

Impact of magneto-optical properties depending on the orientation in the plane of cobalt ferrite locked in a silica matrix.

ABSTRACT :

In this work, we discuss the magneto-optical properties according to the orientation of 15nm-sized cobalt ferrite blocked in a silica matrix in comparison to the study done on 20nm-sized cobalt ferrite. This measurement shows that it is possible to increase the remanence of the Faraday effect by creating a magnetic orientation in the solid matrix, which is interesting for the production of self-polarized components. In addition, this remanence is greater for 15 nm than for 20 nm. A gelation field applied perpendicular to the plane of the layer therefore produces a preferential orientation of the magnetic moments in the direction of the field applied during the measurement.

Keywords : Magnetic liquids, thin layers, cobalt ferrite, sol-gel, Faraday rotation

I. INTRODUCTION:

Having particular magnetic and physical properties, many studies are done on cobalt ferrite nanoparticles in research laboratories for the past twenty years. The development of thin films based on cobalt ferrite and the mastery of this technique have made it possible to achieve enormous progress in the production of self-polarized components. Our choice to develop thin layers of cobalt ferrite by sol-gel process is that this technique preserves the stoichiometry, and requires a combination of good quality and low cost.. In this work, we are interested in the impact of magneto-optical properties according to orientation in the plane of cobalt ferrite blocked in a silica matrix [1,2]. The general objective is to confirm the gelation obtained during previous work in the laboratory and to improve the persistence under gelation.

II. MATERIALS AND METHODS

II-1. Materials

The silica matrix ($\text{SiO}_2 / \text{ZrO}_2$) used was produced by the sol-gel route according to the protocol [3,4] obtained at the LaHC Laboratory. Then the sol will be doped with the 15 nm-sized cobalt ferrite nanoparticle [5]. The nanoparticle is obtained according to the protocol of R. Massart [6] by co-precipitation and an additional hydrothermal treatment at the PHENIX

Laboratory. The study focused on thin films doped with cobalt ferrite nanoparticles of size 15 nm. More specifically, in each case it concerns:

- a thin layer obtained outside the magnetic field: i.e. just after the deposition, the layer has undergone a heat treatment for one hour then UV treatment for 20 minutes (reference sample)
- a thin layer produced and treated under the influence of a perpendicular magnetic field of amplitude 0.7T or 7000 Oe. This is obtained through an electromagnet large enough so that the printing machine can be placed in the air gap.
- a thin layer produced and treated under the influence of a perpendicular magnetic field

II-2. Methods

The spectral polarimetric bench in **Figure 1** was used for the characterization of the samples. The Faraday rotation is achieved by sending unpolarized light from a lamp. Then the light is linearly polarized after exiting the polarizer; and after the sample it is elliptically polarized. All the rest of the elements then make it possible to determine these two parameters: the ellipticity and the Faraday rotation.

