DATA SHEET

SCHOTT BOROFLOAT 33

Floated Borosilicate Glass from SCHOTT

BOROFLOAT® 33 is a high quality borosilicate glass with outstanding properties for a wide-range of applications.

This unique special float glass is manufactured by SCHOTT Technical Glass Solutions GmbH using the Microfloat process and the latest technology. This technology also results in a homogeneous material that has an excellent mirror-like surface, a high degree of flatness and an outstanding optical quality.

BOROFLOAT® 33 is a clear and transparent colourless glass. Its excellent transmission and its very weak fluorescence intensities over the entire light spectrum make BOROFLOAT® 33 ideal for a wide range of applications in optics, optoelectronics, photonics and analytical equipment.

Its low thermal expansion, its high thermal shock resistance and its ability to withstand temperatures up to 450°C for long periods make BOROFLOAT® 33 a good choice for applications which call for good temperature stability (e.g. internal panels in pyrolytic self-cleaning ovens and over plates for high-power floodlights).

BOROFLOAT® 33 is highly resistant to attack by water, strong acids, alkalis as well as organic substances. Therefore it is particularly suitable for applications in the chemical industry such as sight glasses for reaction vessels and fittings.

Another interesting field of application is in medical and analytical technology. Measurements are hardly influenced by the glass receptacle because the exposure to water and acids results only in the leaching out of small amounts of ions from the glass.

BOROFLOAT® 33 has a lower density than soda lime float glass. It makes it possible to construct lightweight laminated glass systems (e.g. bulletproof glass).

BOROFLOAT® 33 has proven itself in many traditional applications and, today, there is an increasing area of usage in new and technically sophisticated special glass applications such as biotechnology, microelectronics and photovoltaics.

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Fields of Application of BOROFLOAT®33

Its special physical and chemical properties make BOROFLOAT® 33 a truly versatile performer with a broad range of uses:

- Home Appliances (interior oven doors, fittings in microwave appliances, window panels for fireplaces)
- Environmental engineering, chemical industry (resistant linings and sight glasses for reaction vessels, microfluidic systems)
- Lighting (protective panels for spotlights and high-power floodlights)
- Photovoltaics (glass for solar collectors)
- Precision engineering, optics (optical filters and mirrors etc.)
- Medical technology, biotechnology (slides, biochips, titration plates, DNA sequencers, microfluidic systems)
- Semiconductor engineering, electronics, sensors (wafers, display glass)
- Safety (bulletproof glazing)

The quality of BOROFLOAT® 33 is ensured by our quality assurance system according to the requirements of the DIN ISO 9001.

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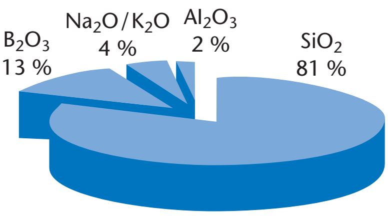
Product Description

Chemical Composition



BOROFLOAT® 33 is a borosilicate glass type 3.3 as specified in the international standard ISO 3585 and EN 1748 T1. BOROFLOAT® 33 products meet most international standards, for example the German, British, American and French standards.

The structural characteristics and the material's purity grade (low content of polyvalent ions) of BOROFLOAT® 33 results in an overall high transmission of ultraviolet, visible and infrared wavelengths.

Thanks to its low alkali content, BOROFLOAT® 33 works as a good electric insulator.

Due to its high boron content, BOROFLOAT® 33 can be used as a neutron absorber glass in nuclear energy applications.

Environmental Safety/ Ecological Reliability

BOROFLOAT® 33 is environmentally friendly and made of natural raw materials. The glass can be recycled several times and disposed of without difficulties.

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Forms Supplied

Panel Thickness

BOROFLOAT® 33 is offered in the following thicknesses and tolerances, in mm (in.):

Thickness		Tolerance	
0.70	(0.027)	± 0.07	(0.003)
1.10	(0.043)	± 0.1	(0.004)
1.75	(0.069)	± 0.1	(0.004)
2.00	(0.079)	± 0.2	(0.008)
2.25	(0.089)	± 0.2	(0.008)
2.75	(0.108)	± 0.2	(0.008)
3.30	(0.130)	± 0.2	(0.008)
3.80	(0.150)	± 0.2	(0.008)
5.00	(0.197)	± 0.2	(0.008)
5.50	(0.216)	± 0.2	(0.008)
6.50	(0.256)	± 0.2	(0.008)
7.50	(0.295)	± 0.3	(0.012)
8.00	(0.315)	± 0.3	(0.012)
9.00	(0.354)	± 0.3	(0.012)
11.00	(0.433)	± 0.3	(0.012)
13.00	(0.512)	± 0.5	(0.020)
15.00	(0.590)	± 0.5	(0.020)
16.00	(0.630)	± 0.5	(0.020)
18.00	(0.708)	± 0.5	(0.020)
19.00	(0.748)	± 0.5	(0.020)
20.00	(0.787)	± 0.7	(0.027)
21.00	(0.827)	± 0.7	(0.027)
25.40	(1.000)	± 1.0	(0.040)

Panel thickness is continuously measured during production using laser thickness measuring equipment. Other nominal thicknesses and tolerances are supplied on request.

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Technical Properties

The values below are generally applicable basic data for BOROFLOAT® 33. Unless stated different these are guide figures according to DIN 55350 T12. However, they also apply to the coated versions (BOROFLOAT® AR and BOROFLOAT® M) except for the transmission data (see Optical Properties, pages 19 ff).

Mechanical Properties

Density (25°C)	ρ	2.2 g/cm³	
Young's Modulus	E	64 kN/mm²	(to DIN 13316)
Poisson's Ratio	μ	0.2	(to DIN 13316)
Knoop Hardness	$HK_{0.1/20}$	480	(to ISO 9385)
Bending strength	σ	25 MPa	(to DIN 52292 T1)
Impact resistance	The impact resistance of BOROFLOAT® 33 depends on the way it is fitted, the size and thickness of the panel, the type of impact involed, presence of drill holes and their arrangement as well as other parameters.		

Thermal Properties

Coefficient of Linear Thermal Expansion (C.T.E.)	$\alpha_{(20-300\,°C)}$	3.25×10^{-6} K^{-1} (to ISO 7991)
Specific Heat Capacity	$c_{p\,(20-100\,°C)}$	0.83 KJ x (kg x K)$^{-1}$
Thermal Conductivity	$\lambda_{(90\,°C)}$	1.2 W x (m x K)$^{-1}$

