Photolithography of magneto-optical grating with modulable properties by piezoelectricity

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The integration of magneto-optical (MO) component on conventional platforms (glass, polymer, SOI or semiconductor) is a technological challenge that has endured since the first demonstration, more than 30 years ago, by Castéra et al [1] . Indeed, MO materials generally require heat treatment at over 700 ° C, which is incompatible with their integration into optical chips with other functions. It has also been shown that the use of 1D structuring enhances these magneto-optical effects [2]. Our recent work shows the possibility of producing at RT, micro / nano MO grating by deep UV photolithography of a nanocomposite with high-performance MO properties based on a sol-gel doped with magnetic nanoparticles (NPM) and their integration for applications both in guided optics and in free space can thus be envisaged [3].

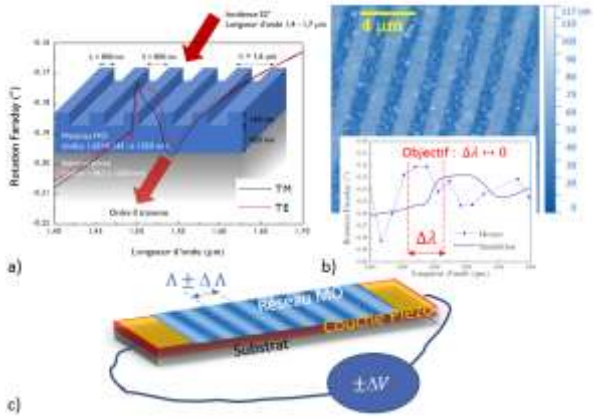

Fig. 1 : Simulation of a nanocomposite MO grating (a), AFM image of a photolithographed grating and measurement & simulation of its MO response (b), and the device considered to modulate the MO properties using a piezoelectric layer (c)

However, the design and manufacture of precise grating parameters is very important to obtain optimal operation of the targeted device. The modulation and tunability of the parameters of MO grating not only provide a means to adjust for manufacturing errors but also a mechanism to increase the functionality of the device as well as a wider range of operating wavelengths.

The goal of this thesis will be to study and control the modulation of photolithographed magneto-optical networks deposited on a thin layer of piezoelectric material which choice will depend essentially on the specific properties expected to meet the requiered needs. Well-known conventional piezoelectric ceramic materials like lead titano-zirconates (PZT) require HT annealing, so it is proposed to use ferroelectric polymer materials such as poly (vinylidene fluoride) and its poly (vinylidene fluoride) copolymer. -co-trifluoroethylene) [4]. Alternatives could be considered, such as the crystallization of the copolymer under confinement (in nanotubes), as well as nanocomposites produced with ferroelectric nanoparticles (PZT or BTO) in a P (VDF-TrFE) matrix which allow an improvement of the ferroelectricity [5]. Ultimately, the objective is the complete realization at low temperature of modular non-reciprocal optical components, hybrid piezo / MO grating structures, with a complete study of their properties (piezo, MO, ME coupling).

[1] J. Castera, G. Hepner, IEEE Trans. Magn. 13 (1977) 1583-1585
[2] S. Kahl, A.M. Grishin, , Applied Physics Letters, 84 (2004) 1438
[3] C. Bidaud, Thèse de doctorat UHA-Mulhouse (2018) ; C. Bidaud et al. (2020), Deep-UV Lithography of Nanocomposite Thin Films into Magnetooptical Gratings with Submicron Periodicity. ChemPhotoChem. doi:10.1002/cptc.202000048
[4] A. J. Lovinger, Science 1983, 220, 1115
[5] X. Zhang et coll., ACS Nano 2016, 10, 7279; M.-C. Garcia-Gutierrez, et al, Nanoscale 2013, 5, 6006