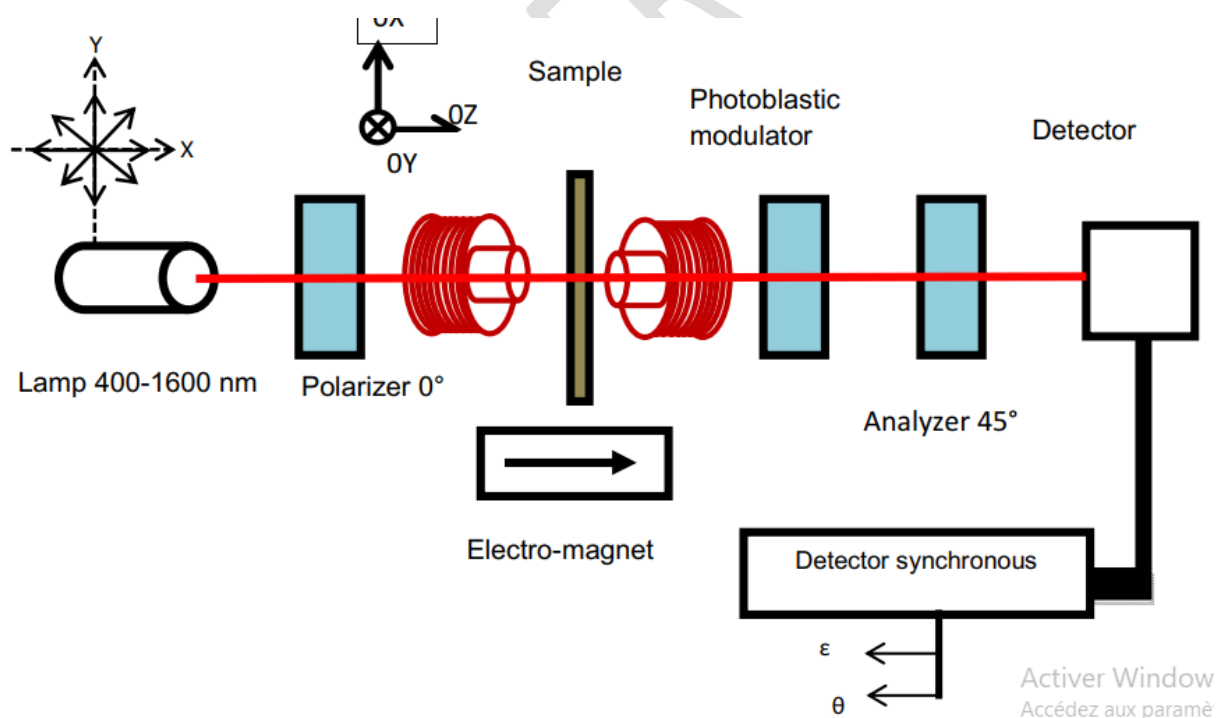


Figure 1 : Spectral polarimetric setup using the modulator photo-elastic

We explain it this way: a luminous vibration from the light is sent to the sample via a polarizer. The magnetic field applied to the sample induces anisotropy in the middle. This

transforms the incident rectilinear state into an elliptical state. The modulator causes the ellipse to oscillate at the frequency $f = 50$ kHz by an angle Θ_F . [11]

III- RESULTS AND DISCUSSION

The Faraday effect measurements made on each of these samples are shown in **Figure 2** and the Faraday rotations of the three samples are shown. These figures show that the magnetic behavior of the three types of samples is different. A perpendicular to the magnetic field applied during gelation induces a increase in remanence and coercive field. The opposite is true for the. The field applied during the product an orientation of the magnetic moments therefore axes of easy magnetization since the particles are then able to move within the host matrix still saturated with solvent. In addition, here the remanence is greater than that observed on the 20 nm size [1]. The measurements were made at the wavelength of 820 nm.

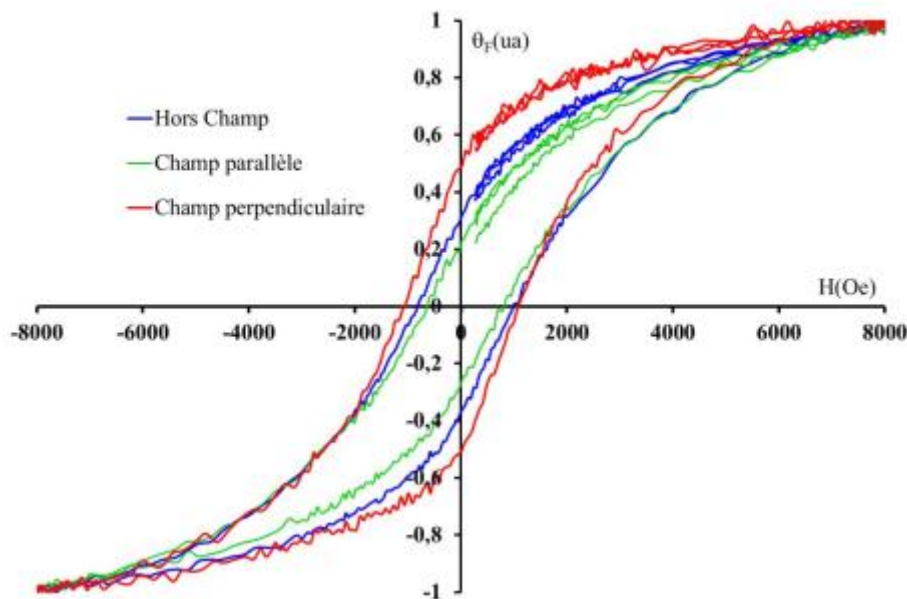


Figure 2 : Comparison of the normalized Faraday rotation between a thin film performed out of field, one under the influence of a magnetic field parallel to the plane of the layer, and one under the influence of a perpendicular field.

By comparison, we have plotted in **Figure 3**, the orientation effect for the 20 nm-sized nanoparticle obtained by simple co-precipitation; and in **Figure 4** the orientation effect demonstrated by F. Choueikani during his work at the Laboratory [7]. These are 12 nm size

cobalt ferrite nanoparticles obtained by simple co-precipitation and without hydrothermal treatment.