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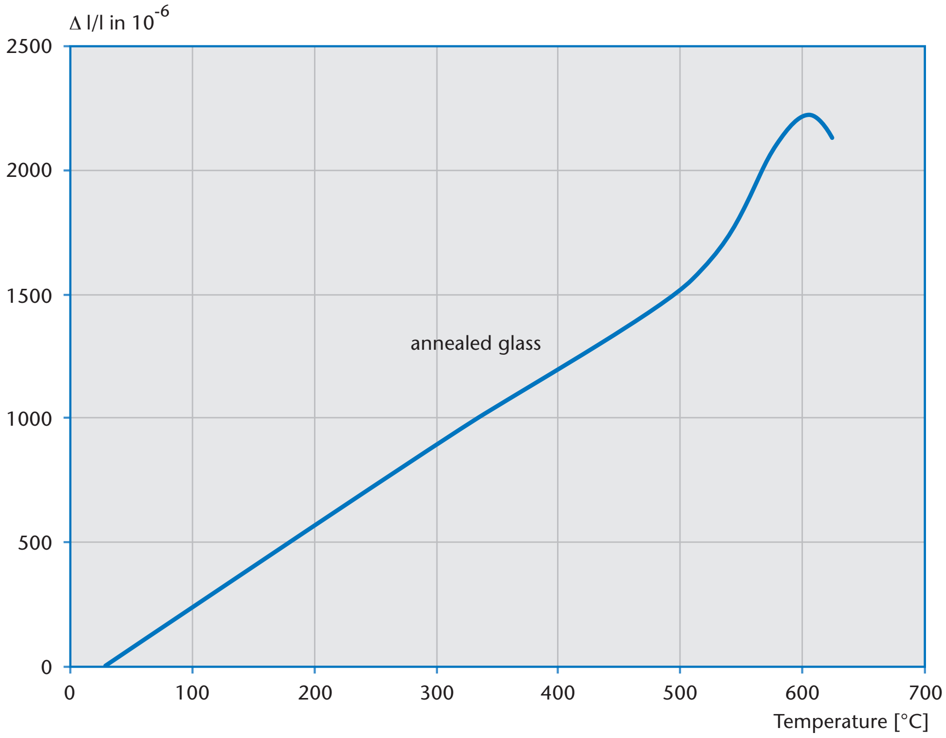
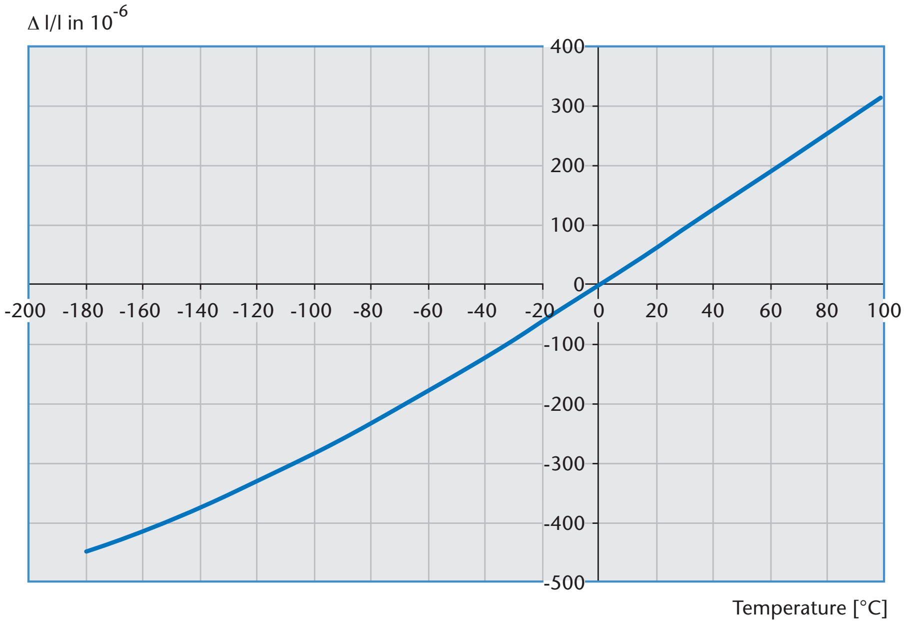
SCHOTT BOROFLOAT 33

Thermal Properties



BOROFLOAT® 33 – Thermal Expansion



BOROFLOAT® 33 – Behavior in the Cryogenic Temperature Range

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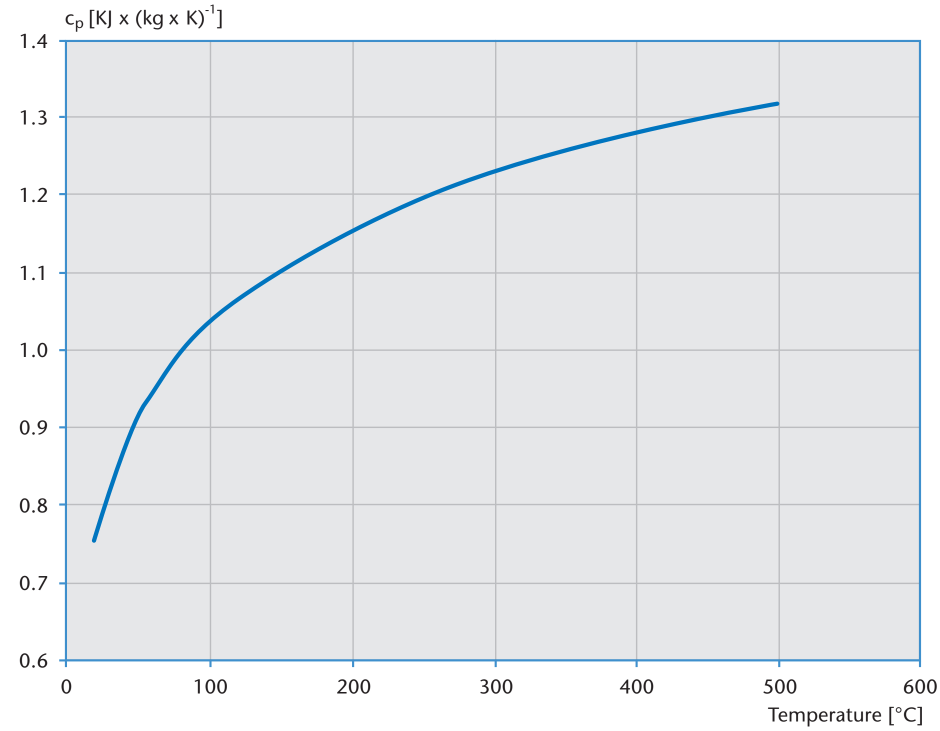
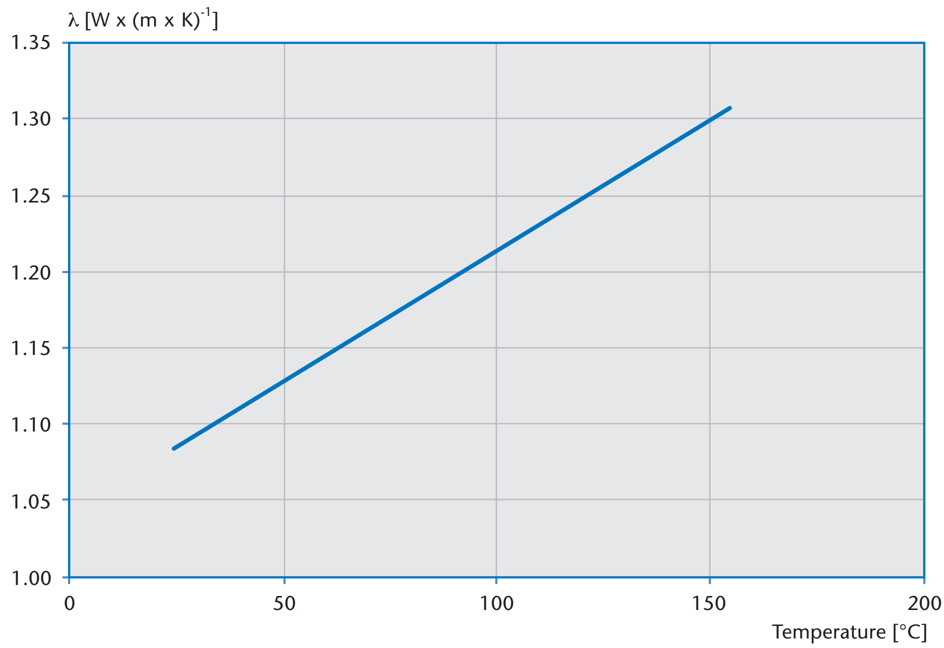
Thermal Properties

▶ ***BOROFLOAT® 33 – Specific Heat Capacity (c_p)***



▶ ***BOROFLOAT® 33 – Thermal Conductivity (λ)***



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Thermal Properties

Maximum Operating Temperature

		T_{max}
For short-term usage	< 10 h	500 °C
For long-term usage	≥ 10 h	450 °C

The maximum temperatures in use indicated apply only if the following RTG and RTS values are observed at the same time.

Resistance to Thermal Gradients (RTG)

The RTG value characterizes the ability of a glass type to withstand a specific temperature difference between the hot center and the cold edges of a panel.

	RTG
< 1 hour	110 K
1–100 hours	90 K
> 100 hours	80 K

Test method: Plates of approximately 25 x 25 cm² (10 x 10 in.²) are heated in the center to a defined temperature, and the edge of the plate is kept at room temperature, at which ≤ 5 % of the samples suffer breakage.
The plates are abraded with 40 grit sandpaper prior to the test. This simulates extreme surface damage which may occur in operation.

Resistance to Thermal Shock (RTS)

The RTS value characterizes the ability of a glass panel to withstand a sudden temperature decrease.

