SUPPORTING INFORMATION

Tunable and switchable polarization rotation with nonreciprocal plasmonic thin-films at designated wavelengths

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DISPERSION SPECTRA FOR TILTED INCIDENCE

The measurements and simulations shown in the main article were performed for normal incidence. Here we elaborate on the case of tilted incidence and supply numerical simulations.

The optical path length through a magneto-optical film can be increased by tilting the incident beam. However, Faraday rotation is proportional to the component of the optical path in the direction of the magnetization of the material, which is perpendicular to the EuSe film. Therefore, for small tilt angles, the polarization rotation by a bare film is independent of the incident angle (if material dispersion is ignored).

The dispersion and, thus, also the Faraday rotation response of the presented hybrid structure depends on the incident angle. The angular dependent dispersion of waveguide-plasmon-polariton structures was studied by Christ et al. for non-magneto-optical hybrid structures.[1,2] It was found that for structure geometries as utilized here, tilting the incident beam in a plane perpendicular to the wires causes two main changes: First, a second TE and TM mode becomes optically active. Second, the two TE and TM branches shift away from each other for increasing incident angle.
Regardless of the more complex spectra in the case of tilted incidence, the criterion for maximum Faraday rotation enhancement is still the same: it occurs where the TM waveguide-plasmon-polariton has the strongest overlap with the TE waveguide modes. This behavior can be demonstrated best in 2D dispersion maps for absorbance and Faraday rotation as found in figure S1 and figure S2. The dispersions were obtained by scattering matrix calculations as described in the main article. The hybrid structure is assumed to consist of a 150 nm thick EuSe slab with 70 nm thick and wide gold wires on top. Furthermore a magnetic Field of 5 T and a temperature of 30 K are assumed.

Figure S1 shows the modal dispersion behavior for normal incidence and for a tilt in the plane perpendicular to the gold wires. As a consequence of the tilt, a second TE waveguide mode and a second TM waveguide mode build up, which cannot be seen at normal incidence because their excitation is in this case symmetry forbidden.[1,2] The comparison with figure S2 confirms that the largest Faraday rotation enhancement occurs in all cases in the intersection regions of the TE waveguide modes and the TM waveguide-plasmon-polariton modes.

