEERING

FACULTY OF POWER ENGINEERING

Dean: ARVI HAMBURG, Professor

Phone: +372 620 3547
e-mail: arvi.hamburg@ttu.ee

Vice-Dean for Research: Senior Research Scientist ARGO ROSIN

Phone: +372 620 3708
e-mail: argo.rosin@ttu.ee

DEPARTMENTS, RESEARCH CENTERS, RESEARCH LABORATORIES:

- Department of Electrical Power Engineering
- Department of Electrical Engineering
  - Laboratory of Lighting Technology
- Department of Mining

The Faculty of Power Engineering is currently employing 11 professors.

The total number of academic staff is 59. 7 doctoral dissertations were defended in 2014.

DEPARTMENT OF ELECTRICAL POWER ENGINEERING

DEPARTMENT OF ELECTRICAL POWER ENGINEERING,
Director: Ivo Palu, ivo.palu@ttu.ee, +372 620 3752

CHAIR OF POWER SYSTEMS,
Professor Heiki Tammoja, heiki.tammoja@ttu.ee, +372 620 3768

CHAIR OF HIGH-VOLTAGE ENGINEERING,
Professor Juhan Valtin, juhan.valtin@ttu.ee, +372 620 3764

MAIN LINES OF RESEARCH

POWER SYSTEMS RESEARCH GROUP

The tasks of the Power System research group are elaboration and assessment of energy sector development scenarios and analysis of activities needed for their realization. The research in energy system planning is done with multiple energy planning models and methods.

Main research outcomes in 2014:

- new mathematical models for back-pressure turbine and for turbines with extractions;
- new mathematical optimization model for optimal load dispatch and unit commitment for co-generation power plants.

CONTACT: Prof. Heiki Tammoja, heiki.tammoja@ttu.ee

POWER SYSTEM DYNAMICS AND CONTROL GROUP

Research in the group is focused on the development of control algorithms and applications, and performing system analysis, in modern power systems. Key research areas are focused on power system real-time control and analysis based on wide-area information in respect to HVDC and FACTS control, wind power connections, power quality and load modelling.

Main research outcomes in 2014:

- development of mathematical models for high-speed trains and their supply systems;
- new approach for applicability of wide-area measurements for power system analysis and control;
- novel methods for power quality monitoring and assessment in transmission networks.

CONTACT: Assoc. Prof. Jako Kilter, jako.kilter@ttu.ee

HIGH-VOLTAGE RESEARCH GROUP

Research of the group is focused on the studies of the high voltage insulation and applications associated with the high voltages and strong electrical fields. Novel approach is the investigation of variable generation impact on high voltage cables and equipment insulation.

Main research outcomes in 2014:

- Carrying out partial discharge tests on cables in cooperation with Aalto University.

CONTACT: Prof. Juhan Valtin, juhan.valtin@ttu.ee

SELECTED PUBLICATIONS:

Taklaja, P.; Hyvönen, P.; Klüss, J. V.; Niitsoo, J.; Palu, I. (2014). Preventing Bird Streamer Outages Using Alternative Tower Configurations. IEEE Transactions on Power Delivery, 29(5), 2402–2409.

Kilter, J.; Elphick, S.; Meyer, J.; Milanovic, J. V. (2014). Guidelines for Power Quality Monitoring – Results from CIGRE/CIRED JWG C4.112. In: Proceedings of 16th International Conference on Harmonics and Quality of Power: 16th International Conference on Harmonics and Quality of Power, Bucharest, Romania, May 25–28, 2014.

Almas, M. S.; Kilter, J.; Vanfretti, L. (2014). Experiences with Steady-State PMU Compliance Testing using Standard Relay Testing Equipment. In: Electric Power Quality and Supply Reliability Conference PQ 2014: Electric Power Quality and Supply Reliability Conference PQ 2014, Rakvere, Estonia, June 11–13, 2014.

DEPARTMENT OF ELECTRICAL ENGINEERING

DEPARTMENT OF ELECTRICAL ENGINEERING,
Director: Tõnu Lehtla, tonu.lehtla@ttu.ee, +372 620 3704

CHAIR OF FUNDAMENTALS OF ELECTRICAL ENGINEERING,
Research Scientist Heigo Mõlder, heigo.molder@ttu.ee, +372 620 3802

CHAIR OF ELECTRICAL MACHINES,
Senior Research Scientist Ants Kallaste, ants.kallaste@ttu.ee, +372 620 3802

CHAIR OF ELECTRICAL DRIVES AND ELECTRICITY SUPPLY,
Professor Valery Vodovozov, valery.vodovozov@ttu.ee, +372 620 3694

CHAIR OF ROBOTICS,
Professor Tõnu Lehtla, tonu.lehtla@ttu.ee, +372 620 3704

LABORATORY OF LIGHTING,
Laboratory Manager Arvo Oorn, arvo.oorn@ttu.ee, +372 620 3703

MAIN LINES OF RESEARCH

POWER ELECTRONIC SYSTEMS

Research in the group is focused on the development and experimental validation of new state of the art power electronic converters for such demanding applications as renewable energy systems, rolling stock, automotive and telecom. Key research directions include synthesis of new converter topologies, development of special control and protection algorithms, implementation of new components and elaboration of design guidelines to further improve the efficiency, power density, reliability and flexibility of the on-market power electronic converters. Other research activities are concentrated on the development of power flow control algorithms and new supervision, fault detection, protection and communication methods for the electronic power distribution grids (Micro- and SmartGrids).

IN 2014:

- new magnetically coupled multiport DC/DC converter technology for integration and power flow control between renewable energy sources and storages
- novel maximum power point tracking (MPPT) algorithms for a grid-connected residential photovoltaic and wind power systems
- new active cell balancing methods for Li-Ion batteries

CONTACT: Senior Research Scientist Dmitri Vinnikov, dmitri.vinnikov@ieee.org

SELECTED PUBLICATIONS:

Fernćo Pires, V.; Romero-Cadaval, E.; Vinnikov, D.; Roasto, I.; Martins, J. F. (2014). Power Converter Interfaces for Electrochemical Energy Storage Systems – A Review. Energy Conversion and Management, 86, 453–475.

Chub, A.; Husev, O.; Vinnikov, D. (2014). Comparative Study of Rectifier Topologies for Quasi-Z-Source Derived Push-Pull Converter. Electronics and Electrical Engineering, 20(6), 29–34.

Chub, A.; Husev, O.; Blinov, A.; Vinnikov, D. (2014). CCM and DCM Analysis of Quasi-Z-Source Derived Push-Pull DC/DC Converter. Informacije MIDEM-Journal of Microelectronics Electronic Components and Materials, 44(3), 224–234.

Husev, O.; Vinnikov, D.; Roncero-Clemente, C.; Romero-Cadaval, E. (2014). New hysteresis current control for grid connected single-phase three-level quasi-Z-source inverter. 2014 Twenty-Ninth Annual IEEE Applied Power Electronics Conference and Exposition (APEC), Fort Worth, TX, USA, March 16–20, 2014. IEEE, 1765–1770.

Chub, A.; Husev, O., Vinnikov, D., Blaabjerg, F. (2014). Novel Family of Quasi-Z-Source DC/DC Converters Derived from Current-Fed Push-Pull Converters. In: Proceedings of the 16th Conference on Power Electronics and Applications, EPE'14-ECCE Europe: The 16th Conference on Power Electronics and Applications, EPE'14-ECCE Europe, August 26–28, 2014, Lappeenranta, Finland. IEEE, 1–10.

ELECTRICITY SUPPLY AND ACTIVE DISTRIBUTION NETWORKS

Studies of the research group are focused on (1) electricity supply of enterprises, buildings and home users, incl. electricity efficiency, power quality, reliability; (2) demand side management in smart and micro grids; (3) energy flow research in networks with alternative energy sources and energy storages.

IN 2014:

New scientific ideas: real time price based load control models (EU FP7 project EcoGRID); new diagnostic models for Li-Ion batteries in cooperation with Prof. Helmuth Biechl from Hochschule Kempten; energy reserve optimization methodology for households with renewable power systems; together with Estonian TSO (Elering) the demand profiles and new demand side management possibilities were analyzed.

CONTACT: Senior Research Scientist Argo Rosin, argo.rosin@ttu.ee

SELECTED PUBLICATIONS:

Kütt, L.; Saarijärvi, E.; Lehtonen, M.; Rosin, A.; Mõlder, H. (2014). Load Shifting in the Existing Distribution Network and Perspectives for EV Charging – Case Study. IEEE PES Innovative Smart Grid Technologies, Europe; Istanbul; October 12–15, 2014. IEEE.

Lebedev, D.; Rosin, A. (2014). Modelling of Electricity Spot Price and Load Forecast Based New Energy Management System for Households. 55th International Scientific Conference on Power and Electrical Engineering of Riga Technical University (RTUCON), Riga Technical University, Riga, October 14, 2014. Latvia: IEEE, 222–226.

Uuemaa, P.; Puusepp, A.; Drovtar, I.; Kilter, J.; Rosin, A.; Valtin, J. (2014). Load Control Implementation in the Energy Intensive Industry. 17th IEEE Mediterranean Electrotechnical Conference – Power Electrical Systems (MELECON 2014), April 13–16, Beirut, Lebanon. IEEE, 213–218.

Rahmoun, A.; Loske, M.; Rosin, A. (2014). Determination of the Impedance of Lithium-ion Batteries Using Methods of Digital Signal Processing. Energy Procedia, 46 (204–213). Elsevier.

ELECTRICAL MACHINES

Studies of the research group are focused on (1) electrical machines for wind generators (incl. analyse, design, experiments, development); (2) special electrical machines with high power density for transport applications; (3) diagnostics and condition monitoring of electrical machines; (4) permanent magnet materials and their application in electrical machines.

IN 2014:

- Novel synchronous reluctance machine design concept was created, modelled and evaluated. A patent application has been filed.
- Novel diagnostic indicators for electrical machine condition monitoring were proposed, propagation of faults and their correlation was shown and proven.
- Properties of novel magnetic materials were studied and characterized.
- Novel design of wheelchairs with intra-hub assistive motors was proposed.

CONTACT: Senior Research Scientist Ants Kallaste, ants.kallaste@ttu.ee

SELECTED PUBLICATIONS:

Belahcen, A.; Rasilo, P.; Arkkio, A. (2014). Segregation of Iron Losses from Rotational Field Measurements and Application to Electrical Machine. IEEE Transactions on Magnetics, 50(2), 893–896.

Vaimann, T.; Belahcen, A.; Kallaste, A. (2014). Changing of magnetic flux density distribution in a squirrel-cage induction motor with broken rotor bars. Electronics and Electrical Engineering, 20(7), 11–14.

Vaimann, T.; Belahcen, A.; Martinez, J.; Kilk, A. (2014). Detection of induction motor broken bars in grid and frequency converter supply. Przeglad Elektrotechniczny, 90(1/2014), 90–94.

Kallaste, A.; Vaimann, T.; Belahcen, A. (2014). Possible manufacturing tolerance faults in design and construction of low speed slotless permanent magnet generator. In: Proceedings of the 16th European Conference on Power Electronics and Applications (EPE'14 ECCE Europe): 16th European Conference on Power Electronics and Applications (EPE '14 ECCE Europe), Lappeenranta, Finland, August 26–28, 2014. Lappeenranta: IEEE, 1–10.

Belahcen, A.; Martinez, J.; Vaimann, T. (2014). Comprehensive computations of the response of faulty cage induction machines. In: Proceedings of the 2014 International Conference on Electrical Machines (ICEM): 21st

International Conference on Electrical Machines (ICEM), Berlin, Germany, September 2–5, 2014. Berlin: IEEE, 1504–1509.

ELECTRICAL ENGINEERING AND ELECTROMAGNETIC COMPATIBILITY

Studies of the research group are focused on ultra high frequency power applications, electromagnetic compatibility in the power and ICT systems, EMC/EMI measurements, EM-field measurements, power quality measurements and logging, welding equipment and electronics.

IN 2014:

Estonian Development Fund national idea contest „What makes life better in Estonia" one year scholarship (Heigo Mõlder) was awarded for the idea „Estonia as a hackerspace".

Three industrial research projects were completed in 2014. For company ThermoHeart Ltd „A preliminary study of special designs and applications for heating mats". Company Deep Systems Ltd „Analysis of Intra-hub Motors Integration Possibilities to the Wheelchair Wheels". Company TSO Elering „Electric and magnetic field measurements in AS Elering substations" and „Analysis of Large Electricity Consumers Demand Profiles to Determine Implementation of Demand-Side Management Measures".

CONTACT: Research Scientist Heigo Mõlder, heigo.molder@ttu.ee

SELECTED PUBLICATIONS:

Shafiq, M.; Hussain, G. A.; Kütt, L.; Lehtonen, M. (2014). Effect of Geometrical Parameters on High Frequency Performance of Rogowski Coil for Partial Discharge Measurements. Measurement, 49, 126–137.

Shafiq, M.; Lehtonen, M.; Kutt, L.; Isa, M. (2014). Design, Implementation and Simulation of Non-Intrusive Sensor for On-Line Condition Monitoring of MV Electrical Components. Engineering (ENG), 6(11), 680–691.

Kütt, L.; Saarijärvi, E.; Lehtonen, M.; Molder, H.; Vinnal, T. (2014). Harmonic load of residential distribution network – Case study monitoring results. In: Proceedings of 2014 Electric Power Quality and Supply Reliability Conference (PQ): 2014 Electric Power Quality and Supply Reliability Conference (PQ), Rakvere, Estonia, June 11–13, 2014. IEEE Conference Publications, 93–98.

Kütt, L.; Saarijärvi, E.; Lehtonen, M.; Mõlder, H.; Niitsoo, J. (2014). Estimating the harmonic distortions in a distribution network supplying EV charging load using practical source data – case example. 2014 IEEE Power and Energy Society General Meeting; National Harbor, MD, USA; July 27–31, 2014. IEEE.

ELECTRICAL DRIVES, INDUSTRY AUTOMATION AND ROBOTICS

Studies of the research group are focused on (1) electrical drives for transportation, industry automation and robotics; (2) smart grid components (storage stations) for industry and transport. The main aim is research and development of technology for industrial and energy applications.

IN 2014:

Studies to complete FP7 project „Large scale Smart Grids demonstration of real time market-based" were carried out. The key objective of the project is to demonstrate efficient operation of a distribution power system with high penetration of many and variable renewable energy resources. A real-time market concept will be developed to give small end-users of electricity and distributed renewable energy sources new options (and potential economic benefits) for offering TSOs additional balancing and ancillary services.

Surveys were conducted to carry out industrial project for Harju Elekter Elektrotehnika „Smart Grid substation with energy storage for use with renewable energy sources". Main result of the application research was development of Li-ion energy storage module for substation (P = 150 kW, E = 150 kWh), microgrid control algorithms, control software for energy storage system and microgrid. Experimental verification of control software of the energy storage module has been performed.

CONTACT: Assoc. Prof. Elmo Pettai, elmo.pettai@ttu.ee

SELECTED PUBLICATIONS:

Mägi, M.; Peterson, K.; Pettai, E. (2014). Development of Testing Method for Smart Substations with Prosumers. Informacije MIDEM-Journal of Microelectronics Electronic Components and Materials, 44(3), 185–200.

Vodovozov, V.; Lillo, N.; Raud, Z. (2014). Variable-Speed Single-Phase Induction Motor Drive for Vehicular Applications. Electrical Engineering Research (EER), 2, 18–24.

Vodovozov, V.; Raud, Z.; Lehtla, T.; Rassolkin, A.; Lillo, N. (2014). Comparative Analysis of Electric Drives for Vehicle Propulsion. 9th International Conference on Ecological Vehicles and Renewable Energies EVER 2014. Monaco: IEEE, 2014, 1–8.

Vodovozov, V.; Lillo, N.; Raud, Z. (2014). Single-Phase Electric Drive for Automotive Applications. In: International Symposium on Power Electronics, Electrical Drives, Automation and Motion SPEEDAM 2014: IEEE, 2014, 1293–1298.

Vodovozov, V.; Bakman, I. (2014). Sensorless Pressure Calculation for Parallel Redundancy in Pumping Systems. EPE'14 ECCE Europe. Lappeenranta, Finland: IEEE, 2014, 1–9.

ELECTRICAL LIGHTING

Research, measurement and development of lighting systems components and installations.

CONTACT: Laboratory Manager Arvo Oorn, arvo.oorn@ttu.ee

DEPARTMENT OF MINING

DEPARTMENT OF MINING,
Director: Ingo Valgma, ingo.valgma@ttu.ee, +372 620 3851

CHAIR OF MINING ENGINEERING,
Professor Ingo Valgma, ingo.valgma@ttu.ee, +372 620 3851

CHAIR OF APPLIED GEOLOGY,
Associate Professor Mall Orru, mall.orru@ttu.ee, +372 620 3856

MAIN LINES OF RESEARCH

RESEARCH GROUP OF MINING TECHNOLOGY AND RESOURCES

Research of the group is focused on studies of mining technologies and economical and resource studies on mineral resources. More specifically the research directions are: monitoring technologies, analyzing mining economy, water survey, rock mechanical tests, mining survey and analyzing environmental impact factors. Today the main priority is to develop aspects for sustainable mining conditions.

CONTACT: Prof. Ingo Valgma, ingo.valgma@ttu.ee

RESEARCH GROUP OF BACKFILL TECHNOLOGY AND WASTE MANAGEMENT

Research is focused on the development of new mining technologies and utilization of waste rock aggregates and power plants oil shale ash as backfill materials in conditions of Estonian oil shale mines. Key research directions include determination of ash and waste rock properties, elaboration of recommended parameters of waste, synthesis of mixture for backfilling, mechanical and physical parameters of mixture, backfill parameters of in situ conditions and feasible mining technology. Other research activities are concentrated on environmental protection and cost estimation problems.

RESEARCH GROUP OF PEAT SCIENCE

Research is focused on: (1) development of analysis methodology of technical indicators of peat, and relationship between these indicators, peat properties of use; (2) biochemical composition of peat, and its usage in balneology; (3) effect of draining of peat fields on technical characteristics and quality of peat and on water system in harvested and surrounding areas in natural state; (4) possibilities of oil shale mining under the mires of Estonian oil shale deposit.

RESEARCH GROUP OF MINING WASTE MANAGEMENT IN DEPARTMENT OF MINING

Studies are carried out in close cooperation with research group of mining survey and mining technology. Waste management research group is focused to trans-national network with regional networks as building blocks of effective multi-lateral cooperation in the field of mining waste management. The activities carried out on the regional and transnational level will secure better access to knowledge, state-of-the-art technologies and good practice to small and medium size enterprises active in the mineral waste management and prevention sector. Research activities address all the waste management challenges and opportunities which face the Baltic Sea region mining industry, which should be understood as extending to all forms of extraction of natural non-renewable resources. Research group has established research and development working pilot unit for reducing mining waste. Research group has good relations and cooperation with Estonian and European industrial companies and with European universities and research institutions. Research group manages Baltic Mining Waste Business Database (http://mi.ttu.ee/db/)

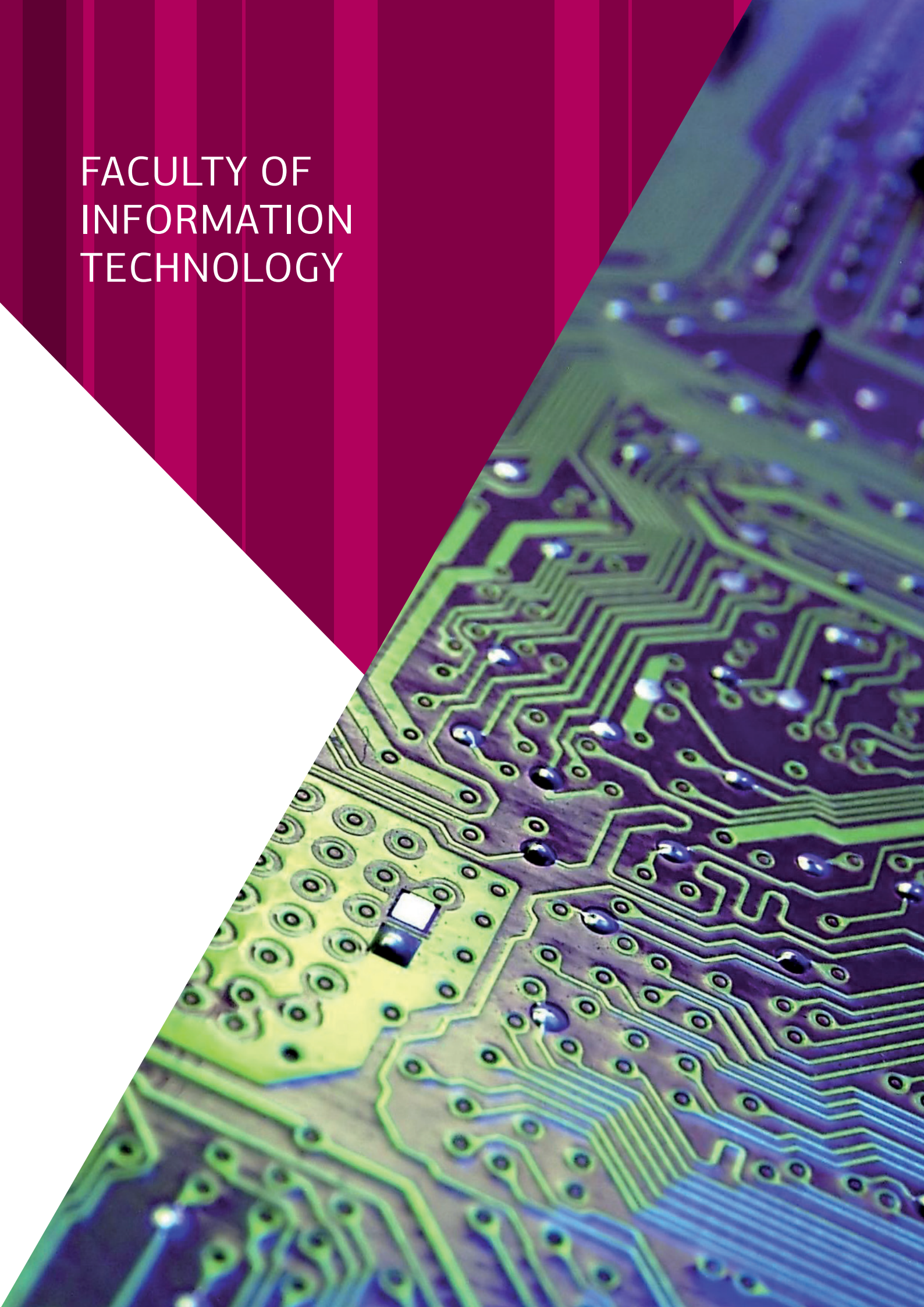
SELECTED PUBLICATIONS:

Pastarus, J.-R.; Reinsalu, E.; Saarnak, M. (2014). Modelling of oil shale concentration processes in Estonian mines. International Journal of Mining, Reclamation and Environment, 1–13.

Kikamägi, K.; Ots, K.; Kuznetsova, T.; Pototski, A. (2014). The growth and nutrients status of conifers on ash-treated cutaway peatland. Trees-Structure and Function, 28(1), 53–64.

Triisberg, T.; Karofeld, E.; Liira, J.; Orru, M.; Ramst, R.; Paal, J. (2014). Microtopography and the properties of residual peat are convenient indicators for restoration planning of abandoned extracted peatlands. Restoration Ecology, 22(1), 31–39.

FACULTY OF INFORMATION TECHNOLOGY



FACULTY OF INFORMATION TECHNOLOGY

Dean: GERT JERVAN, Professor

Phone: +372 620 2261
e-mail: gert.jervan@ttu.ee

Vice-Dean for Research and Development: MAARJA KRUUSMAA, Professor

Phone: +372 518 3074
e-mail: maarja.kruusmaa@ttu.ee

DEPARTMENTS, RESEARCH CENTRES, RESEARCH LABORATORIES:

- Department of Computer Science
- Department of Computer Engineering
- Department of Computer Control
  - Research Laboratory for Proactive Technologies
- Department of Informatics
- Department of Radio- and Communication Engineering
- Thomas Johann Seebeck Department of Electronics
  - Baselab for Semiconductor Electronics Research
  - Baselab for Electronics and Communication Research
- Centre for Biorobotics

Faculty of Information Technology is currently employing 23 professors.

Total number of academic staff is 155. 6 doctoral dissertations were defended in 2014.

DEPARTMENT OF COMPUTER SCIENCE

DEPARTMENT OF COMPUTER SCIENCE,
Director: Professor Jüri Vain, juri.vain@ttu.ee, +372 620 4190

CHAIR OF THEORETICAL INFORMATICS,
Professor Tarmo Uustalu, tarmo.uustalu@ttu.ee, +372 620 4250

CHAIR OF NETWORK SOFTWARE,
Professor Tanel Tammet, tanel.tammet@ttu.ee, +372 620 3457

CHAIR OF GENERAL INFORMATICS,
Professor Jüri Vain, juri.vain@ttu.ee, +372 620 4190

TUT CENTRE FOR DIGITAL FORENSICS AND CYBER SECURITY,
Associate Professor Rain Ottis, rain.ottis@ttu.ee

MAIN LINES OF RESEARCH:

FORMAL METHODS BASED ANALYSIS, VERIFICATION AND PLANNING

Main research activities of the group are focused on the development and application of formal methods (model checking, SMT constraint solving, abstraction refinement, automated reasoning and semantic data mining) for model-based development of distributed cyber physical systems and also social media and crowd-sourced information systems.

IN 2014:

- An aspect-oriented method for modelbased testing using UPPAAL timed automata (UPTA) with the focus on providing a rigorous constructive approach supported by modelling and test automation tool support. This approach provides two contributions: a) it allows for decoupling the design of different aspects of the system, then it uses a set of explicit composition patterns to weave the aspects together; b) it defines a set of coverage criteria for aspect-oriented UPTA models which allows one to generate tests for testing aspects individually or for testing the interference between aspects. In both cases, precise semantics for the composition and, respectively, for the test generation process has been defined.
- The methodology of proving correctness of tests for remote testing of systems with time constraints has been developed. To demonstrate the feasibility of the approach it has been shown how the abstract conformance tests are generated, verified and made practically executable on distributed modelbased testing platform dTron.
- Presence of the linear dependence between the arousal level and state of motor functions has been proven experimentally. Significant difference of the values of motion mass parameters between the PD patients and healthy individuals has been shown.
- It was proposed to use jitter bounds on Networked automation systems and the technical process to study the timing performance. Using the jitter model, the timing performance is verified using tools from model checking. The work-flow has been illustrated using suitable industrial examples. Results indicate that the method can be used effectively during the design and verification stage to verify timing performance before deployment.
- Semantic analyses has been performed and used for creating popular visualization tools (see http://sightsmap.com) for large crowd-sourced, geotagged world-wide datasets created by a large number of individuals: Panoramio photoset (used for photos on Google maps), Foursquare (recording visits to places) and a geotagged subset of Wikipedia. Also highly efficient prover database infrastructure http://whitedb.org suitable for parallel processing of large data sets in shared memory has been included into mainstream Linux distros like Debian and Ubuntu. A system http://dlineage.com for automatic rule- and semantic-based impact analysis in DB systems for Business Intelligence and Data Warehouse services, planning and change management has been built with industry cooperation (ELIKO, Mindworks).

CONTACT: Prof. Jüri Vain, juri.vain@ttu.ee

SELECTED PUBLICATIONS:

Truscan, D.; Vain, J.; Koskinen, M. (2014). Combining aspect-orientation and UPPAAL timed automata. In: Proceedings of the 9th International Conference on Software Paradigm Trends : Aug 29–31, Vienna, Austria, SciTePress, 2014, 159–164.

Vain, J.; Anier, A.; Halling E. (2014). Provably correct test generation for online testing of timed systems. In H.-M. Haav, A. Kalja, T. Robal, eds. Amsterdam, IOS Press. Databases and Information Systems VIII, Frontiers in Artificial Intelligence, 270, 289–302.

Nomm, S.; Kõnnusaar, T.; Toomela, A. (2014). Towards Establishing Relationships Between Human Arousal Level and Motion Mass. In: Neural Information Processing: 21th International Conference, ICONIP 2014, Kuching, Sarawak, Malasya, November 3–6, 2014. (Eds.) Loo, C. K.; Keem Siah, Y.; Wong, K. K. W.; Beng Jin, A. T.; Huang, K. (2014) Springer (Lecture Notes in Computer Science/Theoretical Computer Science and General Issues; 8834), 19–26.

Srinivasan, S.; Buonopane, F.; Ramaswamy, S.; Vain, J. (2014). Verifying response times in networked automation systems using jitter bounds. In: IEEE 25th International Symposium on Software Reliability Engineering Workshops [ISSREW 2014]: November 3–6, 2014, Naples, Italy, Proceedings: Piscataway: IEEE, 47–50.

Tomingas, K.; Tammet, T.; Kliimask, M. (2014). Rule-Based Impact Analysis for Enterprise Business Intelligence. In: Artificial Intelligence Applications and Innovations; AIAI 2014 Workshops: CoPA, MHDW, IIVC, and MT4BD: AIAI 2014; Rhodes, Greece, September 19–21, Springer, (IFIP Advances in Information and Communication Technology; 437), 301–309.

CYBER SECURITY AND DIGITAL FORENSICS

The research group was established in 2014 as well the TUT Centre for Digital Forensics and Cyber Security was formed. Research has been done on following topics: (1) Serious games in cyber security with the focus on technical cyber security exercises (Locked Shields series) and tabletop exercises; (2) Network security: network monitoring, measuring and situational awareness, collecting and reporting security metrics from massive event streams in industrial environments.

IN 2014:

Security metrics from massive event streams in industrial environments were collected. Experiments were carried out with novel noSQL database technologies combining them with existing event correlation and anomaly detection frameworks.

Industrial research results on collecting and reporting security metrics were published as a paper in IEEE MILCOM 2014. The research group was able to put their research efforts into an official Internet Standard (IETF RFC 7196), as well as assist Cisco to turn our research into a commercial product (Cisco VIRL).

CONTACT: Prof. Olaf Maennel, olaf.maennel@ttu.ee

SELECTED PUBLICATIONS:

Rain, O.; (2014). Light Weight Tabletop Exercise for Cybersecurity Education. Journal of Homeland Security and Emergency Management, 11(4), 579–592.

Vaarandi, R.; Pihelgas, M. (2014). Using Security Logs for Collecting and Reporting Technical Security Metrics. In: Proceedings of the 2014 IEEE Military Communications Conference: IEEE, 2014, 294–299.

Škoberne, N.; Maennel, O.; Phillips, I.; Bush, R.; Zorz, J.; Ciglaric, M. (2014). IPv4 address sharing mechanism classification and tradeoff analysis. IEEE/ACM Trans. Netw. 22, 2 (April 2014), 391–404.

Lutu, A.; Bagnulo, M.; Cid-Sueiro, J.; Maennel, O. (2014) Separating Wheat from Chaff: Winnowing Unintended Prefixes using Machine Learning. In Proceedings of IEEE Infocom, Toronto, Canada, April, 2014.

Lutu, A.; Bagnulo, M.; Pelsser, C.; Maennel, O. (2014) Understanding the Reachability of IPv6 Limited Visibility Prefixes. In Proceedings of 15th Passive and Active Measurement Conference (PAM 2014), Los Angeles, USA, March, 2014.

DEPARTMENT OF COMPUTER ENGINEERING

DEPARTMENT OF COMPUTER ENGINEERING,
Director: Associate Professor Margus Kruus, margus.kruus@ttu.ee, +372 620 2250

CHAIR OF COMPUTER SYSTEMS TEST AND VERIFICATION,
Professor Raimund-Johannes Ubar, raimund.ubar@ttu.ee, +372 620 2252

CHAIR OF COMPUTER SYSTEMS DESIGN,
Professor Peeter Ellervee, peeter.ellervee@ttu.ee, +372 620 2258

CHAIR OF SYSTEM SOFTWARE,
Professor Ahto Kalja, ahto.kalja@ttu.ee, +372 620 4210

MAIN LINES OF RESEARCH:

DIGITAL DESIGN AND TEST RESEARCH GROUP

The research group is conducting investigations and development of new methods in the fields of design verification, test, and dependability of digital systems and their components in line with International Technology Roadmap for Semiconductors. The research is targeting important quality factors like time-to-market, power consumption and speed of systems in design, performance and quality in verification and test, as well as fault tolerance and dependability of systems during their life-time. The most important R&D results have been achieved in specific topics of diagnostic modeling of systems, fault simulation, verification, automated design error diagnosis and debugging, test generation, high-performance embedded test instrumentation and system-wide fault management for failure resilience.

IN 2014:

- A new theory has been developed for diagnostic modeling of digital systems with high- and low level decision diagrams. A new model of shared SSBDD was developed which allowed: (a) to reduce the complexity of the previous BDD models, (b) to speed up simulation for both combinational and sequential circuits, and (c) to improve the known methods of fault collapsing both, in speed-up, and in the number of collapsed faults. Based on the new High-Level Decision Diagrams for modeling register transfer level systems, an efficient automated test program synthesis for testing of microprocessors was developed, which allowed to increase the fault coverage compared to the known methods.
- A new method was developed for simulating of transition delay faults (TDF) at different fault propagation conditions. The main idea of the method is to extend the TDF model to a broader class of TDFs with four different detection conditions. A novel sequential 7-valued algebra was developed for TDF reasoning. The new method allows higher accuracy of transition delay fault coverage calculation compared to the known methods.
- A novel very fast fault simulation method was developed, based on exact critical path reasoning in digital circuits. The method has been successfully approbated in evaluation of functional testing quality of signal processing systems.
- A new method for generating rejuvenation sequences for CMOS Integrated Circuits using evolutionary algorithms was developed in cooperation with the researchers of Politecnico di Torino. The method addresses reversing the negative bias temperature instability aging effects by carefully engineered test stimuli.
- A new methodology for abstracting register-transfer level descriptions up to electronic system-level was developed. The methodology is based on a novel loose modeling concept.
- Investigations of the possibilities to improve scalability and dependability of future Network-on-Chip (NoC)-based Multiprocessor System-on-Chip (MPSoC) Platforms was carried out. Considering the Through-Silicon-Vias (TSVs) as enabling technology for MPSoC, in cooperation with TU Darmstadt novel methods have been developed for adaptive routing in 3D chip-stacked NoC architectures, allowing a scalable density of vertical TSV connections. Furthermore a novel NoC dependability service layer „NoCDepend“ (based on the Built-In Self-Test generated system

health map) of a NoC has been developed, which provides fault tolerance with respect to any amount of defective communication links in a NoC and can be combined with any minimal or non-minimal deadlock-free routing algorithm. This dependability method will be the basis for research in mixed-criticality application deployment and dynamic partitioning of NoCs.

CONTACTS: Prof. Raimund Ubar, raimund.ubar@ttu.ee;
Prof. Jaan Raik, jaan.raik@ttu.ee

SELECTED PUBLICATIONS:

Jenihhin, M.; Tšepurov, A.; Tihhomirov, V.; Hantson, H.; Raik, J.; Ubar, R.; Bartsch, G.; Meza E., Jorge H.; Wuttke, H. D. (2014). Automated Bug Localization in Processor Designs. IEEE Design & Test of Computers, 1, 83–92.

Jafri, S. M. A. H.; Tajammul, M. A.; Ellervee, P.; Hemani, A.; Paul, K.; Tenhunen, H.; Plosila, J. (2014). Morphable Compression Architecture for Efficient Configuration in CGRAs. The 17th Euromicro Conference on Digital System Design (DSD 2014), Verona, Italy, Aug. 2014, 1–8.

Jantsch, A.; Tammemäe, K. (2014). A Framework of Awareness for Artificial Subjects. International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS 2014), New Dehli, October 12–17, 2014.

Leier, M.; Jervan, G.; Stork, W. (2014). Respiration Signal Extraction From Photoplethysmogram Using Pulse Wave Amplitude Variation. The 2014 IEEE International Conference on Communications (ICC), Sydney, Australia, June 10–14, 2014. IEEE, 2014, 3541–3546.

Tsertov, A.; Devadze, S.; Jutman, A.; Jasnetski, A. (2014) In-System Programming of Non-Volatile Memories on Microprocessor-centric Boards, in Int. Journal of Microelectronics and Computer Science IJMCS, Vol.5, No.1, 25–34.

SOFTWARE ENGINEERING RESEARCH GROUP

The research activities includes the following topics: web based systems, e-Government, information systems and software development methods. The group has extensive cooperation with researchers from EXCS (*Estonian Centre of eXcellence in Computer Science*).

IN 2014:

Web system user interfaces were investigated and it was shown that the rate of user mistakes while exploiting graphical user interface (UI) depends on whether advanced UI development techniques like prototyping techniques and user tests were applied during UI development or they were disregarded. Poorly working client-vendor relationship has been shown to be among the most common reasons for software project failures. One way to improve it is to set a common ground for communication: above all, by making sure that clients without software development background are knowledgeable of certain concepts and principles.

CONTACT: Prof. Ahto Kalja, ahto.kalja@ttu.ee

SELECTED PUBLICATIONS:

Marenkov, J.; Robal, T.; Kalja, A. (2014). A study on user click behaviour for WIS user interface improvements. Databases and Information Systems VIII: Selected Papers from the Eleventh International Baltic Conference, Baltic DB&IS 2014 (173–186). Amsterdam: IOS Press.

Ojastu, D.; Robal, T.; Kalja, A. (2014). Expectations of software development practitioners for non-technical clients. Databases and Information Systems VIII: Selected Papers from the Eleventh International Baltic Conference, Baltic DB&IS 2014 (317–330). Amsterdam: IOS Press.

DEPARTMENT OF COMPUTER CONTROL

DEPARTMENT OF COMPUTER CONTROL,
Director: Associate Professor Boris Gordon, boris.gordon@ttu.ee, +372 620 2106

CHAIR OF AUTOMATIC CONTROL SYSTEM ANALYSIS,
Professor Ennu Rüstern, ennu.rustern@ttu.ee, +372 620 2104

CHAIR OF REAL TIME SYSTEM,
Professor Leo Mõtus, leo.motus@ttu.ee, +372 620 2118

CHAIR OF CIRCUIT THEORY AND DESIGN,
Professor Vello Kukk, vello.kukk@ttu.ee, +372 620 2111

RESEARCH LABORATORY FOR PROACTIVE TECHNOLOGIES,
Senior Research Scientist Jürgo-Sören Preden, jurgo.preden@ttu.ee, +372 620 2117

MAIN LINES OF RESEARCH:

RESEARCH LABORATORY FOR PROACTIVE TECHNOLOGIES; CHAIR OF REAL TIME SYSTEMS

The main research topic of the Research Laboratory for Proactive Technologies is Cyber-Physical Systems (CPS) in changing environments. The research can be partitioned to the following subtopics: (1) Modelling of CPS; (2) Architectures for CPS; (3) Data processing for cognition.

IN 2014:

In the area of CPS modelling the work was continued in the models of interactive computation. In the area of architectures for CPS work was continued in the development of ProWare. The agreement was signed with the Cittyntel company to apply ProWare in the Smart Street light application, which Citytnel will be deploying in various installations across the world, the first larger deployment being the installation of 600 luminaire controllers in the Old Town of Tallinn.

In the area of data processing the data processing for cognition work was continued in the signal processing and fuzzy classification areas. The research agreement with the US Army Research Lab in the domain of signal processing and classification of PIR sensors was completed.

CONTACTS: Senior Research Scientist Jürgo-Sören Preden, jurgo.preden@ttu.ee;
Prof. Leo Mõtus, leo.motus@ttu.ee

SELECTED PUBLICATIONS:

Preden, J.-S.; Motus, L.; Llinas, J.; Pahtma, R.; Savimaa, R.; Meriste, M.; Astapov, S. (2014). Improvised Explosive Devices in Asymmetric Conflicts: Multisource Data Fusion for Providing Situational Information. Case Studies in System of Systems, Enterprise Systems, and Complex Systems Engineering (407–443).Taylor & Francis.

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Astapov, S.; Ehala, J.; Preden, J.-S. (2014). Collective Acoustic Localization in a Network of Dual Channel Low Power Devices. In: Proceedings of the 21st International Conference „Mixed Design of Integrated Circuits and Systems": 21st International Conference „Mixed Design of Integrated Circuits and Systems" MIXDES 2014, Lublin, Poland, June 19–21, 2014. IEEE, 2014, 430–435.

Riid, A.; Preden, J.-S.; Astapov, S. (2014). Detection, identification and tracking of mobile objects with distributed system of systems. In: System of Systems Engineering (SOSE), 2014 9th International Conference on: 2014 9th International Conference on System of Systems Engineering (SOSE), Adelaide, Australia. IEEE, 2014, 224–229.

Astapov, S.; Preden, J.-S.; Ehala, J.; Riid, A. (2014). Object detection for military surveillance using distributed multimodal smart sensors. In: Digital Signal Processing (DSP), 2014 19th International Conference on: 2014 19th International Conference on Digital Signal Processing (DSP). Hong Kong, Hong Kong: IEEE, 2014, 366–371.

Preden, J.-S.; Pahtma, R.; Tomson, T.; Motus, L. (2014). Solving Big Data: Distributing Computation Among Smart Devices. Databases and Information Systems (245–258). IOS Press Preden, J. (2014).

CHAIR OF AUTOMATIC CONTROL AND SYSTEM ANALYSIS

Research is concentrated on advanced system modeling and control design methods. Core competences are: (1) Control of complex nonlinear systems; (2) Self-learning and adaptation methods in control systems; (3) Computational intelligence based methods in control (artificial neural networks, genetic algorithms, fuzzy logic); (4) Fractional-order modeling and control (FOMCON project http://fomcon.net/).

IN 2014:

Artificial Neural Network based ANARX-tipe model was applied for identification of a model of a real-life process. Parameters of the identified model were used to design a controller based on dynamic feedback linearization. The designed controller is capable of tracking the desired water level for all set points with high degree of accuracy and without significant over/undershoot.

A water boiler process was studied based on real process data. Process was identified and modelled. An MPC controller was developed for process control and tested in virtual (Matlab) environment.