Glass Thickness	RTS
≤ 3.8 mm	175 K
5.0 – 5.5 mm	160 K
6.5 – 15.0 mm	150 K
> 15.0 mm	125 K

Test method: Plates of approximately 20 x 20 cm² (8 x 8 in.²) are heated in an oven with recirculated air and then doused in the center with 50 ml (3.3 oz.) of room temperature water, at which ≤ 5 % of the samples suffer breakage.
The plates are abraded before heating with 220 grit sandpaper to simulate typical surface condition during practical use.

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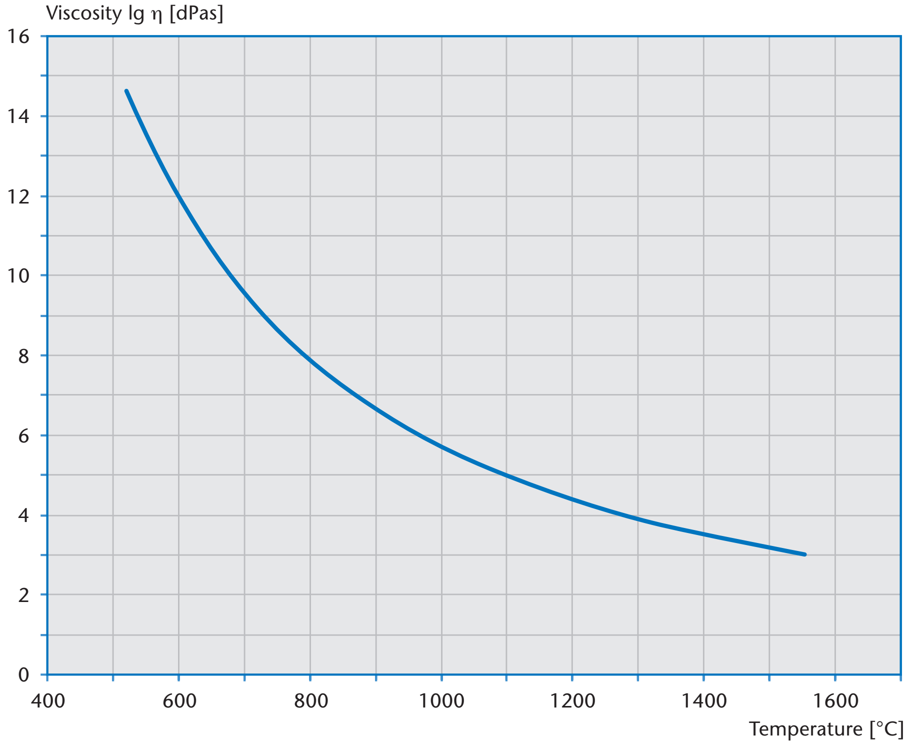
Thermal Properties

▶ ***Viscosity of Borosilicate Glasses***

Viscosity η			
Working Point	10^4	dPas	1270 °C
Softening Point	$10^{7.6}$	dPas	820 °C
Annealing Point	10^{13}	dPas	560 °C
Strain Point	$10^{14.5}$	dPas	518 °C
Transformation Temperature (T_g)			525 °C

▶ ***BOROFLOAT® 33 – Temperature Dependence of the Viscosity (η)***



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Chemical Properties

Hydrolytic resistance	according ISO 719 / DIN 12 111	HGB 1
	according ISO 720	HGA 1
Acid resistance	according ISO 1776 / DIN 12 116	1
Alkali resistance	according ISO 695 / DIN 52 322	A 2

Chemical Resistance of BOROFLOAT® 33 to Selected Reagents

Reagent	Weight Loss [mg/cm²]	Visual Inspection Results/ Appearance
24 h at 95 °C		
5 Vol.% HCl	< 0.01	unchanged
0.02 n H_2SO_4	< 0.01	unchanged
H_2O	< 0.01	unchanged
6 h at 95 °C		
5% NaOH	1.1	white stains
0.02 n NaOH	0.16	white haze
0.02 n Na_2CO_3	0.16	unchanged
20 min at 23 °C		
10% HF	1.1	stained white haze
10% NH_4F x HF	0.14	unchanged

Tin Residues

The phenomenon of tin traces on the surface is commonly known from the manufacture of soda-lime float glass. It is caused by an evaporation effect in the float bath atmosphere. These values are considerably lower for BOROFLOAT® 33 than for soda-lime float glass on both the side in contact with the tin and on the other side which is exposed to the atmosphere. The reciprocal effect with coating is thus markedly less. It is recommended that the top side (labeled by the manufacturer) is used for coatings.

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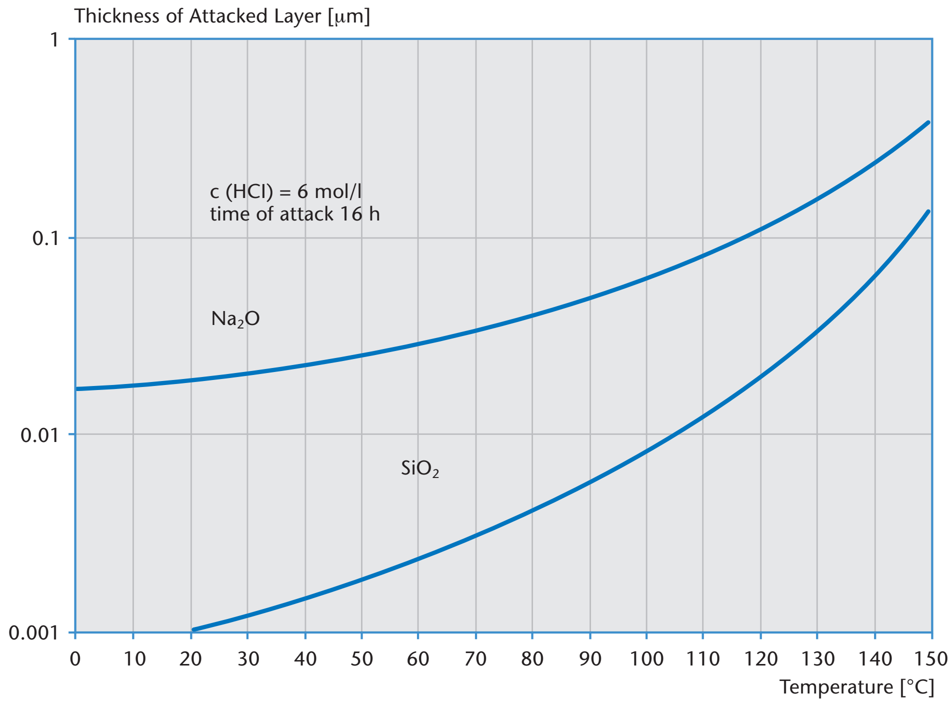
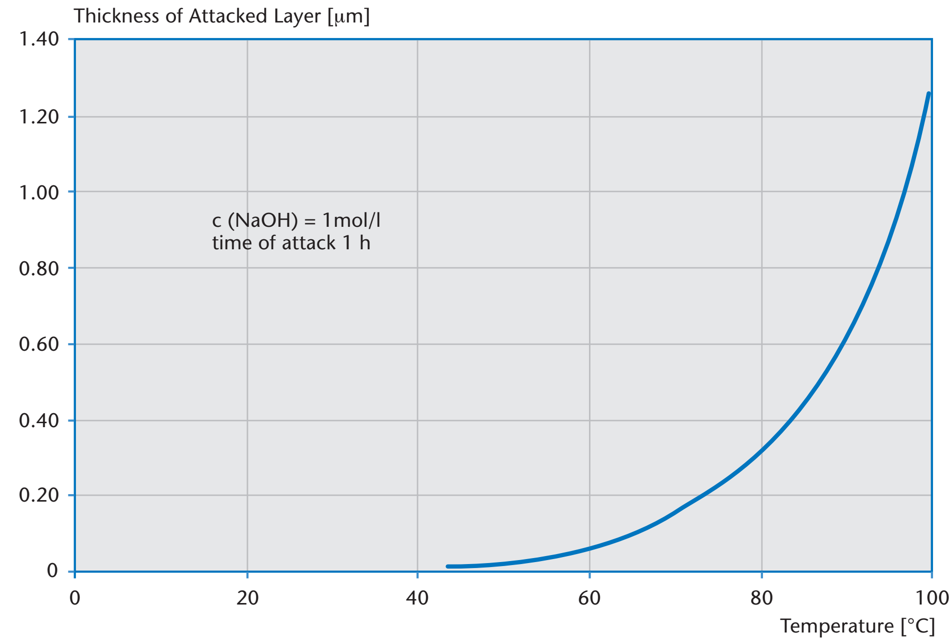
Chemical Properties