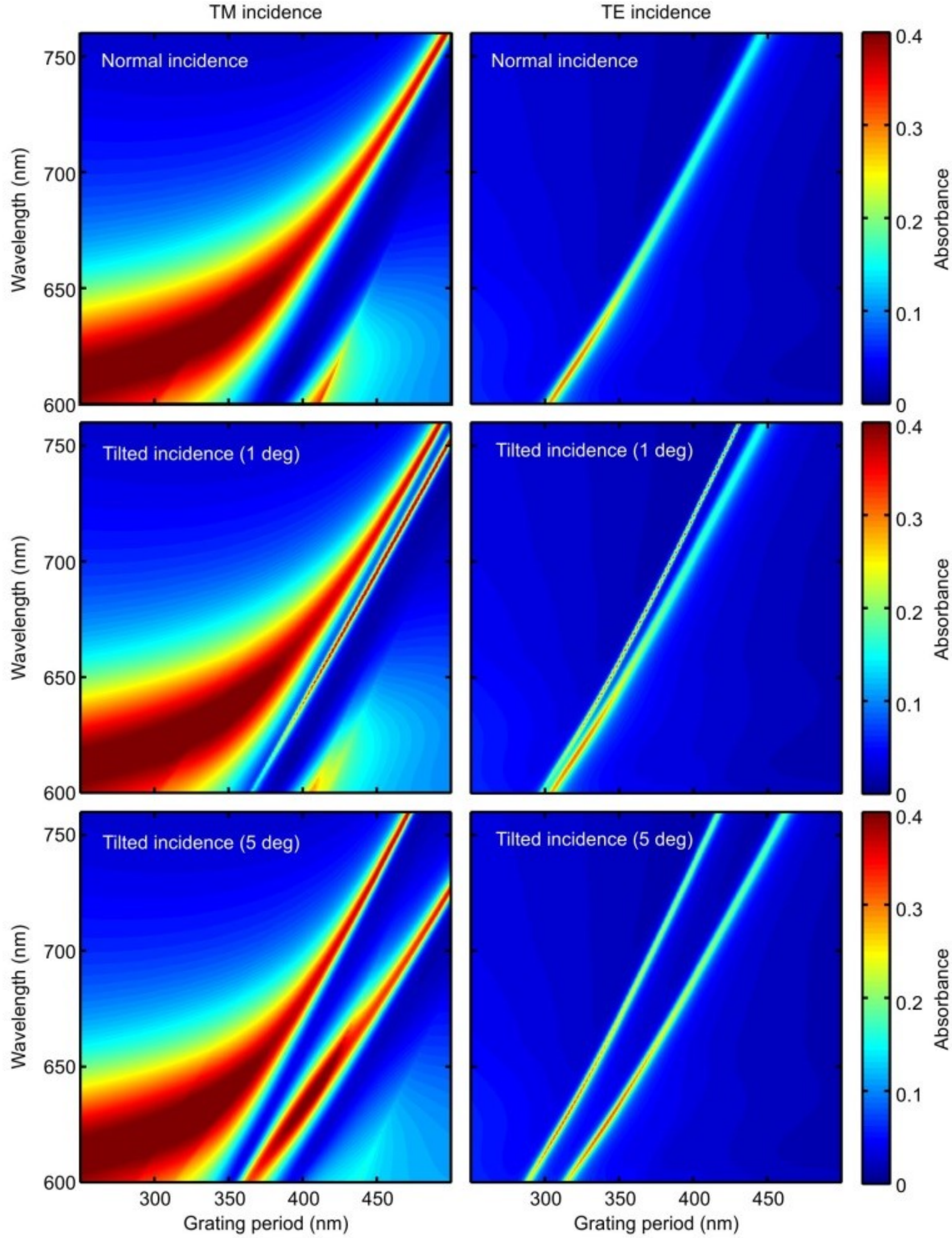

Figure S1: Dispersion diagram for different incidence angles.

ON THE INFLUENCE OF THE WAVEGUIDE THICKNESS

Here we elaborate on influence of thickness variations of the magneto-optical EuSe slab.

In the simplest case of a bare magneto-optical film, the polarization rotation is proportional to the film thickness, which is the primary parameter determining the polarization rotation at a given wavelength. However, in the case of the demonstrated hybrid structures, this is only true for wavelengths far away from the

TE and TM modes. Here, the polarization rotation at a given wavelength is primarily determined by the overlap of the TE waveguide mode and TM waveguide-plasmon-polariton. In other words, there are now three primary parameters: the gold wire width, the grating period, and the film thickness. Each of these parameters determines the shape of the dispersion graph in figure 1 in the main article. The available optical path length resulting from the material thickness only plays a secondary role.