The research was carried out to study the digital implementation of a fractional-order PID controller based on an infinite impulse response (IIR) filter structure obtained by applying the Oustaloup recursive filter generation technique. Software for generating digital fractional-order is developed and tested on an Atmel AVR microcontroller. The results are verified using a MATLAB/Simulink based real-time prototyping platform.

A method based on a gain and order scheduling approach for fractional-order PID controllers was investigated. The method is applied to the control of a real-life laboratory model of an industrial multi-tank system. The majority of necessary computations are performed numerically in the FOMCON toolbox for MATLAB.

The research was carried out to study the problem of fractional-order PID controller design for an unstable plant – a laboratory model of a magnetic levitation system. To this end, model based control design was applied. A model of the magnetic levitation system was obtained by means of a closed-loop experiment. Several stable fractional-order controllers were identified and optimized by considering isolated stability regions. Finally, a nonintrusive controller retuning method was used to incorporate fractional-order dynamics into the existing control loop, thereby enhancing its performance. Experimental results confirm the effectiveness of the proposed approach. Control design methods obtained during this study are general enough to be applicable to a variety of control problems.

CONTACT: Prof. Ennu Rüstern, ennu.rustern@ttu.ee

SELECTED PUBLICATIONS:

Vassiljeva, K.; Belikov, J.; Petlenkov, E. (2014). Application of genetic algorithms to neural networks based control of a liquid level tank system. In: 2014 International Joint Conference on Neural Networks [IJCNN] : July 6–11, 2014, Beijing, China: Piscataway, NJ: IEEE, 2014, 2525–2530.

Belikov, J.; Petlenkov, E. (2014). Model based control of a water tank system. In: 19th IFAC World Congress, IFAC 2014 : Cape Town, South Africa, August 24–29, 2014, Cape Town: IFAC, 2014, (IFAC Proceedings Volumes), 10838–10843.

Vansovitš, V.; Petlenkov, E.; Vassiljeva, K.; Tepljakov, A.; Belikov, J. (2014). Application of MPC to industrial water boiler control system in district heat plant. In: ICARCV 2014 : The 13th International Conference on Control, Automation, Robotics & Vision, December 10–12, 2014, Marina Bay Sands, Singapore, [Proceedings]: IEEE, 2014, 1609–1614.

Tepljakov, A.; Petlenkov, E.; Belikov, J.; Gonzalez, E. A. (2014). Design of retuning fractional PID controllers for a closed-loop magnetic levitation control system. In: ICARCV 2014 : The 13th International Conference on Control, Automation, Robotics & Vision, December 10–12, 2014, Marina Bay Sands, Singapore, [Proceedings]: IEEE, 2014, 1345–1350.

Tepljakov, A.; Petlenkov, E.; Belikov, J. (2014). Fractional-order digital filter approximation method for embedded control applications. International Journal of Microelectronics and Computer Science, 5(2), 54–60.

CHAIR OF CIRCUIT THEORY AND DESIGN

Research is concentrated on: (1) Development of competence-based learning system; (2) The problems of nanoscale and quantum information technology with a view to improve the respective e-learning courses for graduate students.

IN 2014:

The new application oriented themes of voice control devices and wireless RF communication sensor devices were initiated together with Estonian small eneterprices.

New algorithms for answer evaluation were developed and tested. Twodimensional representation of competences was analysed, algorithms building higher level competences were developedincuding probablity-based model for evaluation of difficulty level of a low-level competences.

Development of quantum cascade laser simulation software in cooperation of the Leeds University was carried out.

CONTACT: Prof. Vello Kukk, vello.kukk@ttu.ee

SELECTED PUBLICATIONS:

Umbleja, K.; Kukk, V.; Jaanus, M.; Udal, A. (2014). New Concepts of Automatic Answer Evaluation in Competence Based Learning. In: IEEE EDUCON 2014: IEEE EDUCON2014, Istanbul, Turkey, April 3–5, 2014. IEEE, 922–925.

Jaanus, M.; Udal, A.; Kukk, V.; Umbleja, K. (2014). Competence Based Interactive Learning with HomeLabKits: experience and work in progress. EDUCON2014 – IEEE Global Engineering Education Conference. IEEE, 1082–1084.

Kukk, V. (2014). Student's Behavior in Free Learning Environment and Formal Education System. In: Learning Technology for Education in Cloud. MOOC and Big Data: Third International Workshop, LTEC2014 Santiago, Chile, September 2–5, Springer, 187–194.

Jaanus, M.; Udal, A.; Vello, K.; Umbleja, K. (2014). Implementation of the robot arm in the interactive learning environment. ICSES 2014 International Conference on Signals and Electronic Systems, Poznań, Poland, September 11–13, 2014. IEEE, – 4.

Udal, A.; Jaanus, M.; Umbleja, K.; Reeder, R. (2014). The Method of Quantum Optical Communication Based on Entangled Photon Pairs. In: Proceedings of the 14th Biennial Baltic Electronics Conference: BEC2014, Tallinn, Estonia, October 6–8, 2014. Tallinn: IEEE, 4, 33–36.

DEPARTMENT OF INFORMATICS

DEPARTMENT OF INFORMATICS,
Director: Professor Rein Kuusik, rein.kuusik1@ttu.ee, +372 620 2301

CHAIR OF FOUNDATIONS OF INFORMATICS,
Professor Rein Kuusik, rein.kuusik1@ttu.ee, +372 620 2301

CHAIR OF INFORMATION SYSTEMS,
Associate Professor Erki Eessaar, erki.eessaar@ttu.ee, +372 620 2306

CHAIR OF INFORMATION SECURITY,
Professor Ahto Buldas, ahto.buldas@ttu.ee, +372 620 2300

CHAIR OF SOFTWARE ENGINEERING,
Professor Kuldar Taveter, kuldar.taveter@ttu.ee, +372 620 2313

CHAIR OF KNOWLEDGE-BASED SYSTEMS,
Professor Jaak Tepandi, jaak.tepandi@ttu.ee, +372 620 2308

MAIN LINES OF RESEARCH:

RESEARCH GROUP OF SOCIOTECHNICAL SYSTEMS AND E-GOVERNMENT

The research group is active in ICT exact sciences as well as social sciences, healthcare, and psychology. Main research topics are: (1) service-oriented architectures; (2) archetypes-based software engineering; (3) large relational systems lying in the centre of sociotechnical systems and e-Government registries; (4) data mining; (5) the methodology of agent-oriented modelling for designing sociotechnical systems.

IN 2014:

The research was research was centred on the task to create a method for developing information systems that evolve in an evolutionary way jointly with businesses or governmental organisations by means of constant development. For achieving that goal, an approach of sociotechnical systems[1] was chosen.

- Reference architecture has been proposed for managing dynamic business and governmental processes. The reference architecture can be easily turned into domain-specific architectures and concrete architectures. A resulting domain-specific or concrete architecture can be easily changed and evolved with the help of the reference architecture.
- The framework has been proposed for the transition of local governments to e-Government (e-LocGov model) and an implementation methodology has been created for the launch of paperless management in local governments.
- A study on data linking has been conducted considering that semantic interlinking of data directly supports the development of evolving e-Government services. The study identified proposals for and obstacles to presenting data in a linked form for e-Government services in Estonia.
- The business archetype patterns (Product, Party, Order, Inventory, Quantity and Rule), composed of business archetypes (e.g. Person's Name, Address, etc.) have been presented as information models describing the problem domain of businesses. This enables satisfying evolutionary criteria of the second order – achieving the possibility to change requirements and domain models easily and safely at runtime without damaging the working systems and causing losses for businesses.
- The research on domain model specification has demonstrated that the sentence patterns written in the RAISE Specification Language are semantically equivalent to the patterns expressed in the C-SHARP language.
- Validation of evolving systems has resulted in a method for using genetic algorithms for system testing.

[1] systems that support social processes by hardware and software within and between organisations

- A complete rewriting of the metamodelling system for relational databases was continued. The new system will extensively use database triggers for implementing the main functionality of the database management system.
- It was studied how to use the theory of normalized systems to evaluate the quality of information systems' domain-level architectures. The use of the development practices reduces combinatorial effects between subsystems of an information system but does not eliminate the effects and hence the result is not a normalized system. However, the result largely depends on the selection of platforms and on the design of more fine-grained elements of the system.
- Experimental data mining tools have been developed which can compare and apply different structural pattern mining algorithms (serialization, matrix reordering, etc.), and generate relevant hypotheses, where the datasets analysed consist of events recorded in different information systems. Using such approach enables the researchers to analyse the usage of the sociotechnical system in the bottom-up manner, proceeding from separate events in logs generated by the system to meaningful chains of events, i.e., processes, representing detection of „social trails" in sociotechnical systems. Process mining of this kind helps to decide how the sociotechnical system should be evolved.
- A new contractual research agreement with Mitsubishi Motors Corporation was started on the mining and analysis of big data: „i-MiEV Big Data: Investigating Possibilities to Develop Cost-Efficient Cruising Distance Calculate Method for Huge Running Data from i-MiEV".
- The research was carried out in superpositional graphs (SPG), which are expressive formalisms for representing pattern matching rules. Four versions of the pattern matching problem were defined for SPG, which have different degrees of freedom. For the most general version of the pattern matching problem a dynamic programming algorithm with cashing was developed that tests pattern matching and has time complexity $O(nk)$ where n is the length of the text and k is the length of the pattern. It was proven through implementing prototype software that every match of SPG is a match of the corresponding separable permutations. This result allowed solving an open question about the existence of a linear time algorithm for pattern matching of separable permutations.
- Based on the pattern matching described above, an algorithm for the mining of frequent closed itemsets has been developed. This is an algorithm of zero-factor-free determinacy analysis for finding out how to detect by a monotone systems' algorithm if an object belongs to a class. The methodology of using the algorithm was developed in collaboration with the Estonian social and market research company Saar Poll LLC.
- The agent-oriented method proposed by Sterling & Taveter in 2009 for engineering requirements for sociotechnical systems has been elaborated.
- The method of agent-oriented modelling by Sterling & Taveter was developed further towards designing large sociotechnical service ecosystems.
- Agent-oriented models proposed by Sterling & Taveter have been mapped to Coloured Petri Nets and the relevant methodology has been proposed and applied in the problem domain of personalised healthcare.
- Members of the research group participated in the application-oriented research project by the FP7 research program of the European Union „Modelling crisis management for improved action and preparedness" (CRISMA).
- The area of privacy protection by software agents and its possible support by regulation has been investigated.
- A model-driven development method for Internet of Things (IoT)-solutions usable on mobile devices has been proposed. The method prescribes defining an IoT-solution through the usage of the goal model, decision model, process model, data model, user interface model, and integration model. Based on correctly composed models of these kinds, the user can begin testing the solution.

CONTACT: Prof. Kuldar Taveter, kuldar.taveter@ttu.ee (Group Leader);
Prof. Jaak Tepandi, jaak.tepandi@ttu.ee;
Assoc. Prof. Erki Eessaar, erki.eessaar@ttu.ee;
Assoc. Prof. Innar Liiv, innar.liiv@ttu.ee;
Senior Research Scientist Enn Õunapuu, enn.ounapuu@ttu.ee

SELECTED PUBLICATIONS:

Norta, A.; Grefen, P.; Narendra, N. (2014). A reference architecture for managing dynamic inter-organizational business processes. Data and Knowledge Engineering, 91, 52–89.

Piho, G.; Tepandi, J.; Thompson, D.; Tammer, T.; Parman, M.; Puusep, V. (2014). Archetypes based Metamodeling towards Evolutionary, Dependable and Interoperable Healthcare Information Systems. The 4th International Conference on Current and Future Trends of Information and Communication Technologies in Healthcare (ICTH 2014), Halifax (Canada), September 22–25, 2014. Elsevier, 2014, (Procedia Computer Science; 37), 457–464.

Eessaar, E. (2014). On Applying Normalized Systems Theory to the Business Architectures of Information Systems. Baltic Journal of Modern Computing, 2(3), 132–149.

Liiv, I.; Lepik, O. (2014). Business Process Mining in Warehouses: a Case Study. In: Databases and Information Systems: Proceedings of the 11th International Baltic Conference, Baltic DB&IS 2014, Tallinn, Estonia, June 8–11, 2014. Tallinn University of Technology Press, 2014, 387–394.

Miller, T.; Lu, B.; Sterling, L.; Beydoun, G.; Taveter, K. (2014). Requirements Elicitation and Specification Using the Agent Paradigm: The Case Study of an Aircraft Turnaround Simulator. IEEE Transactions on Software Engineering, VOL. 40(No. 10), 1007–1024.

RESEARCH GROUP OF COMPUTATIONAL LINGUISTICS

The research group is active in the field of multidimensional scaling of large matrixes and tensors. The research group has created and applies a novel unifying method for solving three NP-hard tasks: multidimensional scaling, obtaining minimal crossing number within binary graphs, and graph bandwidth minimising.

IN 2014:

- The research was completed concerning unsupervised clustering of words according to their fine-grained morphosyntactic functions. The proposed approach is very useful for building natural language processing systems for languages for which there is no annotated training data or linguistic description of morphology.
- The research was carried out concerning an experimental system for hierarchical relational systems. A formal methodology has been created for studying polysemy in WordNet-like dictionaries with multiple inheritance between the terms.
- The language models for multi-domain neural networks were investigated to improve performance in the target domain. The proposed architecture provides good estimates for performance on unseen (test) data.
- The Markov Chain Model with Mosteller normalisation have been used to study the Estonian regulatory system. The aim of the study was to identify the core of the Estonian Constitution. Theoretical verification and experiments have been performed to determine the grammatical similarity between the fundamental rights of citizens and Penal Law. The results achieved suggest that the core of the Constitution lies in the first level of citizens' fundamental rights.

CONTACT: Prof. Emeritus Leo Võhandu, leo.vohandu@ttu.ee

SELECTED PUBLICATIONS:

Sirts, K.; Eisenstein, J.; Elsner, M.; Goldwater, S. (2014). POS induction with distributional and morphological information using a distance-dependent Chinese restaurant process. In: The 52nd Annual Meeting of the Association for Computational Linguistics. Proceedings of the Conference. Volume 2: Short Papers: ACL June 22–27, 2014, Baltimore, USA, June 22–27, 20: Stroudsburg, PA: Association for Computational Linguistics, 265–271.

Lohk, A.; Võhandu, L. (2014). Independent Interactive Testing of Interactive Relational Systems. A. Gruca, T. Czachórski, S. Kozielski (Eds.). Man-Machine Interactions 3 (63–70). Springer.

Lohk, A.; Norta, A.; Orav, H.; Võhandu, L. (2014). New Test Patterns to Check the Hierarchical Structure of Wordnets. G. Dregvaite, R. Damasevicius (Eds.). Information and Software Technologies: 20th International Conference, ICIST 2014, Druskininkai, Lithuania, October 9–10, 2014. Proceedings (110–120). Springer.

Tilk, O.; Alumäe, T. (2014). Multi-domain recurrent neural network language model for medical speech recognition. Human Language Technologies – the Baltic Perspective: Proceedings of the Sixth International Baltic Conference, Baltic HLT 2014. (Eds.) Utka, Andrius; Grigonytė, Gintarė; Kapočiūtė-Dzikienė, Jurgita; Vaičenonienė, Jurgita. Amsterdam: IOS Press, 2014, (Frontiers in Artificial Intelligence and Applications; 268), 149–152.

DEPARTMENT OF RADIO AND COMMUNICATION ENGINEERING

DEPARTMENT OF RADIO AND COMMUNICATION ENGINEERING,
Director: Associate Professor Toomas Ruuben, toomas.ruuben@ttu.ee, +372 620 2354

CHAIR OF RADIO ENGINEERING,
Associate Professor Toomas Ruuben, toomas.ruuben@ttu.ee, +372 620 2354

CHAIR OF SIGNAL PROCESSING,
Professor Tõnu Trump, tonu.trump@ttu.ee, +372 620 2350

CHAIR OF TELECOMMUNICATIONS,
Associate Professor Eerik Lossmann, eerik.lossmann@ttu.ee, +372 620 2360

MAIN LINES OF RESEARCH:

SIGNAL PROCESSING RESEARCH GROUP

Research is focused on adaptive signal processing algorithms and robust signal processing. The subareas of research are (1) Robust detection of signals in the presence of nongaussian disturbances; (2) Robust adaptive beamforming; (3) Signal processing in spatially distributed networks of sensors.

CONTACT: Prof. Tõnu Trump, tonu.trump@ttu.ee

SELECTED PUBLICATIONS:

Trump, T. (2014). A Robust Eigenvalue Ratio Detector for Cognitive Radio. 19th International Conference on Digital Signal Processing (DSP 2014), Hong Kong, China, August 20–23, 2014. Hong Kong: IEEE, 2014, 30–35.

Tart, A.; Trump, T. (2014). Two Dimensional Robust Beamforming for Air-Ground Communication System. Integrated Communications, Navigation and Surveillance Conference (ICNS); Westin Washington Dulles Airport, Herndon, Virginia, USA; April 8–10, 2014. IEEE, 2014, B2-1 – B2–8.

Ainomäe, A.; Trump, T.; Bengtsson, M. (2014). Distributed Recursive Energy Detection. In: Proceedings of IEEE Wireless Communications and Networking Conference (WCNC): WCNC 2014 IEEE Wireless Communication and Networking Conference, Istanbul, Turkey, April 6–9, 2014. IEEE, 2014, 1265–1270.

FIBRE OPTICAL COMMUNICATION RESEARCH GROUP

Research is concentrated on investigation phase-sensitive optical parametric amplifiers (PSA) that have unique and superior properties compared with all other optical amplifiers, most notably the potential of noiseless amplification, very broad optical bandwidth, and being an enabler of a range of ultrafast all-optical functionalities. In communication, there is an urgent need to develop new technologies that can break the 'nonlinear Shannon capacity limit', which is considered a serious barrier for continued capacity increase needed to meet the exponentially growing demand for bandwidth. The use of PSAs is expected to be an essential part of this development. The objective is to unleash the unexplored potential of PSAs by generating knowledge and implementing experimental demonstrations that go substantially beyond current state-of-the-art.

CONTACT: Visiting Prof. Peter Avo Andrekson, peter.andrekson@ttu.ee

SELECTED PUBLICATIONS:

Lorences-Riesgo, A.; Chiarello, F.; Lundstrom, C.; Karlsson, M.; Andrekson, P. A. (2014). Experimental analysis of degenerate vector phase-sensitive amplification. Optics Express, 22(18), 21889–21902.

Eriksson, T. A.; Johannisson, P.; Puttnam, B. J.; Agrell, E.; Andrekson, P. A.; Karlsson, M. (2014). K-Over-L Multi-dimensional Position Modulation. Journal of Lightwave Technology, 32(12), 2254–2262.

Corcoran, B.; Malik, R.; Olsson, S. L. I.; Lundstrom, C.; Karlsson, M.; Andrekson, P. A. (2014). Noise beating in hybrid phase-sensitive amplifier systems. Optics Express, 22(5), 5762–5771.

Malik, R.; Kumpera, A.; Olsson, S. L. I.; Andrekson, P. A.; Karlsson, M. (2014). Optical signal to noise ratio improvement through unbalanced noise beating in phase-sensitive parametric amplifiers. Optics Express, 22(9), 10477–10486.

WIRELESS NETWORK RESEARCH GROUP

Research activities of the research group are focused on propagation of radio signals and on reliability of wireless communication networks.

IN 2014:

Radio signal propagation measurements of the ZigBee-based home automation sensor networks (IEEE 802.15.4) were carried out and coexistence problems of ZigBee- and other wireless networks and equipment (WiFi-networks) in the license-free 2.4 GHz frequency band were investigated. Recommendations were given regarding the reliability and maximum communications range of ZigBee networks in various environment. Vulnerability of ZigBee communications link to interference from WiFi routers operating in various modes and at different bit rates was estimated.

The research was done in cooperation with and the results were implemented by Estonian telecommunications service provider Elion Ettevõtted Ltd.

CONTACT: Assoc. Prof. Eerik Lossmann, eerik.lossmann@ttu.ee

THOMAS JOHANN SEEBECK DEPARTMENT OF ELECTRONICS

THOMAS JOHANN SEEBECK DEPARTMENT OF ELECTRONICS,
Director: Professor Toomas Rang, toomas.rang@ttu.ee, +372 620 2154

CHAIR OF COMMUNICATIVE ELECTRONICS,
Professor Toomas Rang, toomas.rang@ttu.ee, +372 620 2154

BASELAB FOR SEMICONDUCTOR ELECTRONICS RESEARCH (MINAKO),
Professor Toomas Rang, toomas.rang@ttu.ee, +372 620 2154

BASELAB FOR ELECTRONICS AND COMMUNICATION RESEARCH (SIE),
Senior Research Scientist Paul Annus, paul.annus@ttu.ee, +371 620 2158

MAINE LINES OF RESEARCH:

BASELAB FOR SEMICONDUCTOR ELECTRONICS RESEARCH (MINAKO)

Research is concentrated on: (1) Experimental and numerical study of wide and semi-wide bandgap materials based semiconductor devices; (2) Design and fabrication of improved semiconductor components using non-traditional technologies (e.g. DWT); (3) Specific investigations (DLTS spectroscopy, numerical experiments) of electro-physical parameters (deep levels and their influence on electrical characteristics) in semiconductor structures.

IN 2014:

- In cooperation with the Furtwangen University of Applied Sciences (Germany) the investigation of the exposure possibilities of the direct laser tool and of selection a suitable photoresist for 3D (greyscale) applications and to provide the preliminary process solution for fabricating greyscale structures in the photoresist have been done.
- The finalization of the cooperation with TI leaded to development of new lay-out realization for low voltage and low noise application in a single LDO. Special low noise architecture was implemented to improve noise performance.
- As a result of studies the nature of the defects associated with the energy level EL_2 is generally caused by atomic permutation or to atomic vacancy complex mechanisms, it was shown that it is important that during the LPE growth of epitaxial GaAs layers the EL_2-level together with HL_2-trap (B center) and HL_5-trap (A-center) participates in the formation of *i*-layer. The appearance of the donor deep level EL_2 is observed at the onset crystallization temperature T_{cryst} > 850°C, and thus the EL_2 level can act as a control engine for A- and B- centers in $_i$-region of GaAs *pin*-structures.
- The applied research for photoresist development concluded that the slope structures introduced the proof that the tactile sensor is applicable for visually impaired people. The provided greyscale solution is suitability for more sophisticated structures (e.g. lenses).

CONTACT: Prof. Toomas Rang, toomas.rang@ttu.ee

SELECTED PUBLICATIONS:

Koel, A.; Rang, T.; Rang, G. (2014). Characterization of the temperature dependent behavior of snappy phenomenon by switch-off of power GaAs diode structures. Heat Transfer XIII (439–449). Great Britain: WIT Press.

Kaste, N.; Filbert, A.; Mescheder, U.; Rang, T.; Rang, G. (2014). Process Development for 3D Laser Litography. High Performance and Optimum Design of Structures and materials (139–150). Inglismaa: Wessex Institute of Techonology Press.

Toompuu, J.; Korolkov, O.; Sleptsuk, N.; Rang, T. (2014). Investigation of Deep Level Centers in i- and n-Layers of GaAs pin-Diodes. In: Proceedings of the 14th Biennial Baltic Electronics Conference: BEC2014 2014 14th Biennial Baltic Electronics Conference. Tallinn: IEEE, 25–28.

BASELAB FOR ELECTRONICS AND COMMUNICATION RESEARCH (SIE)

Research is concentrated on investigation into spectrally sparse signals and sequences, with main emphasis on improved algorithms for synthesis and optimization continued.

IN 2014:

Possibility for optimization of the methods for synchronous real time processing of the spectrally sparse response from objects was investigated. Wide range of possible usability scenarios and application areas were under investigation, including those required for medical diagnosis; for analyzing of micro-droplets; materials and structures like smart composites; precise measurement of the properties of alloys; properties of algae; improvement of pulse oximetry with joint usage of electrical and optical impedance; investigation of the activity of neural cells (together with Chalmers Technical University in Gothenburg) and most importantly for effective differentiation between normal and cancerous tissue. New impedance measurement solutions for improvement of energy consumption estimation and energy efficiency in portable devices were targeted.

Solutions were studied (in cooperation with East Tallinn Central Hospital, North Estoanian Regional Hospital, Sahlgrenska Hospitalet in Gothernburg and TAK ELIKO) for usage in the field of medicine range for creation of an algorithm for generating vascular networks in small tissue scale.

In the field of simulations an electric impedance measurement with 2 electrodes on the dynamic 3D vascular 1 layer network was investigated. The results of the simulation were impedance signals that show changing impedance signal due to pulsatile blood-flow in the small tissue patch.

Research was carried out on conversion and processing algorithms of adaptively oversampled and modulated signals with applications mainly in the impedance spectroscopy and image processing. End-applications range from determining properties of the materials and alloys to smart composites.

The methods for optimal design of spectrally rich excitation signals for impedance spectroscopy have been developed. Applications yield the best results in the world at the moment. The implementation has been patented (3 US patents).

The methods have been developed for the monitoring of structures, materials and surfaces by the aid of novel 3D laser scanning (1 patent application), eddy current excitation and electromechanical impedance analysis (1 US patent).

CONTACT: Senior Research Scientist Paul Annus, paul.annus@ttu.ee

SELECTED PUBLICATIONS:

Märtens, O.; Land, R.; Gordon, R.; Min, M.; Rist, M.; Pokatilov, A. (2014). Precise eddy current measurements: Improving accuracy of determining of the electrical conductivity of metal plates. Lecture Notes on Impedance Spectroscopy: Measurement, Modeling and Applications (109–115). London: Taylor & Francis.

Herranen, H.; Kuusik, A.; Saar, T.; Reidla, M.; Land, R.; Märtens, O.; Majak, J. (2014). Acceleration Data Acquisition and Processing System for Structural Health Monitoring. In: Proceedings of the 2014 IEEE International Workshop On Metrology For Aerospace: IEEE International Workshop On Metrology For Aerospace, Benevento, Italy, May 29–30, 2014. Benevento, Italy: IEEE, 2014, 244–249.

Min, M.; Paavle, T. (2014). Broadband discrete-level excitations for improved extraction of information in bioimpedance measurements. Physiological Measurement (IOP, Bristol, UK), 35(6), May 20, 2014. 997–1010.

Ojarand, J.; Min, M.; Annus, P. (2014). Crest factor optimization of the multisine waveform for bioimpedance spectroscopy. Physiological Measurement (IOP, Bristol, UK), 35(6), May 20, 2014. 1019–1033.

CENTRE FOR BIOROBOTICS

CENTRE FOR BIOROBOTICS,
Professor MAARJA KRUUSMAA, maarja.kruusmaa@ttu.ee, +372 518 3074

MAIN LINE OF RESERACH

Research is concentrated on: (1) Sensors and algorithms for sensing flow; (2) Developing principles for sensing flow based on the biological principles of fish lateral line sensing, in particular, characterisation of uniform and periodic turbulent flows; (3) Validation of the principles in laboratory conditions as well as in semi-natural and natural environments.

IN 2014:

- Development and testing of a biologically inspired underwater robot U-CAT has been done: finalisation of the mechanical design, design and implementation of the control architecture. Improvement of the design of the motor drivers. Development of sensors for obstacle avoidance and the localisation methods with the help of hydrophones array.
- Characterization of flow with an artificial lateral line
- Field testing sensors and methods for flow sensing

CONTACT: Prof. Maarja Kruusmaa, maarja.kruusmaa@ttu.ee

SELECTED PUBLICATIONS:

El Daou, H.; Salumäe, T.; Chambers, L. D.; Megill W.; Kruusmaa, M. (2014) „Modelling of a Biologically Inspired Robotic Fish Driven by Compliant Parts", Bioinspiration and Biomimetics, IoP, Vol 9, No. 1, 2014.

Akanyeti et al (21 authors), „FILOSE for svenning", IEEE Robotics and Automation Magazine, 21(3), 51–62.

Toming, G.; Chambers, L. D.; Kruusmaa, M. „Experimental study of hydrodynamic forces acting on artificial fish in a von Karman vortex street", Underwater Technology, Vol 32, No 2, July 2014, 81–92 (11).

Chambers, L. D.; Akanyeti, O.; Venturelli, R.; Ježov, J.; Brown, J.; Kruusmaa, M.; Fiorini, P.; Megill, W. M. (2014) „A fish prespecive: detecting flow features while moving using an artificial lateral line in steady and unsteady flow", Journal of The Royal Society: Interface 6 October, vol 11 no. 99.

Salumäe, T.; Raag, R.; Rebane, J.; Ernits, A.; Toming, G.; Ratas, M.; Kruusmaa, M. „Design principle of a biomimetic underwater robot U-CAT", In Proc. of. MTS/IEEE OCEANS'14, 2014.

FACULTY OF CHEMICAL AND MATERIALS TECHNOLOGY

FACULTY OF CHEMICAL AND MATERIALS TECHNOLOGY

Dean: VAHUR OJA, Professor

Phone: 372 620 2852
e-mail: vahur.oja@ttu.ee

Vice-Dean for Research and Development ANDRES ÖPIK, Professor

Phone: +372 620 2802
e-mail: andres.opik@ttu.ee

DEPARTMENTS, RESEARCH CENTERS, RESEARCH LABORATORIES:

- Department of Chemical Engineering
- Department of Materials Science
  - Laboratory of Thin Film Chemical Technologies
- Department of Polymer Materials
  - Laboratory for Furniture Testing
  - Laboratory for Textile Testing
  - Laboratory of Oil Shale and Renewables Research
- Department of Food Processing
- Centre for Materials Research
  - Laboratory for Materials Research
  - Laboratory of Inorganic Materials

Faculty of Chemical and Materials Technology is currently employing 11 professors.

Total number of academic staff is 106. 11 doctoral dissertations were defended in 2014.

DEPARTMENT OF CHEMICAL ENGINEERING

DEPARTMENT OF CHEMICAL ENGINEERING,
Director: Professor Vahur Oja, vahur.oja@ttu.ee, +372 620 2852

CHAIR OF CHEMICAL ENGINEERING,
Professor Vahur Oja, vahur.oja@ttu.ee, +372 620 2852

CHAIR OF ENVIRONMENTAL AND CHEMICAL TECHNOLOGY,
Professor Marina Trapido, marina.trapido@ttu.ee, +372 620 2855

MAIN LINES OF RESEARCH

CHEMICAL ENGINEERING

Research team is actively engaged in the following research aspects: phase equilibria and thermodynamic and transport properties of oil shale derived materials; kerogen-solvent interactions; mixture volatilization parameters and vaporization of specific compounds from complex matrices; fundamental aspects of oil shale thermal degradation. The aim of the research is development of the reactors for the elimination of refractory compounds: plug flow reactor for the testing of the photocatalytic activity of thin films and fluidized-bed reactor for the photocatalytic degradation of micropollutants.

IN 2014:

Experimental data have been obtained on basic thermodynamic properties of Estonian kukersite oil shale oil fractions, such as viscosity, boiling point, vapour pressure, molecular weight, molecular weight distribution, surface tension, heats of combustion, pour point and thermal conductivity. Vapor pressure and heats of vaporization data have been analysed on selected classes of pure compounds: alkylresorcinols and benzyl-alcohols.

The activity of industrial and laboratory synthesized photocatalytic coatings was studied by the degradation of methyl tert-butyl ether in air. The photocatalytic coatings of satisfactory abrasion resistance and activity on granulated lightweight materials were elaborated for use in photocatalytic fluidized-bed reactor.

CONTACT: Prof. Vahur Oja, vahur.oja@ttu.ee

SELECTED PUBLICATIONS:

Hruljova, J.; Järvik, O.; Oja, V. (2014). Application of differential scanning calorimetry to study solvent swelling of Kukersite oil shale macromolecular organic matter: A comparison with the fine-grained sample volumetric swelling method. Energy & Fuels, 28(2), 840–847.

Järvik, O.; Rannaveski, R.; Roo, E.; Oja, V. (2014). Evaluation of vapor pressures of 5-methylresorcinol derivatives by thermogravimetric analysis. Thermochimica Acta, 590, 198–205.

Hruljova, J.; Savest, N.; Yanchilin, A.; Oja, V.; Suuberg, E. (2014). Kukersite oil shale macromolecular organic matter solvent swelling in binary mixtures: impact of specifically interacting solvent. Oil Shale, 31(4) 365–376.

Siitsman, C.; Kamenev, I.; Oja, V. (2014). Vapour pressure data of nicotine, anabasine and cotinine using Differential Scanning Calorimetry. Thermochimica Acta, 595, 35–42.

Klauson, D.; Budarnaja, O.; Stepanova, K.; Krichevskaya, M.; Dedova, T.; Käkinen, A.; Preis, S. (2014). Selective performance of sol-gel synthesised titanium dioxide photocatalysts in aqueous oxidation of various-type organic pollutants. Kinetics and Catalysis, 55(1), 47–55.

ENVIRONMENTAL AND CHEMICAL TECHNOLOGY

Research group is engaged in the studies on advanced chemical oxidation as well as combined treatment (chemical + biological oxidation) of polluted water, wastewater and soil.

IN 2014:

The combined treatment schemes for the treatment of five different wastewater types with high content of recalcitrant organics have been studied in cooperation with researchers from University of Tartu. Eeach stage of the treatment was optimized at laboratory scale.

Studies were carried out with the aim to extend advanced oxidation technologies (AOTs) application to environment protection from priority pollutants and emerging micropollutants. The studies covered the application of AOTs for destruction nonylphenol, photocatalytic oxidation of doxycycline and prednisolone, and chemical (with novel oxidants)–biological treatment of PCB-contaminated soil.

CONTACT: Prof. Marina Trapido, marina.trapido@ttu.ee

SELECTED PUBLICATIONS:

Trapido, M.; Epold, I.; Bolobajev, J.; Dulova, N. (2014). Emerging micropollutants in water/wastewater: growing demand on removal technologies. Environmental Science and Pollution Research, 21(21), 12217–12222.

Bolobajev, J.; Kattel, E.; Viisimaa, M.; Goi, A.; Trapido, M.; Tenno, T.; Dulova, N. (2014). Reuse of ferric sludge as an iron source for the Fenton-based process in wastewater treatment. Chemical Engineering Journal, 255, 8–13.

Klauson, D.; Budarnaja, O.; Stepanova, K.; Krichevskaya, M.; Dedova, T.; Käkinen, A.; Preis, S. (2014). Selective performance of sol-gel synthesised titanium dioxide photocatalysts in aqueous oxidation of various-type organic pollutants. Kinetics and Catalysis, 55(1), 47–55.

Budarnaja, O.; Klauson, D.; Dedova, T.; Kärber, E.; Viljus, M.; Preis, S. (2014). Template synthesis of titanium dioxide coatings and determination of their photocatalytic activity by aqueous oxidation of humic acid. Kinetics and Catalysis, 55(6), 608–694.

DEPARTMENT OF MATERIALS SCIENCE

DEPARTMENT OF MATERIALS SCIENCE,
Acting Director: Professor Enn Mellikov, enn.mellikov@ttu.ee, +372 620 2798

CHAIR OF SEMICONDUCTOR MATERIALS TECHNOLOGY,
Professor Enn Mellikov, enn.mellikov@ttu.ee, +372 620 2798

CHAIR OF PHYSICAL CHEMISTRY,
Professor Andres Öpik, andres.opik@ttu.ee, +372 620 2802

LABORATORY OF THIN FILM CHEMICAL TECHNOLOGIES,
Lead Research Scientist Malle Krunks, malle.krunks@ttu.ee, +372 620 3363

MAIN LINES OF RESEARCH

CHAIR OF PHYSICAL CHEMISTRY

RESEARCH GROUP OF THE MOLECULAR IMPRINTED POLYMERS

Research group is engaged in development of robust label-free recognition elements for chemical sensing based on Molecularly Imprinted Polymers. The research activities are focused mainly on (i) careful optimization of the MIP films preparation strategy and (ii) study of target analyte re-binding on the MIP-modified sensors.

IN 2014:

- Computational simulations revealed high probability of the formation of hydrogen bonding between m-phenylenediamine (mPD) and antibiotic, sulfamethizole (SMZ), as well as multiple hydrogen bonding between mPD and IgG molecule.
- Maleimide benzene diazonium electrochemical reduction provided a reliable surface functionalization method for subsequent biomolecule immobilization.
- Poly (m-phenylenediamine) (PmPD) was found to be suitable for polymer matrix formation in term of showing the lowest „non-specific" binding among different polymers tested (polypyrrole, poly (3,4-ethylenedioxythiophene), polydopamine) and producing a homogeneous and uniform polymer film during electropolymerization on the IgG-modified sensor surface as well as in the presence of antibiotics.
- The optimal polymer thickness for IgG-MIP films was found to be 10.6 nm and for SMZ-MIP films 30 nm.
- The optimal IgG removal procedure was developed considering the specificity of the IgG-MIP preparation strategy such as the use of cleavable linker for IgG immobilization as well as the possibility of the multiple non-covalent interactions between antibody and polymer matrix.
- The SMZ-MIP(Dex) films prepared on the Dex-modified QCM sensor surface demonstrated higher specific recognition capacity compared with SMZ-MIP films.
- It was demonstrated that IgG-MIP and SMZ-MIP integrated with SAW chips were capable to detect analyte, IgG and SMZ, respectively, in lower concentration compared to QCM and SPR sensing platforms.

CONTACT: Prof. Andres Öpik, andres.opik@ttu.ee

SELECTED PUBLICATIONS:

Zhang, X.; Rosicke, F.; Syritski, V.; Sun, G.; Reut, J.; Hinrichs, K.; Janietz, S.; Rappich, J. (2014). Influence of the Para-Substitutent of Benzene Diazonium Salts and the Solvent on the Film Growth During Electrochemical Reduction. Zeitschrift Fur Physikalische Chemie-international Journal of Research in Physical Chemistry & Chemical Physics, 228(4–5), 557–573.

CHAIR OF SEMICONDUCTOR MATERIALS TECHNOLOGY

RESEARCH GROUP OF MONOGRAIN POWDERS

The aim of the research was the development of low-cost absorber materials and technologies for photovoltaics. The fundamental research was addressed to new type absorber materials ($Cu_2(Zn,Cd)SnS_4$, $Cu_2Zn(Ge,Sn)Se_4$, $Cu_2ZnSn(S,S)_4$, SnS) as well as to the development of monograin layer (MGL) solar cells based on these absorbers. Outcomes of this research gave improved understanding of the optoelectronic properties of this promising class of compound semiconductors, their point defects and recombination mechanisms, formation and crystallization processes. Gained knowledge will be used in further developments of synthesis process of monograins, post-growth treatments, and improvements of the device structure and the performance of the kesterite based MGL solar cells.

IN 2014:

- It was found, that the growth of $Cu_2ZnSnSe_4$ monograin powder crystals in KI involves two prevailing mechanisms: mass diffusion through the liquid phase and sintering of grains. As novelty, the values of $Cu_2ZnSnSe_4$ crystals growth parameters n = ~ 4 (the geometric factor) and the activation energy of linear crystal growth ΔEd = 0.59 (±0.13) eV were determined for the description of crystal growth in KI by formula: $dm \sim t^{1/n}\exp(-E_d/kT)$.
- It was found, that the chemical formation of $Cu_2ZnSnSe_4$ occurred mainly in the molten phase of used salt. XRD and Raman analyses confirmed that the formation of CZTSe started already at 380°C after the melting of Se that deliberated from the transformation of CuSe to $Cu_{1.8}Se$, and then the CZTSe formation process impeded to a great extent due to the presence of solid NaI (KI). After the melting of NaI (KI), the formation of CZTSe was completed. The formation enthalpy of $Cu_2ZnSnSe_4$ in NaI was determined experimentally for the first time as –36 ± 3 kJ mol^{-1} at 661°C.
- It was found that Cd incorporated into Cu_2ZnSnS_4 by using CdI_2 as flux and forms the $Cu_2Zn_{1-x}Cd_xSnS_4$ solid solutions with limited content of Cd. Cd concentration increased with increasing synthesis temperature. The activation energy of Cd incorporation was determined as 17.5 ± 2 kJ/mol. It was proposed that the incorporation of Cd atoms takes place at the Zn atom sites and amount of substitutions depends on the Cu/Sn concentration ratio. The route of Cd incorporation into CZTS from CdI_2 was described by the formation of CdI^{2+} complexes in the molten phase of cadmium iodide.
- The existence of a complete solid solution series between kesterite-type Cu_2ZnSnS_4 and stannite-type Cu_2CdSnS_4 compounds was confirmed. Structural analysis indicated that the phase transition from kesterite to stannite crystal structure occurred in the solid solutions, where Cd substitutes Zn about 40% (x=0.4). The results suggested that $Cu_2Zn_{1-x}Cd_xSnS_4$ solid solution with x around 0.4, having bandgap 1.41 eV, is optimal for absorber layer in single junction solar cells.

CONTACT: Senior Research Scientist Marit Kauk-Kuusik, marit.kauk-kuusik@ttu.ee

SELECTED PUBLICATIONS:

Leinemann, I.; Zhang, W.; Kaljuvee, T.; Tõnsuaadu, K.; Traksmaa, R.; Raudoja, J.; Grossberg, M.; Altosaar, M.; Meissner, D. (2014). $Cu_2ZnSnSe_4$ formation and reaction enthalpies in molten NaI starting from binary chalcogenides. Journal of Thermal Analysis and Calorimetry: Volume 118, Issue 2, 1313–1321.

Nkwusi, G.; Leinemann, I.; Raudoja, J.; Mikli, V.; Kauk-Kuusik, M.; Altosaar, M.; Mellikov, E. (2014). Synthesis of $Cu_2(Zn,Cd)SnS_4$ Absorber Material for Monograin Membrane Applications. In: MRS Proceedings / Volume 1638 / 2014: 2013 MRS Fall Meeting. SCHOLARONE Manuscripts, (1638 – Symposium W – Next-Generation Inorganic Thin-Film Photovoltaics), 1638.

RESEARCH GROUP OF SEMICONDUCTOR PHYSICS

Research was concentrated on investigation physical properties of different solar cell materials and solar cells. The studies were performed using Raman spectroscopy, photoluminescence spectroscopy, photoreflectance spectroscopy, external quantum efficiency, and electrical measurements. Studied materials were Cu3BiS3, Cu_2ZnSnS_4, $Cu_2ZnSnSe_4$ and $Cu_2Zn(Sn_{1-x}Ge_x)Se_4$.