▶ ***Attack of Acid on BOROFLOAT® 33 Surface – Related to Temperature, Calculated from Weight Loss***



▶ ***Attack of Alkali on BOROFLOAT® 33 Surface – Related to Temperature, Calculated from Weight Loss***



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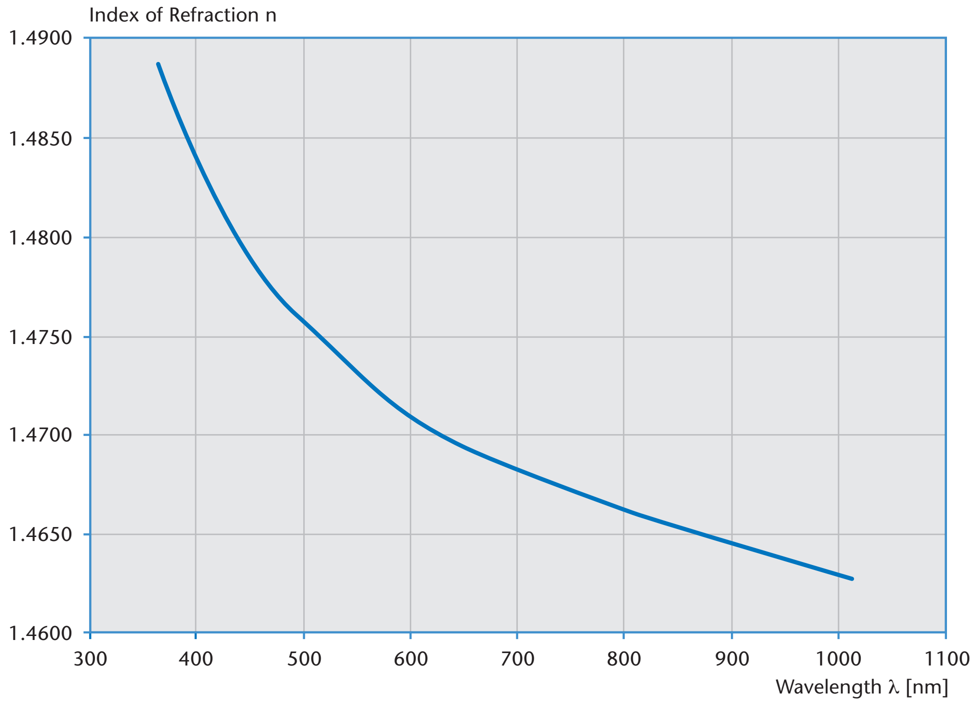
Wavelength λ (nm)	435.8	479.9	546.1	589.3	643.8	656.3
Index of Refraction n	1.48015	1.47676 ($n_{F'}$)	1.47311 (n_e)	1.47133	1.46953 ($n_{C'}$)	1.46916

Abbe Constant	$v_e = (n_e - 1) / (n_{F'} - n_{C'})$	65.41
Refractive Index	n_d ($\lambda_{587.6\ nm}$)	1.47140
Dispersion	$n_F - n_C$	71.4×10^{-4}
Stress-optical Coefficent	K	4.0×10^{-6} mm² N⁻¹



Dispersion of BOROFLOAT® 33 – Index of Refraction (n) vs. Wavelength (λ)

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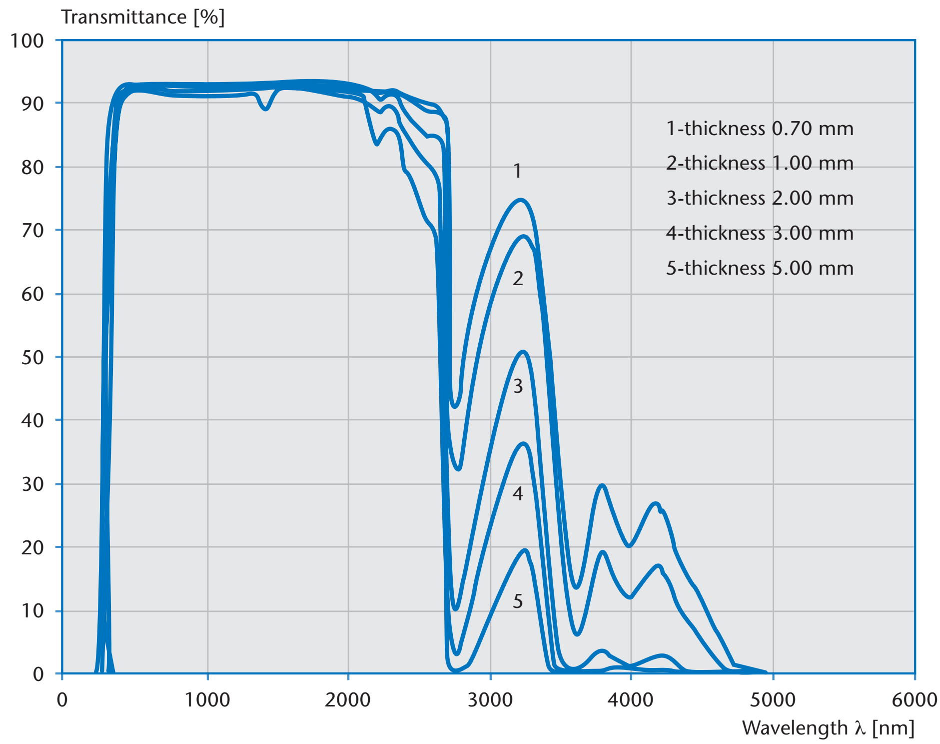
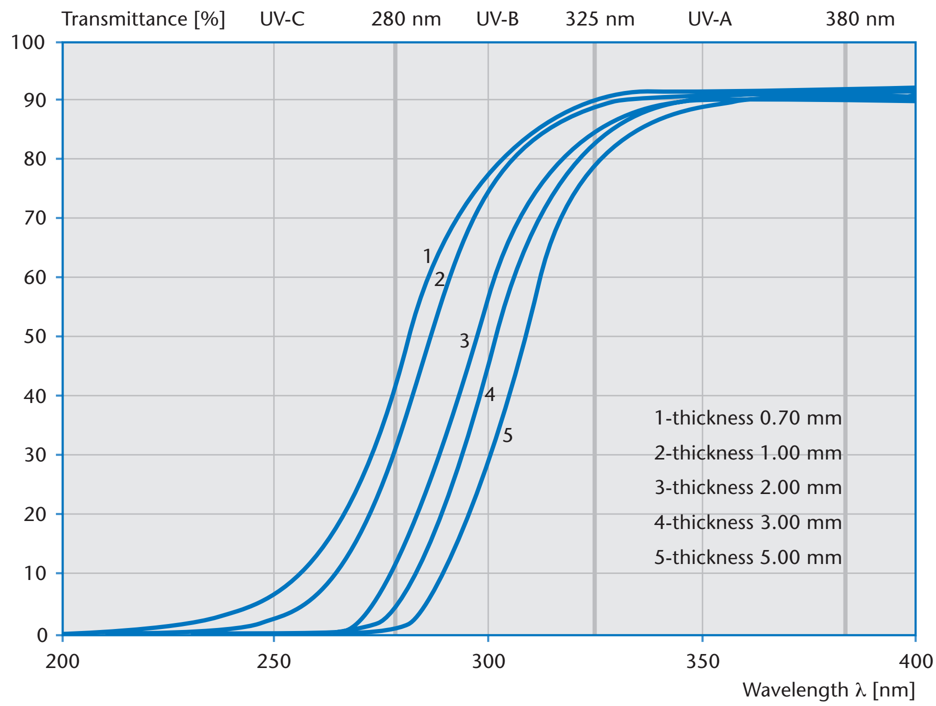
Optical Properties

