Magneto-Optical Faraday Effects in Hybrid Au/SiO_2/Ni Dimer Lattices

S. Pourjamal[1], M. Kataja[1], N. Maccaferri[2], P. Vavassori[2,3], and S. van Dijken[1]

[1]NanoSpin, Department of Applied Physics, Aalto University School of Science, P.O. Box, 15100, FI-00076 Aalto, Finland
[2]CIC nanoGUNE, 20018 Donostia-San Sebastian, Spain
[3]IKERBASQUE, Basque Foundation for Science, 48011 Bilbao, Spain
email: sara.pourjamal@aalto.fi

Magneto-optical effects such as the Faraday and Kerr effect (MOKE) offer the ability to tune the optical response of magnetic materials via external magnetic fields, enabling their use in controllable plasmonic components. Recently, we have shown that the magneto-optical response of ferromagnetic nanoparticles is strongly influenced by localized surface plasmon resonances (LSPRs) [1] and that the magneto-optical activity is enhanced by far-field diffractive coupling between localized plasmon modes in ferromagnetic nanoparticle arrays [2-4]. Hybrid structures, such as nanodisks wherein a dielectric layer separates ferromagnetic and noble metal components, have also been explored as plasmonic systems with integrated magneto-optical activity [5,6]. In this case, the magneto-optical response is determined by near-field dipole-dipole interactions.

Here, we report on magneto-optical Faraday effects in ordered arrays of Au/SiO_2/Ni nanodisk dimers. In our lattices, the magneto-optical activity sensitively depends on near-field *and* far-field coupling effects, which we tune separately by variation of the SiO_2 spacer layer thickness and lattice periodicity. The complex interplay of inter- and intra-particle interactions provides a rich playground for designer magneto-plasmonics. For optimized parameters, the magneto-optical Faraday effect in our hybrid dimer lattices is significantly enhanced. The experimental results are confirmed by numerical simulations based on the Maxwell-Garnet effective medium and discrete dipole approximations, as well as finite difference time domain (FDTD) simulations.

[1] N. Maccaferri et al., Phys. Rev. Lett. 111, 167401 (2013)
[2] M. Kataja et al., Nature Commun. 6, 7072 (2015)
[3] M. Kataja, S. Pourjamal, and S. van Dijken, Opt. Exp. 24, 3562, (2016)
[4] M. Kataja, et al., Opt. Exp. 24, 3652 (2016)
[5] J.C. Banthi et al., Adv. Mater. 24, OP36 (2012)
[6] N. de Sousa et al., Phys. Rev. B 89, 205419 (2014)