IN 2014:

The elemental composition, structural, optical and electronic properties of p-type Cu3BiS3 thin films were investigated. A surface oxidation layer was also clarified using energy dependent X-ray microanalysis.

The influence of the degree of disordering in the cation sublattice on low temperature photoluminescence (PL) properties of Cu_2ZnSnS_4 (CZTS) polycrystals was investigated. The results suggest that in the case of higher degree of cation sublattice disorder radiative recombination involving defect clusters dominates at T = 10 K. These defect clusters induce local band gap energy decrease in CZTS. Giving more time for establishing ordering in the crystal lattice can reduce the concentration of defect clusters. As a result, radiative recombination mechanism changes and band-to-impurity recombination involving deep acceptor defect with ionization energy of about 200 meV starts to dominate in the low temperature PL spectra of CZTS polycrystals.

Temperature dependent PL study CZTS polycrystals was performed. The low temperature PL spectrum consists of two PL bands: PL1 at 0.66 eV and PL2 at 1.35 eV. A new radiative recombination model involving theoretically predicted (Cu_{Zn}^{-} + Sn_{Zn}^{2+}) and ($2Cu_{Zn}^{-}$ + Sn_{Zn}^{2+}) defect clusters in nearly stoichiometric CZTS has been proposed.

The optoelectronic and structural properties of $Cu_2Zn(Sn_{1-x}Ge_x)Se_4$ (CZTGeSe) alloy compounds were also studied. A linear decrease of the lattice parameter a from 0.569 nm to 0.561 nm with increasing Ge concentration was detected. Radiative recombination processes in CZTGeSe polycrystals were studied by using low-temperature PL spectroscopy. A continuous shift from 0.955 eV to 1.364 eV of the PL band position with increasing Ge concentration was detected. Based on the temperature dependent PL measurements of the CZTGeSe polycrystals, two types of recombination mechanisms were detected: band to impurity recombination in $Cu_2Zn(Sn_{1-x}Ge_x)Se_4$ with $x \leq 0.2$, and band to tail recombination in $Cu_2Zn(Sn_{1-x}Ge_x)Se_4$ with $x > 0.2$.

CONTACT: Prof. Jüri Krustok, jyri.krustok@ttu.ee

SELECTED PUBLICATIONS:

Grossberg, M.; Raadik, T.; Raudoja, J.; Krustok J. (2014). Photoluminescence study of defect clusters in Cu_2ZnSnS_4 polycrystals. Current Applied Physics, 14, 447–450.

Grossberg, M.; Krustok, J.; Raadik, T.; Kauk-Kuusik, M.; Raudoja J. (2014). Photoluminescence study of disordering in the cation sublattice of Cu_2ZnSnS_4. Current Applied Physics, 14, 1424–1427.

Yakushev, M. V.; Maiello, P.; Raadik, T.; Shaw, M. J.; Edwards, P. R.; Krustok, J.; Mudryi, A. V.; Forbes, I.; Martin, R. W. (2014). Electronic and structural characterisation of Cu_3BiS_3 thin films for the absorber layer of sustainable photovoltaics. Thin Solid Films, 562, 195–199.

RESEARCH GROUP OF THIN FILM MATERIALS

Main activities were focused on the synthesis of new attractive material SnS for absorber layers of solar cells. The aim of the research was to study regularities of chemical bath deposition (CBD) of tin sulphide thin films as function of tin and sulphur concentrations in the solutions and to develop single-phase SnS photoabsorber layers for the fabrication of solar cells.

THE MAIN RESULTS IN 2014:

- SnS films have the structure of orthorhombic herzenbergite tin monosulphide with stoichiometric composition and good pin-hole free surface morphology of rod (ZnS substrate) or flake (CdS substrate) shape of the particles. XRD, Raman and EDX analyses didn't show any additional phases in the films. Films on both substrates have very high electroresistivity, which should be improved with further chemical and thermal treatments.
- It was additionally shown that phase structure of films depends from the chemical nature of deposition substrate. The additional annealing of obtained SnS films (argon, vacuum, H_2S) improved their phase and crystalline structure and initiated the growth of crystals in films.
- The microstructural properties of the HVE-SnS thin films were influenced by different atmospheres used during annealing. The SnS films annealed in H_2S at 400^{0}C show changes in the phase composition from tin monosulfide before annealing to tin disulfide after annealing. The SnS films annealed in an argon atmosphere for 1 h showed no significant change in the crystal structure or the compositional uniformity of the films. Degradation of the SnS films occured after annealing at 500^{0}C for 2 hours. The SnS films annealed in vacuum at 500^{0}C showed good crystallinity,

dense morphology, and high photosensitivity, and are promising for use as a photoabsorber layer in solar cell structures.

CONTACT: Prof. Enn Mellikov, enn.mellikov@ttu.ee

SELECTED PUBLICATIONS:

Safonova, M.; Nair, P.; Mellikov, E.; Garcia, A.; Kerm, K.; Revathi, N.; Romann, T.; Mikli, V.; Volobujeva, O. (2014). Chemical bath deposition of SnS thin films on ZnS and CdS substrates. Journal of Material Science: Materials in Electronics, 25(7), 3160–3165.

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LABORATORY OF THIN FILM CHEMICAL TECHNOLOGIES

Studies have been performed in the next research areas: (1) Deposition of metal oxide (ZnO, p-NiO) thin films and ZnS nanorod layers by chemical spray and ZnO nanorod layers by electrochemical deposition techniques, properties of nanostructured layers; (2) Preparation and properties of plasmonic materials, properties of Au nanoparticles doped absorber layers, use of plasmonic absorbers in solar cells; (3) Deposition of Earth abundant SnxSy absorber layer by chemical spray method, properties of thin films; (4) Development of chemical bath deposited CdS and close space sublimated CdTe films for efficient solar cells, characterization of thin films and use in solar cells.

MAIN SCIENTIFIC RESULTS IN 2014:

- The possibility to grow ZnS nanorod arrays by non-vacuum technique of chemical spray method in air was shown. We studied the effect of molar ratio of Zn and S precursors in the spray solution and growth temperature on the phase composition, morphology and optical properties of ZnS layers. The main factor determing the purity of sulfide phase is amount of thiourea in the solution sprayed as only with excess of sulfur source pure ZnS phase is obtained. Development of ZnS nanorods is controlled by both the phase purity and growth temperature.
- To find new possible application fields for nanostructured layers fabricated by solution technics photocatalytic properties of different nanostructured layers were studied. It appears that ZnO nanostructured layers have excellent photocatalytic activity which could be efficiently used to clean waste waters from organic pollutants.
- The methodology to grow ZnO layers on light flexible polymeric substrates as substrates for next-generation solar cells or transparent electronic devices was elaborated. It was shown that an un-doped ZnO should be deposited first which acts as a seed layer for the following n-ZnO layer (ZnO:In). It was shown that depend on the seed layer morphology flat compact film or scrolled nanobelt layer of ZnO:In could be grown. The layer morphology determines the electrical properties such as carrier mobility and electrical resistivity, while the carrier concentration is mainly determined by the amount of donor states in the material.
- Metal oxide films with p-type of conductivity are of high importance in electronic devices and also in solar cells. P-NiO films were grown by chemical spray using two different precursor materials. Smooth films were obtained with Ni acetate while rough and porous films formed from Ni chloride. Doping with Li ions of NiO films grown from acetate was used to adjust the concentration of holes in NiO film.
- The technologies to prepare Plasmonic nanoparticles of Au and Ag by techniques of sol gel and spray have been elaborated. Thermoanalytical studies of precursors for Au and Ag nanoparticles provide with data to select nanoparticle deposition temperatures. Methodology of applying noble metal nanoparticles into or onto the films was worked out on TiO_2 films as an inactive model material.
- Deposition and properties of metal sulfide films such as In_2S_3 (prospective absorber for intermediate absorber solar cell) and Sn_xS_y (potentaial absorber for thin film solar cell) grown by non-vacuum chemical spray pyrolysis method were studied. According to Raman spectroscopy study the crystal quality of In_2S_3 increases when deposited at higher temperatures or with an alcohol solvent or applying post-deposition thermal treatment in diluted H_2S atmosphere. Simultaneously, an increase in quality of crystal ordering with Indium in octahedral sites was observed. Earth abundant Sn_xS_y films with reduced content of oxidated phases can be grown by spray using thiourea-rich spray solutions.

- In the field of development of materials for more efficient CdS/CdTe solar cells formation regularities of the structural properties of CdTe thin films deposited by close spaced sublimation in dependence on the temperature of the substrate have been identified and got understanding of the impact of oxychloride activation treatment on the optoelectronic properties of these thin films. Investigations on impact of annealing in different atmospheres on structural, optical and electrical properties of chemical bath deposited CdS thin films revealed that the induced by annealing changes in the properties are connected with decomposition of OH- group incorporated in CdS lattice in the deposition process, with outdiffusion of H_2O and destruction of crystallites, and with creation of Cd excess resulting in transition from $CdS_{1-x}(OH)_x$ to $CdS_{1-y}O_y$ solid solution. Annealing in air and N_2 creates stable $CdS_{1-y}O_y$ solid solution while H_2 annealing removes the oxides and chloride dopant resulting in pure CdS films. Excess of Cd as precipitate decreases the transmittance while incorporation of oxygen into CdS lattice decreases the band gap of the CdS film. As a result of these studies, application of layers with improved properties allows increase efficiencies of CdS/CdTe by 2%, i.e. to 12% for the best cells.

CONTACT: Lead Research Scientist Malle Krunks, malle.krunks@ttu.ee

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DEPARTMENT OF POLYMER MATERIALS

DEPARTMENT OF POLYMER MATERIALS,
Director: Professor Andres Krumme, andres.krumme@ttu.ee, +372 620 2907

CHAIR OF POLYMER TECHNOLOGY,
Professor Andres Krumme, andres.krumme@ttu.ee, +372 620 2907

CHAIR OF WOODWORKING,
Professor Jaan Kers, jaan.kers@ttu.ee, +372 620 2910

CHAIR OF TEXTILE TECHNOLOGY,
Professor Andres Krumme, andres.krumme@ttu.ee, +372 620 2907

LABORATORY OF OIL SHALE AND RENEWABLES RESEARCH,
Senior Research Scientist Hans Luik, hans.luik@ttu.ee, +372 5301 6322

LABORATORY FOR FURNITURE AND WOOD MATERIALS TESTING,
Research Scientist Triinu Poltimäe, triinu.poltimae@ttu.ee, +372 620 2910

LABORATORY FOR TEXTILE TESTING,
Professor Andres Krumme, andres.krumme@ttu.ee, +372 620 2907

MAIN LINES OF RESEARCH

RESEARCH TEAM OF POLYMERIC MATERIALS

Research is carried out in the performance of three main topics:

CARBON NANOTUBE REINFORCED ELECTROSPUN NANO-FIBRES AND YARNS

The main goal is to develop and industrialize a technological process for production of ultra-strong and functionalised polymer nanofibres and yarns for various applications. The process combines electro-spinning of polymers with carbon nanotube (CNT) doping and additional functionalization tools. The main applications of the novel materials are: dynamically adjustable pore size filter for special filtering applications; substrates for cell growth; ultra-strong fabric for reinforcement of plastic film laminates; yarns for special textiles having exceptional strength and special properties as piezoactivity, conductivity and shielding capacity.

IN 2014:

Technological breakthrough was achieved in the field of production of nanofibrous yarns by electrospinning. Prototype of a device having new operation principle was prepared. The key of the new technology is air vortex generated by reduced pressure in the spinning chamber. European patent application has been filed to this technology. The new device can produce yarns approximately 100 times faster than the best methods known up to now and this is certainly not the upper limit of productivity. Improved productivity opens route for commercialisation of several new fibrous materials for smart textiles, wearable electronics and medical textiles.

Also, new composites of PAN, SAN and PANi with several carbon allotropes were produced by electrospinning. Dispersion of the allotropes and ion conductivity of the composites were improved by incorporation of ionic liquids. Mechanical properties and total conductivity of the nanofibrous composites were significantly improved.

Two layer electrospinning was also successfully introduced by the research team. A new carbonous material was developed, in which good mechanical properties were achieved by having tough polymer in inner layer and good conductivity and high specific surface by having high carbon concentration composite on outer layer.

FLOW-INDUCED CRYSTALLIZATION AND RHEOLOGY OF POLYESTER AMIDES AND THEIR COMPOSITES

The main purpose is to study the flow behaviour and flow-induced crystallization process of some novel thermoplastics, derivatives of cellulose and their composites with polyolefins. Studies are carried out

at different shear rates and elongation stresses which similar to that appearing in situation of real polymer processing.

IN 2014:

Thermoplastic cellulose fatty acid esters were developed and studied. The fusion, crystallisation processes and flow properties of the melt were studied and described. Obtained data were used for evaluation of perspectives of application and processing of that type of materials.

Rheological properties of the melts were studied in conditions similar to those polymer processed in industry. The melt behavior of studied cellulose derivatives and their crystallisation processes open perspectives to use them as strength enhancing compounds or as plasticizers and compatibilizers in composite materials made of polymer blends which contains commodity polymer and cellulose or wood products. What is important that conditions of processing and item production could be similar to those used in polymer industry without essential modification. It was proposed different ways of material improvement to achieve good thermoplastic properties which are important in polymer production. Also, the relatively easy modification procedure makes it possible to obtain additives with wide variable properties based on renewable and ecologically friendly materials.

BASICS OF NEW UTILIZATION PROCESSES FOR OIL SHALE COMBUSTION SOLID WASTES

The project deals among others with the problem, how to use fly ash of combustion of oil shale as additive to polyethylene (PE) for formation new cheaper composite materials. The possibility of blending of oil shale ashes with PE for producing blown films of these composites is investigated. Obtained materials will be tested (density, melt flow index, thermal analysis, tensile strength etc.) and selected the best composites for producing blown film.

IN 2014:

Composites of fly ash TPEF3 and LLDPE were investigated by SEM and mechanical testing methods. Composites of ash concentration of 0 to 30 wt-% were prepared by compounding and test specimens were prepared by injection moulding. It was observed, that no adhesion between ash particles and LLDPE exists if no adhesion modificators were used. This behaviour is not depending on ash concentration and decreases mechanical properties of the composite. Surface of the composite turns rough at the ash concentration 30 wt-%. Adding silane improved adhesion between the ash and LLDPE which is expressed by improved mechanical properties. Also, the surface of specimens having higher ash concentration is smooth due do the additive.

CONTACT: Prof. Andres Krumme, andres.krumme@ttu.ee

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Tarkanovskaja, M.; Välbe, R.; Põhako-Esko, K.; Mäeorg, U.; Reedo, V.; Hoop, A.; Saal, K.; Krumme, A.; Kink, I.; Heinmaa, I.; Lõhmus, A. (2014). Novel homogeneous gel fibers and capillaries from blend of titanium tetrabutoxide and siloxane functionalized ionic liquid. Ceramics International, 40(6), 7729–7735.

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RESEARCH TEAM OF WOODEN MATERIALS AND COMPOSITES

Research is carried out in the performance of three main topics:

WOOD-PLASTIC COMPOSITES (WPC): EFFECT OF ARTIFICIAL WEATHERING ON THE MECHANICAL AND PHYSICAL PROPERTIES OF WPC.

The main goal is to evaluate the effect of moisture absorption and UV radiation on the mechanical and physical properties of WPC materials. Objectives are also to investigate the importance of wood flour fraction size on the mechanical properties of WPC and their influence on the accelerated weathering results.

In 2014 effect of different coupling agents was also under study. The composites were made with three different fraction sizes of birch (*Betula*) wood flour. Additionally Bleached-Chemi-Thermo-Mechanical aspen (*Populus tremula*) pulp (Aspen BCTMP) was also used. WPC specimens were prepared by injection molding (Battenfeld BA 230 E). Accelerated weathering tests (water absorption and thickness swelling, UV-radiation) were carried out to evaluate the influence of weathering on the mechanical and physical properties of composites. Three-point bending test and Charpy impact test were done to test mechanical properties.

IMPROVING FIRE RESISTANCE OF BENDED LAMINATED ELEMENTS

The goal is to find the most economical method to improve the fire resistance of bended plywood elements. Investigation of different impregnation processes and fire retardant agents has been conducted. The idea is to get a bended element that has improved low flammability after bending process. The research has been carried out in collaboration with Tarmeko LPD.

PERFORMANCE OF BIO-BASED BUILDING MATERIALS

A folding table with boards made from three different materials (i. e. Norway spruce, English oak and thermally modified Norway spruce) has been used as test object. The table was been tested for optical, aesthetical, moisture and functional performance and durability in ambient conditions. Based on the results it was possible to estimate the exposure severity and performance to be expected of wood materials under climatically different exposure conditions.

CONTACT: Prof. Jaan Kers, jaan.kers@ttu.ee

SELECTED PUBLICATIONS:

Aruniit, A.; Antonov, M.; Kers, J.; Krumme, A. (2014). Determination of Resistance to Wear of Particulate Composite. Engineering Materials & Tribology XXII (188–191).Trans Tech Publications Ltd.

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LABORATORY OF OIL SHALE AND RENEWABLES RESEARCH

Research is carried out in the performance of three main topics:

NEW TECHNOLOGIES OF THERMOCHEMICAL PROCESSING OF OIL SHALE AND BLENDED FUELS

Research is concentrated on investigation of liquefaction and upgrading of Estonian fossil and renewable fuels and fuel blends with the aim of their more rational and appropriate utilisation.

IN 2014:

Upgrading Estonian oil shale heavy bituminous residuum fractions (thermobitumen, 360°C+ fraction, asphalthenes, heavy oil) via catalytic hydrocracking using KF-848, DN 3100TL, KGU-950 catalysts at varied temperature and time combinations was completed and 50–70% of heavy fractions turned to diesel fraction. Regularities of co-pyrolysis fuel blends of oil shale – renewables type were investigated, new synergistic effects were detected and mathematically described. Thermobitumenization process of different oil shales in solvent medium was elucidated and compared.

LIQUEFACTION OF THE ORGANIC MATTER OF DICTYONEMA OIL SHALE WITH SUPERCRITICAL SOLVENTS AND REAGENTS.

Research is concentrated on investigation of regularities of thermochemical liquefaction and upgrading of the dictyonema oil shale with the aim of estimating its potential as a source for synthetic petroleum.

In 2014 thermochemical decomposition of Dictyonema oil shale was investigated in modified Fischer assay pyrolysis.

FUNDAMENTALS TO OIL SHALE MAXIMUM UPGRADING

The project is a continuation of the competence in the field of oil shale liquefaction via complex investigations leading to the new technologies. The direct goals of the project include working out novel technologigal fundamentals of shale oil production and complex upgrading scheme of liquid, gaseous and solid products formed in thermochemical destruction of different oil shales.

IN 2014:

Thermal dissolution of U.S., Jordan and Dictyonema oil shales in the medium of various solvents to generate maximum liquid yield followed with its maximum upgrading via catalytic hydrogenation process was investigated. It was demonstrated that the conditions found to be optimum for Kukersite maximum liquefaction and upgrading were not effective to other oil shales. Different oil shales varying in kerogen content at the same experimental conditions were demonstrated to give different yields of oil, gas and solid residue.

CONTACT: Senior Research Scientist Hans Luik, hans.luik@ttu.ee

SELECTED PUBLICATIONS:

Luik, H.; Luik, L.; Johannes, I.; Tiikma, L.; Vink, N.; Palu, V.; Bitjukov, B.; Tamvelius, H.; Krasulina, J.; Kruusement, K.; Nechaev, I. (2014). Upgrading of Estonian shale oil heavy residuum bituminous fraction by catalytic hydroconversion. Fuel Processing Technology, 2014, 124, 115–122.

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DEPARTMENT OF FOOD PROCESSING

DEPARTMENT OF FOOD PROCESSING,
Director Professor Raivo Vokk, raivo.vokk@ttu.ee, +372 620 2952

CHAIR OF FOOD SCIENCE,
Professor Raivo Vokk, raivo.vokk@ttu.ee, +372 620 2952

CHAIR OF FOOD TECHNOLOGY,
Professor Toomas Paalme, toomas.paalme@ttu.ee, +372 620 2954

MAIN LINES OF RESEARCH

Research at the Institute of Food Processing focuses on cereal, yeast and nutrition with emphasis on the use of foodomics techniques to study the metabolism and interactions between microorganisms in consortia within various food matrices. Quantitative metagenomics and proteomics combined with other omics methods are used to study fermentation patterns of specific yeast, mammalian and bacterial cell cultures and various consortia within rye bread sourdough and the human gastrointestinal tract.

YEAST DERIVED BIOACTIVE COMPOUNDS AND VITAMINS

The goal of this research is to study the content of various bioactive compounds within yeast biomass that can be used as food supplements and processing aids. In 2014 the research focused on two major topics: (1) Analysis of the role of peptides in yeast extract that support the growth of *Saccharomyces cerevisiae*; (2) Development of methods to quantify bioavailable vitamins.

IN 2014:

Saccharomyces cerevisiae S288c was grown in a synthetic grape juice medium containing ammonia, free amino acids, and yeast hydrolysate. Experiments with $^{15}NH_4Cl$ and ^{15}N-labeled yeast hydrolysate were carried out to gain insight into the consumption preferences of yeast cells towards assimilable nitrogen sources (ammonia, free amino acids, and peptides). The results indicate that during first half of fermentation a number of amino acids are more readily obtained from peptides. During the second half of fermentation a temporary decrease in the incorporation of yeast hydrolysate-derived amino acids were observed. The results suggest that yeast extracts are superior natural fermentation aids in wine and cider production.

The efficiency of various sample pre-treatment processes was studied to determine the distribution of vitamins and cofactors in quinoa seeds. It was found that the most efficient method to determine the concentration of simple vitamins was short cold extraction of finely ground seeds together with protease and phosphatase inhibitors. These inhibitors were also found to be effective in inhibiting the endogenous liberation of some of the simple vitamins from cofactors.

CONTACT: Senior Research Scientist Ildar Nisamedtinov, ildar.nisamedtinov@ttu.ee

SELECTED PUBLICATIONS:

Kevvai, K.; Kütt, M.-L.; Nisamedtinov I.; Paalme, T. (2014). Utilization of ^{15}N-labelled yeast hydrolysate in Lactococcus lactis IL1403 culture indicates co-consumption of peptide-bound and free amino acids with simultaneous efflux of free amino acids, Antonie Van Leeuwenhoek, 105, 511–522.

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STUDIES ON THE FORMATION OF FLAVOR WITHIN MODEL FOODS

Main goals of this study are to develop and apply up-to-date sensory analysis methods and contribute to the field of flavor research. In 2014 the research was focused on the following topics: (1) Determination of flavor changes and off-flavor development using instrumental and sensory analysis (pickles and ice-

cream as a model food); (2) Sensory properties development and analysis of black pepper (*Piper nigrum*) and spice-cured sprats; (3) Characterization of the odor profiles using honeys and their corresponding flowers as well as home-made kvass as a model food.

IN 2014:

It was found that every application of thermo-shock increases both „rancid" and „aged" off-flavors in both cardboard and plastic packaging, particularly on the surface of the ice-cream. The compound(s) responsible for a medicinal chalk-like off-odour in pickle brine were identified. GC/MS and GC-O analysis led to the identification of 2-chloro-6-methylphenol. The aroma profiles of thirteen different honey samples from four botanical origins were investigated together with their blossoms. Honeys from the same botanical origin clustered together; however, none of the identified compounds were exclusive to a particular honey/blossom combination.

Odour-active compounds in homemade kvass were determined by GC-O using a modified frequency technique. The key aroma compounds originated from yeast fermentation and specifically the Ehrlich pathway, carotenoid degradation, lactone formation, degradation of amino acids, yeast cell lysis, and Maillard reactions that take place in bread or kvasswort production.

CONTACT: Senior Research Scientist Kristel Vene, kristel.vene@ttu.ee

SELECTED PUBLICATIONS:

Seisonen, S.; Kivima, E.; Vene K. (2014). Characterization of the aroma profile of different honeys and corresponding flowers using solid phase microextraction and gas chromatography-mass spectrometry/olfactometry. Food Chemistry, 169, 34–40.

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Timberg, L.; Koppel, K.; Kuldjärv, R.; Paalme T. (2014). Ripening and Sensory Properties of Spice-Cured Sprats and Sensory Properties Development JOURNAL OF AQUATIC FOOD PRODUCT TECHNOLOGY 23, 129–145.

PREBIOTICS AND BACTERIA IN FOOD SYSTEMS

The major topic of the research in 2014 was: Design and application of novel levansucrase catalysts for the production of functional food ingredients. The aim of this study was to elucidate quantitative peculiarities in the metabolism of various indigestible (by human) saccharides by fecal bacteria using screening (eg Bioscreen, microcalorimetry) and various fermentation methods. The studies were carried out in cooperation with University of Tartu, Competence Center of Food and Fermentation Technologies (CCFFT), National Institute of Chemical Physics and Biophysics and Premia Ltd.

IN 2014:

The metabolism of fructooligo and polysaccharides, including inulin and levan, in a widespread gut bacterium *Bacteroides thetaiotaomicron* was studied. A shortage of amino acids was shown to stimulate the production of propionic acid by *B. thetaiotaomicron*. In addition, both poly-fructan and levan showed great potential for selective modification of gut microbiota. The rheological properties of levan-containing solutions were analyzed using a viscosimeter and compared with solutions of other polysaccharides. It was demonstrated that levan has a high potential as a diatary fiber source in ice cream supplement.

CONTACT: Senior Research Scientist Signe Adamberg, signe.adamberg@ttu.ee

SELECTED PUBLICATIONS:

Adamberg, S.; Sumeri, I.; Uusna, R.; Ambalam, P.; Kondepudi, K. K.; Adamberg, K.; Wadström, T.; Ljungh, Å. (2014). Survival and synergistic growth of mixed cultures of bifidobacteria and lactobacilli combined with prebiotic oligosaccharides in a gastrointestinal tract simulator. Microbial Ecology in Health and Disease, 25, 23062.

Adamberg, S.; Tomson, K.; Vija, H.; Puurand, M.; Kabanova, N.; Visnapuu, T.; Jõgi, E.; Alamäe, T.; Adamberg, K. (2014). Degradation of fructans and production of propionic acid by Bacteroides thetaiotaomicron is enhanced by shortage of amino acids. Frontiers in Nutrition 1:21, 1–10.

EVOLUTION OF MICROBIAL CONSORTIA IN FOOD SYSTEMS

The research aims to develop strategies to control the quality of fermented food by controlling both the composition of the microbial consortia and their dynamic growth. Two approaches has been used: (1)

tracking the changes in technological parameters resulting in the evolution of new microbial consortia in vivo, or (2) composing new starters from preselected bacteria strains with certain technological/ functional traits. Both culture dependent (plating on selective media, fingerprinting and 16S rDNA sequencing) and culture independent (DGGE, high throughput sequencing) methods were used.

IN 2014:

Performance of an „universal" nine strain starter composing from bacterial cultures selected from sourdoughs with different fermentation cycles was evaluated in a back-slopped liquid sourdough (T=30°C, t_{cyc}=12h, water content 50%). *L. paralimentarius* M30I-3, *L. plantarum* M30I-1 and *L. brevis* M30I-2 were found to dominate after the first propagation cycle and the consortium remained stable for the next 13 back-slopping cycles. *L. brevis* M30I-2 showed the highest anti-pathogenic and anti-mould activity in this screening study of our sourdough starter collection.

CONTACT: Senior Research Scientist Inga Sarand, inga.sarand@ttu.ee

SELECTED PUBLICATIONS:

Bessmeltseva, M.; Viiard, E; Simm, J.; Paalme, T; Sarand, I. (2014). Evolution of bacterial consortia in spontaneously started rye sourdoughs during two months of daily propagation. PLoS ONE 9(4), e95449.

FOOD PHYSICS

The main goal of this research is to identify natural sources of ice structuring proteins (ISP) that can be used within frozen foods to improve both their quality and shelf life.

IN 2014:

It was found that Estonian climate, with its cold winters (average temperature in winter is -4°C), has selected for the production of ice structuring proteins in overwintering winter rye (Secale cereale) and winter wheat (*Triticum aestivum*). Preliminary results indicate that ISP extracts from winter wheat display re-crystallization inhibition activity at concentrations of 0.7 g protein/L and reduced ice crystal growth by up to 90% compared with a blank control after temperature cycling. It was found that local fish could also be another source of ice structuring proteins. Baltic herring (*Clupea harengus membras*) and sprat (*Sprattus sprattus balticus*) produce ISPs during winter and total soluble protein extracts can easily be made from either whole fish or fish waste. A crude extract was found to be able to inhibit ice recrystallization by 90% at a concentration of 0.3 g/L.

To isolate ISPs from total fish protein extracts, a novel method of ice affinity purification (IAP) was applied. Compared with the original extract, one run of IAP is able to increase the activity of ice recrystallization inhibition by 10-fold.

CONTACT: Assoc. Prof. Kartin Laos, katrin.laos@ttu.ee

SELECTED PUBLICATIONS:

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SYSTEMS BIOLOGY STUDY OF LACTIC ACID BACTERIA

The aim of this study is to elucidate mechanisms of energy consumption and production pathways to develop more effective (high yield) production processes for starter (lactic acid bacteria) cultivation.

IN 2014:

The protein turnover of individual proteins (~ 800) within *Lactococcus lactis* in chemostat mode at 0.1 and 0.5 1/h was studied and it was shown that almost half of the ATP produced was spent for resynthesis of proteins. In addition, protein turnover (on average) increased by sevenfold with a fivefold increase in growth rate which was reflected by a 35% increase of biomass yield at higher specific growth rate. This is an important finding to select or design strains having more effective proteome management.

We also studied threonine metabolism within *L. lactis* which is known to enhance flavors within dairy products as threonine is degraded to acetaldehyde and glycine. Using a continuous cultivation approach with labelled threonine it was shown that threonine was cleaved mainly to glycine and acetaldehyde (over 90%) which proves that a threonine aldolase pathway is present in this organism. This knowledge allows to select potential dairy starter strains through the 'natural' modification of amino acid metabolism.

CONTACT: Senior Research Scientist Kaarel Adamberg, kaarel.adamberg@ttu.ee

SELECTED PUBLICATIONS:

Aller, K.; Adamberg, K.; Timarova, V.; Seiman, A.; Feštšenko, D; Vilu, R. (2014). Nutritional requirements and media development for Lactococcus lactis IL1403. Applied Microbiology and Biotechnology, 98, 5871–5881.

Lahtvee, P-J.; Seiman, A.; Arike, L.; Adamberg, K.; Vilu, R. (2014). Protein turnover forms one of the highest maintenance costs in Lactococcus lactis. Microbiology-SGM, 160, 1501–1512.

CENTRE FOR MATERIALS RESEARCH

CHAIR OF MATERIALS RESEARCH,
Emeritus Urve Kallavus, urve.kallavus@ttu.ee, +372 620 3152

MAIN LINES OF RESEARCH

Research is related with two main directions:

1. Investigation of hard sintered materials, their formation and structural characterization, metallographic structures, computer-aided feature analysis. Optimization and production of ceramic-based composites, coatings and multi-materials systems for application in extreme conditions – severe wear, high temperatures, complex mechanical loads, oxidative/corrosive media.

In 2014 the focus was on the recycled hardmetal reinforced composite hardfacings with iron based matrixes, produced by plasma transferred arc welding and by powder metallurgy route (liquid phase sintering). Microstructure of the hardfacings was studied by scanning electron and optical microscopy; energy dispersive spectroscopy was applied to determine a possible dissolution of the hardmetal particles in the matrix. The hardfacings studied generally demonstrated higher resistance to abrasive wear than the reference material.

The formation of nanoscopic ripple patterns on top of material surfaces has been reported for different materials and processes, such as sliding against polymers, high-force scanning in atomic force microscopy, and surface treatment by ion beam sputtering. It was shown that such periodic ripples can also be obtained in prolonged reciprocating sliding against nanocrystalline diamond films. Although the underlying mechanisms of ripple formation are not yet fully understood, these surface corrugations could be attributed to the different wear phenomena, including a stress-induced micro-fracture and plastic deformation, a surface smoothening, and a surface rehybridization from diamond bonding to an sp2 configuration.

Different tribomaterials (such as WC-, TiC or Cr_3C_2 – based composites) were investigated to find the ways to increase the resistance of coatings to abrasive wear.

2. Investigation of lignocellulosic materials (wood, cellulose, paper, structure timber), natural and man-made stone, and their degradation by natural and artificial causes; objects of cultural heritage, archaelogy, art and their conservation problems. Investigation of the indoor climate influence to the biodeterioration of materials.

In 2014 lignocellulosic materials were investigated to find an effective and environmentally friendly method to advance the fibrillation of the bleached chemi-thermomechanical pulp (BCTMP). The results show that it is possible to fibrillate BCTMP aspen fibres by using alkaline aqueous solutions at low temperatures followed by a mechanical treatment. A strong dependence of fibrillation of cellulose on temperature, time and alkali concentration was established.

To study the problems related to preservation of cultural heritage, investigation of indoor climate and its adverse effects in Estonian medieval churches has been carried out. The damage types (e.g. microbial impact, high humidity, mould etc.) were described and suggestions for conservation strategies were provided.

CONTACT: Emeritus Urve Kallavus, urve.kallavus@ttu.ee

SELECTED PUBLICATIONS:

Kärner, K.; Elomaa, M.; Kallavus, U. (2014). Study of the effect of mechanical treatment and supercritical CO_2 extraction on aspen BCTMP by surface charge measurements and SEM. Cellulose Chemistry and Technology, 48(5–6), 535–544.

Jõeleht, M.; Pirso, J.; Juhani, K.; Viljus, M.; Traksmaa, R. (2014). The formation of reactive sintered (Ti, Mo) C-Ni cermet from nanocrystalline powders. International Journal of Refractory Metals and Hard Materials, 41, 284–290.

LABORATORY OF INORGANIC MATERIALS

LABORATORY OF INORGANIC MATERIALS,
Lead Research Scientist Rein Kuusik, rein.kuusik@ttu.ee, +372 620 2801

MAIN LINES OF RESEARCH:

Main focus of the research is on development new solutions for exploitation of Estonian natural resources, for obtaining new catalysts and fertilizers with improved properties, for utilizing industrial solid wastes and/or for their environmentally friendly storage. The research covers three closely related topics: (1) Carbonatic/sulphatic systems; wastes of oil shale energetics, PCC, abatement of CO2 emissions; (2) Phosphatic/carbonatic systems; substituted apatites, new sorbents and catalysts; (3) Carbonatic/nitratic systems; new usage areas for mineral resources, fertilizers of improved properties.

IN 2014:

- *The waste ashes of oil shale combustion* as a low-cost lime source for PCC production: a series of tests was conducted to study the effect of operating conditions (mainly gas flow rate and stoichiometric excess of CO_2) on the forming crystalline product in terms of particle size, morphology and textural properties. Preconditions for creating the continuous mode ash leaching and carbonation model were achieved.
- *Phase transformations in oil shale ash-based backfilling concrete* were clarified in terms of environmental hazards and durability.
- It has been shown that the *most voluminous kinds of OS ashes* (electrostatic precipitated ash – ESPA – from CFBC and CA from PF of OS) *can be granulated* for their following using as a liming agent of acidic soils, and a success of the process depends on the number of ash characteristics and process parameters used at granulation and pre- and post-treatment of ashes and granulated products.
- Research in *oxy-fuel combustion* of oil shale of different origin (Estonian, Jordanian, USA) and oil processing wastes (semicoke) was continued and extended. The results obtained allow to determine optimum temperature regimes for oxy-combustion of OS, calculate gas phase composition, get information about heat transfer and optimum solid circulation rates in the furnace. It was shown that there are no fundamental difficulties for applying oxy-combustion to OS and that there are positive side effects in the case of carbonate-rich OS enabling to reduce CO_2 emissions from mineral part of OS.
- *The impact of the components of municipal wastewater (orthophosphate, polyphosphate and biophosphorus organic compounds, urea and surface active compounds) on precipitation of phosphorus with OSA was studied in model solutions*: the mineralogical and chemical composition, crystals size and water solubility of the precipitate were determined.
- The positive effect of *modification of ammonium nitrate* (AN) by covering the seed granules of AN with limestone or dolomite powder to increase the thermal stability of AN, to decrease its negative impact on the soil's acidity, and to increase the durability of fertilizer granules under compression was shown.

CONTACT: Lead Research Scientist Rein Kuusik, rein.kuusik@ttu.ee

SELECTED PUBLICATIONS:

Sanna, A.; Uibu, M.; Caramanna, G.; Kuusik, R.; Maroto-Valer, M. M. (2014). A review of mineral carbonation technologies to sequester CO_2. Chemical Society Reviews, 43(23), 8049–8080.

Uibu, M.; Kuusik, R. (2014). Main physicochemical factors affecting the aqueous carbonation of oil shale ash. Minerals Engineering, 59, 64–70.

I. Klimova, I.; Kaljuvee, T.; Kuusik, R. Investigation of Limestone Powder Layering onto Ammonium Nitrate Prills in Disc Granulator. 2014. J. Materials Science and Engineering. V. 5A, 151–159.

Maaten, B.; Moussa, J.; Desmarets, C.; Gredin, P.; Beaunier, P.; Kanger, T.; Tõnsuaadu, K.; Villemin, D.; Gruselle, M. (2014). Cu-Modified Hydroxy-Apatite as Catalyst for Glaser-Hay C-C Homo – Coupling Reaction of Terminal Alkynes. Journal of Molecular Catalysis A: Chemical, 393, 112–116.

TALLINN SCHOOL OF ECONOMICS AND BUSINESS ADMINISTRATION

TALLINN SCHOOL OF ECONOMICS AND BUSINESS ADMINISTRATION

Dean: ÜLLAS EHRLICH, Professor

Phone: +372 620 3945
e-mail: ullas.ehrlich@ttu.ee

Vice-dean for Research: URVE VENESAAR, Professor

Phone: +372 620 3951
e-mail: urve.venesaar@ttu.ee

DEPARTMENTS, RESEARCH CENTRES, RESEARCH LABORATORIES:

- Department of Accounting
- Department of Finance and Economics
- Department of International Relations
- Department of Business Administration
- Centre for industrial performance and competitiveness

Tallinn School of Economics and Business is currently employing 15 professors.

Total number of academic staff is 115. 5 doctoral dissertations were defended in 2014.

DEPARTMENT OF ACCOUNTING

DEPARTMENT OF ACCOUNTING,
Director: Professor Jaan Alver, jaan.alver@ttu.ee, +372 620 4002

CHAIR OF FINANCIAL ACCOUNTING,
Professor Lehte Alver, lehte.alver@ttu.ee, +372 620 4002

CHAIR OF MANAGEMENT ACCOUNTING,
Professor Jaan Alver, jaan.alver@ttu.ee, +372 620 4002

MAIN LINES OF RESEARCH

RESEARCH ON ACCOUNTING

Department of Accounting continued research activities under topic „Development of Accounting in the Republic of Estonia".

IN 2014:

Under this topic, terminological and curriculum building approaches were covered. The research was based on the legal documents, which regulate accounting in Estonia and EU, International Financial Reporting Standards, on professional literature as well as other sources of information.

In December International Conference on Accounting, Auditing, and Taxation (ICAAT 2014) was organized.

CONTACT: Prof. Jaan Alver, jaan.alver@ttu.ee

SELECTED PUBLICATIONS:

Zheng, X.; Larimo, J. (2014). Identifying Key Success Factors for International Joint Ventures in China: A Foreign Parent Perspective from Finnish Firms. In: Economics and Management, 17 (2), 106–119.

Alver, J.; Alver, L. (2014). On Some Terminological Problems of Accounting and Financial Reporting: The Case of Estonia. In: International Conference on Accounting, Auditing, and Taxation (ICAAT 2014). Lancaster, PA, USA: DEStech Publications, Inc., CD-ROM, 1–9.

Zheng, X.; Alver, J. (2014). Developing a Financial Performance Model Based on Efficacy Coefficient Model. In: International Conference on Accounting, Auditing, and Taxation (ICAAT 2014). Lancaster, PA, USA: DEStech Publications, Inc., CD-ROM, 112–121.

Alver, L.; Alver, J. (2014). Design of Accounting Curriculum: The Case of Estonia. Megatrend Review, Volume 11, No 3, 19–31.

Alver, L.; Alver J.; Talpas L. (2014). Implementation of IFRSs and IFRS for SMEs: the case of Estonia. In: Accounting and Management Information Systems. Volume 13, No 2, 236–258.

DEPARTMENT OF FINANCE AND ECONOMICS

DEPARTMENT OF FINANCE AND ECONOMICS,
Director: Professor Kaie Kerem, kaie.kerem@ttu.ee, +372 620 4054

CHAIR OF BUSINESS MATEMATICS, STATISTICS AND ECONOMETRICS,
Professor Kadri Männasoo, kadri.mannasoo@ttu.ee, +372 620 4051

CHAIR OF ECONOMIC THEORY,
Professor Kaie Kerem, kaie.kerem@ttu.ee, +372 620 4054

CHAIR OF FINANCE AND BANKING,
Professor Enn Listra, enn.listra@ttu.ee, +372 620 4056

CENTRE FOR INDUSTRIAL PERFORMANCE AND COMPETITIVENESS,
Professor Enn Listra, enn.listra@ttu.ee, +372 620 4056

MAIN LINES OF RESEARCH

ECONOMIC CYCLES IN CENTRAL AND EASTERN EUROPE

The research line seeks to provide insights into the causes, consequences and policy implications of economic fluctuations in Central and Eastern European countries. In 2014 the research was carried out in several inter-related themes, each of them focusing on a specific dimension of economic fluctuations, institutional aspects and economic performance. One policy-oriented objective was to devise ways to recognise external and internal vulnerabilities and address possible adverse effects from adverse shocks at an early stage. Another objective was to identify the possibilities of companies, households, financial markets and the public sector to become more adaptable to short-term shocks as well as long-term societal and economic changes.

CONTACT: Prof. Karsten Staehr, karsten.staehr@ttu.ee

SELECTED PUBLICATIONS:

Cuestas, J.-C.; Gil-Alana, L. A.; Staehr, K. (2014). Government debt dynamics and the global financial crisis: has anything changed in the EA12? Economic Letters, 124(1), 64–66.