BOROFLOAT® 33 – Total Optical Transmittance



BOROFLOAT® 33 – Transmittance in the UV Range



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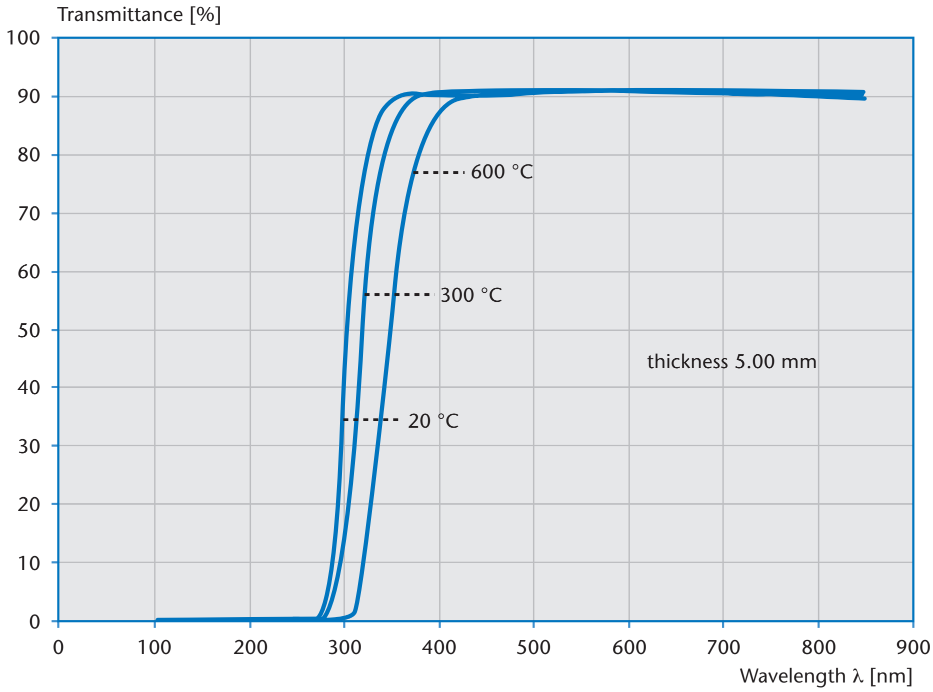
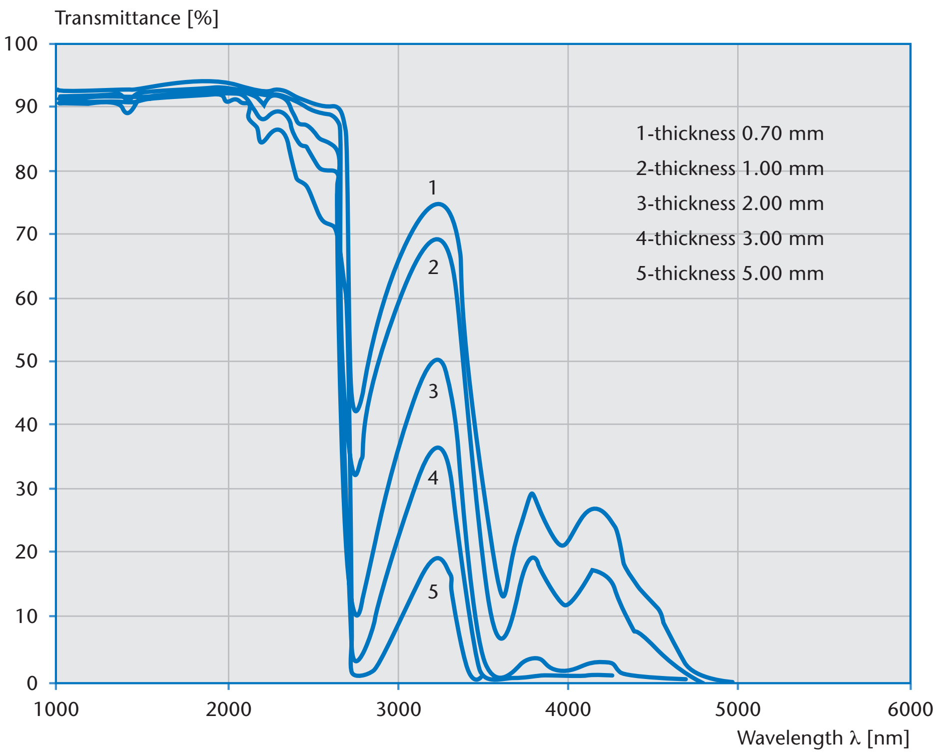
Optical Properties



BOROFLOAT® 33 –
Transmittance in the UV Range
Dependence on Temperature



BOROFLOAT® 33 –
Transmittance in the IR Range

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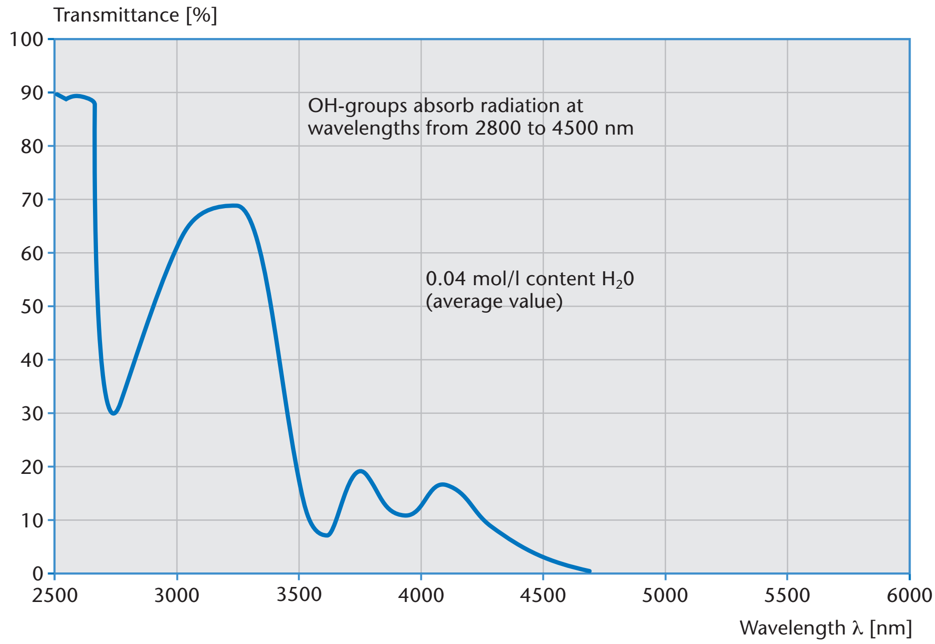
Optical Properties

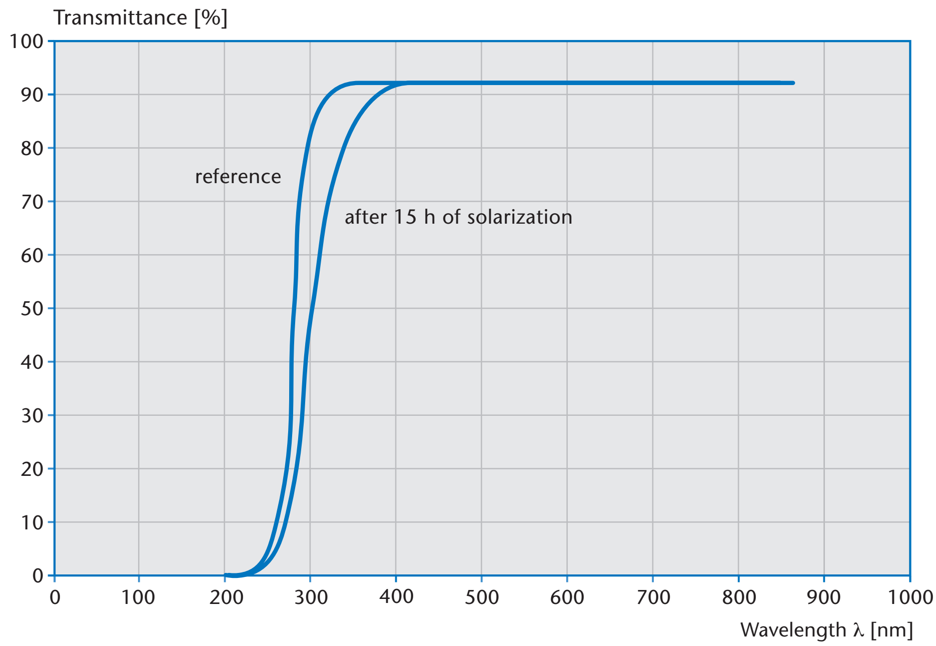
BOROFLOAT® 33 – Influence of Water Content on the Transmittance



BOROFLOAT® 33 – Resistance towards Radiation Degradation

The influence of radiation on the transmittance of BOROFLOAT® 33 is measured according to the SCHOTT test conditions:

The glass sample of a size 30 x 15 x 1 mm³ is radiation-exposed by using the high-pressure mercury vapor lamp HOK 4/120. This lamp works with a radiation intensity of 850 W/cm² and with a main wavelength of 365 nm.



