Element-specific magneto-optical Kerr spectroscopy of Fe/Tb multilayers

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Magneto-optical Kerr effect is known as a powerful method for studying magnetic properties of layered structures. In this work it is demonstrated that under some conditions the Kerr efect can be also an element-specific selective technique in the investigation of complex structures. Magnetic properties and magneto-optical spectra have been studied for a series of Fe/Tb multilayers (MLS) prepared by dc- sputtering on Si(111) substrates with constant Tb sublayer thickness and Fe sublayer thickness changing in the range 1-3 nm. The magnetic properties of the multilayers were studied by measuring hysteresis loops of the Kerr rotation and ellipticity angle in the polar configuration with the magnetic field normal to the sample plane as a function of the wavelength of light.

The investigation of the hysteresis loops in the Fe/Tb MLS studied reveals complex magnetic structures related to the structural heterogeneity of the MLS that can be interpreted as a superposition coming from Fe-Tb interface alloy region with perpendicular anisotropy and a modified Fe volume. In Fig. 1 the polar Kerr rotation hysteresis loops measured at different wavelengths for the multilayer of 70Å Au/[12Å Fe/10.8Å Tb]×50 /50Å Fe/Si are presented.

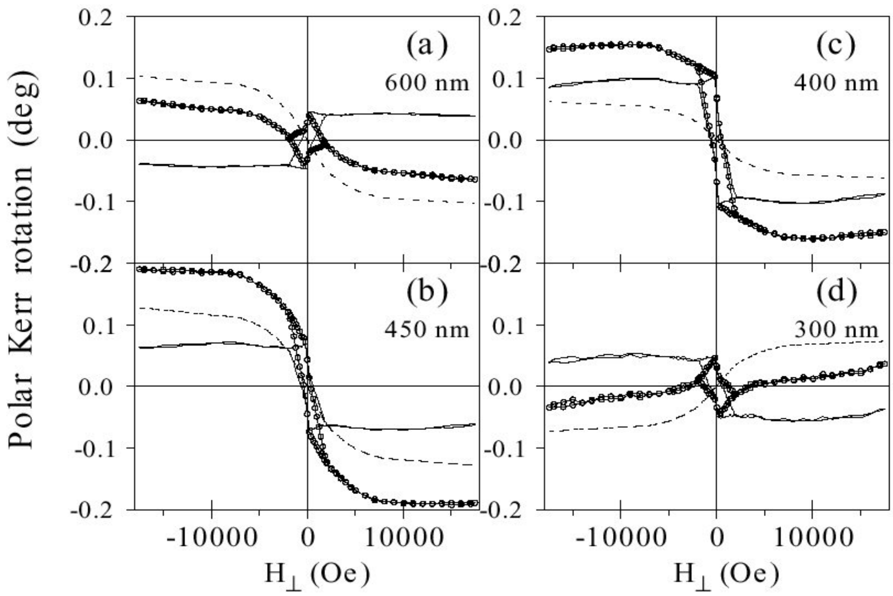

Fig. 1. Decomposition of the polar Kerr rotation hysteresis loops (circles) measured at different wavelengths for 70Å Au/[12Å Fe/10.8Å Tb]×50 /50Å Fe/Si multilayer into the contributions coming from the Fe-Tb interface alloy volume (solid lines) and from the modified Fe volume (dashed lines).

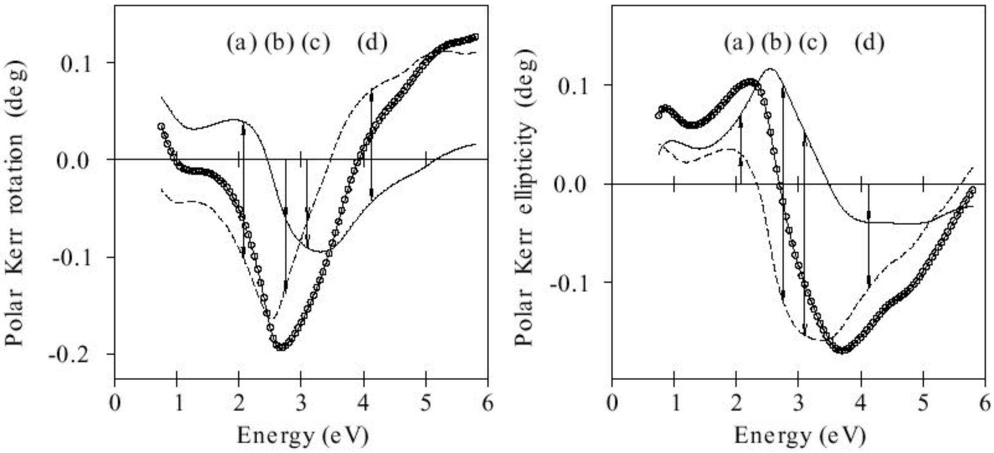

Fig. 2. The polar Kerr rotation and ellipticity spectra of 70Å Au/[12Å Fe/10.8Å Tb]×50 /50Å Fe/Si multilayer measured in the saturation state (circles) and in the remanence (solid lines), representing the Fe-Tb interface alloy volume. The difference spectra, representing the modified Fe volume are denoted by dashed lines. The vertical arrows represent the amplitudes of the corresponding parts of the hysteresis loops shown in the panels (a), (b), (c), and (d) in Fig. 1.

It is seen the high sensitivity of the form and amplitude of the hysteresis loops on the light wavelength. To resolve different contributions to the hysteresis loops coming from different volumes of the multilayer, the Kerr rotation and ellipticity spectra in a wide range of photon energy 0.7-5.8 eV were measured. The complex Kerr rotation spectra of the Fe/Tb MLS in both remanence and saturation states of the samples were measured and the contributions coming from the Fe-Tb interface alloy [1, 2] volume (solid lines) and from the modified Fe volume (dashed lines) have been evaluated (Fig.2.). The change of orientation of Fe magnetic moments with respect to the applied field was observed for Fe sublayer thickness above 2nm. The strong influence of protective Au layer on the effective optical and magneto-optical properties of the Fe/Tb MLS has been also observed and studied. In conclusion, due to high compositional magneto-optical contrast of different sublayers in the Fe/Tb multilayers, the element-specific magnetization processes can be studied. In the Fe/Tb multilayers studied the reorientation of magnetization direction of the Fe-Tb interface volume takes place at Fe thickness in the range of 18-24 Å. The results demonstrate that the use of magneto-optical Kerr effect can be useful in resolving complex magnetization processes in layered structures.

[1] S.J. Lee, R.J. Lange, P.C. Canfield, B.N. Harmon, and D.W. Lynch, Phys. Rev. B 61, 9669 (2000).
[2] L. Uba, S. Uba, E.V. Shipil, O.M. Kuzmak, and S.Ya Kharitonsky, Fizika Nizkikh Temperatur 18, Suppl. S1, 345 (1992).

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