Kukk, M.; Staehr, K. (2014). Income underreporting by households with business income. Evidence from Estonia. Post-Communist Economies, 26(2), 257–276.

Laidroo, L.; Ööbik, U. (2014). Banks' CSR disclosures – headquarters versus subsidiaries. Baltic Journal of Management, 9(1), 47–70.

Männasoo, K.; Meriküll, J. (2014). R&D, credit constraints, and demand fluctuations: comparative micro evidence from ten new EU members. Eastern European Economics, 52(2), 49–64.

Põder, K.; Lauri, T. (2014). When Public Acts Like Private: the failure of Estonia's school choice mechanism. European Educational Research Journal, 13, 220–234.

DEPARTMENT OF INTERNATIONAL RELATIONS

DEPARTMENT OF INTERNATIONAL RELATIONS,
Director: Professor Peeter Müürsepp, peeter.muursepp@ttu.ee, +372 620 4116

CENTRE FOR ASIA-PACIFIC STUDIES,
Professor Peeter Müürsepp, peeter.muursepp@ttu.ee, +372 620 4116

CHAIR OF EUROPEAN STUDIES,
Aksel Kirch, aksel.kirch@ttu.ee, +372 620 4118

CHAIR OF COMMUNICATION AND CULTURE,
Professor Peeter Müürsepp, peeter.muursepp@ttu.ee, +372 620 4116

CHAIR OF ECONOMIC SOCIOLOGY,
Professor Katrin Paadam, katrin.paadam@ttu.ee, +372 620 4106

CHAIR OF INTERNATIONAL RELATIONS AND POLITICAL SCIENCE,
Research Scientist Toomas Varrak, toomas.varrak@ttu.ee

MAIN LINES OF RESEARCH

RESEARCH GROUP: EUROPEAN STUDIES AND EUROPANIZATION

Research is focused on monitoring the influence of the international environment onto the political decision-making in Estonia, to draw out potential results of the international developments domestically.

The results of the research have shown that there are a number of promising developments within the socio-economic process in Baltic Sea Region in general and all South-Baltic states (Estonia, Latvia and Lithuania) have meaningful positive economic results today. At the same time the out-migration from these three countries can have rather negative impact to their future developments. The emigration of two last decades has caused diminishing in labour force that should be either recovered by higher work load for those who have not left or by advancement via new approaches in facilitating the innovation processes. The research group's main focus was on the research aspects on how to measure the extent and how to assess the reasons of continuous „brain-drain" in order to estimate the severity of possible future emigration. At the same time it was necessary to notice that the emigration of a 'knowledge worker' costs for country's economy several times more when compared to numerous 'blue collar' workers who have left their country. Thereby, educational standards, innovation and entrepreneurial environments should be considered the most important factors to influence higher educated youth to relate their professional and personal perspectives to Estonia.

In addition, the studies were carried out that addressed the problems of the years of formation of Estonian foreign policy and enlightened the diverging political aspirations of the different political forces, illuminating the conflicting geopolitical tendencies in Estonian foreign policy at its rebirth in the 1990s. The importance of these studies lied in fact that they highlighted the tendencies that evidently still exist in the undercurrents of Estonian politics and make their impact.

SELECTED PUBLICATIONS:

Kirch, A.; Tuisk, T. (2014). Potential Emigrants and Stayers in the Baltic States and Possible Impact of Their Decisions to EU Eastern Partnership. Muravska, Tatjana; Berlin, Alexandre (Eds.). EU Eastern Partnership: From Capacities to Excellence: Strengthening Research, Regional and Innovation Policies in the Context of Horizon 2020. Riga: University of Latvia Press, 78–94.

Kirch, A. (2014). Estland. Handbuch Europäisher Sozialpolitiken, Münster: LIT, 60–63.

Notermans, T. (2014). Imperial legacy? The EU's developmental model and the crisis of the European periphery. CES Papers – Open Forum. Center for European Studies at Harvard University, 1–19.

Ramiro Troitino, D. (2014). Social Policies in Western Europe Compared with USA. Examples for Central and East Europe Social Development. Journal of Legal and Economic Issues of Central Europe, Vol. 5 (No. 1), 2–8.

Selianko, I.; Lenschow, A. (2015). Energy policy coherence from an intra-institutional perspective: Energy security and environmental policy coordination within the European Commission. EIoP: European Integration online Papers, Vol. 19 (Article 2), 1–29.

RESEARCH GROUP: KNOWLEDGE AND WISDOM AS THE AIM OF SCIENTIFIC RESEARCH

The research is focused on continuing analysis of the essence of scientific research from different angles, often by studying how different branches of science really work. An important motivation for the research group was making sense of the life work of the British philosopher of science Nicholas Maxwell about the need for a revolution in the academia. The core of the revolution has to be the shift from knowledge-inquiry to wisdom-inquiry that would bring important problems of global significance to the focus of scientific research, instead of the currently prevailing emphasis on knowledge acquisition.

The work of the members of the research group has enabled to take a deeper look into the main idea from different perspectives: that of traditional philosophy of science, in the context of a new approach called practical realism, practical philosophy, ethics and cultural studies. The latter has enabled to analyse a wider perspective to the understanding of wisdom in culture and science. The exemplar branches of science under analysis have varied from physics (the traditional 'ideal' science) and chemistry to economics in particular and social science in general. In 2014, the members of the group have given further evidence that it is reasonable to study the essence of scientific research using the practical approach in general and practical realism as a novel approach to science in particular. Still, in several publications the group members take a broader cultural look at the main topic of the group.

CONTACT: Prof. Peeter Müürsepp, peeter.muursepp@ttu.ee

SELECTED PUBLICATIONS:

Müürsepp, P. (2014). Nicholas Maxwell. 2014. How Universities Can Help Create a Wiser World? The Urgent Need for an Academic Revolution. (Societas: Essays in Political and Cultural Criticism). Originally published by Imprint Academic (UK). Digital version: Andrews UK Limited. Dialogue and Universalism. Journal of the International Society for Universal Dialogue, Vol. 24, No. 2 247–250.

Müürsepp, P. (2014). Dawn of the New Enlightenment. Almagest, Vol. 5 (Issue 2 (November 2014)), 70–83.

Miller, L. (2014). Power, Knowledge Generation, Middle Eastern Transcendentalism and Global Rational Discourse. Journal of South Asian and Middle Eastern Studies. Vol. 38, No. 1, 1–21.

Miller, L. (2014). The Split in the Western Intellectual Tradition: the controversy over knowing and what can be known. – Cogito: Multidisciplinary Research Journal. Vol. 6, No. 4, 29–46.

RESEARCH GROUP: URBAN AND RESIDENTAL STUDIES – QUALITY OF LIFE IN AN INTERDISCIPLINARY PERSPECTIVE

The recent focus of the research has been laid on further theoretical elaboration of the concept of ways of residing as it appeared in different urban residential situations and in the dynamic interplay between social, economic, cultural and spatial structures. The primary urban processes under observation were urban renewal, regeneration, gentrification, conversion of space, densification, diversification, the related socio-spatial segregation, and symbolic transgression of urban and residential space as they were negotiated between different actor groups and in the context of constructing identities. Conducted in qualitative as well as quantitative perspectives, the research in 2014 involved studies on the construction of meanings and values in the spatial experience of residing and conceptualising quality of life on interacting private and public spaces, the user perspective of urban waterfront regeneration, converted former industrial areas into multifunctional spaces with accentuated focus on residential practices, experiential and projective assessment of residential strategies of students and the demand for private and public rental housing, the symbolic meaning of objects in home design of cross-cultural families, the interrelated practice of destination branding and construction of symbolic capital in the context of socio-economic activities in urban heritage space.

CONTACT: Prof. Katrin Paadam, katrin.paadam@ttu.ee

DEPARTMENT OF BUSINESS ADMINISTRATION

DEPARTMENT OF BUSINESS ADMINISTRATION,
Acting director: Lecturer. Toomas Piliste, toomas.piliste@ttu.ee, +372 620 3948

CHAIR OF ENTREPRENEURSHIP,
Emeritus Ene Kolbre, ene.kolbre@ttu.ee, +372 620 3952

CHAIR OF ENVIRONMENTAL ECONOMICS,
Head Prof. Üllas Ehrlich, ullas.ehrlich@ttu.ee, +372 620 3945

CHAIR OF ORGANISATION AND MANAGEMENT,
Associate Professor Mike Wahl, mike.wahl@ttu.ee, +372 620 3957

CHAIR OF OPERATIONS MANAGEMENT,
Associate Professor Aleksandr Miina, aleksandr.miina@ttu.ee, +372 620 3970

CHAIR OF MARKETING,
Professor Anu Leppiman, anu.leppiman@ttu.ee, +372 620 3975

CHAIR OF LABOUR ENVIRONMENT AND SAFETY,
Professor Piia Tint, piia.tint@ttu.ee, +372 620 3960

CENTRE FOR ENTREPRENEURSHIP,
Professor Urve Venesaar urve.venesaar@ttu.ee, , +372 620 3951

CENTRE FOR BUSINESS RESEARCH AND DEVELOPMENT,
Professor Urve Venesaar, urve.venesaar@ttu.ee, +372 620 3951

LABORATORY OF ERGONOMICS,
Professor Piia Tint, piia.tint@ttu.ee, +372 620 3960

MAIN LINES OF RESEARCH

ENTREPRENEURSHIP AND BUSINESS DEVELOPMENT

The research group focuses on the research of entrepreneurship and innovation processes, entrepreneurship education, and the development of internal (management, marketing) as well as external (e.g. entrepreneurial ecosystem and sustainable utilisation of natural resources) environment for business development.

Research on entrepreneurial activities of Estonian population under the Global Entrepreneurship Monitor showed relatively high share of early-stage entrepreneurs in Estonia compared with the countries of relevant development phase, but a large share of new businesses fail before three years of activities. However, perceptions of opportunities and individual perceptions of entrepreneurs are contributing positively towards the intention of starting a business in Estonia.

Research on entrepreneurship education included the results of international survey GUESSS (Global University Entrepreneurial Spirit Student Survey) which has improved the understanding of both the similarities and differences of student entrepreneurial activities in European countries. The most influential factors in causing the differences in the process of enterprise foundation in country groups were students' gender, their study level and the type of industry the student enterprise is operating in.

The main implication of current ownership research was the understanding that a strategic audit is useful for developing systemically a successful ownership strategy. Practically, in order to stay sustainable and be able to develop further there is a need for professional corporate governance and also enlightened ultimate owners. The proposed use of strategic audit gives the owner an opportunity to analyse its own actions and behaviour, learning, managing knowledge, and finally clearly expressing his will in the form of an ownership strategy.

Research on dynamic capabilities included different types of capabilities influencing the performance outcome of a company. Capabilities mostly influenced financial performance and less project performance. Traditional project time/scope/cost management (iron triangle) and project delivery capabilities significantly influence the variance of outcome indicators. Surprisingly, companies should be careful in aligning projects with strategy and pay great attention to teamwork threats, as these present the most negative influence on the outcome in circumstances where they have been conventional benefit factors.

In the area of non-market valuation of the environment, research on the Estonian coast as an important natural resource clearly demonstrates that differences within counties were obvious and the most preferred shores are the ones less represented in the respondents' county of residence. The results indicate that unfamiliar landscapes are found more interesting and the further one lives from certain landscape, the less negative aspects one sees in it.

CONTACT: Prof. Urve Venesaar, urve.venesaar@ttu.ee

SELECTED PUBLICATIONS:

Täks, M.; Tynjälä, P.; Toding, M.; Kukemelk, H.; Venesaar, U. (2014). Engineering Students' Experiences in Studying Entrepreneurship. Journal of Engineering Education, 103(4), 573–598.

Prause, G. (2014). A Green Corridor Balanced Scorecard. Transport and Telecommunication, 15(4), 299–307.

Rungi, M. (2014). The impact of capabilities on performance. Industrial Management & Data Systems, 114(2), 241–257.

Riivits-Arkonsuo, I.; Kaljund, K.; Leppiman, A. (2014). Consumer Journey from First Experience to Brand Evangelism. Research in Economics and Business: Central and Eastern Europe, 6(1), 5–28.

Reimann, M.; Ehrlich, Ü.; Tõnisson, H. (2014). Regional differences in recreational preferences of Estonian coastal landscapes. Journal of Coastal Research, SI.70, 420–425.

SAFETY AND RELIABILITY OF INDUSTRIAL PRODUCTS AND SYSTEMS AND WORK ENVIRONMENT

The main issue of the research in the OHS area was the improvement of health and safety of workers in Estonia. The members of the research group have investigated the following topics: safety and health of office-workers, safety management, audit and safety culture, risk assessment of chemicals the work, health issues connected with kidneys (PhD studies) and investigation of noise at workplace, the influence of non-ionizing electromagnetic fields on the health of the workers and environment, e-learning in OHS in Estonia and abroad.

The novelty of the results consists of: (1) improvement of the risk assessment model for the chemicals using the experimental data derived with FTIR measurements; (2) investigations of noise in the workplace; (3) the safety culture improvement through the management of human capital; (4) the influence of the non-ionizing electromagnetic fields on humans' health; (5) e-learning involvement into the safety education.

In 2014 the research was focused on safety management studies – how the organizations influence and deal with the congruence between the human factors, safety and general management with respect to knowledge management. The studies provided proposals on managerial intervention on how to improve management of safety knowledge and overall safety within enterprises, through managing the store of safety social capital inherent in an organization, implementing organizational structures which allow for managers and employees to interact and cooperate, and learning from safety practice and experience. The studies confirmed through new empirical findings the importance of the notion of a Community of Practice, as a source of safety culture and as the 'one important focus' of (collective) learning and transmitting practical safety knowledge. To understand the 'real' state of the safety, procedures, the shared and active values and beliefs that guide behavioral patterns and OH&S activities in the organization, integrated approaches should be used, which allow to reveal important safety culture flaws and fix underlying safety risks.

CONTACT: Prof. Piia Tint, piia.tint@ttu.ee

SELECTED PUBLICATIONS:

Reinhold, K.; Pallon, L. (2014). Metal workers exposure to chemicals and noise caused by using incorrect safety measures, Iranian Journal of Public Health, 43(3), 186–193.

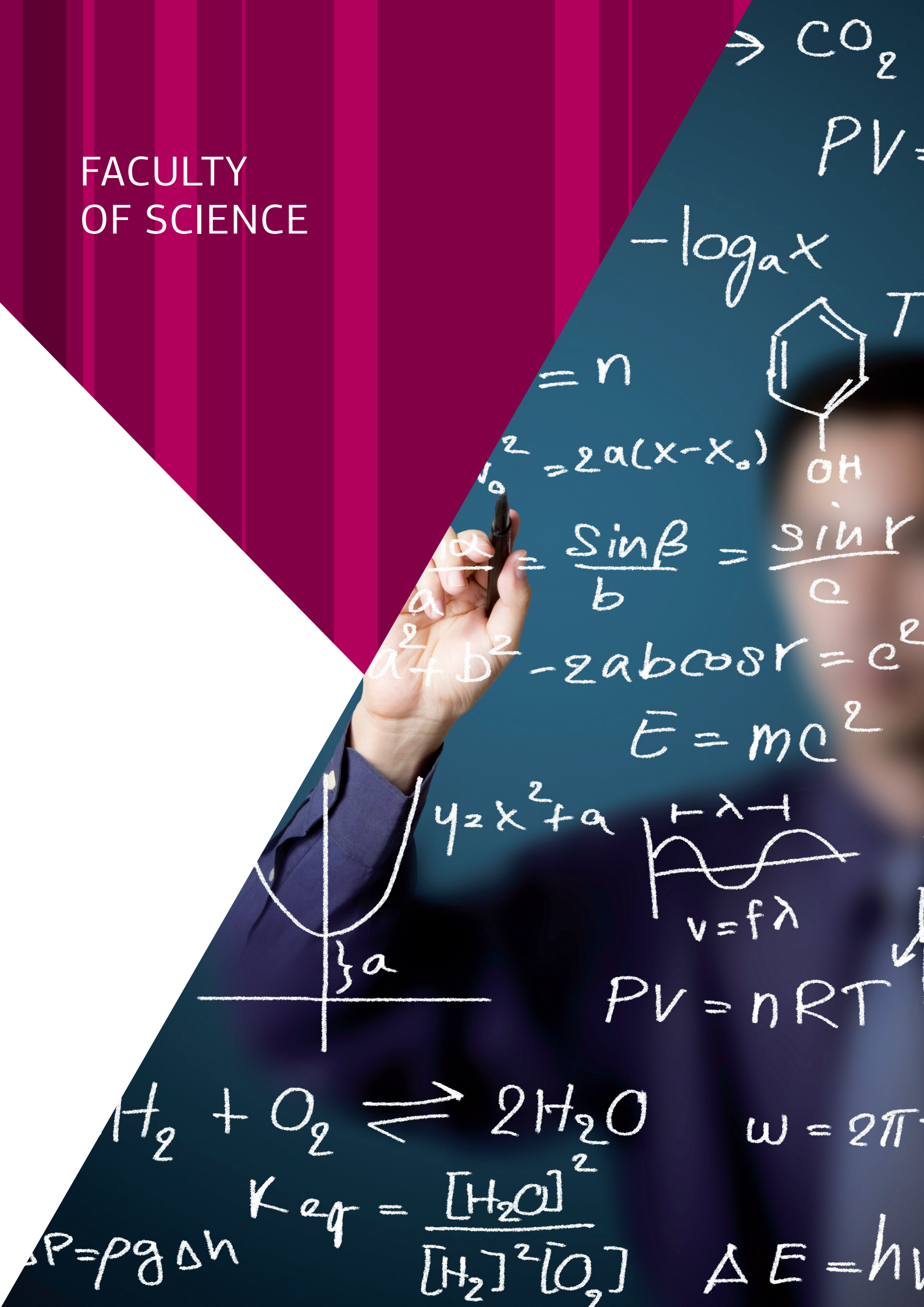
Tint, P.; Traumann, A.; Järvik, O.; Oja, V. (2014). Determination of volatile hazardous components from shale fuel oil during handling. Materials Science, 20(3), 351–356.

Reinhold, K.; Tint, P.; Siirak, V. 2014. The development of higher education in occupational health and safety in Estonia and selected EU countries. Procedia, 142, 52–56.

Järvis, M.; Virovere, A.; Tint, P. (2014). Managers' perceptions of organizational safety: implication for the development of safety culture. The Scientific Journal of Riga Technical University: Safety of Technogenic Environment, 5, 18–28.

Reinhold, K.; Kalle, S.; Paju, J. (2014). Exposure to high/low frequency noise at workplaces: differences between assessment, health complaints and implementation of adequate personal protective equipment. Agronomy Research, 12(3), 895–906.

FACULTY OF SCIENCE



FACULTY OF SCIENCE

Dean: TÕNIS KANGER, Professor

Phone: +372 620 4371
e-mail: tonis.kanger@ttu.ee

Vice-Dean for Research: VELLO TÕUGU, Associate Professor

Phone: +372 620 4411
e-mail: vello.tougu@ttu.ee

DEPARTMENTS, RESEARCH CENTERS, RESEARCH LABORATORIES:

- Department of Physics
- Department of Chemistry
- Research Laboratory of Multiphase Media Physics
- Department of Mathematics
- Centre for Biology of Integrated Systems
- Department of Gene Technology

Faculty of Science is currently employing 14 professors.

Total number of academic staff is 155. 9 doctoral dissertations were defended in 2014.

DEPARTMENT OF PHYSICS

DEPARTMENT OF PHYSICS,
Director: Lecturer Pavel Suurvarik, pavel.suurvarik@ttu.ee, +372 620 3002

CHAIR OF APPLIED PHYSICS,
Professor Jüri Krustok, jyri.krustok@ttu.ee, +372 620 3364

CHAIR OF THEORETICAL PHYSICS,
Professor Emeritus Rein-Karl Loide, karl.loide@ttu.ee, +372 620 3007

MAIN LINES OF RESEARCH

CHAIR OF APPLIED PHYSICS

Research topics are mainly related to semiconductor physics and on a large scale are carried out in collaboration with the Chair of Semiconductor Materials Technology at the Department of Materials Science.

IN 2014:

Physical properties of different solar cell materials and solar cells were studied by Raman spectroscopy, photoluminescence spectroscopy, photoreflectance spectroscopy, external quantum efficiency, and electrical measurements. Studied materials were Cu_3BiS_3, Cu_2ZnSnS_4, $Cu_2ZnSnSe_4$ and $Cu_2Zn(Sn_{1-x}Ge_x)Se_4$. The elemental composition, structural, optical and electronic properties of p-type Cu_3BiS_3 thin films were investigated. The influence of the degree of disordering in the cation sublattice on low temperature photoluminescence (PL) properties of Cu_2ZnSnS_4 (CZTS) polycrystals was also investigated. Temperature dependent PL study of CZTS polycrystals was performed. The low temperature PL spectrum consists of two PL bands: PL1 at 0.66 eV and PL2 at 1.35 eV. The research team proposed a new radiative recombination model involving theoretically predicted (Cu_{Zn}^{-} + Sn_{Zn}^{2+}) and ($2Cu_{Zn}^{-}$ + Sn_{Zn}^{2+}) defect clusters in nearly stoichiometric CZTS.

$Cu_2ZnSnSe_4$ thin films were synthesised by selenisation of magnetron sputtered metal precursors. The band gap determined from the absorption spectra increases from 1.01 eV at 300 K to 1.05 eV at 4.2 K.

The optoelectronic and structural properties of $Cu_2Zn(Sn_{1-x}Ge_x)Se_4$ (CZTGeSe) alloy compounds were also studied. Radiative recombination processes in CZTGeSe polycrystals were studied by using low-temperature PL spectroscopy. A continuous shift from 0.955 eV to 1.364 eV of the PL band position with increasing Ge concentration was detected. Based on the temperature dependent PL measurements of the CZTGeSe polycrystals, two types of recombination mechanisms were detected: band to impurity recombination in $Cu_2Zn(Sn_{1-x}Ge_x)Se_4$ with $x \leq 0.2$, and band to tail recombination in $Cu_2Zn(Sn_{1-x}Ge_x)Se_4$ with $x > 0.2$.

CONTACT: Prof. Jüri Krustok, jyri.krustok@ttu.ee

SELECTED PUBLICATIONS:

Grossberg, M.; Raadik, T.; Raudoja, J.; Krustok, J. (2014). Photoluminescence study of defect clusters in Cu_2ZnSnS_4 polycrystals. Current Applied Physics 14 447–450.

Grossberg, M.; Krustok, J.; Raadik, T.; Kauk-Kuusik, M.; Raudoja, J. (2014). Photoluminescence study of disordering in the cation sublattice of Cu_2ZnSnS_4. Current Applied Physics 14 1424–1427.

Yakushev, M. V.; Maiello, P.; Raadik, T.; Shaw, M. J.; Edwards, P. R.; Krustok, J.; Mudryi, A. V.; Forbes, I.; Martin, R. W. (2014). Electronic and structural characterisation of Cu_3BiS_3 thin films for the absorber layer of sustainable photovoltaics. Thin Solid Films 562 195–199.

CHAIR OF THEORETICAL PHYSICS

MOLECULAR DYNAMICS (MD) SIMULATIONS

Main research topics are related to MD simulations of the nanomaterials (nanotubes, graphene). Physical properties of alkaline-earth metals hydroxides were studied by using density functional theory method.

The studies were performed in collaboration with the Institute of Physics of the Tartu University and Department for Solar Energy of the Institute for Energy Technology (Norway).

CONTACT: Prof. Emeritus Rein-Karl Loide, karl.loide@ttu.ee

SELECTED PUBLICATIONS:

Krasnenko, V.; Boltrushko, V.; Klopov, M.; Hizhnyakov, V. (2014). Conjoined structures of carbon nanotubes and graphene nanoribbons. Physica Scripta, 89(4), 044008.

Kudryavtseva, I.; Klopov, M.; Lushchik, A.; Lushchik, Ch.; Maaroos, A.; Pishtshev, A. (2014). Electronic excitations and self-trapping of electrons and holes in $CaSO_4$. Physica Scripta, 89(4), 044013.

Pishtshev, A.; Karazhanov, S. Zh.; Klopov, M. (2014). Excitons in $Mg(OH)_2$ and $Ca(OH)_2$ from ab initio calculations. Solid State Communications, 193, 11–15.

Pishtshev, A.; Karazhanov, S. Zh.; Klopov, M. (2014). Materials properties of magnesium and calcium hydroxides from first-principles calculations. Computational Materials Science, 95, 693–705.

Hizhnyakov, V.; Haas, M.; Shelkan, A.; Klopov, M. (2014). Theory and molecular dynamics simulations of intrinsic localized modes and defect formation in solids. Physica Scripta, 89(4), 044003.

ASTROPHYSICS

Photogrammetrical study of lunar surface photographs made by the crew of Apollo 12 during their 2 extravehicular activities was carried out. The camera stations map, that contains locations and attitude angles of 298 individual cameras was created. Locations and orientations of Surveyor 3 lunar probe and all ALSEP instruments were found, accuracy estimations were made.

SELECTED PUBLICATIONS:

Pustynski, V.-V.; Jones, E. M. (2014). Photogrammetry of Apollo 11 Surface Imagery. Journal of the British Interplanetary Society, 67(10), 390–398.

Pustynski, V.-V. (2014). On Mathematical Complexity of Śrīyantra. Indian Journal of History of Science, 49(3), 268–277.

QUANTUM FIELD THEORY

The studies of relativistic wave equations for arbitrary spin (superspin) fields and superfields, algebras and superalgebras were continued.

Superfield equations of motion in the case of massive and massless fields were presented together with an application in linear supergravity. An interesting approach to fields and superfields of arbitrary spin and superspin has been developed.

SELECTED PUBLICATIONS:

Loide, R.-K.; Suurvarik, P. (2014). Supersymmetry: superfield equations of motion. Journal of Physics: Conference Series 532, 012016-1 – 012016-7. Institute of Physics Publishing.

DEPARTMENT OF CHEMISTRY

DEPARTMENT OF CHEMISTRY,
Director Professor Mihkel Kaljurand, mihkel.kaljurand@ttu.ee, +372 620 4320

CHAIR OF ANALYTICAL CHEMISTRY,
Professor Mihkel Kaljurand, mihkel.kaljurand@ttu.ee, +372 620 4320

CHAIR OF INORGANIC CHEMISTRY,
Associate Professor Toomas Tamm, toomas.tamm@ttu.ee, +372 620 2810

CHAIR OF BIOORGANIC CHEMISTRY,
Professor Nigulas Samel, nigulas.samel@ttu.ee, +372 620 4376

CHAIR OF BIOTECHNOLOGY,
Professor Raivo Vilu, raivo.vilu@ttu.ee, +372 620 2804

CHAIR OF MOLECULAR TECHNOLOGY,
Senior Research Scientist Mati Karelson, mati.karelson@ttu.ee, +372 620 2814

CHAIR OF ORGANIC CHEMISTRY,
Professor Margus Lopp, margus.lopp@ttu.ee, +372 620 2808

LABORATORY OF CHEMICAL ANALYSIS,
Senior Research Scientist Maria Kulp, maria.kulp@ttu.ee, +372 620 4349

MAIN LINES OF RESEARCH

COMPUTERIZED ANALYTICAL SEPARATION METHODS

Three directions in research were aimed: determination chemical warfare agents and abused drugs in harsh environments and life signatures in the extra-terrestrial atmospheres using digital microfluidics. The research funded by European Space Agency PECS grant „Chemical analysis in shifting environments" was carried on. In addition the team participated in the NATO Science for Peace program MODUM which was aimed to determination of dumped CWAs into the Baltic Sea.

CONTACT: Prof. Mihkel Kaljurand, mihkel.kaljurand@ttu.ee

SELECTED PUBLICATIONS:

Vaher, M.; Borissova, M.; Seiman, A.; Aid, T.; Kolde, H.; Kazarjan, J.; Kaljurand, M. (2014). Automatic Spot Preparation and Image Processing of Paper Microzone-Based Assays for Analysis of Bioactive Compounds in Plant Extracts. Food Chemistry, 143, 465–471.

Hyvärinen, S.; Mikkola, J. P.; Murzin, T. Yu.; Vaher, M.; Kaljurand, M.; Koel, M. (2014). Sugars and sugar derivatives in ionic liquids media obtained from lignocellulosic biomass: Comparizon of capillary electrophoresis and chromatographic analysis. Catalysis Today, 223, 18–24.

Levandi, T.; Püssa, T.; Vaher, M.; Ingver, A.; Koppel, R.; Kaljurand, M. (2014). Principal component analysis of HPLC-MS/MS patterns of wheat (Triticum aestivum) varieties extracts Proceedings of the Estonian Academy of Sciences, 63(1), 86–92.

Kobrin, E.-G.; Lees, H.; Fomitšenko, M.; Kubáň, P.; Kaljurand, M. (2014). „Fingerprinting postblast explosive residues by portable capillary electrophoresis with contactless conductivity detection". Electrophoresis, 2014, 35(8), 1165–1172.

NEW APPLICATIONS OF SUPERCRITICAL CO_2

Personal research grant from Estonian Research Council "Aerogels as materials for chemical analysis" was started in 2014. Under the consideration are two types of aerogels: silica aerogel compositions, resorcinol-formaldehyde organic aerogels (RF) as raw material for carbon aerogels and modified carbon aerogels. Under the study are aerogel-based composite materials where cellulose could be the composite making polymer. Also the possibilities for modification of RF aerogels with metals using different methods for that are studied.

It became evident that it is possible to tune the nanostructure of aerogel materials with determined particle size and surface area, which have suitable mechanical and chemical properties. Also aerogels together with ionic liquids can be used to obtain composite materials with properties useful to develop materials for sensors.

CONTACT: Lead Research Scientist Mihkel Koel, mihkel.koel@ttu.ee

SELECTED PUBLICATIONS:

Hyvärinen, S.; Mikkola, J-P.; Murzin, D. Yu.; Vaher, M.; Kaljurand, M.; Koel, M. (2014). Sugars and sugar derivatives in ionic liquid media obtained from lignocellulosic biomass: Comparison of capillary electrophoresis and chromatographic analysis, Catalysis Today 223(2014), 18–24.

Kreek, K.; Kulp, M.; Uibu, M.; Mere, A.; Koel, M. (2014). Preparation of metal-doped carbon aerogels from oil shale processing by-products, Oil Shale, 31(2), 185–194.

Kreek, K.; Kriis K.; Maaten, B.; Uibu, M.; Mere, A.; Kanger, T.; Koel, M. (2014). Organic and carbon aerogels containing rare-earth metals: Their properties and application as catalysts, Journal of Non-Crystalline Solids, 404, 43–48.

CHAIR OF ORGANIC CHEMISTRY

Research was performed within three different initiatives: (1) National Biotechnology R&D program project „Development of Trk antagonists as drug candidates for the treatment of neuropathic pain"; (2) Center of Excellence in Chemical Biology (funding-period of research activities was ended in 2014); (3) the institutional research grant "Directed asymmetric catalytic synthesis: an integrated approach" (research was started in 2014).

Investigations were carried out in the following directions:

NEW ASYMMETRIC REACTIONS

- Sonogashira cross-coupling reaction of 3-bromo-1,2-diones with different alkynes was developed to open access to alkynylsubstituted 1,2-diketones – usefull starting compounds for many bioactive compounds.
- An asymmetric organocatalytic approach to spiro-cyclopropane oxindole derivatives was developed. Spiro-cyclopropanes were obtained in high enantiomeric purity and moderate to high yields.
- The concept of remote activation of reactivity in organocatalytic alkylation of the isatin was discovered. The nucleophilicity of amide nitrogen was increased by using thiourea catalysts.
- The mechanism of stereochemistry of the asymmetric transformation of Ti alkyl complexes in the cyclopropanation reaction was established.

CONTACTS: Prof. Margus Lopp, margus.lopp@ttu.ee;
Prof. Tõnis Kanger, tonis.kanger@ttu.ee

SELECTED PUBLICATIONS:

Ošeka, M.; Noole, A.; Žari, S.; Öeren, M.; Lopp, M.; Kanger, T. (2014). Asymmetric Diastereoselective Synthesis of Spirocyclopropane Derivatives of Oxindole. European Journal of Organic Chemistry, 17, 3599–3606.

Kulinkovich, O. G.; Kananovich, D. G.; Lopp, M.; Snieckus, V. (2014). Insight into the Mechanism and Stereochemistry of the Transformations of Alkyltitanium Ate-Complexes. An Enhanced Enantioselectivity in the Cyclopropanation of the Carboxylic Esters with Titanacyclopropane Reagents. Advanced Synthesis and Catalysis, 356(17), 3615–3626.

Žari, S.; Kudrjashova, M.; Pehk, T.; Lopp, M.; Kanger, T. (2014). Remote Activation of the Nucleophilicity of Isatin. Organic Letters, 16(6), 1740–1743.

Paju, A.; Kanger, T.; Müürisepp, A.-M.; Aid, T.; Pehk, T.; Lopp, M. (2014). Sonogashira cross-coupling of 3-bromo-1,2-diones: an access to 3-alkynyl-1,2-diones. Tetrahedron, 70(35), 5843–5848.

SYNTHESIS OF NEW COMPOUNDS OF BIOACTIVITY INTEREST

- A general catalytic asymmetric method to obtain substituted lactone carboxylic acids was developed and described. The approach affords enantiomeric starting compounds for nucleoside analogues synthesis.

- A general method to synthesize 5-S-functionalized pyrimidine nucleosides was developed.
- Heterogeneous platinum catalytic oxidation of 1,2-diols was developed.
- In the course of the total synthesis of 9,11-secosterols, asymmetric synthesis of 2,2,3-trisubstituted cyclopentanone – D-ring fragment of the secosterol was developed.

CONTACT: Prof. Margus Lopp, margus.lopp@ttu.ee

SELECTED PUBLICATIONS:

Kananovich, D. G.; Reino, A.; Ilmarinen, K.; Rõõmusoks, M.; Karelson, M.; Lopp, M. (2014). A General Approach to the Synthesis of 5-S-functionalized Pyrimidine Nucleosides and their Analogues. Organic and Biomolecular Chemistry, 12, 5634–5644.

Paju, A.; Oja, K.; Matkevitš, K.; Lumi, P.; Järving, I.; Pehk, T. (2014). Asymmetric synthesis of tertiary 2-substituted 5-oxotetrahydrofuran-2-carboxylic acids. Heterocycles, 88(2), 981–995.

Kõllo, M.; Aav, R.; Tamp, S; Jarvet, J.; Lopp, M. (2014). Asymmetric synthesis of the 2,2,3-trisubstituted cyclopentanone, D-ring fragment of 9,11-secosterols. Tetrahedron, 70(38), 6723–6727.

Reile, I.; Kalle, S.; Werner, F.; Järving, I.; Kudrjashova, M.; Paju, A.; Lopp, M. (2014). Heterogeneous Platinum Catalytic Aerobic Oxidation of Cyclopentane-1,2-diols to Cyclopentane-1,2-diones. Tetrahedron, 70(22), 3608–3613.

COMPUTATIONAL CHEMISTRY

- Computational studies of hemicucurbiturils were continued. The reaction mechanism of interconversion of 6- and 8- membered hemicucurbituril, including the re-cyclization, was studied in detail. The possible reaction pathways were determined and good agreement with experimental findings obtained. VCD spectra of the monomer used in synthesis of the hemicucurbiturils, was determined.
- Reaction mechanisms of CO_2 fixation, as well as interconversion of the subsequent intermediates (formate, methanol), with use of on iridium-based catalysts were studied in additional detail. Several problems which were hindering progress in the area were successfully resolved.
- Stability of different isomers anf conformers of complexes of $Ti(OiPr)_4$ with cyclopentane-1,2-dione was established by using DFT calcualtions.

CONTACT: Prof. Toomas Tamm, toomas.tamm@ttu.ee

SELECTED PUBLICATIONS:

Osadchuk, I.; Pehk, T.; Paju, A.; Lopp, M.; Öeren, M.; Tamm, T. (2014). Isomers and conformers of complexes of Ti(OiPr)4 with cyclopentane-1,2-dione: NMR study and DFT calculations. International Journal of Quantum Chemistry, 114(15), 1012–1018.

Oeren, M.; Shmatova, E.; Tamm, T.; Aav, R. (2014). Computational and ion mobility MS study of (all-S)-cyclohexylhemicucurbit[6]uril structure and complexes. Physical Chemistry Chemical Physics, 16(36), 19198–19205.

Fomitsenko, M.; Shmatova, E.; Oeren, M.; Jarving, I.; Aav, R. (2014). New homologues of chiral cyclohexylhemicucurbit[n]urils. Supramolecular Chemistry, 26(9), 698–703.

DEVELOPMENT OF TRK ANTAGONISTS AS DRUG CANDIDATES FOR THE TREATMENT OF NEUROPATHIC PAIN

Indole-like TrkA inhibitors were synthesized and tested on TrkA inhibition

CONTACTS: Prof. Margus Lopp, margus.lopp@ttu.ee;
Prof. Tõnis Kanger, tonis.kanger@ttu.ee

DESIGN OF HETEROGENEOUS METAL CATALYSTS SUPPORTED ON APATITE

The following results were obtained:

- Synthesis and fully characterization of a new Cu modified hydroxyapatite was achieved;
- Cu modified apatite is an efficient catalyst for the Glaser Hay coupling reaction;
- The acetylenic homo-coupling occurs without additive bases and chelating ligands.

CONTACT: Prof. Tõnis Kanger, tonis.kanger@ttu.ee

SELECTED PUBLICATIONS:

Maaten, B.; Moussa, J.; Desmarets, C.; Gredin, P.; Beaunier, P.; Kanger, T.; Tõnsuaadu, K.; Villemin, D.; Gruselle, M. (2014). Cu-Modified Hydroxy-Apatite as Catalyst for Glaser-Hay C-C Homo- Coupling Reaction of Terminal Alkynes. Journal of Molecular Catalysis A: Chemical, 393, 112–116.

Kreek, K.; Kriis, K.; Maaten, B.; Uibu, M.; Mere, A.; Kanger, T.; Koel, M. (2014). Organic and carbon aerogels containing rare-earth metals: Their properties and application as catalysts. Journal of Non-Crystalline Solids, 404, 43–48.

MOLECULAR CONTAINERS RESEARCH GROUP

Research focuses on development of new molecular containers, mainly chiral hemicucurbiturils. Development of methods for the synthesis of new chiral hemicucurbiturils is accompanied with the studies on their formation mechanism as well as host-guest and supramolecular properties.

MAIN RESULTS IN 2014:

- Existance of new chiral homologues of cyclohexylhemicucurbituril (cycHC6) was discovered and cycHC8 isolated.
- Host-guest properties of cycHC6 were studied and formation of inclusion complexes with anions was confirmed.
- Method for efficient syntheisis of cycHC8 was found.

CONTACT: Assoc. Prof. Riina Aav, riina.aav@ttu.ee

SELECTED PUBLICATIONS:

Fomitšenko, M.; Shmatova, E.; Öeren, M.; Järving, I.; Aav, R. (2014) New homologues of chiral cyclohexylhemicucurbit[n]urils, Supramolecular Chemistry, 26(9), 698–703.

Öeren, M.; Shmatova, E.; Toomas, T.; Aav, R. (2014) Computational and ion mobility MS study of (all-S)-cyclohexylhemicucurbit[6]uril structure and complexes. Physical Chemistry Chemical Physics, 16(36), 19198–19205.

Kõllo, M.; Aav, R.; Tamp, S.; Jarvet, J.; Lopp, M. (2014). Asymmetric synthesis of the 2,2,3-trisubstituted cyclopentanone, D-ring fragment of 9,11-secosterols. Tetrahedron, 70(38), 6723–6727.

Kobrin, E.-G.; Lees, H.; Fomitšenko, M.; Kubáň, P.; Kaljurand, M. (2014) Fingerprinting postblast explosive residues by portable capillary electrophoresis with contactless conductivity detection. Electrophoresis, 35(8), 1165–1172.

CHAIR OF BIOORGANIC CHEMISTRY

Institutional research grant "Structural and regulatory aspects of lipid and lipoprotein metabolism" was started in 2014. The main goals of the project are: elucidation of fundamental structural, catalytic and regulatory aspects of enzymes responsible for biosynthesis of lipid mediators, and study of regulatory mechanisms of lipoprotein metabolism and endothelial lipolysis.

CONTACT: Prof. Nigulas Samel, nigulas.samel@ttu.ee

EICOSANOIDS AND EICOSANOID METABOLIZING ENZYMES

The mechanism of biosynthesis of oxygenated metabolites of arachidonic acid, and their role in homeostasis and survival of different organisms are investigated. The areas of current interest are the following:

1. Structural and functional characterization of allene oxide – lipoxygenase fusion proteins (AOS-LOX). Structures of the metabolites and mechanisms of their formation. The role of the pathway in coral stress response;
2. Discovery and characterization of novel enzymes responsible for prostaglandin synthesis (cyclooxygenases (COX) and downstream isomerases) in lower organisms. Heterologous expression of human COXs in yeast culture;
3. Mutagenesis and X-ray crystallographic studies of calcium-mediated allosteric activation of lipoxygenases (LOX). Control mechanisms of oxygenation specificity of LOXs.
4. Mechanisms of platelet aggregation. Influence and synergetic effects of eicosanoids, antioxidants and glycose metabolites.

IN 2014:

1. It was shown that two AOS-LOX isoforms (AOS-LOXa and –b) which differ by their catalytic specificity and gene regulation exist in the soft coral Capnella imbricata. This data suggest that the AOS-LOXa is involved in mediating early response to wound and temperature stress in vivo.
2. A novel membrane-associated prostaglandin E synthase-2 (mPGES-2) in two amphipod crustaceans was cloned and characterized.
   Human PGHS-1 and -2 were expressed in the yeast Pichia pastoris. Recombinant hPGHS-2 was catalytically active whereas hPGHS-1 was inactive. Characterization of N-glycosylation patterns by nano-LC/MS/MS showed that the isoforms exhibit similar N-glycosylation occupancy. Our results indicate that contrary to previous speculations, insufficient or improper N-glycosylation might not be the cause of COX-1 inactivity.
3. Mutagenesis studies of 11R-LOX showed that the π-cation bridge between Ca^{2+} – binding PLAT-domain and catalytic domain plays a crucial role in the Ca^{2+} – initiated allosteric regulation of LOX activity.
4. Glucose has been found to impair the inhibition of platelets with aspirin and alter the basal activity of nitric oxide synthase (NOS) in platelets. The recent data of research group support the suggestion that the effect of glucose on the inhibition of platelets by agents activating an NOS-dependent pathway is mediated by glucose metabolite lactate.