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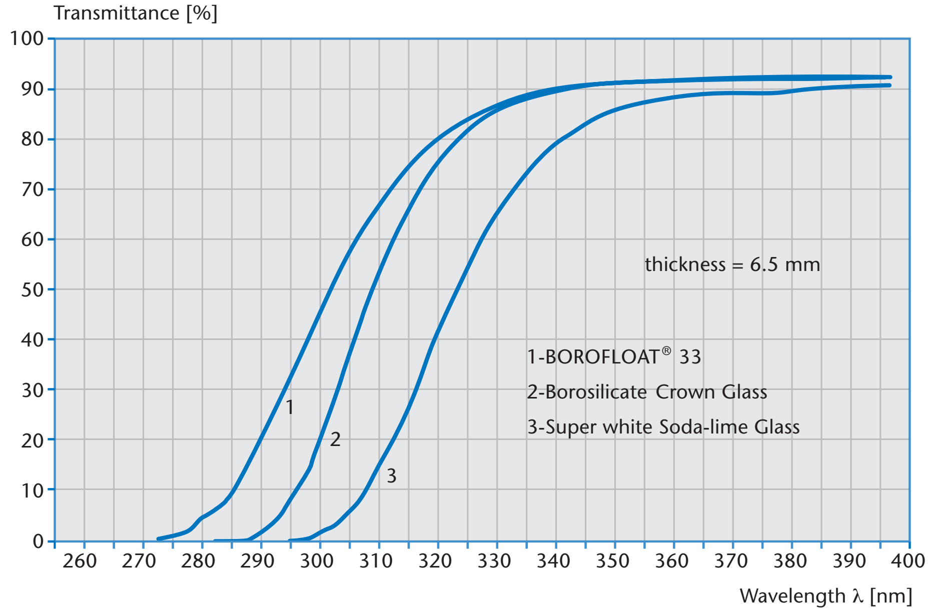
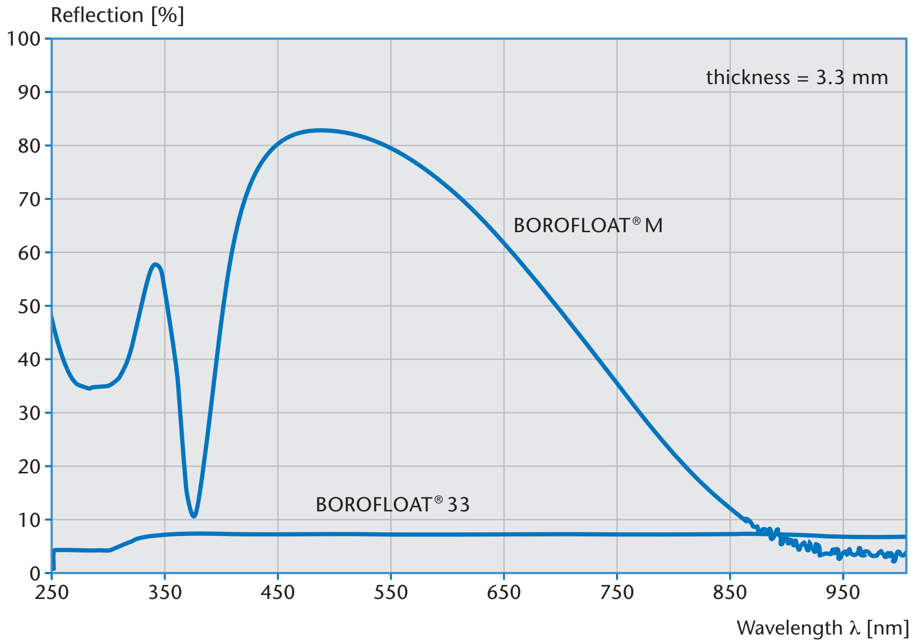
Optical Properties



Transmittance of BOROFLOAT® 33 in Comparison with Borosilicate Crown Glass and Soda-lime Glass (superwhite)



Reflection of BOROFLOAT® 33 in Comparison with BOROFLOAT® M (with reflective coating)

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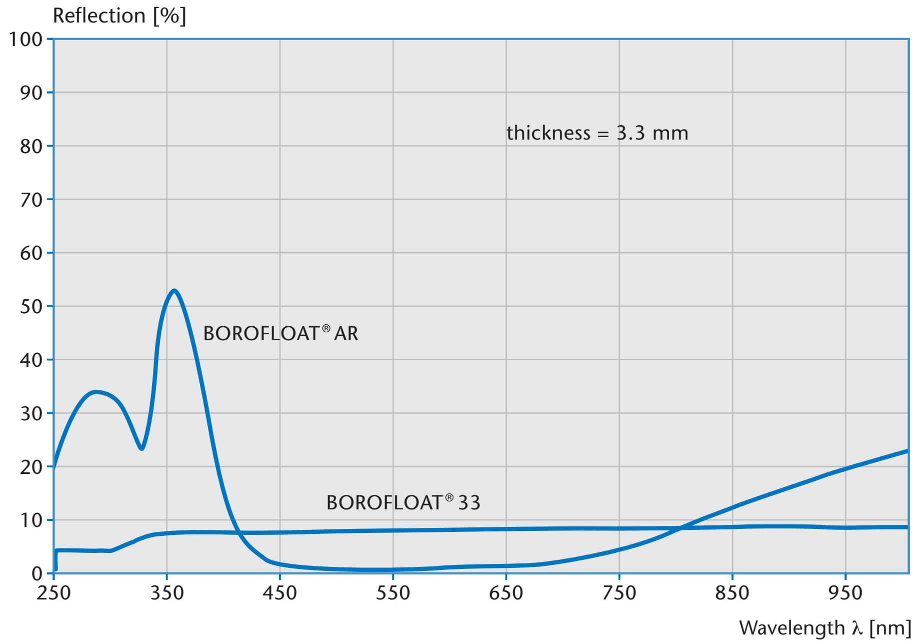
Optical Properties

Reflection of BOROFLOAT® 33 in Comparison with BOROFLOAT® AR (with anti-reflective coating)



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Optical Properties

Fluorescence Behavior of BOROFLOAT® 33

Some materials have the ability to emit electromagnetic radiation after being activated by high frequency short-wave radiation of high energy intensity. This behavior of the materials is called fluorescence and it depends on the material's purity and structural characteristics, as well as the energy per pulse, pulse rate and excitation wavelength of the radiation.

BOROFLOAT® 33 is a material with high transmission showing very weak fluorescence intensities over the whole spectrum of light.