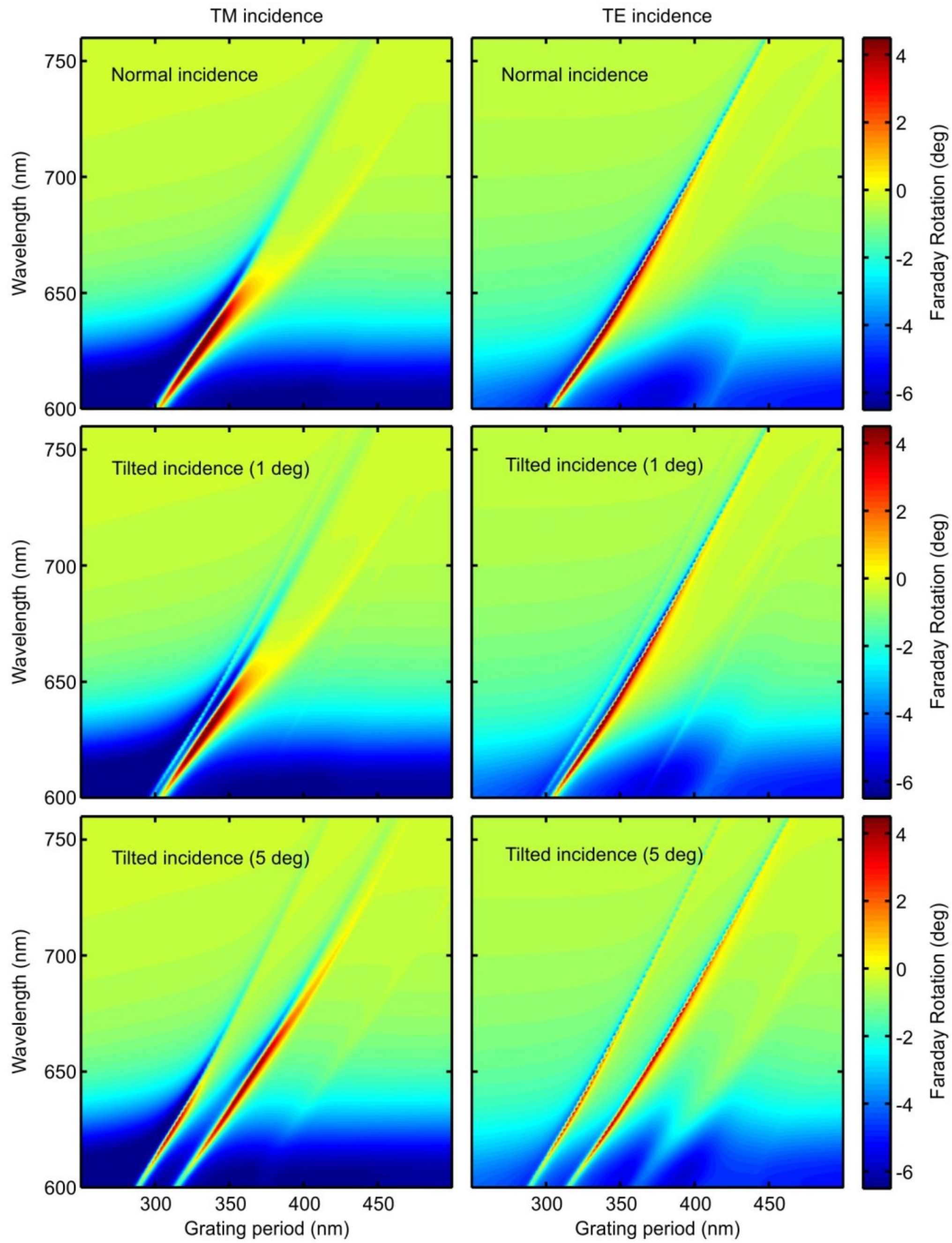

Figure S2: Dispersion of the Faraday rotation for different incidence angles.

To illustrate this, we assume that the wire width is fixed at 70 nm. According to the schematic in figure 1 in the main article, increasing (decreasing) the film thickness induces a redshift (blueshift) of the waveguide modes, whereas the plasmonic resonance remains at the same spectral position (in first approximation). As a result, the TE-TM overlap region shifts to longer (shorter) wavelengths. Figure S3a and S3b show simulated Faraday rotation dispersion spectra for different film thicknesses at different periods.

The simulations confirm that the Faraday rotation of the film alone (far away from the TE and TM modes) increases for thicker EuSe films. This is the behavior expected for bare films. They also confirm that the TE-TM-overlap region is shifted to the red for thicker EuSe films. There, the intrinsic Faraday rotation of EuSe is weaker and as a consequence also the enhanced Faraday rotation.

To summarize, the simulations confirm the dispersion of the Faraday rotation predicted by figure 1 in our manuscript and the theoretical discussion of modes in waveguide-grating structures.[1,2]