CONTACT: Prof. Nigulas Samel, nigulas.samel@ttu.ee

SELECTED PUBLICATIONS:

Teder, T.; Boeglin, W. E.; Brash, A. R. (2014). Lipoxygenase catalyzed transformation of epoxy fatty acids to hydroxy-endoperoxides: A potential P450 and lipoxygenase interaction. Journal of Lipid Research, 55(12), 2587–2596.

Hansen, K.; Varvas, K.; Järving, I.; Samel, N. (2014). Novel membrane-associated prostaglandin E synthase-2 from crustacean arthropods. Comparative Biochemistry and Physiology. B-Biochemistry and Molecular Biology, 174, 45–52.

Kukk, K.; Kasvandik, S.; Samel, N. (2014). N-glycosylation site occupancy in human prostaglandin H synthases expressed in Pichia pastoris. SpringerPlus, 3(436), 436.

Kobzar, G.; Mardla, V.; Samel, N. (2014). Lactate is a possible mediator of the glucose effect on platelet inhibition. Platelets, 25(4), 239–245.

Lõhelaid, H.; Teder, T.; Tõldsepp, K.; Ekins, M.; Samel, N. (2014). Up-Regulated Expression of AOS-LOXa and Increased Eicosanoid Synthesis in Response to Coral Wounding. PLoS ONE, 9(2), e89215.

MECHANISMS OF ENDOTHELIAL LIPOLYSIS

Main goal of this research is to elucidate how metabolism of lipoproteins is regulated by molecular interactions between lipases, angiopoietin-like proteins, cell surface receptors, apolipoproteins and proteoglycans. The knowledge of these interactions in combination with available structural information provides the basis for the design of the drugs that could be used for the treatment of lipid metabolic disease.

IN 2014:

The research group has demonstrated that two regions of GPIHBP1, the acidic N-terminal domain and the central Ly6 domain, interacted with LPL as two distinct binding sites. The data obtained from the study suggest that the two domains of GPIHBP1 interact independently with LPL and that the functionality of LPL depends on its localization on GPIHBP1.

Given the central role of LPL in lipid metabolism attempt was made to find small molecules that could increase LPL activity and serve as starting points for drug development efforts against cardiovascular disease. Using a small molecule screening approach we identified small molecules that can protect LPL from inactivation by the controller protein angiopoietin-like protein 4 during incubations in vitro. One of the selected compounds, 50F10, was directly shown to preserve the active homodimer structure of LPL, as demonstrated by heparin-Sepharose chromatography. On injection to hypertriglyceridemic apolipoprotein A-V deficient mice the compound ameliorated the postprandial response after an olive oil gavage. This is a potential leadcompound for the development of drugs that could reduce the residual risk associated with elevated plasma TGs in dyslipidemia.

CONTACT: Lead Research Scientist Aivar Lõokene, aivar.lookene@ttu.ee

SELECTED PUBLICATIONS:

Larsson, M.; Caraballo, R.; Ericsson, M.; Lookene, A.; Enquist, P. A.; Elofsson, M.; Nilsson, S. K.; Olivecrona, G. (2014) Identification of a small molecule that stabilizes lipoprotein lipase in vitro and lowers triglycerides in vivo. Biochem Biophys Res Commun, 450(2):1063–1069.

RESEARCH GROUP FOR BIOCATALYTIC SYNTHESIS

Biocatalytic resolution of stereoisomers of 1,2-alkanediol and analogous tetrol compounds has been investigated. Biocatalytic stereoselective acylation and deacylation methods for the treatment of γ-hydroxycarboxylic acid sodium salts have been studied with the aim of stereoresolution of the corresponding γ-lactones, such as γ-valerolactone, Grieco lactone etc. A novel chiral derivatizing agent – [(1R)-1-[(2-chloroacetyl)oxymethyl]undecyl] benzoate for the stereochemical analysis of the γ-hydroxycarboxylic acid sodium salts which allows their trapping directly from the reaction mixture has been developed.

The most important results in 2014:

1. Developing of the stereospecific lipase-catalytic acylation method for the treatment of Grieco lactone sodium salts in organic solvent for the resolution of enantiomers.
2. A novel chiral derivatizing agent – [(1R)-1-[(2-chloroacetyl)oxymethyl]undecyl] benzoate for the stereochemical analysis of the γ-hydroxycarboxylic acid sodium salts – which allows their trapping directly from the reaction mixture – has been developed.

CONTACT: Senior Research Scientist Omar Parve, omar.parve@ttu.ee

SELECTED PUBLICATIONS:

Villo, L.; Metsala, A.; Tamp, S.; Parve, J.; Vallikivi, I.; Järving, I.; Samel, N.; Lille, Ü.; Pehk, T.; Parve, O. (2014). Thermomyces lanuginosus Lipase with Closed Lid Catalyzes Elimination of Acetic Acid from 11-Acetyl-Prostaglandin E2. ChemCatChem, 6(7), 1998–2010.

Metsala, A.; Tamp, S.; Danilas, K.; Lille, Ü.; Villo, l.; Vija, S.; Pehk, T.; Parve, O. (2014). An Assessment of Alternative Low Level Calculation Methods for the Initial Selection of Conformers of Diastereomeric Esters. Journal of Theoretical Chemistry, 1–10.

CHAIR OF BIOTECHNOLOGY

FOOD SYSTEMS BIOLOGY AND PHYSICS

The key subjects of the study were: (1) lactic acid bacteria, probiotics and yeast; (2) development of single cell model of microorganisms; (3) study of growth space of microorganisms; (4) role of peptides and bioactive compounds as media components. The aims of the study were a) development of systems biology of microorganisms and food production processes using omics methods and mathematical modelling, and b) development of processes of anaerobic waste treatment, and biomethane production from different wastes including slaughterhouse solid wastes.

IN 2014:

Single cell models (SCM) for the optimization of biotechnological processes of synthesis of biomass, ethanol, lactate etc. using recombinant E. coli and L. lactis based on the use of multi-omics data were developed. Models for aerobic growth of lactic acid bacteria were developed and mutants for the study of regulation mechanisms were designed. Optimization of anaerobic processes of co-digestion of biodegradable wastes including solid slaughterhouse wastes was carried out. Evaluation of ecological efficiency of Estonian economy using multisector I/O models was carried out. Growth efficiency and amino acid metabolism of bacteria was evaluated using novel microcalorimetric methods for the study of lactic acid bacteria in milk and milk gels.

CONTACT: Prof. Raivo Vilu, raivo.vilu@ttu.ee

SELECTED PUBLICATIONS:

Aller, K.; Adamberg, K.; Timarova, V.; Seiman, A.; Feštšenko, D.; Vilu, R. (2014). Nutritional requirements and media development for Lactococcus lactis IL1403. Applied Microbiology and Biotechnology, 98, 5871–5881.

Lahtvee, P.-J.; Seiman, A.; Arike, L.; Adamberg, K.; Vilu, R. (2014). Protein turnover forms one of the highest maintenance costs in Lactococcus lactis. Microbiology-SGM, 160, 1501–1512.

Pitk, P.; Kaparaju, P.; Palatsi, J.; Belen, F.; Vilu, R. (2014). Mesophilic co-digestion of dairy manure and lipid rich solid slaughterhouse wastes: process efficiency, limitations and floating granules formation. Bioresource Technology, 166, 168–177.

Peebo, K.; Valgepea, K.; Nahku, R.; Riis, G.; Õun, M.; Adamberg, K.; Vilu, R. (2014). Coordinated activation of PTA-ACS and TCA cycles strongly reduces overflow metabolism of acetate in Escherichia coli. Applied Microbiology and Biotechnology, 5131–5143.

Abner, K.; Aaviksaar, T.; Adamberg, K.; Vilu, R. (2014). Single-cell model of prokaryotic cell cycle. Journal of Theoretical Biology, 341, 78–87.

CHAIR OF MOLECULAR TECHNOLOGY

Institutional research grant Modeling of biomedically and environmentally important systems using computational chemistry. The subject of the research was the computational study of detailed mechanisms of interactions of chemical compounds with the living organisms and environment. The methodology developed is applicable for the description and prediction of (1) physicochemical properties; (2) pharmacodynamic and pharmacokinetic data; (3) antiviral activity of compounds; (4) activity of mimetics of neurotrophic factors; (5) structure and properties of peptide delivery vectors.

IN 2014:

The methodological work included a critical evaluation of the applicability of various machine-learning methods such as artificial neural networks (ANN), support-vector machines (SVM) and others for the prediction of novel biologically active compounds (e.g. drug candidates). The advances and limitations of these methods were extensively discussed.

New sets of effective molecular descriptors (topological fingerprints) were developed and tested for the virtual screening of large molecular libraries. The new descriptors enabled to predict novel scaffolds for the inhibitors of leucine-rich repeat kinase 2 (LRRK2), mutations of which have been associated with Parkinson's disease type 8. A dual inhibition of enzymes α-glucosidase and butyrylcholinesterase by small drug-like molecules, including 1,4-disubstituted-1,2,3-triazoles, chalcones, and benzothiazepines, was rationalized with the help of Molecular Field Topology Analysis. Quantitative structure-property relationships were developed for the cell-penetrating peptides that were instrumental for the rational design of new, more efficient compounds.

CONTACT: Senior Research Scientist Mati Karelson, mati.karelson@ttu.ee

SELECTED PUBLICATIONS:

Kahn, I.; Lomaka, A.; Karelson, M. (2014). Topological Fingerprints as an Aid in Finding Structural Patterns for LRRK2 Inhibition. Molecular Informatics, 33, 269–275.

Kananovich, D. G.; Reino, A.; Ilmarinen, K.; Rõõmusoks, M.; Karelson, M.; Lopp, M. (2014). A General Approach to the Synthesis of 5-S-functionalized Pyrimidine Nucleosides and their Analogues. Organic and Biomolecular Chemistry, 5634–5644.

Regberg, J.; Srimanee, A.; Erlandsson, M.; Sillard, R.; Dobchev, D. A.; Karelson, M.; Langel, Ü. (2014). Rational design of a series of novel amphipathic cell-penetrating peptides. International Journal of Pharmaceutics, 464, 111–116.

Dobchev, D.; Pillai, G.; Karelson, M. (2014). In Silico Machine Learning Methods in Drug Development. Current Topics in Medicinal Chemistry, 16, 1913–1922.

RESEARCH LABORATORY OF MULTIPHASE MEDIA PHYSICS

RESEARCH LABORATORY OF MULTIPHASE MEDIA PHYSICS,
Head of laboratory Senior Research Scientist Ülo Rudi, ulo.rudi@ttu.ee, +372 620 4080

MAIN LINES OF RESEARCH

Research group is active in development of the theory of the particulate channel, shear and vortical flows and its practical application in technologies. The main objective of the research of the flows is to develop 3D complete mathematical model for numerical simulation of the turbulent particulate flows in pipes and channels, jets and shear flow. The modelling is mainly based on the RANS mathematical method and develops the theory of a free and wall-bounded particulate flows as well as the particles deposition onto various surfaces. The second task of the research group is to develop the analytical and numerical modelling of the vortex ring-like structures. The asymptotic analysis, entrainment diagram method and direct numerical simulation are applied for analysing the structural features of these types of a vortex flow. For investigation of the mixing and transport inside the starting vortex flows the Lagrangian method is applied.

IN 2014:

The project „Mathematical modelling of turbulent dense flows and applications" was completed. The numerical results showed that the effect of particles creates rapid anisotropy in a channel particulate flow. Results can be applied for optimal designing and structural calculations of various devices for solid fuel power plants, pneumo-conveying devices as well as various gas-purifying equipment.

In the frame of Norwegian-Estonian Research Cooperation Programme project „DNS and 3D Reynolds Stress Turbulence Modelling in Particulate Channel Flows with Inter-Particle Collisions and Applications" was started. 3D RANS modelling of the turbulent particulate channel flow with square/rectangular cross-section was performed.

Joint research was carried out with Centre for Energy Technology (Adelaide University, Australia). Main attention has been focused to 3D RANS modelling of the vertical pipe turbulent downward air flow loaded with solid light particles of various Stokes numbers with considering of effect of the Saffman lift and turbophoretic forces on the particles distribution.

Calculations of single-phase turbulent flow in the experimental setup including confusor, shear-forming apparatus, test section in the k-epsilon and LES approaches have been carried out. The results obtained are in good agreement with the experimental data. Calculations of particles dispersion from a point source in the previous calculations obtained shear flow were performed.

The model of confined vortex ring has been developed and its predictions have been compared with the results of the numerical simulations. Also the generalization of the vortex ring with elliptical core taking into account effects of the confinement is designed and applied for prediction of the formation number.

CONTACT: Senior Research Scientist Ülo Rudi, ulo.rudi@ttu.ee

SELECTED PUBLICATIONS:

Kartushinsky, A.; Hussainov, M.; Michaelides, E. E.; Rudi, Y.; Shcheglov, I.;Tisler, S.; Krupenski, I. (2014). Particles deposition at horizontal flat plate in turbulent particulate flow. Canadian Journal of Chemical Engineering, 92(1), 1–12.

Kartushinsky, A.; Rudi, Y.; Shcheglov, I.; Tisler, S.; Krupenski, I. (2014). RANS Numerical Simulation of Turbulent Particulate Pipe Flow for Fixed Reynolds Number. Computational and Numerical Simulations. Rijeka, Croatia: InTech – Open Access Publisher, 21–40.

Kartushinsky, A.; Rudi, Y.; Hussainov, M.; Shcheglov, I.; Tisler, S.; Krupenski, I.; Stock, D. (2014). RSTM Numerical Simulation of Channel Particulate Flow with Rough Wall. Computational and Numerical Simulations. Rijeka, Croatia: InTech – Open Access Publisher, 41–63.

DEPARTMENT OF MATHEMATICS

DEPARTMENT OF MATHEMATICS,
Director: Professor Jaan Janno, jaan.janno@ttu.ee, +372 620 3052

CHAIR OF ALGEBRA AND GEOMETRY,
Professor Peeter Puusemp, peeter.puusemp@ttu.ee, +372 620 3054

CHAIR OF MATHEMATICAL ANALYSIS,
Senior Research Scientist Gert Tamberg, gert.tamberg@ttu.ee, +372 620 3056

CHAIR OF APPLIED MATHEMATICS,
Professor Jaan Janno, jaan.janno@ttu.ee, +372 620 3052

CHAIR OF MATHEMATICAL PHYSICS,
Professor Eugen Paal, eugen.paal@ttu.ee, +372 620 3057

MAIN LINES OF RESEARCH

RESEARCH GROUP OF ALGEBRA AND GEOMETRY

The aim of the research is to develop the endomorphism theory of groups and quasigroups. The studies have been carried out to find some methods for describing these algebraic systems by their endomorphism semigroups.

IN 2014:

The endomorphism algebra of idempotent medial quasigroup was introduced and it was proved that each idempotent medial quasigroup is determined by its endomorphism algebra in the class of all idempotent medial quasigroups.. It was proved that each group of order 32 which has a maximal subgroup isomorphic to the direct products $C_4 \times C_2 \times C_2$ or $C_8 \times C_4$ of cyclic groups C_8, C_4, and C_2 is determined by its endomorphism semigroup in the class of all groups. It was proved that a multiple wreath product of groups is determined by its endomorphism semigroup in the class of all groups.

CONTACT: Prof. Peeter Puusemp, peeter.puusemp@ttu.ee

SELECTED PUBLICATIONS:

Puusemp, Peeter; Puusemp, Piret. (2014). On endomorphisms of groups of order 32 with maximal subgroups $C_4 \times C_2 \times C_2$. Proc. Estonian Academy of Sciences, 63, 2, 105–120.

Puusemp, Peeter; Puusemp, Piret. (2014). On endomorphisms of groups of order 32 with maximal subgroups $C_8 \times C_4$. Proc. Estonian Academy of Sciences, 63, 4, 355–371.

Leibak, A.; Puusemp, Peeter. (2014). On determinability of some classes of medial quasigroups by their endomorphisms. Journal of Physics: Conference Series. 532, 1–9.

REASEARCH GROUP OF MATHEMATICAL ANALYSIS

Research is concentrated on the studies of: (1) generalized Shannon sampling operators – the representations of functions in terms of series, where the expansion coefficients are its samples and expansion functions are translates of a certain kernel function; (2) generalized summability methods – the case if the elements of the sequence belong to the Banach space and the elements of the matrix are linear bounded operators.

IN 2014

Sampling operators, defined using an even band-limited kernel function were considered. Approximation properties of generalized sampling operators in Lebesgue spaces were studied. The order of approximation by sampling operators via modules of smoothness was estimated. The Kantorovich-type sampling operators were generalized. Instead of the Steklov means Fejer-type singular integrals were used, which allowed to estimate the order of approximation via a modulus of smoothness of higher order. Norms of generalized Kantorovich-type sampling operators were also estimated and the approximation properties of generalized

sampling operators in the case of functions with bounded variation were studied. The Tauberian remainder theorems in the case of the generalized methods of summability, especially for weighted means method were proved. The Tauberian conditions in the case of the generalized methods of summability were weakened.

CONTACT: Senior Research Scientist Gert Tamberg, gert.tamberg@ttu.ee

SELECTED PUBLICATIONS:

Kivinukk, A.; Tamberg, G. (2014). On window methods in generalized Shannon sampling operators. In: New Perspectives on Approximation and Sampling Theory – Festschrift in honor of Paul Butzer's 85th birthday. Birkhaeuser Verlag, 63–86.

RESEARCH GROUP OF INVERSE PROBLEMS AND STATISTICS

The main topics of the research are inverse problems, scattering theory and integral equations and methods of mathematical statistics.

IN 2014

A strong positivity principle for generalized time-fractional parabolic equations was proved. Using this principle, uniqueness of an inverse problem to determine a space-dependent component of the free term was proved. The cooperation continued with the Environmental Technology Institute of TUT. This was implemented within the framework of nonparametric trend analyzes of Estonian rivers pollution load analysis. Mann-Kendall rank correlation was used primarily to test to investigate the flow of the rivers flowing into Lake Peipsi and the dynamics of the load over the last 40 years.

The distributions of asymmetry and kurtosis measures were modeled. On this kind of modeling the central limit theorem was applied. These results will generalize to the multivariate case. Knowing distribution of symmetry and kurtosis measures (even approximate) of the statistical models residuals allows to significantly improve the diagnostic adequacy.

CONTACT: Prof. Jaan Janno, jaan.janno@ttu.ee

SELECTED PUBLICATIONS:

Kasemets, K.; Janno, J. (2014). A weak inverse problem for a parabolic integro-differential equation containing two kernels. Electronic Journal of Differential Equations, Article nr 176, 19.

Iital, A.; Klõga, M.; Pihlak, M.; Pachel, K.; Zahharov, A.; Loigu E. (2014). Nitrogen content and trends in agricultural catchments in Estonia. Agriculture, Ecosystems and Environment, 198, 44–53.

RESEARCH GROUP OF MATHEMATICAL PHYSICS

The basis of operadic variational formalism were elaborated which is necessary when modeling the operadic systems. Based on this, the rational (cohomological) variational principle was proposed. Based on a simple example, it is explained how the homological analysis may be applied for modeling of the electric circuits. The homological branch, mesh and nodal analyses are presented. Geometrical interpretations are given. The operadic Lax representations of the harmonic oscillator were used to construct the quantum counterparts of 3d real Lie algebras in the Bianchi classification. From this it followed that in this model only the discrete values of the spatial coordinates are physically allowed.

CONTACT: Prof. Eugen Paal, eugen.paal@ttu.ee

SELECTED PUBLICATIONS:

Paal, E. (2014). The operadic modeling of gauge systems of the Yang-Mills type. Reports on Mathematical Physics, 74, 109–126.

Paal, E.; Umbleja, M. (2014). Note on homological modeling of the electric circuits. Journal of Physics: Conference Series, 532, 012022-1 – 012022-7.

Paal, E.; Virkepu, J. (2014). Operadic quantization as a tool for discrete geometry. Journal of Physics: Conference Series, 532, 012023 -1 – 012023-9.

Paal, E.; Kuusk, P.; Stolin, A. (2014). 3Quantum: Algebra Geometry Information (QQQ Conference 2012, Proceedings). Journal of Physics: Conference Series, 532, 011001-1 – 011001-7.

Maklouf, A.; Paal, E.; Silvestrov, S.; Stolin, A. (2014). Preface. Algebra, Geometry and Mathematical Physics, VII-IX. Heidelberg: Springer Verlag, (conference proceedings).

CENTRE FOR BIOLOGY OF INTEGRATED SYSTEMS

CENTRE FOR BIOLOGY OF INTEGRATED SYSTEMS,
Acting head: Associate Professor Anu Aaspõllu, anu.aaspollu@ttu.ee, +372 620 4428

MAIN LINES OF RESEARCH

In 2014 the research was focused on several directions:

- Research group continued development and validation of bioinformatic tools for 18S marker based NGS data management for forensic purposes, especially for soil sample analysis.
- High-throughput small RNA sequencing of paired samples of peritoneal endometriotic lesions was used and matched healthy surrounding tissues together with eutopic endometria of the same patients. Five miRNAs (miR-34c, miR-449a, miR-200a, miR-200b and miR-141) were found specific to epithelial cells showing significantly higher expression in peritoneal endometriotic lesions compared to healthy peritoneal tissues. The expression levels of miR-200 family target genes E-cadherin, ZEB1 and ZEB2 were also determined and found that the expression level of E-cadherin was significantly higher in endometriotic lesions compared to healthy tissues. The findings indicate that only particular miRNAs with a significantly higher expression in endometriotic cells can be detected from lesion biopsies, and can serve as diagnostic markers for endometriosis.
- The profile of gut microbiota was described in extremely low birth weight (<1200 g) critically ill infants during the first two months of life. The diversity of gut microbiota in preterm neonates in the first week of life was low but increased significantly over two months. Colonization of Escherichia coli and uncultured Veillionella was positively correlated with maturity. Infants born to mothers with chorioamnionitis had significantly higher bacterial diversity than those without. It was found that high prevalence and abundance of potentially pathogenic Enterobacteriaceae and Staphylococcaceae with low prevalence and abundance of colonization resistance providing taxa bifidobacteria, Bacteroides and lactobacilli may lead to high infection risk via microbial translocation from the gut.
- Research group was involved in the study related to the evolution of bacterial consortia in six semi-solid rye sourdoughs during long-term backslopping at different temperatures. The changes in bacterial diversity over time were studied.
- The approach for detection of Aleutian mink disease virus in Euroean minks (Mustela lutreola) living in Tallinn Zoo was implemented.

CONTACT: Assoc. Prof. Anu Aaspõllu, anu.aaspollu@ttu.ee

SELECTED PUBLICATIONS:

Saare, M.; Rekker, K.; Laisk-Podar, T.; Sõritsa, D.; Roost, A. M.; Simm, J., Velthut-Meikas, A.; Samuel, K.; Metsalu, T.; Karro, H.; Sõritsa, A.; Salumets, A.; Peters, M. (2014) High-throughput sequencing approach uncovers the miRNome of peritoneal endometriotic lesions and adjacent healthy tissues. PLoS One, 9(11), e112630.

Drell, T.; Lutsar, I.; Stšepetova, J.; Parm, U.; Metsvaht, T.; Ilmoja, M.L.; Simm, J.; Sepp, E. (2014) The development of gut microbiota in critically ill extremely low birth weight infants assessed with 16S rRNA gene based sequencing. Gut Microbes, 5(3), 1–7.

Bessmeltseva, M.; Viiard, E.; Simm, J.; Paalme, T.; Sarand, I. (2014) Evolution of bacterial consortia in spontaneously started rye sourdoughs during two months of daily propagation. PLoS One. Apr 18;9(4):e95449. doi: 10.1371/journal.pone.0095449. eCollection 2014.

DEPARTMENT OF GENE TECHNOLOGY

DEPARTMENT OF GENE TECHNOLOGY,
Director: Senior Research Scientist Andres Veske, andres.veske@ttu.ee, +372 620 4402

CHAIR OF GENE TECHNOLOGY,
Associate Professor Maria Cecilia Sarmiento Guerin, cecilia.sarmiento@ttu.ee, +372 602 4422

CHAIR OF MOLECULAR BIOLOGY,
Researcher-Professor Tõnis Timmusk, tonis.timmusk@ttu.ee, +372 620 4445

CHAIR OF MOLECULAR DIAGNOSTICS,
Professor Lilian Järvekülg, lilian.jarvekulg@ttu.ee, +372 620 4430

CHAIR OF GENOMICS AND PROTEOMICS,
Professor Peep Palumaa, peep.palumaa@ttu.ee, +372 620 4410

MAIN LINES OF RESEARCH

CHAIR OF GENE TECHNOLOGY

Plant genetics group dealt with fine mapping, phenotypic characterization and validation of non-race-specific resistance to powdery mildew in a wheat (*Triticum militinae*) introgression line. The group was the partner for sequencing wheat chromosome 4A within the frames of the Wheat Genome Initiative. In order to find functional marker(s) for the light blight resistance in the Estonian potato cultivar 'Ando', an analysis of expressed sequences comprising the conserved NB-ARC domain of R-genes has been started.

Plant virology group sequenced sobemoviruses SNMoV and CnMoV. Analysis of grass and cereal field samples was started using next-generation sequencing technology. The complete genomes of sobemoviruses SNMoV and CnMoV were described for the first time. Utilization of next-generation sequencing technology for wheat virus field monitoring revealed plant viruses BYDV-PAV, BYDV-MAV and BYDV-RPV spread in Estonia.

RNA silencing group continued with the research on human and *Arabidopsis* RNase L inhibitor (ABCE1 and AtRLI2). The involvement of ABCE1 in cellular growth, cell cycle and translation was further investigated. It was found that ABCE1 role as suppressor of RNA silencing is conserved in *Nicotiana benthamiana*, HEK293 cells and *Caenorhabditis elegans*. Potential ABCE1-interacting proteins that might support its function as an endogenous suppressor were identified. ABCE1 depletion in human cells has a strong effect on cell proliferation and cell cycle progression even at conditions when total protein synthesis is not significantly affected.

The group of *Arabidopsis* motor proteins completed the studies on the role of myosins in gravitropic behaviour of *Arabidopsis* stem. Abnormal gravitropic behaviour was described in *Arabidopsis* myosin triple, quadruple, and quintuple mutant lines.

CONTACT: Assoc. Prof. Maria Cecilia Sarmiento Guerin, cecilia.sarmiento@ttu.ee

SELECTED PUBLICATIONS:

Olspert, A.; Kamsol, K.; Sarmiento, C.; Gerassimenko, J.; Truve, E. (2014). Cocksfoot mottle virus coat protein is dispensable for the systemic infection. Virol J. Feb 4; 11:19.

Wang, Y.; Cheng, Z.; Lu, P.; Timofejeva, L.; Ma, H. (2014). Molecular cell biology of male meiotic chromosomes and isolation of male meiocytes in Arabidopsis thaliana. Methods Mol Biol. 2014; 1110:217–30.

Sõmera, M.; Truve, E. (2014) Rottboellia yellow mottle virus is a distinct species within the genus Sobemovirus. Archives of Virology DOI 10.1007/s00705-015-2336-z.

CHAIR OF MOLECULAR BIOLOGY

Tõnis Timmusk group studied the molecular mechanisms of the regulation of gene expression and signalling in mammalian nervous system. In 2014 Tõnis Timmusk group showed that the forkhead transcription factor FOXO3a levels are increased in HD cells as a result of overactive positive feedback loop. Using modified bacterial artificial chromosome, group generated several transgenic cell lines expressing humanised Renilla luciferase-EGFP fusion reporter gene under the control of rat BDNF gene regulatory

sequences in HeLa background and showed that the generated cell lines respond to known modulators of BDNF expression and could be used for screening of compounds/small molecules or transcription factors altering BDNF expression.

Kaia Palm group studied molecular mechanisms of stem cell differentiation and cancer, including transcriptional mechanisms, alternative splicing and molecular markers. Kaia Palm group showed that LXXLL-motif of the human SRC-1 nuclear receptor box 1 peptide converts transportan 10 to a potent inducer of apoptosis in breast cancer cells.

Mart Speek group analyzed further transcriptional interference (TI) effects induced by retroelements L1, Alu and SVA, and nested non-coding RNA and protein-coding genes. These molecular effects included intron retention, forced exonization and cryptic polyadenylation. Using different experimental approaches we determined nucleosome occupation and positions of transcription bubbles of transcriptionally engaged/terminated RNAPII in L1- *NCAM1* TI experimental model system. The results of these experiments showed that (1) insertion of L1 into intron of NCAM1 could change the nucleosome occupation and depending on position could influence the level of TI and (2) RNAPII transcription terminates at discrete chromatin positions, in accordance with experimentally determined locations of trancription bubbles.

Urmas Arumäe group studied the mechanisms of cell death and survival, in particular the neuronal apoptotic machinery and its control by survival-promoting neurotrophic factors. Two survival-promoting proteins, Mesencephalic Astrocyte-derived Neurotrophic Factor (MANF) and Cerebral Dopamine Neurotrophic Factor (CDNF), are of special interest as they can promote neuronal survival. In collaboration with the University of Helsinki the group studied the anti-apoptotic mechanisms of MANF and CDNF and identified two structural motifs on MANF that are required for its survival-protecting potency. Group has found that one of these motifs – the CXXC motif can protect the cells also when applied as a tetrapeptide, and studied the anti-apoptotic properties of this peptide on different cells.

Teet Velling group focused on the role of filamin A (FLNa) in the function of integrin-type collagen receptors, EGF receptor (EGFR), and in the regulation of PKB/Akt and ERK1/2 kinases by these receptors. Their analysis demonstrate a role of FLNa in the regulation of the function of integrin α1β1, PKB/Akt and ERK1/2 kinases, and identify ERK1/2 as a putative novel interaction partner of FLNa.

Andres Veske group studied semaphorins and plexins, which are implicated in a host of cellular responses including regulation of cell migration, immune response, tumor progression and tissue organisation during development. They had previously observed that Plexin-B1 and B3 interact with microtubule end-binding proteins (EBs) that are central adaptors at growing microtubule tips, and this interaction is involved in neurite growth. Therefore, group hypothesized that plexins regulate microtubule dynamics and through that also neuronal dendritogenesis. The role of all three B-plexins was systematically examined in these processes.

CONTACT: Researcher-Professor Tõnis Timmusk, tonis.timmusk@ttu.ee

SELECTED PUBLICATIONS:

West, A. E.; Pruunsild, P.; Timmusk, T. (2014). Neurotrophins: transcription and translation. Handb. Exp. Pharmacol., 220, 67–100.

Jaanson, K.; Sepp, M.; Aid-Pavlidis, T.; Timmusk, T. (2014). BAC-based cellular model for screening regulators of BDNF gene transcription. BMC Neuroscience, 15:75.

Kannike, K.; Sepp, M.; Zuccato, C.; Cattaneo, E.; Timmusk, T; (2014). Forkhead transcription factor FOXO3a levels are increased in Huntington disease because of overactivated positive autofeedback loop. J. Biol. Chem., 289, 32845–32857.

Laht, P.; Otsus, M.; Remm, J.; Veske, A. (2014). B-plexins control microtubule dynamics and dendrite morphology of hippocampal neurons. Exp Cell Res., 326(1):174–84.

Tints, K.; Prink, M.; Neuman, T.; Palm, K. (2014). LXXLL peptide converts transportan 10 to a potent inducer of apoptosis in breast cancer cells. Int J Mol Sci., 15, 5680–5698.

Kazantseva, J.; Palm, K. (2014). Diversity in TAF proteomics: consequences for cellular differentiation and migration. Int J Mol Sci., 15, 16680–16697.

CHAIR OF MOLECULAR DIAGNOSTICS

Merike Kelve group. 2',5'-oligoadenylate synthetases from marine sponges and other phylogenetically distant animals were characterized for their activities and genomic structures of their genes in order to elucidate the origin and evolution of OASs. In parallel the research of several other sponge enzymes

was carried on. The purification of the novel 2',5'-specific endoribonuclease from sponges, discovered by us in 2012, was continued to establish its amino acid sequence and in order to identify its genomic structure and to express it as a recombinant protein. Previously group had established the activity of another novel enzyme, ATP N-glycosidase, in the marine sponge *Axinella polypoides* as well as in the freshwater sponge *Ephydatia muelleri* but the protein structure is still unknown. The protein purification had proven to be unsuccessful due to the loss of the enzymatic activity during the purification process. Therefore a bioinformatic search for this enzyme in the *E. muelleri* SRA database was initiated. By now several candidate genes had been selected for the further studies and the characterisation of the enzymatic activities of the respective recombinant proteins had been started. Finally, our general interest for the whole purine metabolism in sponges had led to the conclusion about the absence of the purine *de novo* biosynthesis pathways in demosponges. The studies about the role of symbiotic bacteria in sponge metabolism were going on.

Sirje Rüütel-Boudinot group had been working on regulator of G-protein signalling (RGS16) gene during the past 5 years, and has shown that this gene is involved in inflammation and antiviral immunity by different approaches. Group has developed relevant tools and protocols, and now has a precise view of the expression of RGS16 by different types of immune cells, including myeloid cells. They have found that RGS proteins have an important impact on inflammation and the group has started to investigate the implication of RGS in autoimmune diseases and more specifically in multiple sclerosis.

Lilian Järvekülg group was focused mainly on plant potyviruses. Investigation of the relations between the structure and function of the viruses was aimed at:

a) Biological and molecular characterization as well as genetic diversity analyses of PVY strains in Estonia. The study of PVY strains prevalence and distribution in potatoes in different locations of Estonia was, for the first time, conducted concurrently at biological, serological, and molecular levels. Three virus strains (PVY^{N}, PVY^{O} and PVY^{C}), recombinant strains PVY^{NTN} and PVY^{N-W}, and some new recombinant forms were detected and characterized.

b) A detailed study of structural characteristics of potyvirus (PVA) virions and virus coat protein (CP). With the help of a number of physico-chemical methods we observed that PVA CP just released from the virions by heating at 60–70°C undergoes association into oligomers and transition to beta conformation. The PVA CP isolated by LiCl method was also transformed into cross-β-structure on heating to 60°C. With the help of algorithms for protein aggregation prediction we found that the aggregation-prone segment should be located in the central region of PVA CP molecule.

CONTACT: Prof. Lilian Järvekülg, lilian.jarvekulg@ttu.ee

SELECTED PUBLICATIONS:

Suurväli, J.; Robert, J.; Boudinot, P.; Rüütel-Boudinot, S. (2014) R4 regulators of G protein signaling (RGS) identify an ancient MHC-linked synteny group. Immunogenetics, 65, 145–156.

Suurväli, J.; Jouneau, L.; Thepot, D.; Grusea, S.; Pontarotti, P.; Du Pasquier, L.; Rüütel-Boudinot, S.; Boudinot, P. (2014). The Proto-MHC of Placozoans, a Region Specialized in Cellular Stress and Ubiquitination/Proteasome Pathways. Journal of Immunology, 193, 2891–2901.

Suurväli, J.; Pahtma, M.; Saar, R.; Paalme, V.; Nutt, A.; Tiivel, T.; Saaremäe, M.; Fitting, C.; Cavaillon, J-M.; Rüütel-Boudinot, S. (2014). RGS16 restricts the pro-inflammatory response of monocytes. Scandinavian Journal of Immunology doi: 10.1111/sji.12250

Päri, M.; Kuusksalu, A.; Lopp, A.; Kjaer, K. H.; Justesen, J.; Kelve, M. (2014) Enzymatically active 2',5'-oligoadenylate synthetases are widely distributed among Metazoa, including protostome lineage. Biochemie, 97, 200–209.

CHAIR OF GENOMICS AND PROTEOMICS

Peep Palumaa group has continued ongoing research projects by focusing to following topics:

1. Role of oxidative and nitrosoactive stress in functioning of zinc finger proteins.
2. Structure and functioning of iron-sulphur cluster assembly proteins and their role in mitochondrial functioning
3. Role of zinc and copper ions in aggregation of amyloidogenic peptides.
4. Investigation of cellular toxicity of different oligomeric and metalloforms of Alzheimer's amyloid peptide.

Redox potentials for CCHH and CCCH type of zinc finger proteins were determined by ESI MS based methodology for apo- and Zn(II)-bound proteins, which demonstrated that apo zinc finger proteins are most probably oxidized in cellular conditions and Zn(II) ions protect zinc finger proteins from oxidation.

Structure and functioning of iron-sulphur cluster assembly proteins GRX5, ISCA1 and ISCA2 has been determined by multitechnique approach using NMR, ERP and MS. Group has structurally characterized the Fe/S cluster binding properties of human ISCA2 and investigated in vitro whether and how a [4Fe-4S] cluster is assembled when human ISCA1 and ISCA2 interact with the physiological $[2Fe\text{-}2S]^{2+}$ cluster-donor human GRX5. Group found that (i) ISCA2 binds either [2Fe-2S] or [4Fe-4S] cluster in a dimeric state, and (ii) two molecules of $[2Fe\text{-}2S]^{2+}$ GRX5 donate their cluster to a heterodimeric ISCA1/ISCA2 complex. This complex acts as an „assembler" of [4Fe-4S] clusters; i.e., the two GRX5-donated $[2Fe\text{-}2S]^{2+}$ clusters generate a $[4Fe\text{-}4S]^{2+}$ cluster. The formation of the same $[4Fe\text{-}4S]^{2+}$ cluster-bound heterodimeric species is also observed by having first one $[2Fe\text{-}2S]^{2+}$ cluster transferred from GRX5 to each individual ISCA1 and ISCA2 proteins to form $[2Fe\text{-}2S]^{2+}$ ISCA2 and $[2Fe\text{-}2S]^{2+}$ ISCA1, and then mixing them together. These findings imply that such heterodimeric complex is the functional unit in mitochondria receiving [2Fe-2S] clusters from hGRX5 and assembling [4Fe-4S] clusters before their transfer to the final target apo proteins.

Thermodynamic binding constants for zinc ions to monomeric insulin have been determined. The dissociation constant value of the monomeric 1 : 1 Zn-insulin complex is equal to 0.40 μM. The apparent binding affinity decreases drastically at higher insulin concentrations where the peptide forms dimers. Cu(2+) ions also bind to monomeric insulin, whereas the apparent Cu(2+)-binding affinity depends on HEPES concentration. The conditional dissociation constant of the Cu(2+)-insulin complex is equal to 0.025 μM. The analysis demonstrated that insulin cannot form complexes with zinc ions in circulation due to the low concentration of free Zn(2+) in this environment.

The accumulation of the Aβ peptides into amyloid plaques is considered as the key step in the pathology of Alzheimer's disease (AD). Copper as well as zinc and iron ions are enriched within these extracellular fibrillar Aβ aggregates. The electrochemically active copper ions can catalyze a large variety of unspecific redox reactions that substantially contribute to the oxidative stress in the brains of AD patients. Copper ions can also directly contribute to the plaque formation since they can enhance the peptide aggregation and fibril formation in vitro. The estimates to K_D values for copper binding range from 10 pm to 100 nM. We determined that the Y10 fluorescence titration curves correspond to the affinity at the lower limit, however, as the peptide co-aggregates with two copper ions, higher affinities cannot be ruled out.

The toxicity of several Aβ molecular forms on the SHSY cell cultures was determined. Since Aβ peptides showed surprisingly low toxicity with dose-response curves suggesting heterogeneity we proceed the experiments with differentiated cells.

CONTACT: Prof. Peep Palumaa, peep.palumaa@ttu.ee

SELECTED PUBLICATIONS:

Brancaccio, D.; Gallo, A.; Mikolajczyk, M.; Zovo, K.; Palumaa, P.; Novellino, E.; Piccioli, M.; Ciofi-Baffoni, S.; Banci, L. (2014) Formation of [4Fe-4S] clusters in the mitochondrial iron-sulfur cluster assembly machinery. J. Am. Chem. Soc. 136, 16240–16250.

Gavrilova, J.; Tõugu, V.; Palumaa, P. (2014) Affinity of zinc and copper ions for insulin monomers. Metallomics. 6(7), 1296–300.

Tõugu, V.; Friedemann, M.; Tiiman, A.; Palumaa, P. (2014) Copper(II) ions and the Alzheimer's amyloid-β peptide: Affinity and stoichiometry of binding. In: AIP Conference Proceedings: International Conference of Computational Methods in Sciences and Engineering (ICCMSE) 2014, Athens, Greece, April 4–7, 2014. (Toim.) T. E. Simos, Z. Kalogiratou, T. Monovasilis American Institute of Physics, (1618), 109–111.

FACULTY OF MECHANICAL ENGINEERING

FACULTY OF MECHANICAL ENGINEERING

Dean: TAUNO OTTO, Professor

Phone: +372 620 3266
e-mail: tauno.otto@ttu.ee

DEPARTMENTS, RESEARCH CENTRES, RESEARCH LABORATORIES:

- Department of Machinery
- Department of Mechatronics
- Department of Thermal Engineering
- Department of Materials Engineering

Faculty of Mechanical Engineering is currently employing 15 professors.

Total number of academic staff is 99. 7 doctoral dissertations were defended in 2014.

DEPARTMENT OF MACHINERY

DEPARTMENT OF MACHINERY,
Director: Associate Professor Kristo Karjust, kristo.karjust@ttu.ee, +372 620 3260

CHAIR OF AUTOMOTIVE ENGINEERING,
Professor Jüri Lavrentjev, juri.lavrentjev@ttu.ee, +372 620 3262

CHAIR OF MANUFACTURING SYSTEMS,
Professor Jüri Riives, jyri.riives@gmail.com, +372 620 3256

CHAIR OF PRODUCT DEVELOPMENT,
Professor Martin Eerme, martin.eerme@ttu.ee, +372 620 3270

CHAIR OF PRODUCTION ENGINEERING,
Professor Tauno Otto, tauno.otto@ttu.ee, +372 620 3266

CHAIR OF DESIGN,
Visiting Professor Martin Pärn, martin.parn@ttu.ee, +372 620 3250

MAIN LINES OF RESEARCH

OPTIMAL DESIGN OF COMPOSITE AND FUNCTIONAL MATERIAL STRUCTURES, PRODUCTS AND MANUFACTURING PROCESSES

The goal of the research project is to develop methods and techniques for optimal design of products and manufacturing processes. Main sub-goals can be outlined as: 1. Optimal design of composite and functional material structures, products and manufacturing processes, 2. Exploiting advanced materials and structures in design, 3. Development of sustainable manufacturing technologies.