Selected Standard Laser Wavelength and Lasing Media

Wavelength (nm)	Lasing Medium	Wavelength (nm)	Lasing Medium	Wavelength (nm)	Lasing Medium
308	XeCl	488	Ar	1047	Nd:YLF
325	HeCd	514.5	Ar	1053	Nd:YLF
337	N_2	532	Nd:YAG	1064	Nd:YAG
350	XeF	632.8	HeNe	1153	HeNe
351.1	Ar	694.3	Ruby	1319	Nd:YAG
363.8	Ar	730-780	Alexandrite	1730	Er:YLF
427	N_2	850	Er:YLF	2060	Ho:YLF
441.6	HeCd	905	GaAs	10640	CO_2

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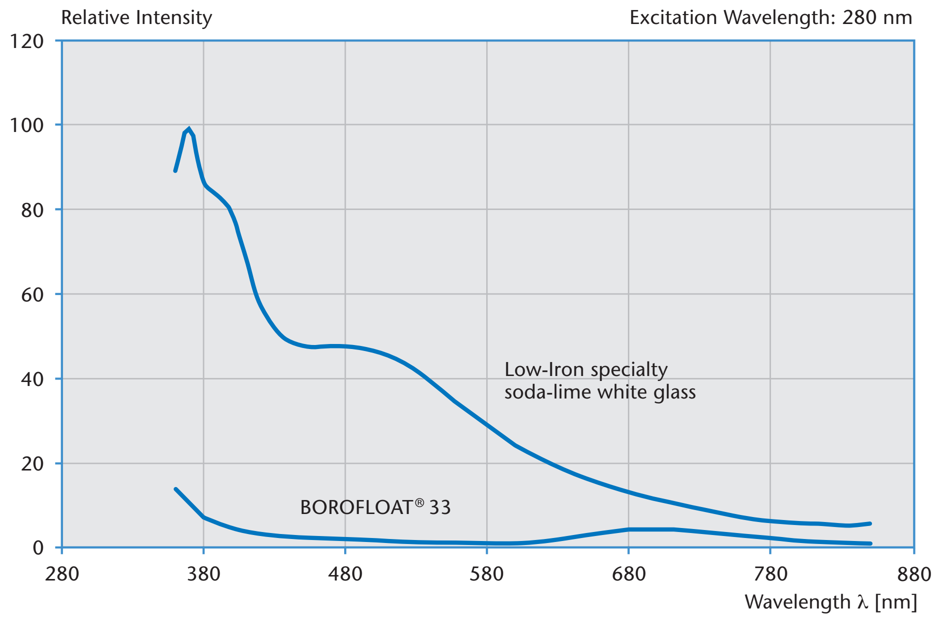
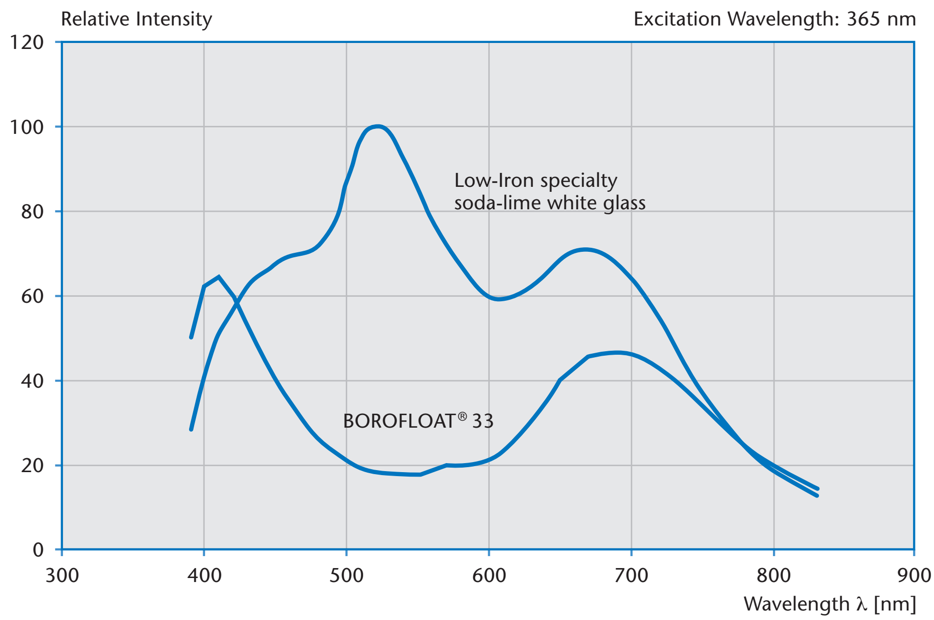
Optical Properties

- ***Fluorescence Behavior of BOROFLOAT® 33 and Soda-Lime Glass Type for Different Wavelength Excitation***



- ***Fluorescence Behavior of BOROFLOAT® 33 and Soda-Lime Glass Type for Different Wavelength Excitation***



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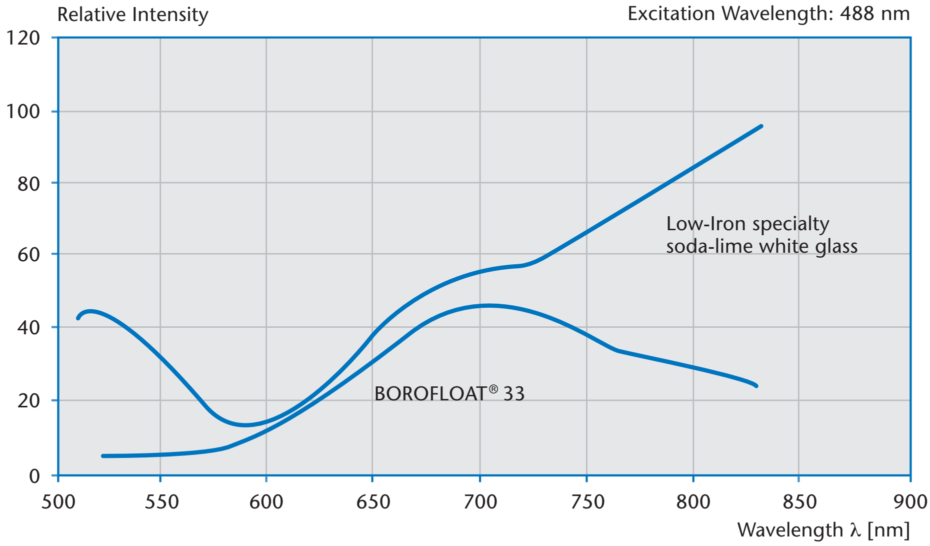
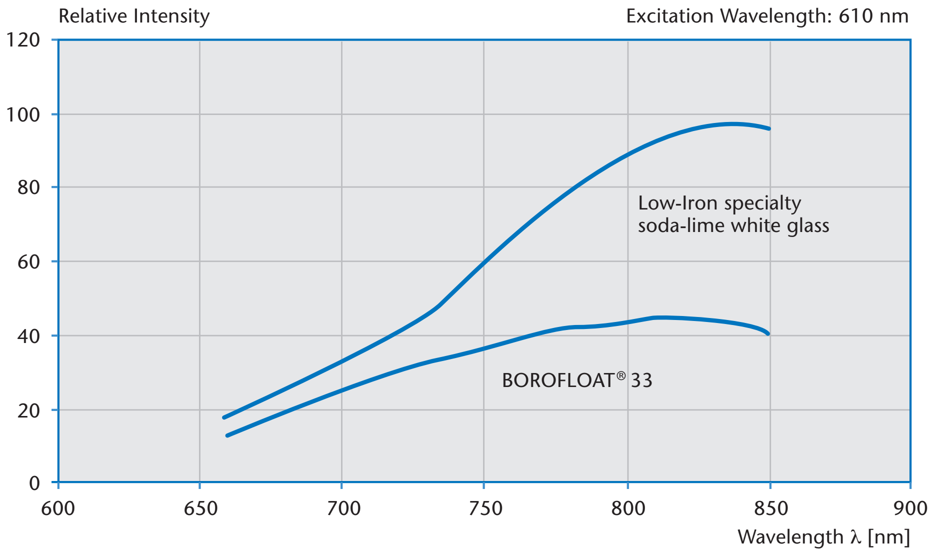


Fluorescence Behavior of BOROFLOAT® 33 and Soda-Lime Glass Type for Different Wavelength Excitation



Fluorescence Behavior of BOROFLOAT® 33 and Soda-Lime Glass Type for Different Wavelength Excitation