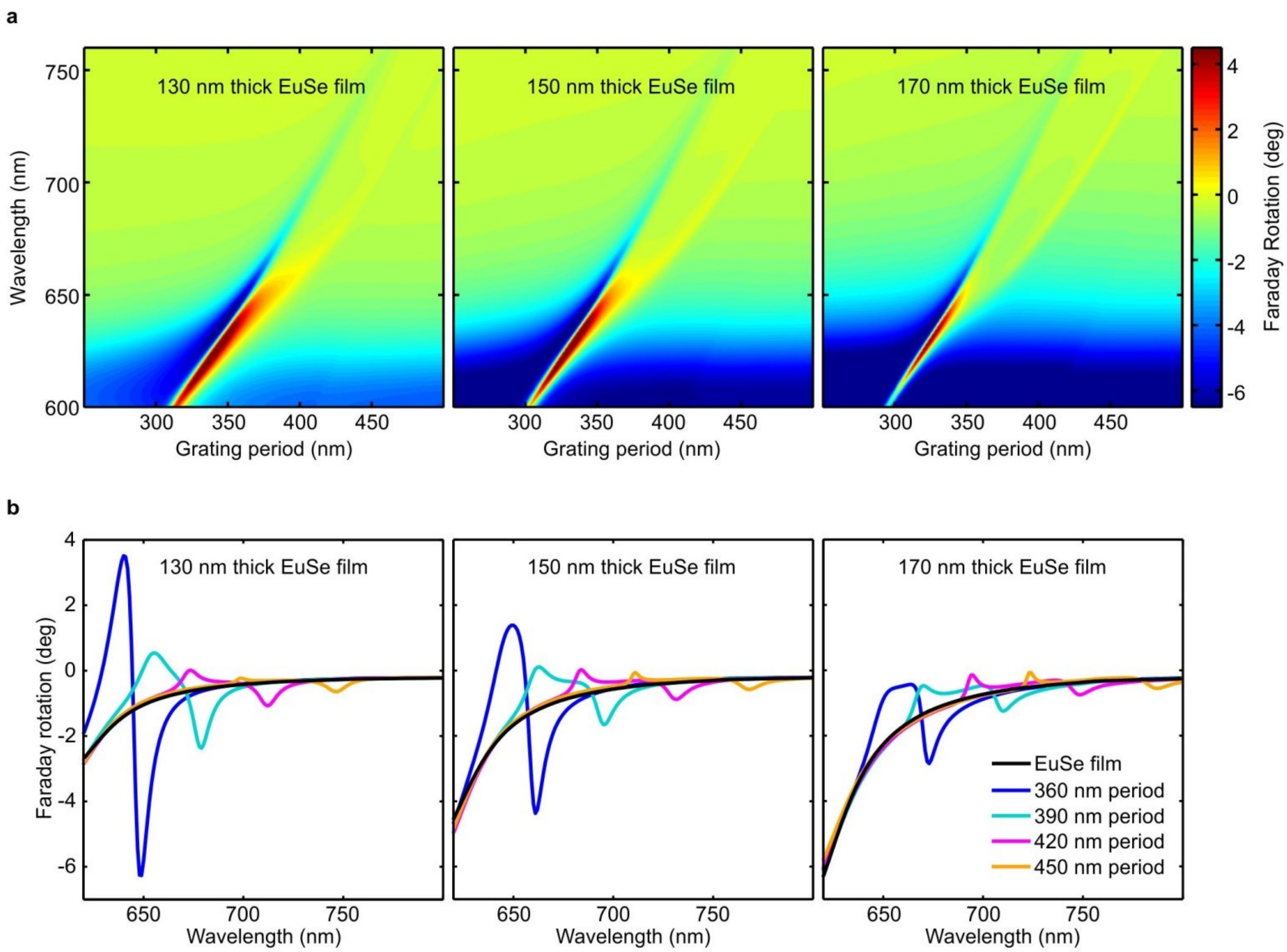

Figure S3: Dispersion on Faraday rotation for different EuSe film thicknesses for TM incidence.

REFERENCES

1 Christ A, Tikhodeev S, Gippius N, Kuhl J, Giessen H. Waveguide-Plasmon Polaritons: Strong Coupling of Photonic and Electronic Resonances in a Metallic Photonic Crystal Slab. *Phys Rev Lett* 2003; **91**: 1–4.

2 Christ A, Zentgraf T, Kuhl J, Tikhodeev S, Gippius N, Giessen H. Optical properties of planar metallic photonic crystal structures: Experiment and theory. *Phys Rev B* 2004; **70**: 1–15.