# Detection of thin ferromagnetic layers based on Faraday effect

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**Abstract**

Optical head with magnetized garnet layer is used to detect presence of thin ferromagnetic layers such as printed text. Mathematical model of the system presented further was created. By varying opaque material, layer thicknesses and air gap between optical head and scanned object optimal configuration of the system was calculated. Incident P-polarized light affected by garnet layer changes its polarization due to Faraday effect. We can detect presence or absence of ferromagnetic after studying changes in polarization of the reflected light. Comparing results with and without influence of the ferromagnetic layers recognition of printed pattern under opaque material is achieved.

*Keywords:* ferromagnetics; detection; Faraday effect; plasmonics; magneto-plasmonics

## 1. Introduction

Recently, magneto-optic effects and their applications are becoming subjects of high interest. Magneto-plasmonic periodic structures with gold grating and ferrite garnet layers have great potential when it comes to resonant amplification of transmittance coefficient and Faraday effect[1,2].

Layers of ferromagnetic creates magnetic image that can be detected and resolved. Carriers of these magnetic images are securities, banknotes and audio and video recordings. Recognition of the images will lead to successful verification of such documents, without any direct contact with the object. Aim of this work was to understand the realization of mentioned effects and their possible practical implementation.

## 2. Method realization

The principle working scheme of the optical scanning head is shown on Fig.1. Incident P-polarized light changes its polarization and reflects onto analyzer [3]. Change occurs due to Faraday effect because light is influenced by magnetized garnet layer. When we scan an object that contains ferromagnetic layer, garnet demagnetizes and we can observe significant change in the polarization angle of the reflected light. By adjusting layer heights we can create resonating structure that amplifies the effect.

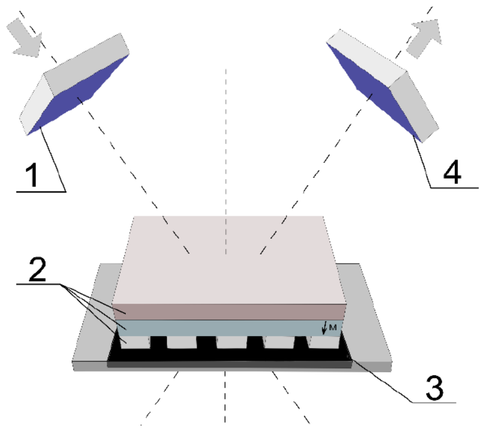


**Fig. 1.** Optical scanning head scheme. 1 - polarizer, 2 - magneto-optic structure, 3 - ferromagnetic layer, 4 - analyzer.

Experimental model of described device for the visualization and registration of magnetic images can be seen on Fig. 2. Different light sources and image capturing and analyzing systems can be attached.

In course of this work, mathematical model of the system, based on finite element analysis has been created. Geometry of the model shown on Fig. 3. Layers 1 and 6 are glass substrate ($SiO_2$), 2 is ferrite garnet (BYIG), 3 is gold grating, 4 is medium (Air) and 5 is ferromagnetic (Fe). By comparing results we got to know the relations of Faraday angle with grating height $h$, garnet height $h_g$, period $d$ and incident angle $\theta$.

Mathematical modeling enabled us to gain results such as Faraday rotation spectra shown in Fig.4. Here we have light incident at $\theta = 60°$, $h = 100nm$, $h_g = 650nm$, $d = 400nm$. Ferromagnetic layer height in this example is 70 nm. We have studied four different configurations of the structure, compared and analyzed gathered results.

**Fig. 2.** Device experimental model.

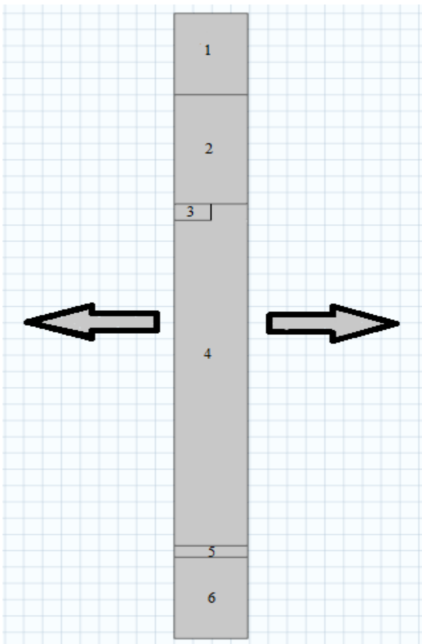


**Fig. 3.** Periodic mathematical model.

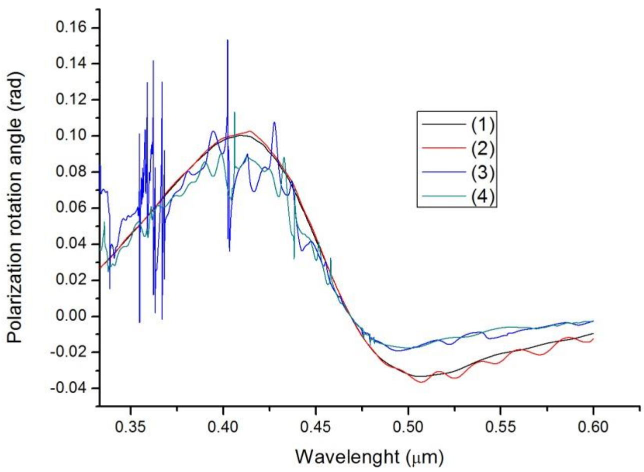


**Fig.4.** Faraday rotation spectra. (1) without ferromagnetic and gold grating; (2) with ferromagnetic, but without gold grating; (3) with ferromagnetic and gold grating; (4) without ferromagnetic, but with gold grating.

Here we can clearly see that presence of the ferromagnetic strongly influences Faraday angle. Additionally we can observe the amplification of the magneto-optic effect occurring because of excitation of quasi waveguide modes provided by gold grating.

## 3. Conclusion

Based on mathematical modeling and theory we can say that detection of the magnetic images with the method described above is a concept possible to realize. This will improve verification and security systems, add new layers of safety against forgery.

## References

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