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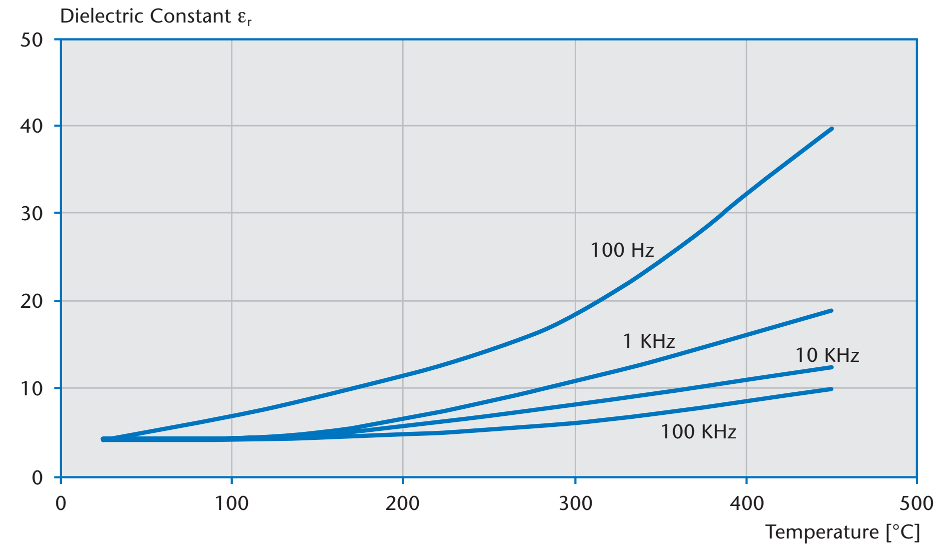
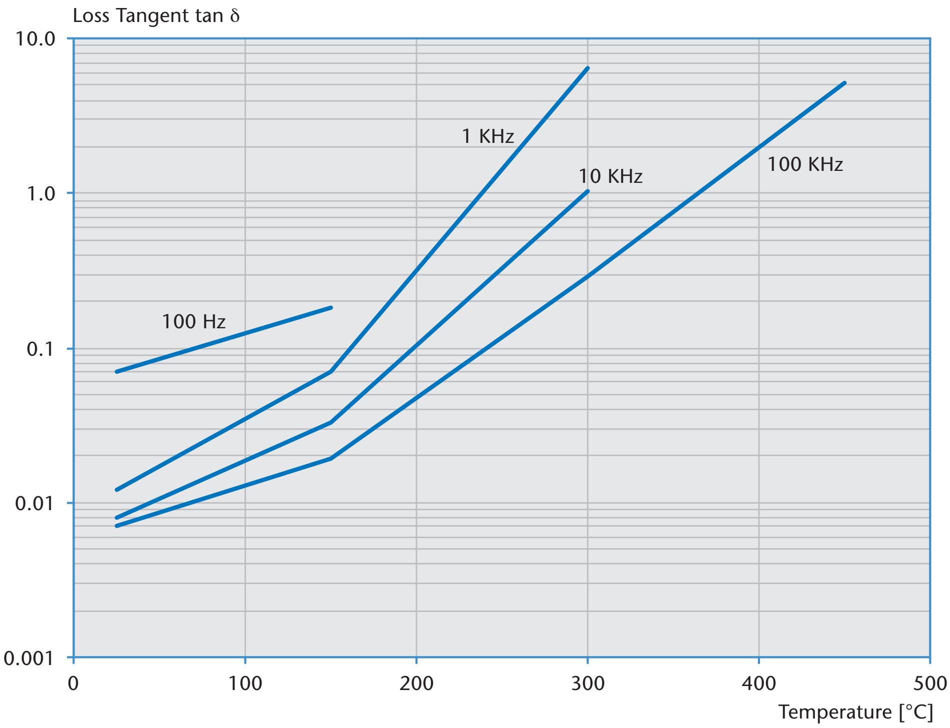
Electrical Properties

Dielectric Constant	ε_r	(25 °C, 1 MHz)	4.6
Loss Tangent	tan δ	(25 °C, 1 MHz)	37 x 10^{-4}

BOROFLOAT® 33 – Dielectric Constant as a Function of Temperature



BOROFLOAT® 33 – Loss Tangent as a Function of Temperature



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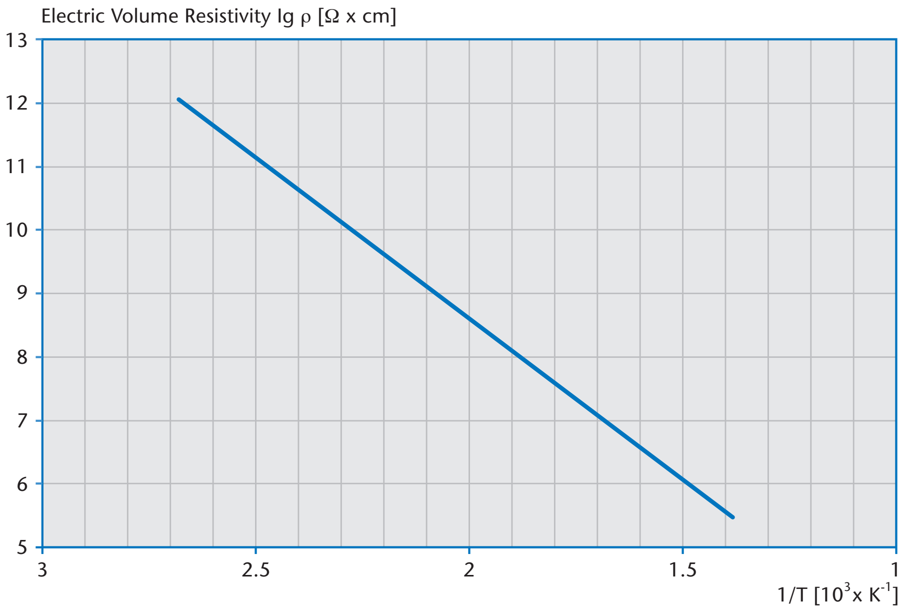
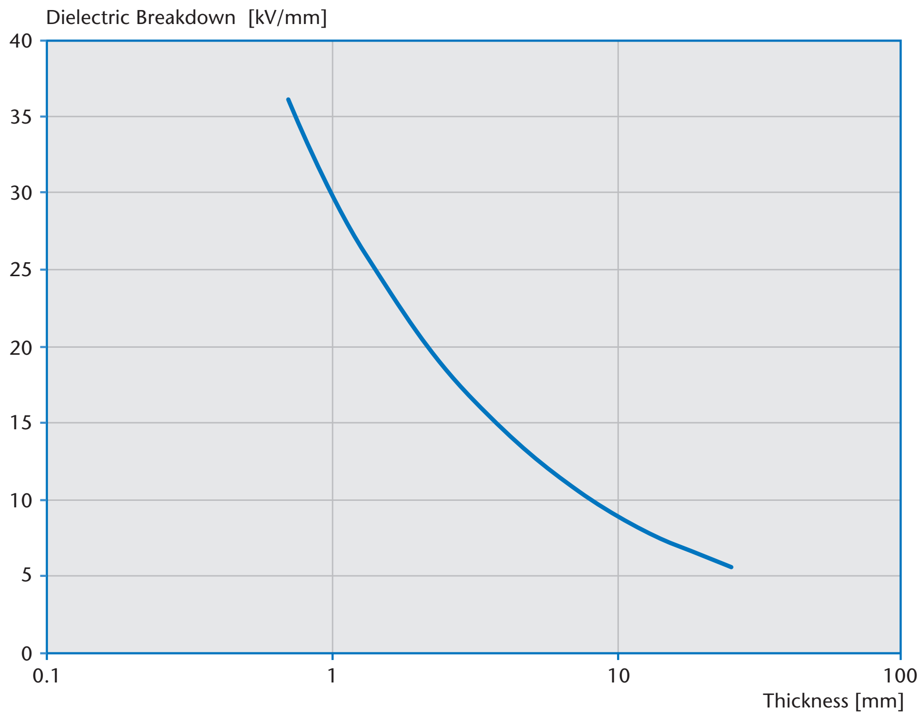
Electrical Properties

Logarithm of the Electric Volume Resistivity: lg ρ	250 °C	8.0 Ω x cm
	350 °C	6.5 Ω x cm



BOROFLOAT® 33 – Electric Volume Resistivity as a Function of Temperature



BOROFLOAT® 33 – Dielectric Breakdown as a Function of Glass Thickness (in air)

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