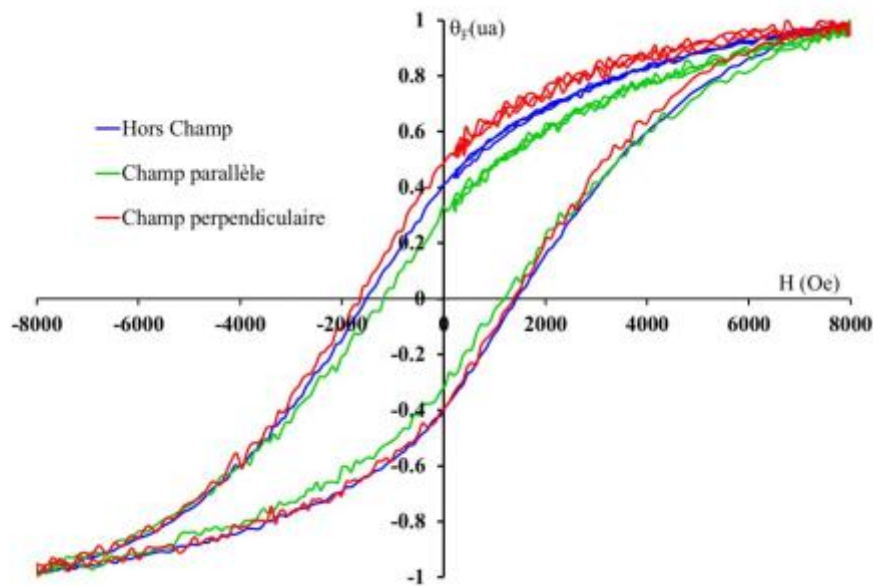


Figure 3 : Comparison of the normalized Faraday rotation between a thin film performed out of field, one under the influence of a magnetic field parallel to the plane of the layer, and one under the influence of a perpendicular field. Sample: S487, size 20 nm [1].

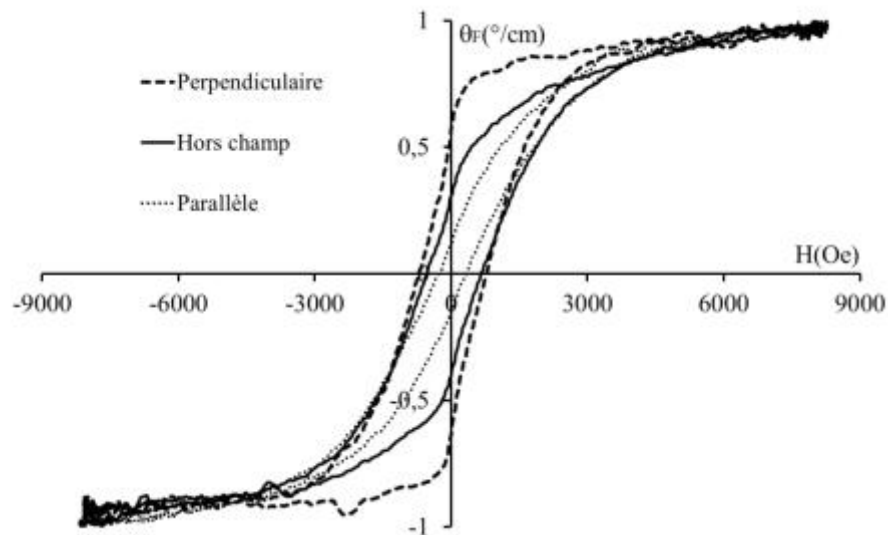


Figure 4 : Orientation effect on Faraday rotation [7]

The orientation effect is therefore much greater, which seems confirm that simple co-precipitation leads to the production of rather uniaxial nanoparticles, while the addition of hydrothermal treatment leads to the production of particles with multi-axis (cubic) anisotropy.

Ultimately, to maximize the effect of self-polarized components, it is necessary to orient the nanoparticles during matrix gelation, use large size particles and favor that obtained by simple co-precipitation.

IV- CONCLUSION

We have illustrated in this work the magnetic behavior of the Faraday effect produced by Cobalt ferrite nanoparticles. In the case of magneto-optical applications based on the use of solid composite material, the following elements can be retained:

- To promote the low field sensitivity of a magnetic field based sensor on using the Faraday effect, an average size of 10nm is most appropriate.
- To promote the remanence of the self-polarized components, it is necessary to increase the size of the particles, and to generate a preferential magnetic orientation. In this case, the hydrothermal treatment does not necessarily seem the most adequate.

In general, it is more advantageous to use cobalt ferrites obtained by co-precipitation.

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