DEEP-UV LITHOGRAPHY OF NANOCOMPOSITE THIN FILMS INTO MAGNETOOPTICAL GRATINGS WITH NANOMETRIC PERIODICITY

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ABSTRACT:

Non-reciprocal magneto-optical (MO) devices are essential components for the development of innovative integrated devices in telecommunication technologies or sensing applications. However, actual MO materials require multi-steps processes at high temperature which impedes a direct integration as optical components in complex systems. Thanks to its formulation flexibility, the sol-gel chemistry is a powerful way to develop new functional materials. In this work, we prepared a MO material, based on a sol-gel matrix doped with magnetic nanoparticles (MNP). [1,2]
The sol gel matrix is prepared from inorganic precursors. Titanium acts as photoinitiator under Deep UV irradiation (DUV) [3]. The first challenge of this composite approach lies in the incorporation of crystalized MNP in the photostructurable host matrix in a randomly dispersed regime, and the avoider of any aggregation. The MNP has been chosen to exhibit good MO properties: at a 1.5 µm wavelength the cobalt ferrite $CoFe_2O_4$ NP present an enhanced Faraday rotation, which is the MO effect expected here.
Moreover, this MNP doped matrix has been nanostructured (500 nm periodicity) through direct Deep UV laser writing process. The preparation of such structures with a sub-micrometric period hence does not necessitate any curing, which is coherent with the integration of this MO optical material in complex optical devices.
The combination of the intrinsic MO effect of the MNP with a nanostructure allowed us to obtain a good Faraday rotation: those structured thin films turn out to be excellent candidates to be used as a MO qualified material. [4] A demonstrator of a Faraday rotator has been prepared, which consists in this nanostructured hybrid material deposited on a waveguide, with properties that are comparable to the devices commercially available [5].

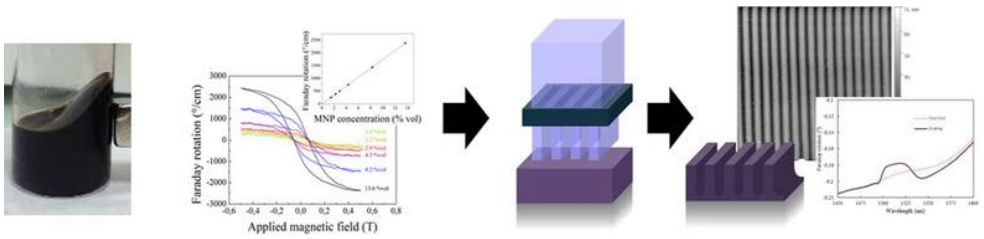

Figure 1: The photosensitive hybrid sol-gel matrix with $CoFe_2O_4$ MNPs, to obtain a hybrid magneto-optical nanocomposite film doped by up to 20%vol with NPs that can be photostructured using lithography methods to obtain a submicrometer periods MO gratings.

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References

1- F. Stehlin, et al., J. Mater. Chem. 2 (2014) 277-285.
2- H.C. Lin, et al., Scientific Reports. 5 (2015).
3- C. Bidaud, et al., Scientific Reports 11 (2021) Article number 5075. DOI : 10.1038/s41598-021-84376-6
4- H. Amata, et al., Appl. Phys. Lett. 99 (2011).
5- C. Bidaud et al., (2020). ChemPhotoChem 4 (2020), 5353-5363. DOI : 10.1002/cptc.202000048