IN 2014:

The convergence theorem for Haar wavelet discretization method has been proved analytically for general n-th order ordinal differential equations. The rate of convergence has been validated numerically in a number of examples provided by workgroup and found in literature.

The methodology for design optimization of graphene/nanostructures has been proposed.

It was shown that the results and also some design rules are principally different in the case of macro and nanostructures. The necessary optimality conditions for multilayer graphene sheets were derived by applying averaged and multilayer plate theory. It was shown that the necessary optimality conditions corresponding to these two theories are equivalent (results the same optimal design).

The optimization procedures for design of smart/advanced composite structures were improved. ALT technology was adopted for design of defensive housings for electronic components embedded in composite. The procedure for price performance optimization of the sandwich structure was proposed. A Pareto concept was employed to estimate the price performance behaviour of a structural material composed of discrete component materials.

SMART COMPOSITES – DESIGN AND MANUFACTURING

The general goal of the project is to develop smart composite materials and structures according to the needs of Estonian industry. Topics: (1) Design of smart composite materials and structures; (2) Development of computational modelling capabilities and manufacturing techniques for the design of smart materials and structures; (3) Validation and evaluation of the smart composites.

IN 2014:

Development of sensor node for multi-sensor measurement system (strain, vibration, humidity and temperature) has been done. Experimental vibration analysis of small wind turbine blade for damage detection was developed. Development of carbon fibre yarn base strain sensor has was.

The methodology for the design of smart composites with structural health and performance monitoring capabilities was developed and validated in laboratory tests and real world applications (Goliath wind

OÜ). The proposed methodology includes formulation of the multicriteria and multilevel optimization problem, development of solution procedure and concepts. The impact of embedded electronics on the mechanical properties was minimized by employing design optimization.

A microscale finite element model was developed in order to investigate stress distribution inside the specimens.

The integration of embedded electronics was improved by introducing ALT technology. A novel concept of using additive layer technology to produce optimized encapsulation for the foreign object was proposed. Asymmetric ellipse cross-section was found to be the most optimal shape for NCF fabric material.

The characterization of acoustic performance of a novel type of advanced acoustic materials micro grooved element (MGE) was provided.

EMEREEG – A PORTABLE DEVICE FOR EARLY DETECTION AND TREATMENT OF TRAUMATIC BRAIN INJURY BASED ON ADVANCED QEEG AND HD-TES TO PREVENT MAJOR HEALTH PROBLEMS AND SPECIALLY FOR USE IN EMERGENCIES AND TELEMEDICINE.

Traumatic Brain Injury (TBI) is recognized as a major public health concern, especially for teenagers and young adults, since it can lead to significant disruption in education, working ability, and quality-of-life in general. Currently, there is no objective method for diagnosing TBI in an early stage or in emergency, which is a premise to prevent serious health impact. The aim of the project is to develop a portable medical device for objective and reliable emergency diagnosis of TBI and a monitored personalized treatment based on qEEG (quantitative electroencephalography) and HD-TES (High-Definition Transcranial Electric Stimulation).

IN 2014:

System requirements of portable device for early detection and treatment of traumatic brain injuries, and concept analyses were determined. Vacuum based head device was under the development, first stage was finished and tested. In head device instrumentation system electrode and electrode gel technology was selected and first experiments were carried out.

ENHANCING SUSTAINABILITY OF MANUFACTURING ENTERPRISES THROUGH RELIABILITY ENGINEERING

The purpose of this grant is to redesign the manufacturing processes in reliable way. The focus is on increasing the internal effectiveness of production processes. Major research directions are: (1) Intelligent module elaboration for optimal allocation of resources and elimination of the production processes faults; (2) Reducing waste by changing the patterns of production, using Green initiatives; (3) Development the maintenance plan: maintenance activities on operational level.

IN 2014:

The new framework for continuous improvement of reliability of production process and Key Performance Indicators (Quality, Cost and Throughput) was introduced. Various tools and methods into five steps of Six Sigma DMAIC (Define, Measure, Analyse, Improve, Control) methodology were integrated.

The presented new framework was adapted into the database – Data Mart, which will play the role of a source for „dashboard" that allows monitoring production processes (collect data about production problems, failures) in real time.

The Green Matrix from the general TRIZ (Theory of Inventive Problem Solving) Contradiction Matrix was elaborated to resolve environmental conflicts by using GE (Green Engineering) principles. Developed Waste Matrix was derived as an evaluation tool of Lean and GM techniques integration into each other.

The integrated method for evaluating the remanufacturability of the used equipment was adopted and extended. On the basis of technological, economic and environmental assessment parameters of remanufacturability, the necessity of the GM (Innovation part of the decision-making framework) use was defined.

One of the main achievements of this work is that three independent modules were united under one mechanism and all of them can be implemented separately. It allows finding standard and non-standard solutions through innovation-oriented module by directing it, not just following the world's best practices.

ANALYSIS AND DEVELOPMENT OF ADDITIVE MANUFACTURING PROCESSES

The objective of the research project is to analyse the processes involved in Additive Manufacturing (AM) technologies and find ways to improve them. The main tasks of the study are: (1) to develop new simulation models of Selective Laser Sintering (SLS) process by implementing more accurate material models and simulation procedures; (2) to improve accuracy of SLS; (3) to improve SLS process by developing method to apply composite particles/fibers into model in controlled way so that parts with FGM could be produced and to develop multidisciplinary topology optimization procedures for parts made with AM.

IN 2014:

Material properties, modelling techniques and procedures how to implement the models were studied. The most promising approaches were selected, the process of implementing the models is in progress.

For studying the recycling issues of the SLS leftover material experimental analysis was performed. The material samples were produced, different approaches of changing physical properties were tested. Samples of new material with improved properties for Fused Deposition Modelling process were produced. The work is in progress.

MICRO-PERFORATED LOCALLY RESONANT ACOUSTIC METAMATERIALS: A COMBINED APPROACH FOR NOISE CONTROL

The objective of this research project is the enhancement of the acoustic properties of thin membrane locally-resonant acoustic meta-materials by including properly designed micro-apertures or micro-perforated masses on the element surface.

IN 2014:

To improve the measurement sensitivity a new test-rig for 2-port measurements (which are used for the characterization of this type of acoustic elements) was developed. In order to prove the high sensitivity of the measurements achievable, the damping of the acoustic waves in presence of turbulent flow in straight ducts was under investigation.

A number of samples exhibiting unique impedance and absorptive characteristics, while being cost effective and ready-to-use in a wide range of engineering applications are designed, engineered, modeled and tested.

CONTACT: Assoc. Prof. Kristo Karjust, kristo.karjust@ttu.ee

SELECTED PUBLICATIONS:

Tiikoja, H.; Lavrentjev, J.; Rämmal, H.; Åbom, M. (2014). Experimental Investigations of Sound Reflection from Hot and Subsonic Flow Duct Termination. Journal of Sound and Vibration, 333(3), 788–800.

Auriemma, F.; Rammal, H.; Lavrentiev, J. (2014). Extended Investigations on Micro-Grooved Elements – A Novel Solution for Noise Control. SAE International Journal of Materials and Manufacturing, 1(1), 600–611.

Karaulova, T.; Poljantshikov, I.; Shevtshenko, E.; Kramarenko, S. (2014). Fractal approach for manufacturing project management. Mechanika, 20(3), 352–359.

Herranen, H.; Kuusik, A.; Saar, T.; Reidla, M.; Land, R.; Märtens, O.; Majak, J. (2014). Acceleration Data Acquisition and Processing System for Structural Health Monitoring. In: Proceedings of the 2014 IEEE International Workshop On Metrology For Aerospace: IEEE International Workshop On Metrology For Aerospace, Benevento, Italy, May 29–30, 2014, Benevento, Italy: IEEE, 2014, 244–249.

Aruväli, T.; Otto, T. (2014). Digital object memory integration into indirect surface roughness measurement in turning. In: Applied Mechanics and Materials: 4th International Conference on Mechanical and Manufacturing Engineering „Innovative Solutions for Sustainable Engineering", Putrajaya, Malaysia, December 17–18, 2013. Switzerland: Trans Tech Publications Ltd, 2014, 764–768.

DEPARTMENT OF MECHATRONICS

DEPARTMENT OF MECHATRONICS,
Director: Professor Mart Tamre, mart.tamre@ttu.ee, +372 620 3202

CHAIR OF QUALITY ENGINEERING AND METROLOGY,
Professor Toomas Kübarsepp, toomas.kubarsep@ttu.ee, +372 620 3211

CHAIR OF MECHANOSYSTEM COMPONENTS,
Professor Trieu Minh Vu, trieu.vu@ttu.ee, +372 620 3304

CHAIR OF MECHATRONICS SYSTEMS,
Professor Mart Tamre, mart.tamre@ttu.ee, +372 .620 3202

LABORATORY FOR MECHATRONICS, MECHANO AND MEASUREMENT SYSTEMS,
Teaching assistant Leo Teder, leo.teder@ttu.ee, +372 620 3305

MAIN LINES OF RESEARCH

METROLOGY AND QUALITY ENGINEERING

Main research is connected with the investigations and developments in three directions of fundamentals of measurements: electrical conductivity, measurements of geometric and optical quantities. These three directions are tightly connected from the point of measurements and measurement technique and one of the goals is focusing on the theoretical basis of the coherency of those fields.

IN 2014:

Improved measurement methods (electrical conductivity measurements with planar coils) were worked out and unique design of high-level measurement equipment (photodetectors for precise measurements of low photon flows – single to some thousand photons) was done. There was an active collaboration with other EU universities and research institutions (PTB, MIKES, EURAMET, etc.). A good example of collaboration is work at the EU Metrology programme EMRP project NEWSTAR – New Primary Standards and Traceability for Radiometry (EURAMET JRP SIB57 project).

CONTACT: Prof. Toomas Kübarsepp, toomas.kubarsep@ttu.ee

SELECTED PUBLICATIONS:

Rastello, M. L. et al (2014). Metrology for industrial quantum communications: the MIQC project. Metrologia, S267–S275.

Dhoska, K.; Vabson, V.; Hermaste, A.; Kübarsepp, T. (2014). Dimensional Accuracy for Multi-element Photodetector. Proceedings of NEWRAD 2014, The 12th International Conference on New Developments and Applications in Optical Radiometry, Espoo, Finland, June 24–27, 2014, 352.

Kübarsepp, T.; A. Pokatilov, A.; Vabson, V.; Dhoska, K.; Porrovecchio, G.; Götzinger, S.; Manninen, A.; Kück, S. (2014). High-attenuation tunnel-type detector for calibration of single-photon devices. Proceedings of NEWRAD 2014, The 12th International Conference on New Developments and Applications in Optical Radiometry, Espoo, Finland, June 24–27, 2014, 115–116.

Dhoska, K.; Kübarsepp, T.; Hermaste, A. (2014). Uncertainty evaluation of angle measurements by using 3d coordinate measuring machine. Proceedings of 9th International Conference of DAAAM Baltic Industrial Engineering, April 24–26, 2014, Tallinn, Estonia, 221–225.

MECHANOSYSTEM MODELING

The focus in the research is on multibody system dynamics, vibration analysis and monitoring targeted on modeling, and optimization of systems and materials behavioral characteristics and essentially the research is focused on the performance of teleoperated robots, which depends on the remote human awareness and the remote robot manipulation ability. The new systems help to interpret the sensing data, to improve the judgments about the remote environments.

IN 2014:

Innovative technologies were investigated to enhance autonomous and/or hybrid car technology and to improve the potential of this technology applicability in everyday life. The new technology focus is in improving autonomous driving and especially complicated maneuvering capabilities of future cars and in optimization of hybrid drive assemblies and their components to reduce energy consumption. The technology is combined with multimodal interfaces to provide multiple sensory channels and enhance the controller and operator performance symbiosis.

CONTACT: Prof. Trieu Minh Vu, trieu.vu@ttu.ee

SELECTED PUBLICATIONS:

Vu, T. M. (2014). Feasible Path Planning for Autonomous Vehicles. Mathematical Problems in Engineering, 2014, 1–20.

Vu, T. M. (2014). Computational Intelligence for Decision Support in Cyber-Physical Systems Studies in Computational Intelligence – Trajectory Generation for Autonomous Mobile Robots. Studies in Computational Intelligence (195–214). Springer-Verlag.

Vu, T. M. (2014). Trajectory Generation for Autonomous Vehicles. Mechatronics 2013: Recent Technological and Scientific Advances (615–626). Springer.

Vu, T. M. (2014). Predictive control for controlling and driving autonomous vehicles. In: Proceedings of the 9th International Conference of DAAAM Baltic, INDUSTRIAL ENGINEERING: 9th International Conference DAAAM Baltic, INDUSTRIAL ENGINEERING, Tallinn, Estonia, 24–26 April 2014. Tallinn: Tallinn University of Technology, 311–316.

MECHATRONICS SYSTEMS

The research is focused on proactive smart machine and robotic industrial systems for production and service automation. Activity is concentrated on proactive industrial hardware systems and on smart control capable to work in networked systems.

IN 2014:

Proactive system behavior was investigated on the example of the whole production and logistic chain of forestry production. Much attention was on developing high efficiency new waste sorting technologies for paper and plastic wastes. New high effective sorting methods were proposed. Different logistics and transportation stages in whole production chain were also investigated to introduce new smart monitoring technologies utilizing today's mobile and sustainability technologies. In parallel to abovementioned reconfigurable robot control and smart algorithms were investigated and new solutions were proposed for industrial applications (especially human-machine high efficiency interaction and control) and for unmanned autonomous control of vehicular systems for open air terrain and indoor industrial applications.

CONTACT: Prof. Mart Tamre, mart.tamre@ttu.ee

SELECTED PUBLICATIONS:

Lees, Ü.; Hudjakov, R.; Tamre, M. (2014). Development of virtual reality interface for remote robot control. In: Proceedings of the 9th International DAAAM Baltic Conference „INDUSTRIAL ENGINEERING", 24–26th April 2014, Tallinn, ESTONIA: 9th International DAAAM Baltic Conference "Industrial Engineering", Tallinn, Estonia, Aprill 24–26, 2014. Tallinn: Tallinn University of Technology, 247–250.

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Roosileht, I.; Lentsius, M.; Mets, O.; Heering, S.; Hiiemaa, M. & Tamre, M. (2014). Automated inspection system of electric motor stator and rotor sheets. In: Proceedings of the 9th International DAAAM Baltic Conference „INDUSTRIAL ENGINEERING", April 24–26, 2014, Tallinn, ESTONIA: 9th International DAAAM Baltic Conference „Industrial Engineering", Tallinn, Estonia, Aprill 24–26, 2014. Tallinn: Tallinn University of Technology, 283–288.

Shvarts, D.; Tamre, M. (2014). Bulk material volume estimation method and system for logistic applications. In: Proceedings of the 9th International Conference of DAAAM Baltic, INDUSTRIAL ENGINEERING: 9th International Conference DAAAM Baltic, INDUSTRIAL ENGINEERING, Tallinn, Estonia, Aprill 24–26, 2014. Tallinn: Tallinn University of Technology, 289–294.

DEPARTMENT OF THERMAL ENGINEERING

DEPARTMENT OF THERMAL ENGINEERING,
Acting Director: Professor Aadu Paist, aadu.paist@ttu.ee, +372 620 3638

CHAIR OF THERMAL POWER ENGINEERING,
Professor Aadu Paist, aadu.paist@ttu.ee, +372 620 3638

CHAIR OF THERMAL POWER EQUIPMENT,
Professor Andres Siirde, andres.siirde@ttu.ee, +372 620 3902

CHAIR OF HEAT ENGINEERING,
Professor Ivan Klevtsov, ivan.klevtsov@ttu.ee, + 372 620 3914

MAIN LINES OF RESEARCH

RESEARCH LABORATORY OF COMBUSTION PROCESSES

The research is focused on investigation of new opportunities for efficient and environment friendly utilisation of oil shale and other local fuels. The topics involve: (1) Environmentally and economically competitive new technologies of low grade fuel based energy production – Clean Estonian Oil Shale; (2) Local fuels fired power units safety, reliability and environmental problems; (3) Combined utilization (gasification) of oil shale and biomass for energy production.

The main results concern the technology basis for oil shale combustion in oxygen rich environment. The experimental results are directed to ensure the reliability of Estonian electricity and heat production; increase in competitiveness; environmental footprint reduction; increase of effectiveness of energy equipment by augmentation of convective heat transfer.

CONTACT: Prof. Andres Siirde, andres.siirde@ttu.ee

SELECTED PUBLICATIONS:

Konist, A.; Loo, L.; Valtsev, A.; Maaten, B.; Siirde, A.; Neshumayev, D.; Pihu, T. (2014). Calculation of Estonian Oil Shale Combustion Products in Regular and Oxy-fuel Mode in a CFB Boiler. Oil Shale, 31(3), 211–224.

SMART DISTRICT HEATING SYSTEMS RESEARCH GROUP

The research is focused on the development of new technical solutions for the transition of district heating (DH) systems towards an intelligent, highly efficient and regenerative energy supply concept. The results of the research can be used to reduce energy consumptions and carbon dioxide emissions within the Baltic Sea region (BSR).

MAIN RESULTS IN 2014

The processes characterising DH systems were analysed and optimised, taking into account relevant operational boundary conditions and legal frameworks.

Optimising the heat generation, distribution and consumption within DH systems, the primary energy use has been improved.

CONTACT: Prof. Andres Siirde, andres.siirde@ttu.ee

SELECTED PUBLICATIONS:

Mašatin, V.; Link, S.; Siirde, A. (2014). The Impact of Alternative Heat Supply Options on CO^2 Emission and District Heating System. In: Chemical Engineering Transactions: PRES 2014. 17th Conference Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction. August 23–27, 2014, Prague, Czech Republic. Chemical Engineering Transactions; 39, 1105–1110.

OIL SHALE BOILERS TESTS AND AIR EMISSIONS RESEARCH GROUP

The research is focused on investigation of new opportunities for efficient and environment friendly utilization of oil shale and other local fuels.

MAIN RESULTS IN 2014:

Co-firing of bio mass and oil shale in CFB boilers have been investigated. The main concern here was possible fouling of convective heat transfer surfaces because of changed fly ash properties. Analyzing the ash and deposits properties proved that co-firing of biomass with 40–50% moisture up to 15% by mass is possible without major changes in CFB boiler operation conditions. Tests with bio mass ratio up to 30% are planned to near future.

Investigations of different oil shale fired boilers PM 2,5 and PM 10 emissions resulted to conclusions, that approximately half of emitted particulates belong to PM 2,5 grade and the finest particulate emissions comes from CFB boiler.

Tests at Narva Power Plants old pulverized oil shale fired boilers proceeded with the aim of decreasing NOx emissions to the acceptable level.

Fortum DeNOx system tests without urea injection at boiler 3B proved the system to be reliable and NOx concentration below the limit value of 200 mg/nm^3 was reached at different oil shale fuels and loads.

Hard coal and oil shale co-firing at CFB boiler (11 A) was tested. Main problem was much higher NOx emission (>500 mg/Nm^3) because of hard coal higher nitrogen content, but also elevated temperature (~20°C) level in furnace and flue gas.

CONTACT: Tõnu Pihu, tonu.pihu@ttu.ee

SELECTED PUBLICATIONS:

Gusca, J.; Siirde, A.; Eldermann, M.; Rohumaa, P. (2014). Production of Fuel Oil from Estonian Oil Shale: an Indicator-based Decomposition Analysis. 27st International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact, Turku, Finland, June 15–19, 2014.

DIAGNOSTICS AND RELIABILITY OF HIGH PRESSURE EQUIPMENT OF POWER PLANTS

Research is focused on assessment of operational integrity of the ageing power plant components operated at high temperature, including: (1) Investigation of the reliable approaches for life consumption assessment of the components operated in the conditions of creep and fatigue; (2) Determination of mechanical properties by testing of miniaturized specimens extracted from the in-service components; (3) Investigation of high temperature corrosion of boiler steels; stress analysis of power plant components by means of finite element modelling.

95% of electricity in Estonia is produced at thermal power plants by firing of oil shale, low-grade local fuel. Most of the units of Narva power plants were built about 50 years ago and all of them have exceeded their design lifetime. Further operation of these units is allowable only if careful metal condition monitoring of the blocks main elements is carried out.

MAIN RESULTS IN 2014:

The investigation of metal condition of the basic components of some units in Eesti Power Plant and in Balti Power Plant was carried out. These components were main steam piping, hot reheat steam piping, boiler drums, turbine casings and rotors. The research was performed by using of NDT methods: hardness measurement, investigation of the metal structure (replication), mechanical properties measurement of the metal using miniature tensile specimens sampled from the components, the measurement of creep deformation of the internal rotor boors. Based on the results of the investigation have been issued permission for a certain period of operation till the next mandatory inspection.

The high temperature corrosion of heating surfaces, particularly steam super heaters was also studied.

The strength calculation of hot reheat piping of power unit 8 in Eesti Power Plant was carried out to check the stress level and reveal the most loaded components of the piping.

CONTACT: Ivan Klevtsov, ivan.klevtsov@ttu.ee

SELECTED PUBLICATIONS:

Priss, J.; Rojacz, H.; Klevtsov, I.; Dedov, A.; Winkelmann, H.; Badisch, E. (2014). High temperature corrosion of boiler steels in hydrochloric atmosphere under oil shale ashes. Corrosion Science.

Priss, J.; Klevtsov, I.; Dedov, A.; Antonov, M.; Rojacz, H.; Badisch, E. (2014). High Temperature Cyclic Impact/Abrasion Testing of Boiler Steels. Engineering Materials & Tribology XXII (289–292).Trans Tech Publications Ltd.

DEPARTMENT OF MATERIALS ENGINEERING

DEPARTMENT OF MATERIALS ENGINEERING,
Director: Professor Renno Veinthal, renno.veinthal@ttu.ee, +372 620 3351

CHAIR OF MATERIALS STUDIES,
Professor Priit Kulu, priit.kulu@ttu.ee, +372 620 3352

CHAIR OF METALS PROCESSING,
Associate Professor Fjodor Sergejev, fjodor.sergejev@ttu.ee, +372 620 3346

RESEARCH LABORATORY OF POWDER TECHNOLOGY,
Senior Research Scientist Lauri Kollo, lauri.kollo@ttu.ee, +372 620 3356

RESEARCH LABORATORY OF TRIBOLOGY,
Senior Research Scientist Maksim Antonov, maksim.antonov@ttu.ee, +372 620 3355

RESEARCH AND TESTING LABORATORY OF MATERIALS RECYCLING,
Research Scientist Dmitri Goljandin, dmitri.goljandin@ttu.ee, +372 620 3349

MAIN LINES OF RESEARCH

PROJECT: „MULTI-SCALE STRUCTURED CERAMIC-BASED COMPOSITES FOR EXTREME APPLICATIONS“

The project was launched in 2014. Research in the frame of the project has been divided into three subprograms:

1. TRIBO-MATERIALS FOR A WIDE RANGE OF TEMPERATURES.

The overall goal of this subprogram is design and development of tribo-materials (wear resistant materials) of enhanced performance in conditions of complex mechanical loading, corrosive media and/or high temperatures.

In 2014: A study was conducted to increase the corrosion resistance and durability of cemented carbides. A new field of development and characterization of biocompatible Ni- and Co- free composites was focused on four compositions: TiC-FeCr (ferrite binder); TiC-FeCrMn (austenite binder); TiC-Fe_3Al (intermetallic binder) and Cr_3C_2-FeTi/TiFe. The research was started to increase the performance and reliability of cermets, ceramic matrix and metal matrix composites at high temperatures. The main focus was pointed to WC-, ZrC-, HfC-, and TiC – based composites. For development and optimisation of technology for composites fabrication effect of the processing parameters on mechanical and tribo-reliability of the produced materials was studied.

2. MULTI-MATERIALS SYSTEMS

The overall objective of this subprogram is development of technology for gradient structured materials to be used either for thin and/or thick coatings deposition or joining processes.

In the area of thick coatings development, the following studies were conducted: (1) Development of the technological process for production of plasma transferred arc (PTA) hardfacings based on hardmetals/cermet granules; (2) Deposition of the coatings based on hardmetal particles, which were produced by MAS and RTS methods, by novel HVOF method; (3) Studying of wear resistance and wear mechanisms of the produced coatings; (4) Development of effective methods for abrasive wear studying; (5) Adaptation of PM/PTA technology to the thick coatings (up to 5 mm) deposition.

In the area of thin tribo-coatings development and studying, the following can be reported: (1) Studying adhesion of diamond particles to a surface by scratching; (2) Making suspension of diamond nanoparticles (4–5 nm) with the help of an ultrasonic bath; (3) Application of PECVD (Plasma Enhanced Chemical Vapor Deposition) for production of the diamond coatings of high quality.

3. HIERARCHICALLY STRUCTURED MULTIFUNCIONAL COMPOSITES

The overall goal of this subprogram is design and development of ceramic-based composites reinforced/toughened by nanofillers. The main focus of the research is toughened ceramic-matrix materials (such as alumina, zirconia, etc.) with alumina nanofibers.

The main studies in 2014 were as following: (1) Elaboration of mixing procedure for homogeneous additives distribution within the matrix material; (2) Modification/functionalization of the nanofibers by chemical precipitation, metals infiltration, etc.; (3) Development and optimization of the technological parameters for fabrication of nanofibers reinforced ceramic-based composites. For composite fabrication both traditional and recently developed (such as SPS, for example) methods are continuously used; (4) Modelling of interphases for better understanding of strengthening/toughening mechanisms.

CONTACT: Prof. Jakob Kübarsepp, jakob.kubarsepp@ttu.ee

PROJECT: „ADVANCED THIN HARD COATINGS IN TOOLING (HARDCOAT)"

Objectives of the project: implementation of PVD and CVD coatings with different architecture to increase the working reliability of cutting tools by studying processes of advanced coatings pre- and post-treatment and wear mechanisms.

Main results: Methods for the selection of proper architecture of coatings for specific tooling applications were developed. Description of wear mechanisms of advanced coatings in specific industrial application was drafted.

CONTACT: Senior Researcher Priidu Peetsalu, priidu.peetsalu@ttu.ee

PROJECT: „NANOCOM – NANO-GEOMETRY AND ENTANGLEMENT FOR DESIGN AND PROTOTYPING OF CERAMIC-BASED HIGH-PERFORMANCE NANO-COMPOSITES (NANOCOM)"

The aim of the project: elaboration of novel materials based on industry's needs – the ceramic-based composites to overcome the intrinsic brittleness and mechanical unreliability of monolithic ceramics by using ceramic fibers and carbon nanotubes as the reinforcements.

Main results: Elaboration of constituents of ceramic-based composites. Defining precursors: mixing, milling and functionalization of components. Consolidation of the constituents. Characterization of elaborated composites.

PARTNERS: Metallurgy Engineering OÜ, Sumar OÜ, Desintegraator Tootmine OÜ

CONTACT: Prof. Jakob Kübarsepp, jakob.kubarsepp@ttu.ee

PROJECT: „PERMANENT MAGNETS FOR SUSTAINABLE ENERGY APPLICATION (MAGMAT)"

Objectives of the project: to gain deeper insights into the magnetic properties of NdFeB magnets; design of materials with comparable or even better magnetic properties for materials commercially available today, with reduced cost and impact on the environment; develop criteria's for the selection of suitable alloy compositions and microstructures.

Project results: PM alloys were developed with controlled composition and microstructure based on NdFeB induction melting and melt-spinning. Magnets with improved performance at high operation temperatures (up to 150°C) and/or combined mildly corrosive environments were developed. Prototyping of several new grades of permanent magnets with reduced content of Nd and Dy was performed. New materials and grades for wind generators were designed.

PARTNERS: Molycorp Silmets AS, ABB Estonia AS.

CONTACT: Prof. Renno Veinthal, renno.veinthal@ttu.ee

PROJECT: „DEVELOPMENT OF ADVANCED COATINGS AND POLYMER-CERAMIC COMPOSITES FOR ROAD CONSTRUCTION MACHINERY WEAR PARTS (WEARHARD)"

Objectives of the project: creation of new cost-efficient products with higher wear resistance, increased service life and new enhanced engineering designs.

Main results: PTA strengthening technology for wear parts was developed. Hardmetal based tribocomposites and polymer-cermet composite materials for wear parts were proposed.

PARTNERS: Meiren Engineering OÜ, Paide Masinatehas AS.

CONTACT: Prof. Priit Kulu, priit.kulu@ttu.ee

SELECTED PUBLICATIONS:

Hussainova, I.; Voltsihhin, N.; Cura, E.; Hannula, S.-P. (2014). Densification and characterization of spark plasma sintered ZrC–ZrO_2 composites. Materials Science and Engineering A-Structural Materials Properties Microstructure and Processing, 597, 75–81.

Kübarsepp, J.; Pirso, J.; Juhani, K. (2014). Developments in cermet design, technology and performance. International Journal of Materials & Product Technology, 49(2/3), 160–179.

Podgursky, V.; Hantschel, T.; Bogatov, A.; Kimmari, E.; Antonov, M.; Viljus, M.; Mikli, V.; Tsigkourakos, M.; Vandervorst, W.; Buijnsters, J.; Raadik, A.; Kulu, P. (2014). Rippling on Wear Scar Surfaces of Nanocrystalline Diamond Films After Reciprocating Sliding Against Ceramic Balls. Tribology Letters, 55(3), 493–501.

Kulu, P.; Käerdi, H.; Surzenkov, A.; Tarbe, R.; Veinthal, R.; Goljandin, D.; Zikin, A. (2014). Recycled hardmetal-based powder composite coatings: optimisation of composition, structure and properties. International Journal of Materials and Product Technology, 49(2/3), 180–202.

Jõeleht, M.; Pirso, J.; Juhani, K.; Viljus, M.; Traksmaa, R. (2014). The formation of reactive sintered (Ti,Mo)C-Ni cermet from nanocrystalline powders. International Journal of Refractory Metals and Hard Materials, 41, 284–290.

FACULTY OF SOCIAL SCIENCES

FACULTY OF SOCIAL SCIENCES

Dean: SULEV MÄELTSEMEES, Professor

Phone: +372 620 2654
e-mail: sulev.maeltsemees@ttu.ee

Vice-Dean for Research: TIINA RANDMA-LIIV, Professor

Phone: +372 620 2670
e-mail: tiina.randma-liiv@ttu.ee

Vice-Dean for International Relations: WOLFGANG DRECHSLER, Professor

Phone: +372 620 2664
E-mail: wolfgang.drechsler@ttu.ee

DEPARTMENTS, RESEARCH CENTERS, RESEARCH LABORATORIES:

- Ragnar Nurkse School of Innovation and Governance
- Department of Industrial Psychology
- Tallinn Law School
- Language Centre
- Sport Centre

Faculty of Social Sciences is currently employing 15 professors.

Total number of academic staff is 86. 1 doctoral dissertations was defended in 2014.

RAGNAR NURKSE SCHOOL OF INNOVATION AND GOVERNANCE

RAGNAR NURKSE SCHOOL OF INNOVATION AND GOVERNANCE,
Director: Senior Research Scientist Veiko Lember, veiko.lember@ttu.ee, +372 620 2671

CHAIR OF PHILOSOPHY,
Professor Ahti-Veikko Pietarinen, ahti-veikko.pietarinen@ttu.ee

CHAIR OF PUBLIC MANAGEMENT AND PUBLIC POLICY,
Professor Tiina Randma-Liiv, tiina.randma-liiv@ttu.ee, +372 620 2670

CHAIR OF INNOVATION POLICY AND TECHNOLOGY GOVERNANCE,
Professor Rainer Kattel, rainer.kattel@ttu.ee, +372 620 2661

CHAIR OF LOCAL SELF-GOVERNMENT AND REGIONAL POLICY,
Professor Sulev Mäeltsemees, sulev.maeltsemees@ttu.ee, +372 620 2654

CHAIR OF GOVERNANCE,
Professor Wolfgang Drechsler, wolfgang.drechsler@ttu.ee, +372 620 2664

MAIN LINES OF RESEARCH

CHAIR OF INNOVATION POLICY AND TECHNOLOGY GOVERNANCE

Main fields of research and development include innovation policy and economic development and their relation with public administration.

In 2014 the research was related to the performance of the following projects: (1) Monitoring Science and Innovation Policy (TIPS); (2) "Public sector innovation: The case of modern identity management technologies" (PUT grant); (3) Financialisation, economy, society and sustainable development (FESSUD, FP7 funded project); (4) Learning from innovation in Public Sector Environments (LIPSE, FP7 funded project); (5) the Norwegian-Estonian science project „Understanding policy change: Financial and fiscal bureaucracy in the Baltic Sea Region"; (6) Innovation and the state: How should government finance and implement innovation policy? (funded by INET-America).

CONTACT: Prof. Rainer Kattel, rainer.kattel@ttu.ee

SELECTED PUBLICATIONS:

Raagmaa, G.; Kalvet, T.; Kasesalu, R. (2014). Europeanization and De-Europeanization of Estonian Regional Policy. European Planning Studies, 22(4).

Kattel, R.; Reinert, E. S. (2014). Failed and Asymmetrical Integration: The Baltics and the Non-financial Origins of the European Crisis . The Contradictions of Austerity. The Socio-Economic Costs of the Neoliberal Baltic Model (64–86). London: Routledge Taylor & Francis Ltd.

Juuse, E.; Endresen, B. S; Kattel, R. (2014). Foreign Direct Investment in Estonia – Understanding the Impact of Public Policies on Local Embeddedness and Networking in the Food Retail and Related Industries. Understanding Innovation in Emerging Economic Spaces. Global and Local Actors, Networks and Embeddedness (97–118). Farnham: Ashgate Publishing Ltd.

Mathews, J. A.; Reinert, S. E. (2014). Renewables, manufacturing and green growth: Energy strategies based on capturing increasing returns. Futures, 61, 13–22.

Burlamaqui, L.; Kattel, R. (2014). Development Theory: Convergence, Catch-up or Leapfrogging? A Schumpeter–Minsky–Kregel Approach. Contributions to Economic Theory, Policy, Development and Finance: Essays in Honor of Jan A. Kregel (175–195). London: Palgrave Macmillan.

CHAIR OF GOVERNANCE

Chair focuses its research and development on the following topics: the State, public economics, public administration, political science, and public finance and e-Governance (both are sub-fields of governance and state theory).

In 2014 the research was related to the performance of the following projects: (1) Understanding Policy Change: Financial and Fiscal Bureaucracy in the Baltic Region; (2) „Verifiability" in Internet Voting: A Multiple Case Study Identifying Reasons for and Modalities of its Implementation in Estonia, Norway and Switzerland; (3) Challenges to state modernization in 21st century Europe: Theoretical developments and future scenarios.

CONTACT: Prof. Wolfgang Drechsler, wolfgang.drechsler@ttu.ee

SELECTED PUBLICATIONS:

Drechsler, W. (2014). What is and why do we study Islamic Public Administration in the former Second World? Halduskultuur – Administrative Culture, 15(2), 123–142.

Drechsler, W. (2014). Towards understanding Wang Anshi and Confucian Public Management. Public Money and Management, 34(4), 246–248.

Kregel, J. (2014). Economic Development and Financial Instability. Anthem Press, 376.

Kostakis, V.; Bauwens, M. (2014). Network Society and Future Scenarios for a Collaborative Economy. Palgrave Macmillan, 98.

Kattel, R.; Raudla, R. (2014). The Baltic Republics and the Crisis of 2008 – 2011. Transition Economies after 2008: Responses to the crisis in Russia and Eastern Europe (56–79). Routledge.

CHAIR OF PUBLIC MANAGEMENT AND PUBLIC POLICY

Chair is focused in its research and development activities on public administration reforms, comparative public administration, public-private partnership, civil service, policy analysis and policy transfer from other countries. The Chair leads FP7 grant Coordinating for Cohesion in the Public Sector of the Future (COCOPS).

CONTACT: Prof. Tiina Randma-Liiv, tiina.randma-liiv@ttu.ee

SELECTED PUBLICATIONS:

Savi, R. (2014). Public policy making in time of crisis: The responses of the street level bureaucrats in cutback management in Estonia. Halduskultuur – Administrative Culture, 15(1), 100–117.

Karo, E.; Looga, L. (2014). Understanding Institutional Changes in Economic Restructuring and Innovation Policies in Slovenia and Estonia. Journal of International Relations and Development, http://dx.doi.org/10.1057/jird.2014. 23.

Karo, E.; Kattel, R. (2014). Public Management, Policy Capacity, Innovation and Development. Brazilian Journal of Political Economy, 34(1), 80–102.

Lember, V.; Kattel, R.; Kalvet, T. (2014). Public Procurement, Innovation and Policy: International Perspectives. Heidelberg: Springer, VIII, 309.

Sarapuu, K.; Metsma, M.; Randma-Liiv, T.; Uudelepp, A. (2014). Estonia. Leadership and Culture: Comparative Models of Top Civil Servant Training (73–88). Palgrave Macmillan.

CHAIR OF LOCAL SELF-GOVERNMENT AND REGIONAL POLICY

Main fields of research and development include Local Self-Government, Regional Management and Regional Policy. The Chair is focused on the following fields in its research and development activities: interdisciplinary research of local and regional public adminsitration in the legal, economic, leadership-related, territorial etc. context both in terms of theory and practice, including analyzing the experience of other countries and developing further proposals for improving Estonian regional management and local government (administrative reform in Estonia).

CONTACT: Prof. Sulev Mäeltsemees, sulev.maeltsemees@ttu.ee

SELECTED PUBLICATIONS:

Mäeltsemees, S.; Ratas, J. (2014). Increasing competitiveness of cities. The 22nd NISPAcee Annual Conference: „Government vs. Governance in Central and Eastern Europe from Pre-Weberianism to Neo-Weberianism?" May 22–24, 2014, Budapest, Hungary; Corvinus University of Budapest. NISPA (Network of Institutes and Schools of Public administration in Central Eastern Europe).

CHAIR OF PHILOSOPHY

R&D activities of the Chair cover a broad range of topics, including philosophy of science; core analytic philosophy; philosophy of logic; philosophy of mathematics; philosophy and history of technology; philosophy of cognitive sciences and artificial intelligence.

CONTACT: Prof. Ahti-Veikko Pietarinen, ahti-veikko.pietarinen@ttu.ee

SELECTED PUBLICATIONS:

Pietarinen, A.-V. (2014). A Scholastic-Realist Modal-Structuralism. Philosophia Scientiae, 18(3), 127–138.

Marion, M.; Moktefi, A. (2014). La logique symbolique en débat à Oxford à la fin du dix-neuvième siècle : Les disputes logiques de Lewis Carroll et John Cook Wilson. Revue d'Histoire des Sciences, 67(2), 185–205.

Pietarinen, A.-V. (2014). Logical and Linguistic Games from Peirce to Grice to Hintikka (with comments by J. Hintikka). Teorema, 33(2), 121–136.

Pietarinen, A.-V. (2014). Misrepresentation in „Misrepresentation in Context" in Context. Foundations of Science, Springer, 381–386.

Pietarinen, A.-V.; Bellucci, F. (2014). New Light on Peirce's Concept of Retrduction and Scientific Reasoning. International Studies in the Philosophy of Science, 28 (4), 21.

TALLINN LAW SCHOOL

TALLINN LAW SCHOOL,
Director: Professor Tanel Kerikmäe, tanel.kerikmae@ttu.ee, +372 620 2430

CHAIR OF PUBLIC LAW,
Associate Professor Lehte Roots, lehte.roots@ttu.ee, +372 620 2422

JEAN MONNET CHAIR OF EUROPEAN LAW,
Professor Tanel Kerikmäe, tanel.kerikmae@ttu.ee, +372 620 2430

CHAIR OF LAW AND TECHNOLOGY,
Professor Katrin Nyman-Metcalf, katrin.nyman-metcalf@ttu.ee, +372 620 2427

CHAIR OF ECONOMIC LAW,
Lecturer Kristi Joamets, kristi.joamets@ttu.ee, +372 620 2422

HUMAN RIGHTS CENTRE,
Research Scientist Evhen Tsybulenko evhen.tsybulenko@ttu.ee, +372 620 2426

MAIN LINES OF RESEARCH

EU LEGAL DEVELOPMENTS

Several projects were carried out related to the Development Aid projects (cooperation with the Ministry of Foreign Affairs) related to Moldavia as neighbourhood country and specific fields of EU law. The analysis under Jean Monnet project „Functional Capacity of the European Union" financed by the European Commission were conducted. The group was also related to EU-ASEAN research, a contribution to the Cambodian Administrative law textbook was provided and there were several Asian module activities. Some of the activities were related to Latin America, lecture series in EAFIT, Columbia.

A book on EU Charter was composed to be published by Springer Verlag.

RESEARCH GROUP ON TECHNOLOGY AND LAW

The research group has had various successful projects in the field of Intellectual Property: transferring the knowledge on intellectual property for Palestinian judges to support intellectual property reform in Palestine; a TEMPUS project Promoting Intellectual Property Law Studies in the Mediterranean Region. R&D activities concerning IT and law are targeted at experimental research, in the following fields: automated decision-making, Artificial Intelligence and systematization of legal norms (together with experts from TUT IT faculty). In 2014 Prof. Nyman Metcalf was elected to be a head of research Council of E-government Academy.

CONTACT: Prof. Tanel Kerikmäe, tanel.kerikmae@ttu.ee

SELECTED PUBLICATIONS:

Nyman Metcalf, K. (2014). The Content and Context of Hate Speech. Rethinking Regulation and Responses. International and Comparative Law Quarterly, 63(2), 510–513.

Rull, A.; Täks, E.; Norta, A. (2014). Towards software-agent enhanced privacy protection. Regulating eTechnologies in the European Union: Normative Realities and Trends (73–94). Springer.

