Generalized Magneto-Optical Ellipsometry (GME) for Magnetic Materials Characterization

A. Berger

CIC nanoGUNE Conslider, E-20018, Donostia-San Sebastián, Spain

a.berger@nanogune.eu

For the past several decades, ellipsometry has proven itself as an advanced measurement and characterization technique for optical materials properties as well as a crucial metrology tool for multilayer and film growth. Its applications are widespread, reaching from basic research to industrial utilization, furthermore initiating the growth of an ellipsometer instrumentation industry. Besides numerous other advantages, ellipsometry is non-destructive, fast, compatible with many environmental conditions and can be implemented even through very simple experimental configurations.

A more recently developed implementation and extension of this technique, named Generalized Magneto-Optical Ellipsometry (GME), has emerged during the last decade as a methodology to characterize magnetic materials with a high degree of precision, by means of utilizing the magneto-optical Kerr effect [1-2]. Compared to other magneto-optical characterization methods based on the same effect [3-4], GME has two key advantages: it can measure both the optical and magneto-optical constants simultaneously and with a high degree of precision, and it allows full vector magnetometry, all with only one experimental set-up and measurement configuration. The GME method, which is based on measurements of the light reflection change upon applying a magnetic field cycle, know as hysteresis loop, has been successfully utilized in the study of diverse magnetization reversal processes [5], the investigation of magneto-optical coupling in ferromagnetic films [6], and for the purpose of identifying spin-polarized electronic states in multiferroic materials [7], as well as for the measurement of the magnetization orientation using two- and three-dimensional vector magnetometry [2,8].

In the talk, the GME methodology will be introduced, its experimental implementation presented and recent developments discussed, such as data set optimization [9] and the detection and methodological incorporation of optical anisotropy [10], which is so far generally ignored in the realm of most magneto-optics measurements.

The author acknowledges fruitful discussions with J.B. Gonzalez-Diaz, O. Idigoras, J.A. Arregi, and E. Bergaretxe on the topic of GME and magneto-optics in general. Funding from the Basque Government under Program No. PI2009-17 and the Spanish Ministry of Science and Education under Project No. MAT2009-07980 is acknowledged.

References

[1] A. Berger and M. R. Pufall, Appl. Phys. Lett. **71**, 965 (1997)
[2] A. Berger and M. R. Pufall, J. Appl. Phys. **85**, 4583 (1999)
[3] K. Sato, Jpn. J. Appl. Phys. **20**, 2403 (1981)
[4] W. S. Kim, M. Aderholz and W. Kleemann, Meas. Sci. Technol. **4**, 1275 (1993)
[5] M. R. Pufall and A. Berger, J. Appl. Phys. **87**, 5834 (2000)
[6] K. Mok, G. J. Kovacs, J. McCord, L. Li, M. Helm, and H. Schmidt, Phys. Rev. **B 84**, 094413 (2011)
[7] M. Bastjan, S.G. Singer, G. Neuber et al., Phys. Rev. **B 77**, 193105 (2008)
[8] K. Mok, N. Du and H. Schmidt, Rev. Sci. Inst. **82**, 033112 (2011)
[9] J.A. Arregi, J.B. Gonzalez-Diaz, E. Bergaretxe, O. Idigoras, T. Unsal, and A. Berger, submitted to J. Appl. Phys.
[10] J.B. Gonzalez-Diaz, O. Idigoras, J.A. Arregi, E. Bergaretxe, and A. Berger, in preparation