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ANALYSIS OF MAGNETO OPTICAL PROPERTIES IN NOVEL MAGNETIC SUPERLATTICE SYSTEM

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ABSTRACT- The variation of refractive index with frequency of Silver doped magnetic material (YIG) of bulk nanocomposite system is studied. Hence, the polariton dispersion of a novel magnetic superlattice system consisting alternating layers of YIG based metal nanocomposite system and YAG is studied. The polaritonic gap is analysed for various filling factor for both the bulk and superlattice system. It is found that the width of the polaritonic gap is reduced in the case of superlattice system when compared to the bulk system.

KeyWords- [Phonon-Polariton; Superlattice; Nanocomposites; YIG/YAG]

1. INTRODUCTION

The basic and applied research of modern condensed matter materials relies on the development of new materials or in unusual configurations. The discovery and preparation of novel magnetic materials with unusual geometries and properties are the current basic research for many morden magneto optical devices. Magnetic polaritons [1,2], coupled electromagnetic and spin wave modes, although discussed by many authors in magnetic films and superlattices is a topic of continuing interest. The effective-medium description was realized by Raj and Tilley for polaritons in magnetic superlattices [3]. The increasing interest in superlattice structures, in which successive layers of two different component media are deposited to form a specimen has led to drastic change in its behavior. Magnetic SL's composed of magnetic materials (ferromagnetic or antiferro-magnetic) have been studied extensively [4,5].

In this work the superlattice consist of silver nano particles doped YIG nanocomposite system and YAG as alternative layers. The effective permeability with frequency of the nanocomposite system is calculated using the equation

$$\text{«}_{eff} = \left(\frac{\mu_1(\mu_1 + \mu_2) - \mu^2}{\mu_1{}^2 - \mu^2} \right) \qquad (1)$$

$\mu_1 = \gamma H_0$

$\mu_2 = 4\gamma\pi M_0$

H_0 = applied magnetic field
M_0 = saturation magnetization
γ = gyromagnetic ratio

The bulk metallic dielectric permittivity with Drude approximation of the nanoparticles system can be expressed in the following way

$$\varepsilon_m(\omega) = \left(1 - \frac{\mu_p^2}{\omega^2}\right) \quad (2)$$

Where ωp is a plasma frequency

The effective permittivity of silver doped nanocomposite system is calculated using Maxwell-Garnet equation[6] and is given by

$$\varepsilon_{eff} = \varepsilon * \frac{(2-f)\varepsilon_n(\omega) + f\varepsilon}{f\varepsilon\ (\omega) + (2-f)\varepsilon} \quad (3)$$

Where ε is dielectric constant of YIG

Hence the refractive index of the nanocomposite system can be calculated

$$n^2 = \varepsilon_{eff} * \mu_{eff} \quad (4)$$

The polariton dispersion of the novel superlattice consist of metal nanocomposite system and material YAG are the consititutant layers is using the following dispersion relation[3]

$$K_y^2(a+b)^2 = \varepsilon_{eff} = \frac{\omega^2}{C^2}(\mu_{eff}(a+b)(\varepsilon_{eff}a + \varepsilon_2 b) \quad (5)$$

Where a & b thickness of nanocomposite layer and YAG.

2. RESULT AND DISCUSSION

The variation of the square of the refractive index with the frequency is studied for the filling factor f=0.5 and shown in figure 1. From this the figure optical phonon frequencies are determined. Transverse optical phonon frequency of nanocomposite (μ_{TO}) and longitudinal optical phonon frequency of nanocomposite (μ_{LO}) are found be 330 THz and 319.9 THz respectively. It is found that the optical phonon frequencies increases with filling factor of the nanocomposite system.

The magnetic polariton dispersion of a magnetic material say YIG is analysed. The polaritonic gap lies in the GHZ region as in the literature. The width of the polaritonic gap is found to be 15 GHZ. When the nanoparticles are added in the system one more additional mode of propagation is formed in THZ region. Frequency of this mode is found decreases with filling factor of the nanocomposite system. In the case of novel magentic superlattice system, the dispersion is similar to the bulk nanocomposite system except small changes in the phonon frequencies. The polaritonic gap remains the same for various filling factor. It is almost constant and is equal to 7.5 GHZ which is very narrow compare to bulk nanocomposite system. Similar to the bulk material the frequency of top most mode decrease with the filling factor.

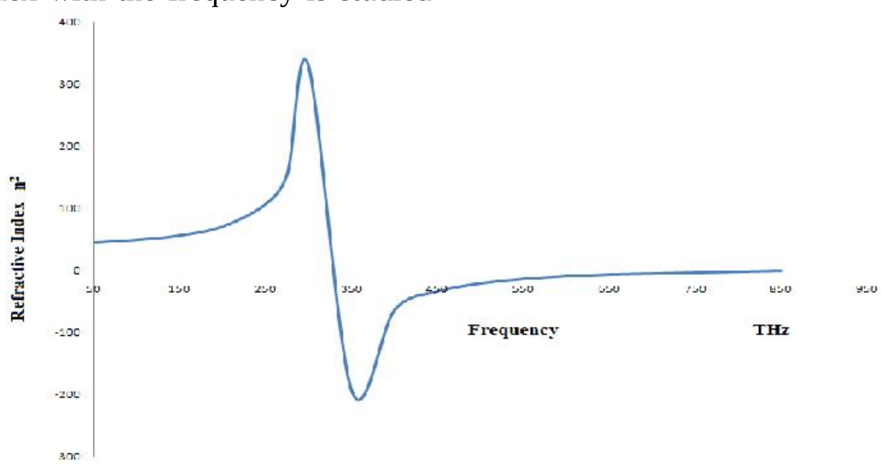

Figure 1- Variation of refractive index with filling factor f=0.5 of magnetic composite system

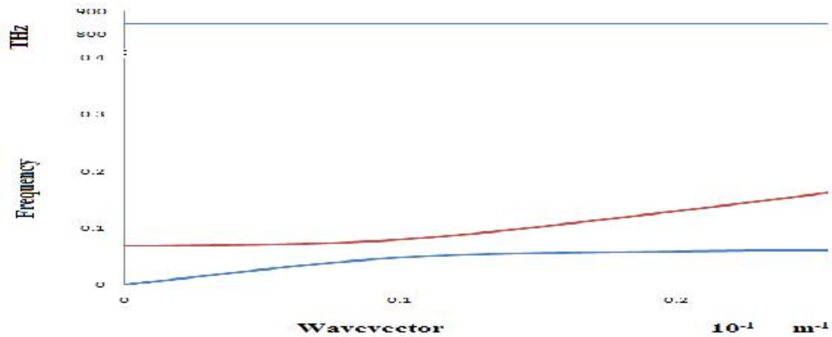

Figure 2- Polariton dispersion of novel magnetic superlattice with filling factor f=0.5.

CONCLUSION

The effective refractive index of the magnetic nanocomposite system is studied for various filling factors. It is found that the optical phonon frequencies increases with filling factor of the nanocomposite system. The polariton dispersion of a novel magnetic superlattice is analysed for a various filling factor. The width of the polaritonic gap is found be reduced due to the presence of metal nanoparticles. This type of tuning is applied in the field of optical communication.

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