Nyman-Metcalf, K.; Dutt, P. K.; Chochia, A. (2014). The Freedom to Conduct Business and the Right to Property: The EU Technology Transfer Block Exemption Regulation and the relationship between Intellectual Property and Competition Law. Protection of Human Rights in the EU: Controversies and Challenges of the Charter of Fundamental Rights (37–70). Springer Verlag.

Nyman-Metcalf, K. (2014). Digitalisation and beyond: Media freedom in a new reality. Media Freedom and Regulation in the New Media World (65–83). Kluwer.

Kerikmäe, T.; Nyman-Metcalf, K.; Gabelaia, D.; Chochia, A. (2014). Cooperation of Post Soviets with the Aim of not being „Post" and „Soviets". From Eastern Partnership to the Association. The Legal and Political Analysis (144–159). Cambridge Scholars Publishing.

Roots, L. (2014). Balance between national interests and EU citizenship. Citizen, state, international community. A collection of studies (543–556).C. H. Beck.

Evas, T. (2014). Estonia. EU Law in the Member States Viking, Laval and Beyond. (139–153). Oxford: Hart Publishing.

DEPARTMENT OF INDUSTRIAL PSYCHOLOGY

DEPARTMENT OF INDUSTRIAL PSYCHOLOGY,
Director: Professor Mare Teichmann, mare.teichmann@ttu.ee, +372 620 2656

CHAIR OF PERSONNEL DEVELOPMENT,
Associate Professor Mario Martinez-Corcoles, mario.martinez-corcoles@ttu.ee, +372 620 2656

CHAIR OF PSYCHOLOGY,
Professor Mare Teichmann, mare.teichmann@ttu.ee, +372 620 2656

ESTONIAN CENTRE FOR ENGINEERING PEDAGOGY,
Associate Professor Tiia Rüütmann, tiia.ruutmann@ttu.ee, +372 620 3255

MAIN LINES OF RESEARCH

QUALITY OF WORKING LIFE (QWL) AND OCCUPATIONAL STRESS.

The research focuses on occupational stress through the sources of pressure in the job and includes quality of life studies with the purpose of demonstrating how these pressures affect quality of life.

IN 2014:

The relation of the sources of occupational stress with quality of life was investigated and it was found consistent being negative, yet moderate or low. In the quality of life domains, the strongest relations were between the sources of occupational stress and physical health and psychological well-being. In addition, it was found that the increase of income is improving the quality of life, but beyond a certain optimum level. Higher income in „over-the-limit-area" is associated with decreased life satisfaction that related with decrease in performance, aggravation of fatigue, and reduction of opportunities for recreation and leisure, deterioration of personal relationships.

CONTACT: Prof. Mare Teichmann, mare.teichmann@ttu.ee

SELECTED PUBLICATIONS:

Teichmann, M. (2014). Occupational Stress and Quality of Life. International Applied Psychology Congress ICAP 2014 Paris, France July 8–13, 2014.

Murdvee, M.; Teichmann, M. (2014). Quality of Life and Income. International Applied Psychology Congress ICAP 2014. Paris, France July 8–13, 2014.

PROJECT „NEW EUROPEAN INDUSTRIAL RELATIONS"

Clarifying roles and expectations between employer and employee representatives (ERs) there is a need to develop a constructive dialogue within organizations. The aim of this study was to improve the quality of social dialogue as a tool for innovation, by exploring European employers' experiences and expectations on structures, roles, attitudes and competencies of ERs.

IN 2014:

Historical context of the labour movement in Estonia was studied. Estonian unions' membership rate was compared with other EU countries' unions membership rates. The results of the study showed that majority of Estonian employees are not represented by the unions. Moreover, like in many EU countries, there exists the continuing downward trend of union membership in Estonia. Both, the employees and employers assessing works councils as more democratic and innovative than the unions. However, still the majority of employees are not represented at all – not in unions and nor in the works councils. For the majority of employees in Estonia, working conditions, and in particular pay, are fixed in direct discussions between the employer and the individual worker.

The main employers' concerns were summarized regarding the ERs' role in Estonia: (1) Need for professionalism; (2) Attitudes of the employee representatives; (3) Low mutual trust; (4) Lack of competencies; (5) Low prestige.

CONTACT: Prof. Mare Teichmann, mare.teichmann@ttu.ee

PROJECT „HUMAN FACTORS AND SAFETY IN PARATROOPERS“

The aim of the research project was to assess the most crucial human factors in paratroopers and explore their impact on safety performance.

CONTACT: Prof. Mario Martinez-Corcoles, mario.martinez-corcoles@ttu.ee

SELECTED PUBLICATIONS:

Martínez-Córcoles, M.; Gracia, F.; Tomás, I.; Peiró, J. M. (2014). Strengthening safety compliance in nuclear power operations. A role-based approach. Risk Analysis 34(7), 1257–1269.

PROJECT „PSYHOSOCIAL FACTORS AT WORK“

The virtual workplaces were analysed, advantages and drawbacks of virtual workplaces were described.

CONTACT: Prof. Mare Teichmann, mare.teichmann@ttu.ee

PROJECT „PRODUCTIVITY AND LEARNING PERFMOMANCE ASPECTS RELATED TO INDOOR AND PSYCO-SOCIAL ENVIRONMENT IN OFFICES AND SCHOOLS“

Evidence based quantitative relations between productivity and learning performance, and indoor environmental and psycho-social parameters were reported. Indoor climate was measured in 12 school and office buildings and the guidance material was prepared.

CONTACT: Prof. Mare Teichmann, mare.teichmann@ttu.ee

ENGINEERING EDUCATION

The main goals are to develop new methodologies and prepare didactic teaching materials (exploratory learning, contextual learning, problem-based learning, blended learning, etc.).

The project „Conceptual framework for increasing society's commitment in ICT: approaches in general and higher education for motivating ICT-related career choices and improving competences for applying and developing ICT“ has been started in cooperation with University of Tartu, Tallinn University of Technology and the Estonian Information Technology College. As the representatives of enterprisers, Association of Information Technology and Telecommunications is roped in along with foreign scientific consulting partners. The general aim of the project is to assess the approach and implemented solutions for the development of essential competences in the field of ICT and for motivation of the career planning in the field.

IN 2014:

Additional sets of questionnaires for the survey and research of first year students were designed. Research in three stages of students at Tallinn University of Technology, University of Tartu and IT College was carried out.

CONTACT: Prof. Tiia Rüütmann, tiia.ruutmann@ttu.ee

SELECTED PUBLICATIONS:

Mironova, O.; Amitan, I.; Vendelin, J.; Saar, M.; Rüütmann, T. (2014). Strategies for the Individualization of an Informatics Course . In: Annals of Computer Science and Information Systems: Federated Conference on Computer Science and Information Systems, September 7–10, 2014. Warsaw, Poland. IEEE, 2014, 835–840.

Siiman, L. A.; Pedaste, M.; Tõnisson, E.; Sell, R.; Jaakkola, T.; Alimisis, D. (2014). A Review of Interventions to Recruit and Retain ICT Students. International Journal of Modern Education and Computer Science, 6(3), 45–54.

THE EDUCO DEVELOPMENT PROGRAMME FOR EDUCATION SCIENCES AND TEACHER TRAINING

Research is directed to: (1) Evaluation of the quality of teacher education; (2) Development and design of the pedagogical teaching practice; (3) Development of methodology for teaching STEM (Science, Technology, Engineering, Mathematics).

IN 2014:

Learner-centered guided in-service program for technical teacher continuing education was implemented. A model of a flexible teacher education program for general school teachers and university staff was implemented. An on-line self-evaluation model questionnaire for engineering educators has been piloted and workshops were carried out.

CONTACT: Prof. Tiia Rüütmann, tiia.ruutmann@ttu.ee

SELECTED PUBLICATIONS:

Sell, R.; Rüütmann, T.; Seiler, S. (2014). Inductive Teaching and Learning in Engineering Pedagogy on the Example of Remote Labs. International Journal of Engineering Pedagogy, 4(4), 12–15.

Rüütmann, T.; Kipper, H. (2014). Design, Implementation and Analysis of Learner-Centered Guided In-Service Programme for Technical Teacher Education. International Journal of Engineering Pedagogy, 2, 4–9.

Rüütmann, T. (2014). Optional STEM Courses for Secondary Schools Designed and Implemented for Enhancement of K-12 Technology Education in Order to Excite Students' Interest in Technology and Engineering Education. In: Proceedings of 2014 International Conference on Interactive Collaborative Learning (ICL): World Engineering Education Forum, Dubai UAE, December 3–6, 2014. Dubai, UAE, 2014, 144–150.

Rüütmann, T.; Kipper, H. (2014). Analysis of the Program for Continuing Education of Technical Teachers on the Basis of Graduates' Feedback Results. In: Proceedings of 2014 International Conference on Interactive Collaborative Learning (ICL): World Engineering Education Forum, Dubai UAE, December 3–6, 2014. Dubai UAE, 2014, 7–12.

AFFILIATED INSTITUTIONS

AFFILIATED INSTITUTIONS

INSTITUTE OF CYBERNETICS

Director: ANDRUS SALUPERE, Professor

Phone: +372 620 2560
e-mail: andrus.salupere@ttu.ee

DEPARTMENTS, RESEARCH CENTERS, RESEARCH LABORATORIES:

- Laboratory of Phonetics and Speech Technology
- Laboratory of Photoelasticity
- Laboratory of Control Systems
- Laboratory of Wave Engineering
- Laboratory of Nonlinear Dynamics
- Laboratory of Systems Biology
- Laboratory of Software Science

Total number of academic staff is 57. 5 doctoral dissertations were defended in 2014.

INSTITUTE OF CYBERNETICS

INSTITUTE OF CYBERNETICS,
Director: Professor Andrus Salupere, andrus.salupere@ttu.ee, +372 620 2560,

LABORATORY OF PHONETICS AND SPEECH TECHNOLOGY,
Senior Research Scientist Einar Meister, einar@ioc.ee, +372 620 4200

LABORATORY OF PHOTOELASTICITY,
Senior Research Scientist Johan Anton, johan@ioc.ee, +372 620 4182

LABORATORY OF CONTROL SYSTEMS,
Lead Research Scientist Ülle Kotta, kotta@ioc.ee, +372 620 4153

LABORATORY OF WAVE ENGINEERING,
Lead Research Scientist Tarmo Soomere, soomere@cs.ioc.ee, +372 620 4176

LABORATORY OF NONLINEAR DYNAMICS,
Senior Research Scientist, Jaan Kalda, kalda@ioc.ee, +372 620 4174

LABORATORY OF SYSTEMS BIOLOGY,
Senior Research Scientist, Marko Vendelin, markov@ioc.ee, +372 620 4169

LABORATORY OF SOFTWARE SCIENCE,
Lead Research Scientist, Tarmo Uustalu, tarmo.uustalu@ttu.ee, +372 620 4250

MAIN LINES OF RESEARCH

PHONETICS AND SPEECH TECHNOLOGY

Laboratory of Phonetics and Speech Technology is focused on experimental studies of Estonian phonetics and research and development of methods and prototypes for Estonian speech recognition.

MAIN RESULTS IN 2014

A neural network based phone duration model for speech recognition was developed. The model was trained to estimate a phone duration PDF based on its neighbouring phones and the already observed durations of the previous phones. Experimental results on Estonian, English and Finnish recognition tasks showed that the method results in a consistent drop in word error rate. An effective and simple multi-domain recurrent neural network language model which enables training a joint model over multiple domains was also proposed. The model was found to outperform all other compared models in Estonian radiology speech recognition experiments. Many improvements were developed in our publicly available Estonian speech recognition systems. For example, the word error rate of Estonian broadcast conversational speech dropped from 20.3% to 16.9%.

Morphosyntactic clustering has been found potentially beneficial for building NLP systems for languages for which annotated training data lack. The research group proposed a generative probabilistic model that induces those morphosyntactic clusters combining two information sources: distributional information taking into account the context of words and morphological information using the words' suffixes. The utility of this model on English was demonstrated.

The evaluation of the Estonian audiovisual text-to-speech synthesis using perception experiments with acoustic and audiovisual stimuli sets with different levels of background noise showed that visual articulatory gestures of the talking head enhance speech perception in noisy conditions.

The study on the production of Estonian quantity contrasts by foreign-language speakers with Latvian language background showed that Latvian subjects successfully produced the Estonian Q1/Q2 contrast, but failed to produce Q2/Q3 contrast.

CONTACT: Senior Research Scientist Einar Meister, einar@ioc.ee

SELECTED PUBLICATIONS:

Alumäe, T. (2014). Neural network phone duration model for speech recognition. In: Interspeech 2014: 15th Annual Conference of the International Speech Communication Association, September 14–18, Singapore, Proceedings: Singapore: International Speech Communication Association, 1204–1208.

Tilk, O.; Alumäe, T. (2014). Multi-domain recurrent neural network language model for medical speech recognition. Human Language Technologies – the Baltic Perspective: Proceedings of the Sixth International Baltic Conference, Baltic HLT 2014. (Eds.) Utka, Andrius; Grigonytė, Gintarė; Kapočiūtė-Dzikienė, Jurgita; Vaičenonienė, Jurgita. Amsterdam: IOS Press, (Frontiers in Artificial Intelligence and Applications; 268), 149–152.

Sirts, K.; Eisenstein, J.; Elsner, M.; Goldwater, S. (2014). POS induction with distributional and morphological information using a distance-dependent Chinese restaurant process. In: The 52nd Annual Meeting of the Association for Computational Linguistics. Proceedings of the Conference. Volume 2: Short Papers: ACL June 22–27, Baltimore, USA, June 22–27, 20: Stroudsburg, PA: Association for Computational Linguistics, 2014, 265–271.

Meister, E.; Metsvahi, R.; Fagel, S. (2014). Evaluation of the Estonian audiovisual speech synthesis. In: Human Language Technologies – the Baltic Perspective: Proceedings of the Sixth International Baltic Conference, Baltic HLT 2014: (Eds.) Utka, A.; Grigonytė, G.; Kapočiūtė-Dzikienė, J.; Vaičenonienė, J. Amsterdam: IOS Press, (Frontiers in Artificial Intelligence and Applications; 268), 11–18.

Meister, E.; Meister, L. (2014). Estonian quantity degrees produced by Latvian subjects. Linguistica Lettica, 22, 85–106.

NONLINEAR CONTROL SYSTEMS

Nonlinear Control Theory group has competence in dynamical control systems on time scales. The research is focused on novel algebraic methods and symbolic software tools for solving fundamental problems for nonlinear control systems towards unification of discrete- and continuous-time control.

MAIN RESULTS IN 2014

A problem, how nonlinear realization theory can contribute to the linear parameter-varying (LPV) realization theory having a clear orientation toward practical applications, was studied. The necessary and sufficient solvability conditions were obtained, and three additional subclasses of LPV input-output equations were suggested that are guaranteed to have a realization of the considered type.

The input-output linearization problem by dynamic output feedback was solved for multi-input multi-output nonlinear systems, described by the set of higher order difference equations.

Necessary and sufficient solvability conditions were obtained together with the constructive procedure to check the conditions and compute the feedback.

Computation-oriented necessary and sufficient accessibility (controllability) conditions were derived for nonlinear system, described by the set of higher order input-output differential equations.

The conditions were derived for the existence of a state transformation, bringing the state equations, defined on (homogeneous) time scales, into the observer form, which is linear up to some nonlinear input and output-dependent functions. Desing of the nonlinear state observer was relatively easy for such form.

CONTACT: Lead Research Scientist Ülle Kotta, kotta@ioc.ee

SELECTED PUBLICATIONS:

Belikov, J.; Kotta, Ü.; Tõnso, M. (2014). Adjoint polynomial formulas for nonlinear state-space realization. – IEEE Transactions on Automatic Control, 59, 1, 256–261.

Belikov, J.; Kotta, Ü.; Tõnso, M. (2014). Comparison of LPV and nonlinear system theory: A realization problem. – Systems & Control Letters, 64, 72–78.

Ciulkin, M.; Kaparin, V.; Kotta, Ü. (2014). Pawluszewicz, E. Linearization by input-output injections on homogeneous time scales. – Proceedings of the Estonian Academy of Sciences, 63, 4, 387–397.

Kaldmäe, A.; Kotta, Ü. (2014). Input-output linearization of discrete-time systems by dynamic output feedback. – European Journal of Control, 20, 2, 73–78.

Kotta, Ü.; Tõnso, M.; Kawano, Y. (2014). Polynomial accessibility condition for the multi-input multi-output nonlinear control system. – Proceedings of the Estonian Academy of Sciences, 63, 2, 136–150.

WAVE ENGINEERING

Wave Engineering group has competence in nonlinear wave theory and modelling of fluids with the focus on applications in the marine and coastal environments. The attention is concentrated to wave excitation and propagation over the sea surface; impact of waves in coastal regions; unified framework for wave-driven phenomena.

MAIN RESULTS IN 2014

The Carrier-Greenspan transform for wave run-up on a plane beach was generalised for inclined channels of arbitrary cross-section. It has been demonstrated that nonlinear effects are most strongly pronounced for the run-up of a solitary wave of depression.

A measure of finite-time compressibility of flow fields was developed that accounts for time correlations of realistic flows and is capable to quantify the ability of clustering of passive tracers on the sea surface.

The locations for spontaneous formation of surface patches have been established for the Gulf of Finland through the analysis of time correlations of the convergence field and the Lagrangian transport.

The wave energy resource theoretically and practically available in a semi-sheltered shelf sea of moderate depth and with highly intermittent wave climate has been quantified on the example of the Baltic Sea.

The options for using an ensemble of projections to evaluate return periods of extreme water levels were established for selected locations of the Estonian coast.

CONTACT: Lead Research Scientist Tarmo Soomere, soomere@cs.ioc.ee

SELECTED PUBLICATIONS:

Soomere, T.; Viška M. (2014). Simulated sediment transport along the eastern coast of the Baltic Sea. Journal of Marine Systems, 129, 96–105.

Rybkin, A.; Pelinovsky, E.; Didenkulova, I. (2014). Nonlinear wave run-up in bays of arbitrary cross-section: generalization of the Carrier–Greenspan approach. Journal of Fluid Mechanics, 748, 416–432.

Soomere, T.; Eelsalu, M. (2014). On the wave energy potential along the eastern Baltic Sea coast. Renewable Energy, 71, 221–233.

Didenkulova, I. I.; Pelinovsky, E. N.; Didenkulov, O. I. (2014). Run-up of long solitary waves of different polarities on a plane beach. Izvestiya RAS. Physics of the Atmosphere and Ocean, 50, 5, 532–538.

Giudici, A.; Soomere, T. (2014). Finite-time compressibility as an agent of frequent spontaneous patch formation in the surface layer: a case study for the Gulf of Finland, the Baltic Sea. Marine Pollution Bulletin, 89, 1–2, 239–249.

NONLINEAR DYNAMICS

Nonlinear Dynamics group deals with (i) nonlinear wave motion in solids; (ii) soft matter physics; (iii) photoelasticity; (iv) applied mathematics. Attention is on hierarchical behaviour of microstructured solids under dynamical impact; solitons and solitary waves; turbulent mixing; processes with power laws; nonlinear photoelastic tomography; inverse problems to determine properties of complex materials; fast methods for solving integral equations.

MAIN RESULTS IN 2014

For the first time in the theory of microstructured solids, the effects of microdeformation and microtemperature were described simultaneously within one mathematical model using double dual internal variables approach.

Based on Mindlin's model of microstructured solids, the concept of wave hierarchies in the Whitham's sense was generalized to hierarchies of second order wave operators and to nonlinear media.

A comparison of finite element method, isogeometric analysis, and finite volume method in numerical simulation of one-dimensional elastic wave propagation problems with stress discontinuities was performed.

Numerical simulation of crack propagation under conditions of 3-point bending test was performed in order to estimate the bridging effect of the reinforcement of Al_2O_3 by fibers covered by graphene layer.

The formation of solitons in a microstructured continuum and the sensitivity of this process to the initial conditions was modelled by a hierarchical Korteweg-de Vries equation.

Zabolotskaya-Khokhlov-type 2D evolution equation two-dimensional evolution equation derived for the description of wave beams in microstructured solids using the Mindlin-type model.

The mathematical model was derived to describe the nonlinear interaction of tone bursts in functionally graded materials with strongly variable properties; the obtained equations were solved numerically.

The scaling exponents describing the temporal behaviour of the size of the intersections of fractal sets which fluctuate in time were derived.

Finite-time Lyapunov exponents have been expressed for isotropic homogeneous chaotic two-dimensional flows with finite correlation time in terms of the velocity gradient tensor statistics.

Light propagation in inhomogeneous media with fluctuating coefficient of refraction has been interpreted as a chaotic mixing of the wavefront in the 6-dimensional phase space.

CONTACT: Senior Research Scientist Jaan Kalda, kalda@ioc.ee

SELECTED PUBLICATIONS:

Engelbrecht, J.; Salupere, A. (2014). Scaling and hierarchies of wave motion in solids. Zeitschrift für Angewandte Mathematik und Mechanik, 94(9), 775–783.

Salupere, A.; Lints, M.; Engelbrecht, J. (2014). On solitons in media modelled by the hierarchical KdV equation. Archive of Applied Mechanics, 84, 1583–1593.

Berezovski, A.; Engelbrecht, J.; Van, P. (2014). Weakly nonlocal thermoelasticity for microstructured solids: microdeformation and microtemperature. Archive of Applied Mechanics, 84(9–11), 1249–1261.

Ravasoo, A. (2014). Interaction of bursts in exponentially graded materials characterized by parametric plots. Wave Motion, 51(5), 758–767.

Kalda, J.; Soomere, T.; Giudici, A. (2014). On the finite-time compressibility of the surface currents in the Gulf of Finland, the Baltic Sea. Journal of Marine Systems, 129, 56–65.

SYSTEMS BIOLOGY

Systems Biology group is focused on unravelling the intricacies behind regulation of intracellular processes in cardiac muscle cells. Efforts are mostly concentrated on studying regulatory mechanisms of metabolic processes in the heart, expanding our knowledge of cardiac energetics and contractile function, and shedding light on novel aspects of excitation-contraction coupling in rat, trout and mouse hearts. Both experimental and computational approaches are applied in investigating these topics.

MAIN RESULTS IN 2014

We have demonstrated that in oxidative muscle, such as a heart, some ATPases are tightly coupled to glycolysis and do not use ATP provided by mitochondria. Namely, we have shown that plasmalemma Na+/K+-ATPase (NKA) is exclusively fueled by ATP provided through tightly coupled glycolytic enzymes with undetectable flux of ATP between mitochondria and NKA. Such tight coupling of NKA to PK is in line with its increased importance in the pathological states of the heart when the substrate preference shifts to glucose.

On the basis of our data, we suggest that at least part of the diffusion restriction at the mitochondrial outer membrane level is not by the membrane itself, but due to the close physical association between the sarcoplasmic reticulum and mitochondria.

CONTACT: Senior Research Scientist Marko Vendelin, markov@ioc.ee

SELECTED PUBLICATIONS:

Sepp, M.; Sokolova, N.; Jugai, S., Mandel, M.; Peterson, P.; Vendelin, M. (2014). Tight Coupling of Na+/K+-ATPase with Glycolysis Demonstrated in Permeabilized Rat Cardiomyocytes. PLoS ONE, 9(6), e99413, 1–12.

Birkedal, R.; Laasmaa, M.; Vendelin, M. (2014). The location of energetic compartments affects energetic communication in cardiomyocytes. Frontiers in Physiology, 5, Article 376, 1–9.

SOFTWARE SCIENCE

The Laboratory of Software Science conducts research into language and automata theory, programming languages and software engineering.

MAIN RESULTS IN 2014

Language and automata theory:

To clarify the connection of residual automata to atoms of regular languages, the maximized automaton of a language was defined and studied.

The transformation of context-free grammars to Chomsky normal form was certified in the Agda dependently typed programming language.

Programming languages:

A coherence theorem was proved for skew-monoidal categories and formalized in Agda.

Normalization by evaluation for typed lambda calculus was reconstructed using computation in the delay monad and formalized in Agda.

A novel structure for bidirectional transformations, update lenses, refining ordinary state-based lenses, was defined and studied in detail.

Different intensional aspects of stackful computation were shown to be analyzable using special monads more refined than the state monad.

An abstract categorical semantics was developed for functional reactive programming with resources.

Software engineering:

The linked data technology was shown to have the potential to serve as an integrator of technologies by providing tools for interlinking big data, internet of things data and social media data.

The Cocovila system was used for modelling and simulation of different types of hydraulic valves, scheduling of a floor manufacturing process, modelling of heating, ventilation and air conditioning systems.

CONTACT: Lead Research Scientist Tarmo Uustalu, tarmo.uustalu@ttu.ee

SELECTED PUBLICATIONS:

Ahman, D.; Chapman, J.; Uustalu, T. (2014) When is a container a comonad? Logical Methods in Computer Science, 10(3:14), 1–48.

Altenkirch, T.; Chapman, J.; Uustalu, T. (2014). Relative monads formalised. Journal of Formalized Reasoning, 7(1), 1–43.

Brzozowski, J.; Tamm, H. (2014). Theory of átomata. Theoretical Computer Science, 539, 13–27.

Firsov, D.; Uustalu, T. (2014) Certified CYK parsing of context-free languages. Journal of Logical and Algebraic Methods in Programming, 83(5-6), 459–468.

INSTITUTE OF GEOLOGY

Director: ATKO HEINSALU, Senior Research Scientist

Phone: +372 5912 3761
e-mail: atko.heinsalu@ttu.ee

DEPARTMENTS, RESEARCH CENTERS, RESEARCH LABORATORIES:

- Chair of Physical Geology
- Department of Isotope-paleoclimatology
- Department of Lithosphere Studies
- Department of Paleontology and Stratigraphy
- Department of Postglacial Geology
- Department of Collections

Institute of Geology is currently employing 2 professors.

Total number of academic staff is 39. 2 doctoral dissertations were defended in 2014.

INSTITUTE OF GEOLOGY

INSTITUTE OF GEOLOGY,
Director: Senior Research Scientist Atko Heinsalu, atko.heinsalu@ttu.ee, +372 5912 3761

CHAIR OF PHYSICAL GEOLOGY,
Professor Alvar Soesoo, alvar.soesoo@ttu.ee, +372 513 6994

DEPARTMENT OF ISOTOPE-PALEOCLIMATOLOGY,
Professor Emeritus Rein Vaikmäe, rein.vaikmae@ttu.ee, +372 5884 5991

DEPARTMENT OF LITHOSPHERE STUDIES,
Professor Alvar Soesoo, alvar.soesoo@ttu.ee, +372 513 6994

DEPARTMENT OF PALEONTOLOGY AND STRATIGRAPHY,
Professor Olle Hints, olle.hints@ttu.ee, +372 513 0157

DEPARTMENT OF POSTGLACIAL GEOLOGY,
Professor Siim Veski, siim.veski@ttu.ee, +372 5884 6968

DEPARTMENT OF COLLECTIONS,
Ursula Toom, ursula.toom@ttu.ee, +372 620 3009

MAIN LINES OF RESEARCH

DEPARTMENT OF ISOTOPE-PALEOCLIMATOLOGY

The main research applies isotopic and geochemical indicators of climate and environmental changes on three integrated directions: (1) groundwater flow history, global palaeoclimate signals and antropogenic influence in the Baltic Artesian Basin (BAB): a synthesis of numerical models and hydrogeochemical data; (2) study of new polar ice core records in order to link climate records from different polar areas; (3) estimation of capacity and safety of Baltic sedimentary basin for CO_2 geological storage.

MAIN RESULTS IN 2014:

(1) The first ^{81}Kr and ^{85}Kr measurements in groundwater from seven exploitation wells in the BAB confirmed that glaciations and deglaciations in the BAB area during last million years did not impact on groundwater flow strongly enough as to replace of deep saline Na-Ca-Cl basinal brines with fresh and isotopically depleted glacial meltwater over all the BAB area. On the basis of the variations in groundwater isotope and chemical composition in the Ordovician-Cambrian aquifer system in Estonia three types of groundwater were observed: groundwater originating from modern precipitation located in the northern and north-eastern part of the aquifer system; groundwater of glacial origin located in the north-western part of the aquifer system, and groundwater originating from brine waters located in the southern part of the aquifer system.

(2) Seasonal variability of bromine and iodine in polar snow and ice was investigated to evaluate their emission, transport and deposition in Antarctica and the Arctic and better understand potential links to sea ice. Stable isotope ratios and surface mass balance (SMB) data from eight shallow firn cores retrieved at Fimbul Ice Shelf, East Antarctica, have been investigated. Isotope ratios and SMB from the stacked record of all cores were also related to instrumental temperature data from Neumayer Station on Ekström Ice Shelf. Since the second half of the twentieth century the SMB shows a statistically significant negative trend, whereas the $\delta^{18}O$ of the cores shows a significant positive trend. Samples from two ice cores drilled at Lomonosovfonna, Svalbard, covering the period 1957–2009, and 1650–1995, respectively, were analysed for NO_3^- concentrations, and NO_3^- stable isotopes ($\delta^{15}N$ and $\delta^{18}O$). We suggest that the $\delta^{15}N$ recorded at Lomonosovfonna is influenced mainly by fossil fuel combustion, soil emissions, and forest fires; the first and second being responsible for the marked decrease in $\delta^{15}N$ observed in the post-1950s record with soil emissions being associated to the decreasing trend in $\delta^{15}N$ observed up to present time, and the third being responsible for the sharp increase of $\delta^{15}N$ around 2000.

(3) Petrophysical, geophysical and geological structure-scale modelling was finalised and collecting data for the basin-scale modelling of CO_2 storage in the Baltic Cambrian Basin. New classification of reservoir quality of rocks for CO_2 geological storage in terms of gas permeability and porosity

was proposed for Middle Cambrian sandstones of Deimena Formation in the Baltic Region and applied to interpret petrophysical changes of the reservoir rocks caused by CO_2 injection-like alteration experiment. Results of EU CCS Directive implementation showed that the main challenges include high investment costs and lack of public and consequently political support for onshore storage in Europe.

CONTACT: Prof. Emeritus Rein Vaikmäe, rein.vaikmae@ttu.ee

SELECTED PUBLICATIONS:

Raidla, V.; Kirsimäe, K.; Ivask, J.; Kaup, E.; Knöller, K.; Marandi, A.; Martma, T.; Vaikmäe, R. (2014). Sulphur isotope composition of dissolved sulphate in the Cambrian-Vendian aquifer system in the northern part of the Baltic Artesian Basin. Chemical Geology 383, 147–154.

Spolaor, A.; Vallelonga, P.; Gabrieli, J.; Martma, T.; Björkman, M. P.; Isaksson, E.; Cozzi, G.; Turetta, C.; Kjær, H. A.; Curran, M. A. J.; Moy, A. D.; Schönhardt, A.; Blechschmidt, A.-M.; Burrows, J. P.; Plane, J. M. C.; Barbante, C. (2014). Seasonality of halogen deposition in polar snow and ice. Atmospheric Chemistry and Physics 14, 9613–9622.

Schlosser, E.; Anschütz, H.; Divine, D.; Martma, T.; Sinisalo, A.; Altnau, S.; Isaksson, E. (2014). Recent climate tendencies on an East Antarctic ice shelf inferred from a shallow firn core network. Journal of Geophysical Research, Atmospheres 119, 6549–6562.

Shogenova, A.; Piessens, K.; Holloway, S.; Bentham, M.; Martínez, R.; Flornes, K. M.; Poulsen, N. E.; Wójcicki, A.; Sliaupa, S.; Kucharič, L.; Dudu, A.; Persoglia, S.; Hladik, V.; Saftic, B.; Kvassnes, A.; Shogenov, K.; Ivask, J.; Suárez, I.; Sava, C.; Chikkatur, A. (2014). Implementation of the EU CCS Directive in Europe: results and development in 2013. Energy Procedia 63, 6662–6670.

Wendl, I. A.; Eichler, A.; Isaksson, E.; Martma, T.; Schwikowski, M. (2014). 800 year ice-core record of nitrogen deposition in Svalbard linked to ocean productivity and biogenic emissions, Atmospheric Chemistry and Physics 14, 24667–24700.

DEPARTMENT OF LITHOSPHERE STUDIES

In 2014 the research was focused on correlation based on bentonites of Ordovician and Silurian, palaeovolcanism, palaeo-environmental studies, palaeotectonics, genesis of layered intrusions and metal-rich shales.

Main results: Geochemical similarity of Katian (Ordovician) bentonites of the eastern Baltic with bentonites in Scandinavia and Scotland was discovered and the same volcanic source for all was proposed. The use of high-resolution geochemical methods on Silurian bentonites allowed correlation from Lithuania to Estonia. In Precambrian sediments anomalous sulphur isotope compositions were discovered and interpreted as a result of impact generated dust in the palaeo-atmosphere. Study of Precambrian rocks of Karelia emphasize the importance of distinguishing primary versus secondary isotopic compositions in studies of carbonate rocks used for reconstruction of global environmental change. Grain size studies of the Upper Ordovician rocks of Latvia showed significant fluctuations and increase in size due to the glaciations and sea level fall already in Katian, before widely known Hirnantian glaciation. Our crustal evolution observations support the model that the crust develops a self-organized critical state during magma generation. In this state, magma batches accumulate in a non-continuous, step- wise manner to form ever-larger accumulations. There is no characteristic length or time scale in the partial melting process or its products. A joint comparative study of the central and southern parts of the Palaeo-Proterozoic Svecofennian orogen in the Baltic/Fennoscandian Shield and the platform area to the east and south of the Baltic Sea indicates that at least these parts of the orogen are built up of several NW-SE trending, 100–300 km wide tectonic megadomains separated from each other and complicated by major zones of mostly dextral shearing. The generation of these zones occurred successively between 1.86 and 1.75 Ga, concomitantly with continuing crustal accretion getting younger towards the southwest. Even considering the distorting presence of a number of microcontinents, this indicates the one-time existence and repeated episodic activity of a master subduction zone stepwise falling back to the present south-southwest. The multi-proxy study of Tremadocian black shales from the eastern Baltic Palaeobasin (Türisalu Fm.) reveals that primary muds of those complexes likely deposited mainly as the result of intermittent event deposition. Redox-sensitive element distribution, widely used as palaeo-redox proxy, shows significant cm-scale vertical variation in the Türisalu Fm. and could have been more strongly linked with micro-environmental changes at sediment water interface rather than with oscillations of redox potential of marine water.

CONTACT: Prof. Alvar Soesoo, alvar.soesoo@ttu.ee

SELECTED PUBLICATIONS:

Hints, R.; Hade, S.; Soesoo, A.; Voolma, M. (2014). Depositional framework of the East Baltic Tremadocian black shale revisited. GFF 136, 464–482.

Hints, R., Soesoo, A., Voolma, M., Tarros, S., Kallaste, T., Hade, S. 2014. Centimetre-scale variability of redox-sensitive elements in Tremadocian black shales from the eastern Baltic Palaeobasin. Estonian Journal of Earth Sciences 63, 233–239.

Kiipli, T.; Soesoo, A.; Kallaste, T. (2014). Geochemical evolution of Caledonian volcanism recorded in the sedimentary rocks of the eastern Baltic region. Geological Society, London, Special Publications 390, 177–192.

Lepland, A., Joosu, L., Kirsimäe, K., Prave, A. P., Romashkin, A. E., Črne, A. E., Martin, A. P., Fallick, A. E., Somelar, P., Üpraus, K., Mänd, K., Roberts, N. M. W., van Zuilen, M. A., Wirth, R., Schreiber, A. 2014. Potential influence of sulphur bacteria on Palaeoproterozoic phosphogenesis. Nature Geoscience 7, 20–24.

Van Zuilen, M. A.; Philippot, P.; Whitehouse, M. J.; Lepland, A. (2014). Sulfur isotope mass-independent fractionation in impact deposits of the 3.2 billion-year-old Mapepe Formation, Barberton Greenstone Belt, South Africa. Geochimica et Cosmochimica Acta 142, 429–441.

DEPARTMENT OF PALEONTOLOGY AND STRATIGRAPHY

In 2014 the research was focused on Early Paleozoic paleobiology and paleobiodiversity, paleoenvironments, paleoclimate and integrated bio- and chemostratigraphy.

HIGHLIGHTS IN 2014:

Discovery of copulatory organs of Devonian placoderm fish provided evidence on the primitive origin of internal fertilization of all crown jawed vertebrates. This study, published in Nature and largely based on fossils found in South Estonia, implies that external fertilization and spawning, characteristic of most extant aquatic gnathostomes, must be derived from internal fertilization, even though this transformation has been thought implausible. Other paleontological studies provided new ideas on the phylogeny of Silurian jawless vertebrates and Ordovician brachiopods, showed paleogeographical dispersal and environmental tolerance of polychaete worms, and helped to understand the evolution and diversity of chitinozoans, trilobites and coral faunas. In addition, several new enigmatic fossils were first described and discussed.

Reference successions in Estonia, Sweden and Ukraine thoroughly studied for biostratigraphy and isotope geochemistry allowed to increase the temporal resolution and created the basis for more reliable correlations and environmental interpretations for the Baltica paleocontinent. It was revealed that the global Ordovician-Silurian boundary most likely falls into the Juuru Regional Stage in Baltoscandia, hitherto considered as of Silurian age. New radiometric dates for an Ordovician bentonite and Ediacaran and Cambrian detrital zircons further contributed to the improvement of the geological time scale and helped to better understand the large-scale developments of Baltoscandian sedimentary basins. Specific attention was paid to the development of the reefs in Estonia and Sweden, where integrated sedimentological-paleontological approach allowed the evaluation of climatic and environmental conditions.

CONTACT: Prof. Olle Hints, olle.hints@ttu.ee

SELECTED PUBLICATIONS:

Hints, O.; Martma, T.; Männik, P.; Nõlvak, J.; Põldvere, A.; Shen, Y.; Viira, V. (2014). New data on Ordovician stable isotope record and conodont biostratigraphy from the Viki reference drill core, Saaremaa Island, western Estonia. GFF 136 (1), 100–104.

Kaljo, D.; Grytsenko, V.; Kallaste, T.; Kiipli, T.; Martma, T. (2014). Upper Silurian stratigraphy of Podolia revisited: carbon isotopes, bentonites and biostratigraphy. GFF 136 (1), 136–141.

Männik, P.; Põldvere, A.; Nestor, V.; Kallaste, T.; Kiipli, T.; Martma, T. (2014). The Llandovery–Wenlock boundary interval in the west-central continental Estonia: an example from the Suigu (S-3) core section. Estonian Journal of Earth Sciences 63 (1), 1–17.

Märss, T., Afanassieva, O., Blom, H. 2014. Biodiversity of the Silurian osteostracans of the East Baltic. Earth and Environmental Science Transactions of the Royal Society of Edinburgh 105, 73–148.

Pärnaste, H.; Bergström, J. (2014). Lower to middle Ordovician trilobite faunas along the Ural border of Baltica. Bulletin of Geosciences 89, 431–450.

DEPARTMENT OF POSTGLACIAL GEOLOGY

In 2014 the research was focused on postglacial paleoecology and paleoclimate in the Baltic area.

MAIN RESULTS IN 2014:

Present-day functional and phylogenetic plant diversity was shown to be dependent on the past landscape structure, the management history and the post-glacial migration history. Studies that combine knowledge from contemporary ecology and past vegetation development clearly show that there is plenty of untapped potential for closer cooperation between ecology and palaeoecology.

Sedimentation cyclicity in small lakes was attributed to climate variability and its influence on the lake hydrological regime and sediment influx was cleared. Sediment composition during the Little Ice Age and Medieval period differs clearly, which is an additional indicator studying landscape openness. Biostratigphy and shoreline changes during the Limnea Sea stage in the surroundings of Tallinn were elucidated and the isolation history of Lake Harku adjusted to the general shoreline displacement scheme.

Pollen data and historical evidence suggested that the forest structure changed from fairly open wooded meadow type grazed forests during early periods to closed boreal forest communities typical of the area today. Maximum landscape openness was reached in the 1700s and 1800s, when almost all of the available land was cultivated or used for cattle rearing. Reconstruction of the long-term development and lateral expansion of a south Swedish peat bog was performed using a multi-proxy approach, including dendrochronology, peat stratigraphy and macrofossil and pollen analyses to gain information on peatland responses to climate change at the end of the 'Holocene Thermal Maximum' (5000–4000 cal yr BP).

Pollen-based reconstructions of the spatio-temporal dynamics of northern European regional vegetation abundance through the Holocene demonstrated that RV-based estimates of diversity indices, timing of shifts, and rates of change in reconstructed vegetation provide new insights into the timing and magnitude of major human disturbance on Holocene regional vegetation, features that are critical in the assessment of human impact on vegetation, land-cover, biodiversity, and climate in the past. The regional vegetation cover in central and northern Europe, for five time windows in the Holocene [around 6 k, 3 k, 0.5 k, 0.2 k, and 0.05 k calendar years before present (bp)] at a 1°×1° spatial scale was quantitatively reconstructed. A set of statistical models that create spatially continuous maps of past land cover by combining pollen-based point estimates and spatially continuous estimates of past land cover, obtained by combining simulated potential vegetation with an anthropogenic land-cover change scenario was proposed and its performance tested against modern observations. The direct effects of anthropogenic deforestation on simulated climate at two contrasting periods in the Holocene, ~6 and ~0.2 k BP in Europe where estimated to be from −1°C in south-western Europe to +1°C in eastern Europe.

New pollen based reconstructions of summer (May-to-August) and winter (December-to-February) temperatures between 15 and 8 ka BP along a S–N transect in the Baltic–Belarus area displayed trends in temporal and spatial changes in climate variability complemented by chironomid-based July mean temperature reconstructions. The magnitude of change compared with modern temperatures was more prominent in the northern part of Baltic–Belarus area. The Younger Dryas cooling in the area was 5 C° colder than present, as inferred by all proxies. Analyses showed an early Holocene divergence in winter temperature trends with modern values reaching 1 ka earlier (10 ka BP) in southern Baltic–Belarus compared to the northern part of the region (9 ka BP). Latitudinal and longitudinal patterns of inferred temperature change were in excellent agreement with simulations by the ECHAM-4 model, implying that atmospheric general circulation models can successfully predict regionally diverging temperature trends in Europe, even in non-analogue situations.

