Magnetic information sensing based on magneto-optic plasmonic nanostructure

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Abstract. Magnetized garnet layer is used to detect thin ferromagnetic layers. Incident light changes its polarization when passing through garnet layer due to Faraday effect. External sources of magnetic field impacts this process. We can detect these changes and so understand nature of external sources.

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 and silver grating and ferrite garnet layers have great potential when it comes to resonant amplification of polarization rotation due to Faraday effect[1-4].

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

2. Method realization

Please 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 [5]. 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.

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. 2. This is an example of one period of the structure. Layers 1 is gadolinium gallium garnet (GGG), 2 is magnetized ferrite garnet (BYIG), 3 is gold or silver grating, 4 is medium (Air), 5 is ferromagnetic (Fe) and 6 is substrate (SiO_2). By comparing results we got to know the relations of Faraday angle with grating step height h, spacing between grating steps l, garnet height h_g, period d and incident angle θ.

Mathematical modeling enabled us to gain results such as Faraday rotation spectra shown in Fig.3. Here we have silver grating for plasmon resonance. Particular structure with next parameters is suitable for studying with helium-neon laser due to its peak performance appearing at around 632.8nm wavelength $h = 40nm$, $h_g = 500nm$, $d = 310nm, l = 60nm$ and incident P-polarized light at 10°.

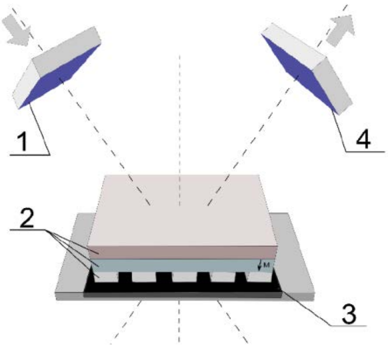

Figure 1. Optical scanning head scheme. 1 - polarizer, 2 - magneto-optic structure, 3 - ferromagnetic layer, 4 - analyzer.

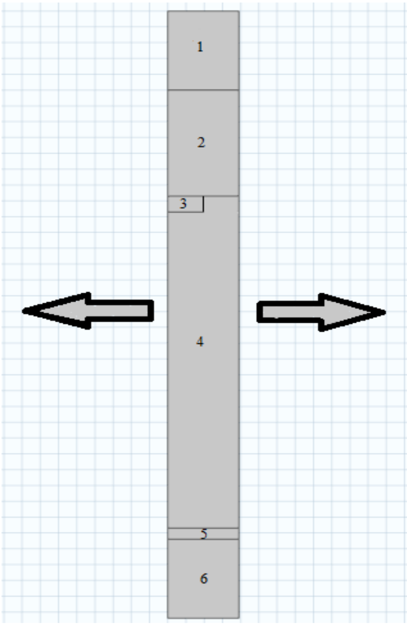

Fig. 2. Periodic mathematical model.

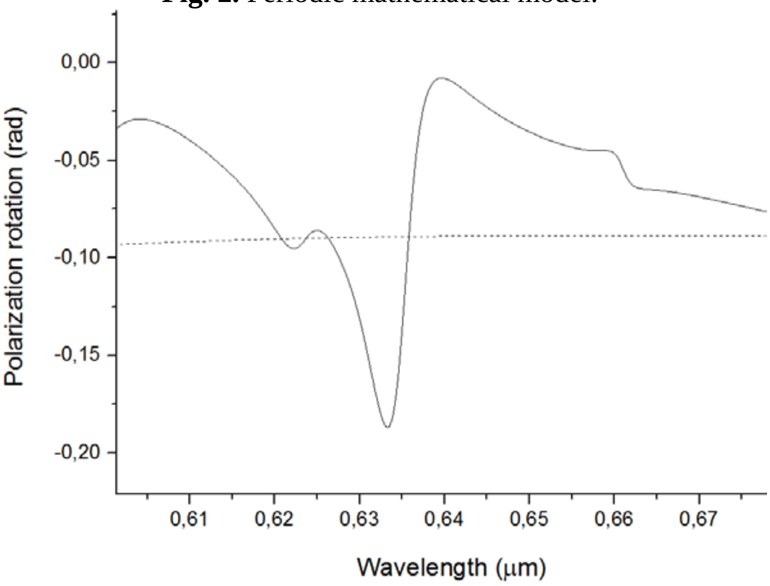

Fig.3. Faraday rotation spectra. Strait line – spectrum with grating, dash line – spectrum without grating.

We can observe the amplification of the magneto-optic effect occurring because of excitation of quasi waveguide modes provided by silver grating. In this example we have a three times amplification, though as further investigation have shown, much better amplification can be obtained using light sources with wavelength closer to IR.

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. Polarization rotation amplification can noticeably improve sensing ability of devices based on these effects. This will improve verification and security systems, add new layers of safety against forgery.

4. References

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