Spectroscopic Ellipsometry for Metamaterials by Glancing Angle Deposition

D. Schmidt*, T. Hofmann, E. Schubert, and M. Schubert

+ Department of Electrical Engineering and Nebraska Center for Materials and Nanoscience, University of Nebraska-Lincoln, U.S.A.

*schmidt@huskers.unl.edu
ellipsometry.unl.edu

Our Message

- Glancing angle deposition is utilized to grow achiral and chiral metallic sculptured thin films
- Generalized Ellipsometry (GE) is employed to determine optical and geometrical properties; slanted columnar thin films have monoclinic optical properties
- Polar Magneto-Optical Kerr Effect measurements are analyzed to determine magneto-optical activity and giant Kerr rotation of low-symmetric ferromagnetic nanostucture thin films was measured
- Vector Magneto-Optical Generalized Ellipsometry (VMOGE) allows for determination of the entire dielectric tensor by measuring at arbitrary magnetic field orientations and will give insight into magnetic domain switching of complex nanostructures

Ferromagnetic Nanostructures


Generalized Ellipsometry

Ellipsometry measures the polarization state change of an electromagnetic wave upon reflection off a sample surface.

If the sample is anisotropic, generalized (Mueller matrix) ellipsometry allows for determination of complete and accurate sets of optical constants.

Dielectric Tensor

The 4x4 real-valued Mueller matrix connects the incident and emergent Stokes vector components, which are linear combinations of different polarization states.

Monoclinic Slanted Columnar Thin Films

Mueller Matrix Ellipsometry

Generated and experimental non-redundant Mueller matrix data at different angles of incidence versus sample azimuth

Magneto-Optical Generalized Ellipsometry

Polar Magneto-Optical Kerr Effect

The sample is magnetized in a magnetic field created by an electromagnet. Generalized ellipsometry in the polar configuration (incident light parallel to the magnetic field) can be performed by shining light through a hole in the magnetic pole piece.

Photon Energy in eV

At 1.8 T all domains are parallel to the external magnetic field. Only an azimuthally independent \( \theta \) is necessary to model magneto-optic coupling.

Giant Kerr-Rotation

Giant Kerr rotation is calculated and observed for certain in-plane orientations.

Octupole Magnet

An octupole vector magnet allows for generalized ellipsometry measurements at arbitrary magnetic field orientations.

0.4 T is not sufficient to force all domains along the external magnetic field \( \rightarrow \) also \( \theta \) present in present configuration, for example

Vector Magneto-Optical Generalized Ellipsometry

LP-VMOGE Results

\( \theta = \cos^{-1}(\theta) \)

\( \sin^{-1}(\theta)/\cos^{-1}(\theta) \)

Acknowledgements

Funding: CAREER, MRSEC, COE, JAWF

ICSE-V, International Conference on Spectroscopic Ellipsometry, Albany, NY, May 2010