CONTACT: Prof. Siim Veski, siim.veski@ttu.ee

SELECTED PUBLICATIONS:

Heiri, O.; Brooks, S. J.; Renssen, H.; Bedford, A.; Hazekamp, M.; Ilyashuk, B.; Jeffers, E. S.; Lang, B.; Kirilova, E.; Kuiper, S.; Millet, L.; Samartin, S.; Toth, M.; Verbruggen, F.; Watson, J. E.; van Asch, N.; Lammertsma, E.; Amon, L.; Birks, H. H.; Birks, H. J. B.; Mortensen, M. F.; Hoek, W. Z.; Magyari, E.; Sobrino, C. M.; Seppä, H.; Tinner, W.; Tonkov, S.; Veski, S.; Lotter, A. F. (2014). Validation of climate model-inferred regional temperature change for late-glacial Europe. Nature Communications 5, 4914.

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Feurdean, A.; Perşoiu, A.; Tanțău, I.; Stevens, T.; Magyari, E. K.; Onac, B. P.; Marković, S.; Andrič, M.; Connor, S.; Fărcaş, S.; Gałka, M.; Gaudeny, T.; Hoek, W.; Kolaczek, P.; Kuneš, P.; Lamentowicz, M.; Marinova, E.; Michczyńska, D. J.; Perşoiu, I.; Płóciennik, M.; Słowiński, M.; Stancikaite, M.; Sumegi, P.; Svensson, A.; Tămaş, T.; Timar, A.; Tonkov, S.; Toth, M.; Veski, S.; Willis, K. J.; Zernitskaya, V. (2014). Climate variability and associated vegetation response throughout Central and Eastern Europe (CEE) between 60 and 8 ka. Quaternary Science Reviews 106, 206–224.

Poska, A.; Saarse, L.; Koppel, K.; Nielsen, A. B.; Avel, E.; Vassiljev, J.; Väli, V. (2014). The Verijärv area, South Estonia over the last millennium: A high resolution quantitative land-cover reconstruction based on pollen and historical data. Review of Palaeobotany and Palynology 207, 5–17.

DEPARTMENT OF COLLECTIONS

The department has been leading the development of multi-institutional database software for geocollections and geoscience data. Used by three universities and two museums in Estonia, this system makes most of its content freely available online (at Estonian geocollections portal http://geocollections.info and associated resources. Ca 20 000 new specimens and samples were electronically catalogued and ca 5800 digital images added to the database in 2014. Notably the information system joined the international DataCite consortium and started issuing global digital object identifiers (DOIs) for geoscience data sets, making various research data resources better accessible as well as universally citable.

CONTACT: Ursula Toom, ursula.toom@ttu.ee

SELECTED PUBLICATIONS:

Vinn, O.; Toom, U. (2014). First record of the trace fossil Oikobesalon from the Ordovician (Darriwilian) of Baltica. Estonian Journal of Earth Sciences 63, 118–121. doi: 10.3176/earth. 11.

Vinn, O.; Wilson, M. A.; Mõtus, M.-A.; Toom, U. (2014). The earliest bryozoan parasite: Middle Ordovician (Darriwilian) of Osmussaar Island, Estonia. Palaeogeography, Palaeoclimatology, Palaeoecology 414, 129–132.

Vinn, O.; Wilson, M. A.; Toom, U. (2014). Earliest rhynchonelliform brachiopod parasite from the Late Ordovician of northern Estonia (Baltica). Palaeogeography, Palaeoclimatology, Palaeoecology 411, 42–45.

Vinn, O.; Wilson, M. A.; Zatoń, M.; Toom, U. (2014). The trace fossil Arachnostega in the Ordovician of Estonia (Baltica). Palaeontologia Electronica 17.3.40A, 1–9.

MARINE SYSTEMS INSTITUTE

Director: JÜRI ELKEN, Professor

Phone: +372 620 4302
e-mail: juri.elken@msi.ttu.ee

DEPARTMENTS, RESEARCH CENTERS, RESEARCH LABORATORIES:

- Department of Marine Physics
- Department of Modeling and Remote Sensing
- Laboratory of Marine Ecology
- Chair of Oceanography

Marine Systems Institute is currently employing 4 professors. Total number of academic staff is 37.

MARINE SYSTEMS INSTITUTE

MARINE SYSTEMS INSTITUTE,
Director: Professor Jüri Elken, juri.elken@msi.ttu.ee, +372 620 4302

DEPARTMENT OF MARINE PHYSICS,
Professor Urmas Lips, urmas.lips@msi.ttu.ee, +372 620 4304

DEPARTMENT OF MODELING AND REMOTE SENSING,
Professor Urmas Raudsepp, urmas.raudsepp@msi.ttu.ee, +372 620 4303

LABORATORY OF MARINE ECOLOGY,
Senior Research Scientist Inga Lips, inga.lips@msi.ttu.ee, +372 620 4306

CHAIR OF OCEANOGRAPHY,
Professor Sirje Keevallik, sirje.keevallik@msi.ttu.ee, +372 620 4305

MAIN LINES OF RESEARCH

The main areas where MSI is conducting research are:

- Systematic investigation and modelling of physical and biogeochemical processes in the sea and other water-bodies in the context of the atmospheric and land processes and anthropogenic influences
- Investigation of the functioning and stability of aquatic ecosystems, modelling and prediction of the changes in their states with the aim of the applications in the marine environment protection and management
- Quantitative estimation and modelling of the interactive processes between coastal sea, land and human activities, including applications in the areas of coastal engineering and management
- Development of the operational methods of the analysis and forecasting of the state of the sea and other water bodies together with the applications in the management of marine resources, environmental impact assessment, navigation safety and national defence

MAIN RESULTS IN 2014:

- Circulation in the Gulf of Riga (GoR) in the Baltic Sea was studied based on the results of a 10-year simulation (1997–2006) using the General Estuarine Transport Model and Princeton Ocean Model. Initial conditions and atmospheric forcing were taken from HIROMB and HIRLAM output for the ice-free period of May 1 – December 31, 2012. From the ten-year study time series analysis of PCA and vorticity, calculated from velocity data and model sensitivity tests showed that in spring the anticyclonic circulation in the upper layer of the southern GoR is driven primarily by the estuarine type density field. This anticyclonic circulation is enhanced by easterly winds but blocked or even reversed by westerly winds. The estuarine type density field is maintained by salt flux in the northwestern connection to the Baltic Proper and river discharge in the southern GoR. During the year 2012 mean summertime surface circulation displays a whole-basin anticyclonic gyre with more intense currents in the western half of the gyre. Two seasonal currents are identified: the Northern Longshore Current in the western part of GoR and the Southern Subsurface Longshore Current in the eastern part of GoR. During the cold season of the year (when seasonal pycnocline is absent), the anticyclonic gyre in GoR is replaced by a cyclonic gyre.
- A series of projects were conducted with the main aim to determine the mixing zone of hazardous substances related to wastewater outfalls into the coastal waters. Monitoring of hazardous substances in the wastewater and surface waters near the outfalls was carried out. The mixing zone depends on the concentration of hazardous substances in the wastewater as well as the outfall configuration and hydrographic conditions in the receiving surface waters. Two models have been applied to define the largest extent of spreading of hazardous substances exceeding the defined limit values (or detection limits for priority hazardous substances): CORMIX and 3D ocean circulation model POM. CORMIX was used to get the estimates of wastewater mixing in the immediate vicinity of the outfalls. By applying the 3D circulation model, the spreading

of wastewater in different hydrographic conditions, e.g. in case of stratified or mixed water column and varying local wind forcing, was simulated. Until now the mixing zones for Kohtla-Järve, Tallinn and Pärnu wastewater treatment plants and a number of hazardous substances were defined.

CONTACT: Prof. Jüri Elken, juri.elken@msi.ttu.ee

SELECTED PUBLICATIONS:

Lips, U.; Lips, I. (2014). Bimodal distribution patterns of motile phytoplankton in relation to physical processes and stratification (Gulf of Finland, Baltic Sea). Deep-Sea Research Part II: Topical Studies in Oceanography, 101, 107–119.

Soosaar, E.; Maljutenko, I.; Raudsepp, U.; Elken, J. (2014). An investigation of anticyclonic circulation in the southern Gulf of Riga during the spring period. Continental Shelf Research, Volume 78, 75–84.

Laas, P.; Simm, J.; Lips, I.; Metsis, M. (2014). Spatial variability of winter bacterioplankton community composition in the Gulf of Finland (the Baltic Sea). Journal of Marine Systems, 129, 127–134.

TECHNOMEDICUM

Director: KALJU MEIGAS, Professor

Phone: +372 620 2204
e-mail: kalju@cb.ttu.ee

DEPARTMENTS, RESEARCH CENTERS, RESEARCH LABORATORIES:

- Department of Biomedical Engineering
  - Chair of Biomedical Engineering
  - Chair of Medical Physics
- Department of Cardiovascular Medicine
  - Chair of Cardiovascular Medicine
- Department of Clinical Medicine
  - Chair of Clinical Medicine
  - Chair of Health Care Technology
- eMedicine Laboratory
- NMR group

Technomedicum is currently employing 8 professors.

Total number of academic staff is 36. 2 doctoral dissertations were defended in 2014.

DEPARTMENT OF BIOMEDICAL ENGINEERING

CHAIR OF BIOMEDICAL ENGINEERING,
Director: Professor Kalju Meigas, kalju@cb.ttu.ee, +372 620 2204

CHAIR OF MEDICAL PHYSICS,
Professor Ivo Fridolin, ivo@cb.ttu.ee, +372 620 2206

DEPARTMENT OF CARDIOVASCULAR MEDICINE

CHAIR OF CARDIOVASCULAR MEDICINE,
Professor Margus Viigimaa, margus@cb.ttu.ee, +372 620 2207

DEPARTMENT OF CLINICAL MEDICINE

CHAIR OF CLINICAL MEDICINE,
Professor Ruth Sepper, ruth.sepper@ttu.ee, +372 5341 3125

CHAIR OF HEALTH CARE TECHNOLOGY,
Professor Peeter Ross, peeter.ross@ttu.ee, +372 5635 3460

E-MEDICINE LABORATORY,
Professor Peeter Ross, peeter.ross@ttu.ee, +372 5635 3460

NMR GROUP,
Lead Research Scientist Ago Samoson, ago.samoson@ttu.ee, +372 620 2216

MAIN LINES OF RESEARCH

BIOFLUID OPTICS GROUP

The aim of the BFO team is to develop an optical technology for monitoring of uremic toxins related to malnutrition-inflammation complex syndrome on the End Stage Renal Disease patients and to cardiovascular disease risk in general. The outcome of the research will help doctors to improve the life quality of the patients, and decrease hospitalisations and interventions. In 2014 the research was focused on two directions: On-line monitoring of uremic toxins, and Analysis of uremic toxins – cardiovascular disease markers.

- A study was undertaken to examine the possibility of post-dialysis urea rebound assessment utilizing UV-absorbance measurements in spent dialysate. 26 patients on chronic three-times-a-week hemodialysis (HD) were studied in two separate studies. Double-beam spectrophotometer was used for the determination of UV-absorbance in the collected spent dialysate samples. Also, on-line UV-absorbance was monitored. The equilibrium concentration (Ceq) of urea at the end of the rebound phase was calculated based on urea concentration in blood, in dialysate and UV-absorbance in spent dialysate. Based on Ceq, urea rebound was expressed relative to urea concentration at the end of HD (R1) and relative to the fall in urea concentration during HD (R2). Estimates based on UV-absorbance values in spent dialysate (R1_a, R2_a) slightly over assess post-dialysis rebound compared to results based on the blood sample drawn 30 min after HD (R1_30post, R2_30post), but R1_a and R2_a presented greater consistency and accuracy compared to the estimates based on the intradialytic blood sample (R1_b, R2_b). In summary, the results showed that it is possible to assess post-dialysis urea rebound in blood based on UV-absorbance measurements in spent dialysate.
- Survival rate of dialysis patients is still alarmingly low and various factors may have in it an important role. Research was carried out to observe the relationship between the survival of dialysis patients and the serum level of urea, creatinine, and uric acid (UA). The idea of combining the concentrations and removal of urea and UA into a single model for predicting the patients outcome was introduced. The study included 33 hemodialysis patients from Sweden and 10 from Estonia. Kaplan-Meier analysis was used for survival analysis. Logistic and Cox regression analysis was applied to create models for predicting patients three-year survival. It was observed that higher serum UA is significantly related to poor survival in dialysis patients ($p = 0.026$). A reverse effect was observed in case of urea ($p = 0.095$). The level of creatinine was not related to survival ($p = 0.905$). The best logistic regression model for predicting patients outcome included both UA and urea based parameters (Chi Square 21.0, $p = 0.0001$). Survival of dialysis patients seems to be determined by a set of causal factors and combined models may have a predictive relevance. A possibility for automatic

online monitoring of small molecule uremic markers was proposed. Larger studies including more patients and testing the models in independent validation cohort is the future goal.

- A study was carried out to determine if fluorescence chromatography can be used to measure modified beta-2-microgobulin (B2M) from the spent dialysate. Amyloid B2M is the main pathogenic component of dialysis-related amyloidosis. This component is in our sphere of interest being one of the fluorescent advanced glycation end products (AGE). AGEs are potential uremic toxins that can cause amyloidosis and cardiovascular problems in chronic kidney failure patients. Two haemodialysis patients with high levels of B2M were selected for this study. Their spent dialysate samples were collected 10 minutes after the start of the dialysis process and less hydrophilic compounds were concentrated using solid phase extraction column. Sediment from the concentrate and spent dialysate were analysed. Brown coloured fluorescent sediment of the concentrate was identified as amyloid B2M. AGE modified B2M was also found from spent dialysate. However the fluorescence intensity was very low compared to overall fluorescence of spent dialysate. In summary, the study revealed that the fluorescence of AGE modified B2M is possible to detect in spent dialysate. However, the measuring system needs high selectivity and sensitivity for detection due to low contribution of AGE modified B2M to overall fluorescence.
- A study assessed the connection of urea rebound and the difference between spKt/V and eKt/V and also the possibility of utilizing UV-absorbance measurements to assess urea rebound. Ten patients of chronic three-times-a-week hemodialysis (HD) were studied. On-line UV-absorbance of spent dialysate was monitored. Single-pool Kt/V (spKt/V), equilibrated Kt/V (eKt/V) and the percentage difference between spKt/V and eKt/V (deltaKt/V) were calculated. Urea rebound was calculated based on urea concentration in blood (Rb) and UV-absorbance in spent dialysate (Ra). deltaKt/V and Rb were not statistically different. Also, Ra and Rb were not statistically different. In summary, the results show that it is possible to assess post-dialysis urea rebound in blood based on UV-absorbance in spent dialysate, which may offer the opportunity to estimate the true dialysis dose and a more personalized approach to the dialysis treatment.
- A study investigated the possibility of assessing lean body mass (LBM) based on UV-absorbance measurements in spent dialysate. Nine patients on chronic three-times-a-week haemodialysis were studied. A double-beam spectrophotometer was used for the determination of UV-absorbance in the collected spent dialysate samples. LBM was calculated based on creatinine concentration in blood (LBMblood), creatinine concentration in spent dialysate and UV-absorbance in spent dialysate (LBMa). Although LBMa was slightly lower compared to LBMblood, the estimates based on UV-absorbance in spent dialysate were not statistically different from LBMblood. In summary, the results show that it is possible to asses LBM based on UV-absorbance in spent dialysate.

CONTACT: Prof. Ivo Fridolin, ivo@cb.ttu.ee

SELECTED PUBLICATIONS:

Tomson, R.; Uhlin, F.; Fridolin, I. (2014) Urea rebound assessment based on UV-absorbance in spent dialysate. ASAIO Journal. 60(4):459–465, July/August.

Holmar, J.; Fridolin, I.; Uhlin, F.; Fernström, A.; Luman, M. (2014). Estimation of dialysis patients' survival through combined approach of small molecule uremic markers. Proceedings of the Estonian Academy of Sciences, 63, 227–233.

Kalle, S.; Kressa, H.; Tanner, R.; Holmar, J.; Fridolin, I. (2014). Fluorescence of Beta-2-microglobulin in the Spent Dialysate. In: 16th Nordic-Baltic Conference on Biomedical Engineering: Nordic-Baltic Conference on Biomedical Engineering and Medical Physics & 10th Medicinteknikdagarna, Göteborg, Sweden, October 14–16, 2014. Springer-Verlag, 2014, (IFMBE Proceedings; 48), 59–62.

Tomson, R.; Uhlin, F.; Fridolin, I. (2014). Optical Urea Rebound Estimation During Dialysis. In: IFMBE Proceedings: 16th Nordic-Baltic Confrence on Biomedical Engineering, October 14–16, 2014, Göteborg, Sweden. Springer, 109–112.

Tomson, R.; Fridolin, I. (2014) „Lean Body Mass Assessment Based on UV-absorbance in Spent Dialysate." The 14th Biennial Baltic Electronics Conference, October 6–8, Tallinn, Estonia.

BRAIN RESEARCH GROUP

The research activity is continuously aimed to development of algorithms for detection of characteristic changes in the brain electroencephalographyc (EEG) signal related to the mental disorders and the effect of external physical stressor.

In 2014 for this purpose:

- the new recordings of EEG signals from healthy persons selected from medical centre Qvalitas and patients with mental disorders selected by family doctors were performed;
- sensitivity of various EEG analysis methods as spectral asymmetry index (SASI), Lempel Ziv Complexity, Detrended Fluctuation Analysis and Higuchi's fractal dimension for detection of depression was analyzed;
- SASI was applied for analysis of the effect of microwave radiation as a physical stressor on the human brain;
- optimal EEG frequency bands were selected for detection of depression;
- the mechanism of the effect of microwave radiation as a physical stressor on the brain was explained using the model of hydrogen bonding and diffusion.

In conclusion: SASI as an original spectral asymmetry method for EEG analysis, protected by TUT US patent from 2012, was shown to have 1) a sensitivity for detection of characteristic features in depression comparable and even better compared to various much more complicated nonlinear EEG analysis methods in a single-channel EEG and 2) ability to detect the effect of physical stressor on human EEG.

CONTACT: Prof. Emeritus Hiie Hinrikus, hiie@cb.ttu.ee

SELECTED PUBLICATIONS:

Hinrikus, H.; Lass, J.; Karai, D.; Pilt, K.; Bachmann, M. (2014). Microwave effect on diffusion: a possible mechanism for non-thermal effect. Electromagnetic Biology and Medicine, Posted online on May 23.

Bachmann, M.; Lass, J.; Suhhova, A.; Hinrikus, H. (2014). Spectral asymmetry index and Higuchi's fractal dimension for detecting microwave radiation effect on electroencephalographic signal. Proceedings of the Estonian Academy of Sciences, 63, 3, 234–239.

Bachmann, M.; Kalev, K.; Suhhova, A.; Lass, J.; Hinrikus, H. (2014). Lempel Ziv Complexity of EEG in Depression. In: IFMBE Proceedings vol. 45, 58–61. 6th European Conference of the International Federation for Medical and Biological Engineering, Dubrovnik, 7–11.09.

Bachmann, M.; Suhhova, A.; Lass, J.; Aadamsoo, K.; Võhma, Ü.; Hinrikus, H. (2014) Detrended Fluctuation Analysis of EEG in Depression. IFMBE Proceedings, vol. 41, 694–697: XIII Mediterranean Conference on Medical and Biological Engineering and Computing, September 25–28, Sevilla, Spain.

Kalev, K.; Bachmann, M. (2014). Selection of EEG Frequency Bands for Detection of Depression. IFMBE Proceedings, Vol. 48, 55–58, 16. NBC & 10. MTD 2014 joint conferences. October 14–16, Gothenburg, Sweden.

CARDIOVASCULAR MEDICINE RESEARCH GROUP

Main research target is to develop new inexpensive non-invasive methods for diagnostics of atherosclerosis at a very early stage.

In 2014 the research was focused on direct assessment of arterial wall impairment (arterial thickness, arterial wall properties), studies of free radical peroxidation of low-density lipoproteins and vascular wall injure in atherosclerosis and assessment of novel antiatherosclerotic drugs. The possibilities to use photoplethysmographic (PPG) signal waveform analysis for the arterial stiffness and ageing estimation were investigated. The PPG waveform index PPGAI was proposed for the estimation of increased arterial stiffness. In addition the arterial stiffness caused changes in PPG waveform rising front were investigated and the algorithm was developed. The PPG waveform index PPGAI and slope of the rising front were compared with the results of aortic augmentation index measured with SphygmoCor. For this purposes the number of physiological signals and reference parameters (pulse waves from different locations of the body, peripheral pressure pulse wave, electrocardiographic signal, phonocardiography waves, augmentation indices and pulse wave velocity in aorta) were measured from volunteers and atherosclerotic patients (diabetes mellitus). The novelty is in the concept for the development of the new optical method and its evaluation. New signal processing methods were developed.

A strong correlation ($r = 0.85$) between the PPGAI and the aortic augmentation index and a positive correlation of both indices with subject's age were found. Age corrections for the indices PPGAI and augmentation index as regression models from the signals of healthy subjects were constructed. Both indices revealed a significant difference between the groups of diabetes patients and healthy controls. However, the PPGAI provided the best statistical discrimination for the group of subjects with increased arterial stiffness.

Negative correlation relationships ($r = -0.68$ and $r = -0.77$) were found between the age and the slopes of the PPG signal. Significant differences were found between the healthy controls and diabetes pa-

tients. The highest difference between the two groups was found using the advanced signal processing algorithm for the slope calculation. The sensitivity, specificity, and accuracy of the method were 85%, 88%, and 86%, respectively.

In conclusion: the PPG technology with the advanced signal processing algorithms can be used for the discrimination of subjects with increased arterial ageing and can be considered as a perspective measure of increased arterial stiffness estimation in clinical screenings.

CONTACT: Prof. Margus Viigimaa, margus@cb.ttu.ee;
Prof. Kalju Meigas, kalju@cb.ttu.ee

SELECTED PUBLICATIONS:

Pilt, K.; Meigas, K.; Kööts, K.; Viigimaa, M. (2014) Photoplethysmographic signal rising front analysis for the discrimination of subjects with increased arterial ageing. Proceedings of the Estonian Academy of Sciences 63(3), 221–226.

Pilt, K.; Meigas, K.; Ferenets, R.; Temitski, K.; Viigimaa, M. (2014). Photoplethysmographic signal waveform index for detection of increased arterial stiffness. Physiological Measurement 2014; 35, 2027–2036.

White, H. D.; Held, C.; Stewart, R.; Tarka, E.; Viigimaa, M. (2014) et al. Darapladib for Preventing Ischemic Events in Stable Coronary Heart Disease. New England Journal of Medicine; 370, 1702–1711.

Jensen-Urstad, M.; Viigimaa, M.; Sammul, S. (2014) et al. Impact of smoking: All-cause and cardiovascular mortality in cohort of 55-year-old Swedes and Estonians. Scandinavian Journal of Public Health; 42(8):780–785.

Lankin, V.; Konovalova, G.; Tikhaze, A.; Shumaev, K.; Kumskova, E.; Viigimaa, M. (2014) The initiation of free radical peroxidation of low-density lipoproteins by glucose and its metabolite methylglyoxal: a common molecular mechanism of vascular wall injure in atherosclerosis and diabetes. Molecular and Cellular Biochemistry; 395, 241–252.

SLEEP MEDICINE RESEARCH GROUP

The research is focused on evaluation of new generation event recorders and telemetric data transmission, including ambulatory sleep apnea monitors. Evaluation of novel heart rate and cuff-less blood circulation Holter devices (European Space Agency project: Development of the Heart Rate and Cuff-less Blood Circulation Holter Device for Non-invasive, Simultaneous and Continuous Monitoring of Cardiovascular Parameters on the Earth and in Space, stage 3).

Main results in 2014: Evaluation of the dependance of various physiological parameters (ventricular repolarization reflecting parametres, pulss arrivial time, etc.) on different sleep stages and on the severity of sleep apnea.

CONTACT: Senior Research Scientist Jüri Kaik, jyri@cb.ttu.ee

SELECTED PUBLICATIONS:

Kaik, J.; Pindmaa, M.; Viigimäe, M.; Karai, D.; Pilt, K. (2014). Comparison of Different QT-interval Variability Assessment Models in Patients with Various Degree of Sleep Apnea. In:12th International Dead Sea Symposium (IDSS) on Innovations in Cardiac Arrhythmias and Devices Therapy. March 3–5, 2014, Tel-Aviv. 98. (1):24–27.

CLINICAL MEDICINE RESEARCH GROUP

The research is focused on investigations on causes and development and early diagnostics of asthma and chronic obstructive lung disease.

Main results in 2014: It was demonstrated that lung function deviation and lung structural changes are present in chronic smokers before the clinical signs of airway obstruction reveal and these changes are associated with early onset of chronic obstructive pulmonary disease (COPD). Further investigations will be performed to find early COPD biomarkers by use of data mining and bio-informatic approach.

CONTACT: Prof. Ruth Sepper, ruth.sepper@ttu.ee

RESEARCH GROUP OF E-HEALTH APPLICATIONS AND SERVICES

Scientific work is focused on the effect of the use of e-health services on diagnostic and treatment processes in public health and healthcare. The research topics include investigation of the actors and

processes influencing the implementation of shared workflow, the use of digital medical databases in development of early diagnostic algorithms and decision support systems, and research of a medical text as a sublanguage of medicine.

Research area also includes health and medical data exploitation in developing new e-health services for citizen and healthcare professionals, data sharing among healthcare and with the citizen, process reengineering in healthcare, telemedicine services for the patients and personal health record services and patient motivation.

CONTACT: Prof. Peeter Ross, peeter.ross@ttu.ee

SELECTED PUBLICATIONS:

Valdre, E.; Ross, P.; Tsepelina, K.; Veskis, K.; Vaino, T.; Kaalep, H.-J. (2014). Corpus-based analysis of abbreviations and abbreviating in Estonian radiology reports. Eesti Arst, 93(9), 502–512.

Parv, L.; Kruus, P.; Mõtte, K.; Ross, P. (2014). An evaluation of e-prescribing at a national level. Informatics for Health and Social Care, Early Online: 1–18, 2014. Informa UK Ltd. ISSN: 1753-8157 print / 1753-8165 online DOI: 10.3109/17538157.2014.948170.

Ristolainen, A.; Ross, P.; Gavšin, J.; Semjonov, E.; Kruusmaa, M. (2014) Economically affordable anatomical kidney phantom with calyxes for puncture and drainage training in interventional urology and radiology Acta Radiologica Short Reports. Volume: 3(5), 2047981614534231.

Ranschaert, E.; Bosmans, J.; Ross, P.; Dugar, N.; Schillebeeckx, J.; Mildenberger, P.; Ratib O. (2014) ESR white paper on teleradiology: an update from the teleradiology subgroup. Insights into Imaging 01/2014; DOI:10.1007/s13244-013-0307-z.

NMR GROUP

The structure of Li-ion battery materials an ion conductivity was investigated. Heavy NMR line-broadenings due to presence of the unpaired electron shells are characteristic to these materials. Interaction of the magnetic moment and the external field makes sample spinning even more complicated. We were able to get reasonable spectra due to small sample amounts and low fields. To best of our knowledge, it is the first time that a direct comparison of ESR and NMR spectra was made on the identical structures.

Several EMI seals for a reliable contact between probe scaffold and external shield for spectroscopy of biological samples at high magnetic fields were tested.

The first time a prototype for *in situ* MAS-NMR measurements was developed.

Cutting edge results on nano-materials for a new kind of hydrogen storage and improved ion conductor for fluoride ion batteries were published.

CONTACT: Lead Research Scientist Ago Samoson, ago.samoson@ttu.ee

SELECTED PUBLICATIONS:

Strobridge, F. C.; Middlemiss, D. S.; Pell, A. J.; Leskes, M.; Clément, R. J.; Pourpoint, F.; Lu, Z.; Hanna, J. V.; Pintacuda, G.; Emsley, L.; Samoson, A.; Grey, C. P. (2014). Characterising local environments in high energy density Li-ion battery cathodes: a combined NMR and first principles study of LiFexCo1−xPO4. Journal of Materials Chemistry A, 2, 11948–11957.

Stoyanova, R.; Ivanova, S.; Zhecheva, E.; Samoson, A.; Simova, S.; Tzvetkovac, P.; Barrad, A-L. (2014). Correlations between lithium local structure and electrochemistry of layered LiCo1 2xNixMnxO_2 oxides: 7Li MAS NMR and EPR studies. Physical Chemistry Chemical Physics, 16, 2499–2507.

Lamley, J. M.; Iuga, D.; Öster, C.; Sass, H.-J.; Rogowski, M.; Oss, A.; Past, J.; Reinhold, A.; Grzesiek, S.; Samoson, A.; Lewandowski, J. R. (2014). Solid-State NMR of a Protein in a Precipitated Complex with a Full-Length Antibody. Journal of the American Chemical Society.

Agarval, V.; Penzel, S.; Szekely, K.; Cadalbert, R.; Testori, E.; Oss, A.; Past, J.; Samoson, A.; Ernst, M.; Böckmann, A.; Meier, B.H. (2014). De Novo 3D Structure Determination from Sub-milligram Protein Samples by Solid-State 100 kHz MAS NMR Spectroscopy. Angewandte Chemie International Edition, 53(45), 12253–12256.

Hu, J.; Witter, R.; Shao, H.; Felderhoff, M.; Fichtner, M. (2014). Beneficial effects of stoichiometry and nanostructure for a LiBH4–MgH2 hydrogen storage system. Journal of Materials Chemistry A, 2, 66–72.

Rongeat, C.; Reddy, M. Anji; Witter, R.; Fichtner, M. (2014). Solid Electrolytes for Fluoride Ion Batteries: Ionic Conductivity in Polycrystalline Tysonite-Type Fluorides. ACS Applied Materials and Interfaces, 6(3), 2103–2110.

ESTONIAN MARITIME ACADEMY

Director: ROOMET LEIGER

Phone: +372 613 5500
e-mail: roomet.leiger@ttu.ee

DEPARTMENTS, RESEARCH CENTERS, RESEARCH LABORATORIES:

- Shipping Centre
- Centre for Maritime Studies
- Centre for General and Basic Studies
- Research and Development Centre
- Maritime Training Centre
- Simulator Centre

Estonian Maritime Academy is currently employing 2 professors, 8 associate professors.
Total number of academic staff is 58.

ESTONIAN MARITIME ACADEMY

ESTONIAN MARITIME ACADEMY,
Director: Roomet Leiger, roomet.leiger@ttu.ee, +372 613 5500

SHIPPING CENTRE,
Head Ülve Luige, +372 613 5562

CENTRE FOR MARITIME STUDIES,
Associate Professor Andres Tolli, andres.tolli@ttu.ee, +372 613 5554

CENTRE FOR GENERAL AND BASIC STUDIES,
Lecturer Anna Saksa, anna.saksa@ttu.ee, +372 613 5514

RESEARCH AND DEVELOPMENT CENTRE,
Director for Development Anatoli Alop, anatoli.alop@ttu.ee, +372 613 5524

MARITIME TRAINING CENTRE,
Lecturer Toomas Tammeorg, toomas.tammeorg@ttu.ee, +372 613 5588

SIMULATOR CENTRE,
Head Olev Tõnismaa, olev.tonismaa@ttu.ee, +372 613 5562

MAIN LINES OF RESEARH

A TECHNOLOGICAL AND ECONOMIC FEASIBILITY STUDY ON USING LIQUEFIED NATURAL GAS AS AN ALTERNATIVE SHIP FUEL

The aim of the study is to examine the technical aspects of the use of LNG as ship fuel and to compile an economic cost-benefit analyse based on the most common ship types visiting Estonian ports. In 2014, a survey was conducted to find out the possibility of using LNG as ship fuel.

CONTACT: Madli Kopti, madli.kopti@ttu.ee

THE NEED FOR LABOUR FORCE WITH HIGHER AND VOCATIONAL EDUCATION IN THE ESTONIAN MARITIME SECTOR IN THE YEARS 2015–2025

The study on the need for labour force in the Estonian maritime sector is an initial study for developing the Estonian maritime educational concept, which is one of the measures in order to achieve the objectives set in the national maritime development plan.

CONTACT: Madli Kopti, madli.kopti@ttu.ee

The members of Centre for Maritime Studies have been currently involved in marine research carried out by other TUT research groups (e.g. Institute of Cybernetics at TUT, Faculty of Civil Engineering at TUT, Faculty of Chemical and Materials Technology at TUT).

KURESSAARE COLLEGE

Director: ANNE KEERBERG

Phone: +372 452 4033
e-mail: anne.keerberg@ttu.ee

DEPARTMENTS, RESEARCH CENTERS, RESEARCH LABORATORIES:

- Division of Business Management and the Humanities
- Division of the Sciences and Technology
- Division of Tourism, Catering and Service
- Library
- Small Craft Competence Centre

Kuressaare College number of academic staff is 7.

KURESSAARE COLLEGE

MAIN LINES OF R&D

The main R&D activities are concentrated in the Small Craft Competence Centre (SCC). SCC was established to accumulate and develop engineering knowhow in the region and to transfer it to companies as well as to facilitate intersectoral cooperation. The fields of expertise of SCC are boat design, material technology, production technology and electronic systems. The centre also includes a unique in the Baltic region tank of 60 m length for testing boat models.

In 2014 SCC provided and developed new research services to companies.

SCC will reach its full capacity at 2015. Further information: http://www.scc.ee/en/.

CONTACT: Anni Hartikainen, anni.hartikainen@ttu.ee

TARTU COLLEGE

Director: LEMBIT NEI, Professor

Phone: +372 620 4802
e-mail: lembit.nei@ttu.ee

DEPARTMENTS, RESEARCH CENTERS, RESEARCH LABORATORIES:

- Department of Environmental Protection
- Department of Landscape Architecture
- Department of Sustainable Technology
- Department of Basic Studies

Tartu College is currently employing 4 professors.

Total number of academic staff is 29.

TARTU COLLEGE

TARTU COLLEGE,
Director Professor Lembit Nei, lembit.nei@ttu.ee, +372 620 4802, + 372 5345 8322

DEPARTMENT OF ENVIRONMENTAL PROTECTION,
Professor Mari Ivask, mari.ivask@ttu.ee, +372 620 4809

DEPARTMENT OF LANDSCAPE ARCHITECTURE,
Lecturer Sulev Nurme, sulev.nurme@ttu.ee, +372 620 4808

DEPARTMENT OF SUSTAINABLE TECHNOLOGY,
Associate Professor Aime Ruus, aime.ruus@ttu.ee, +372 620 4805

DEPARTMENT OF BASIC STUDIES,
Associate Professor Ernst Tungel, ernst.tungel@ttu.ee, +372 620 4807

MAIN LINES OF RESEARCH

RESEARCH GROUP OF BUILT ENVIRONMENT

PROJECT „ENLIGHTENMENT EDUCATIONAL IDEAS APPLIED BY GEORGES FRÉDÉRIC PARROT AND THOMAS JEFFERSON AND THE INTERPRETATIONS OF THESE EDUCATIONAL CONCEPTIONS IN THE 21. CENTURY“

MAIN RESULTS:

In 2014, based on the research results of the project the PhD thesis „Reception of Ancient Art: the Cast Collections of the University of Tartu Art Museum in the Historical, Ideological and Academic Context of Europe (1803–1918)“ was completed.

PROJECT „LABORATORY TESTING AND RESEARCH OF NATURAL RESOURCES POTENTIALLY APPLICABLE IN BUILDING AND ENERGETICS BY TARTU RURAL DEVELOPMENT ASSOCIATION AND VÕRTSJÄRVE REGION“

In 2014 an overview of existing studies and technologies was prepared, and pilot areas were selected from the activity areas of the TRDA and Võrtsjärve Association where the following construction and energy related studies will be carried out (in cooperation with Environment technology working group):

- study on hygrothermal properties of building materials, study on indoor climate, microbiological studies;
- assessment of the caloric value and humidity content of natural materials in a laboratory,
- mapping out pilot areas and a cost-benefit analysis, on the basis of which 3 energy solutions will be proposed.

Within the doctoral studies of Jane Peda (Microbial community and indoor air quality in Estonian straw bale houses) five houses were selected and monitored for microbiology in the air and boarders. Also indoor climate (air temperature, relative humidity and carbon dioxide), air temperature and relative humidity in the boarder were monitored for evaluating the mould growth risk.

MAIN RESULTS:

1. Indoor environment investigation in Lake Võrtsjärv Visitor Center indicated good indoor climate, as well a low number of microorganisms.
2. Energetic analyses of the area were carried out and practical suggestions concerning technologies were worked out.
3. Development plans of district heating network for 4 local governments were completed.

CONTACT: Assoc. Prof. Aime Ruus, aime.ruus@ttu.ee

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ENVIRONMENTAL TECHNOLOGY RESEARCH GROUP

PROJECT „MESOFAUNA IMPACT ON THE DECOMPOSITION PROCESSES FOR SOIL QUALITY, THEIR SIGNIFICANCE IN THE FOOD CHAIN AND SUCCESSION ON HUMAN AFFECTED AREAS“

The field and laboratory studies for investigation of soil, forest litter and floor layer were carried out to find the relationships between litter characteristics, abundance and diversity of soil invertebrates as well as activities of soil microbial community and litter decomposition. The research was focused on problem how to promote the development of soil communities on recultivated mining areas to accelerate the litter decomposition by more abundant decomposer communities. Several substrates (the composts of different waste materials, peat) were used to establish better conditions decomposers. The data were collected (using pitfall traps) for describing and modeling the structure and function of soil communities on areas damaged by human activities by oil shale mining.

MAIN RESULTS:

New knowledge of diversity, systematics and ecology of soil biota in Estonia was obtained. On recultivated mining areas, the activity and abundance of microbial and invertebrate decomposer communities can be accelerated by using different substrates which consist additional nutrients for organisms.

PROJECT „SPATIAL DISTRIBUTION OF SOIL BIOTA AND POST-FLOODING RECOLONIZATION OF FLOODPLAIN AND COASTAL MEADOWS IN MATSALU NATIONAL PARK“

On flooded area the net of 14 sensors for monitoring the water level, temperature and electroconductivity was established in 2012. (Solinst Levellogger Junior 3001, one hour interval of measurements). Study areas were selected using the altitude- and flooding model by principle that some areas are recolonized more quickly and some are covered by flooding water for very long time. In 2014 soil samples from 36 study areas were collected to analyse the content of nutrients in soil, the activity and biomass of microbial community as well as the abundance and diversity of springtails Collembola and the mites Acari (abundance only). The analysis of the taxonomical and ecological structure of soil invertebrates communities sampled in 2013 by pitfall traps were completed.

MAIN RESULTS:

In Matsalu wetland, the content of nutrients in soil as well as the activity of soil microbial community and abundance of soil mesofauna (springtails and mites) highly depend on duration of flood and salinity

of flooding water. The abundance and activities were the highest in non-flooded areas and significantly lower in flooded soil after withdrawing of flood.

PROJECT „LABORATORY TESTING AND RESEARCH OF NATURAL RESOURCES POTENTIALLY APPLICABLE IN BUILDING AND ENERGETICS BY TARTU RURAL DEVELOPMENT ASSOCIATION AND VÕRTSJÄRVE REGION"

In 2014 the investigations of microbial communities on straw and reed as ecological building material and its potential energetical value were undertaken. The effectiveness of three chemical agents (boric acid, sodium hypochlorite and commercial fungicide Biotol) against micro-organisms colonizing straw bales used in environmentally friendly construction was tested. Also the major geni of bacteria and fungi colonizing the straw were identified. The energetic value of straw of different cereal species (wheat, barley and rye) was also analyzed.

MAIN RESULTS:

The concentrations needed for the inhibition of the microbial population were 2,25 g/l, 0,5 g/l and 1,0 g/l, respectively. The most abundant geni were *Aspergillus*, *Penicillium*, *Cladosporium* for fungi and *Streptomyces*, *Pseudomonas* for bacteria. The study also revealed that the initial content of moisture in straw biomass was unsuitable (too high) for biofuel production. The using of straw as energetical resource is not profitable because of high expenses (for example transport, drying).

PROJECT „OPTIMIZATION OF SEWAGE SLUDGE COMPOSTING TECHNOLOGIES: PROBLEMS AND SOLUTIONS"

The microbial parameters of the composting process of sewage sludge in a controlled environment at the constant temperature of 20°C was analyzed. The microbial parameters consisted of basal respiration, substrate induced respiration (SIR) and fungal-to-bacterial ratio. During 2 months of composting the basal respiration value decreased from 3,2 mg O2/g dw to 0,5 mg O2/g dw and the SIR value from 15,85 mg biomassC/g dw to 2,58 mg biomassC/g dw. The fungal-to-bacterial ratio shifted from 58,9–41,1 at the beginning to 52,0–48,0 at the end of the experiment.

MAIN RESULTS:

The microbial parameters of the composting process as well the fungal-to-bacterial ratio of sewage sludge in a controlled environment at the constant temperature of 20°C, decreased during 2 months of composting significantly; this indicates the higher degree of compost maturity.

PROJECT „ULTRASTABLE METAL NANOPARTICLES SYNTHESIS AIMED AT APPLICATIONS IN NANOMEDICINE" (2014–2017)

The first year was dedicated to the characterization of the metal nanoparticles (MNPs) and the optimization of the method of synthesis, more particularly for cobalt MNPs.

In 2014, more emphasis was put on the study of the structural and physical properties of silver MNPs. The structure of the silver MNPs have been studied by XRD showing pure, highly crystalline cubic silver nanoparticles. Thermal analyses showed that there is no surfactant/organic species on their surface, which should promote the attachment of thiol reactants for functionalization and should allow targeted treatments. Two main studies were performed on the Ag MNPs: The cytotoxicity of the pure Ag MNPs was tested on HEK (human embryonic kidney) cells and also on cancerous cell lines like PPC-1 (prostate cancer cell line). Different concentrations of MNPs were tested and their toxicity in cells by MTT assay was studied, showing no toxicity to human cells. The functionalization of the Ag MNPs via the encapsulation of the MNPs in pH-sensitive polymersomes has been undertaken.

CONTACT: Prof. Mari Ivask, mari.ivask@ttu.ee

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