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NEAR IR FARADAY ROTATION ON YIG DOPED WITH TETRAVALENT AND PENTAVALENT ELEMENTS

F. D'Orazio, F. Giammaria, F. Lucari and G. Parone

Dept. of Physics, Univ. of L'Aquila 67100, Italy

Abstract. – We report 300 and 4 K Faraday Rotation measurements in function of wavelength on bulk YIG doped with tetravalent (Ge, Sn, Zr) or pentavalent elements Sb. On the samples doped with octahedral localized dopage we observe spectra with maxima at 1.1, 1.45 and 2.05 μm and a strong dip at 1.75 μm . We analyse them in connection with Magnetic Circular Dichroism measurements.

Introduction

The study of the Yttrium Iron Garnet doped with tetravalent and pentavalent elements was extensively made with Magnetic Circular Dichroism (MCD) and Magnetic Linear Dichroism (MLD) measurements [1, 2]. The magneto-optical results showed one transition at 1.0 μm attributed to the Fe^{3+} ions of the crystal and other transitions at 1.2, 1.6 and 2.1 μm originated by Fe^{2+} ions. These ions are produced by charge transfer from the doping elements imitted in the crystal during its growth. The position in the crystal, where the doping atoms are located, strongly influences the localization in the cell of the produced Fe^{2+} ions. The Fe^{2+} can be localized in lattice sites coordinated octahedrally or tetrahedrally with the surrounding oxygen atoms and with different axis of symmetry [3]. The magneto-optical signals observed, coming from these centers, depend on their localization and on the orientation of the symmetry axis of the site with respect to the magnetization direction of the sample; so they can be utilized for investigating the charge transfer mechanism and the energies associated with each site. In this way it was also possible to study the additive magneto-optical centers originated by oxygen vacancies in the garnet crystal matrix [4]. Faraday Rotation (FR) measurement, which is complementary to MCD, can add information to the knowledge of the magneto-optical transitions and clarify the results previously obtained.

Results and discussion

The samples utilized are single crystal platelets with orientation of the face parallel to the crystallographic plane (110) and with the following characteristics: pure YIG thickness in μm $t = 510$; YIG doped with Ge concentration in at./unit. form. $c = 0.05$ and $t = 310$; YIG(Zr) $c = 0.20$ and $t = 263$; YIG(Sn) $c = 0.20$ and $t = 338$; YIG(Sb) $c = 0.03$ and $t = 265$. Only the last sample concentration was obtained by a EMP analysis, all the others are the nominal values coming from the dope concentration in the melt of growth. The Ge tetravalent ions are localized usually in tetrahedral sites

of garnet cell while the Zr, Sn tetravalent and Sb pentavalent ions are localized preferentially in octahedral sites [5].

The FR measurements are made in function of wavelength, in the interval $0.9 \div 2.6 \mu\text{m}$, and at 300, 77 and 4 K of temperature. At 4 K we made also the measurement of the MCD spectrum which was not previously obtained. In figure 1 we report the results of FR measurements made at $T = 300$ K. There it is possible to see that the FR signal show a structure on all the samples at wavelengths smaller than 1.2 μm . In accordance with the results previously known [6] we can say that this is originated by the Fe^{3+} ions of the

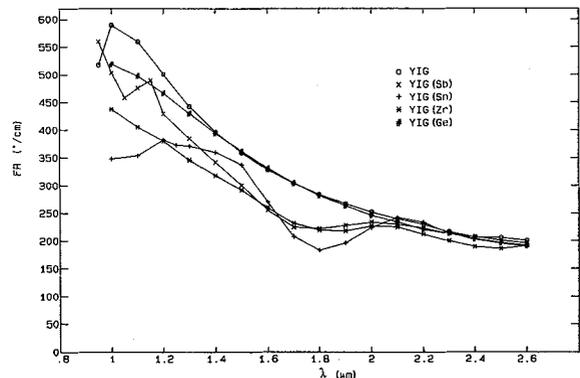


Fig. 1. – Faraday Rotation at 300 K measured versus wavelength. The samples are identified by the symbols reported in figure.

crystal matrix. At higher wavelength values we do not find appreciable difference between YIG(Ge) and pure YIG results also because of the very little concentration of Ge ions in our sample. On the contrary all the other samples show deviation from the behaviour of the pure YIG in the region of wavelength between 1.1 and 2.3 μm . These differences can be better observed in figure 2 where we report the results of the analogous FR measurements made at 4 K. Here it is possible to clearly observe two maxima, the first one centered at

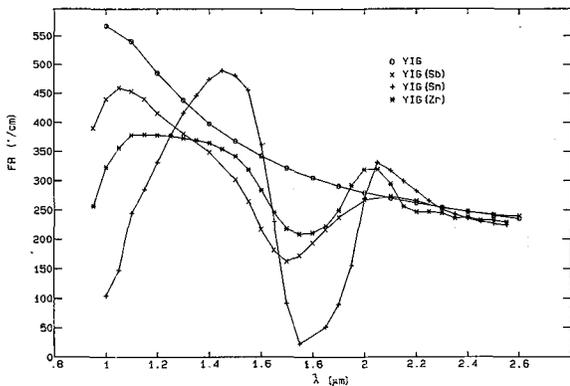


Fig. 2. - FR at 4 K reported versus wavelength. The YIG(Ge) sample was not measured because of the small difference found with respect to pure YIG.

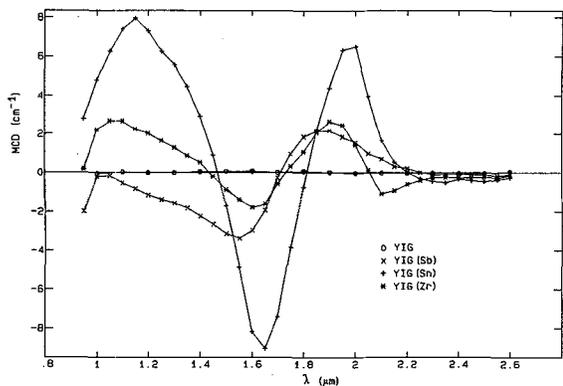


Fig. 3. - Magnetic Circular Dichroism at 4 K versus wavelength.

1.45 μm and the second one near to 2.05 μm , which value is higher than that of pure YIG, and a strong dip in the central region of the wavelength centered at 1.75 μm .

The wavelengths, characteristic of this structure in the FR spectra, well agree with those observed in the MCD spectra as reported in figure 3. The temperature of these measurements is 4 K and the results shown confirm those previously measured at higher temperatures [3], but here it is possible to more clearly identify

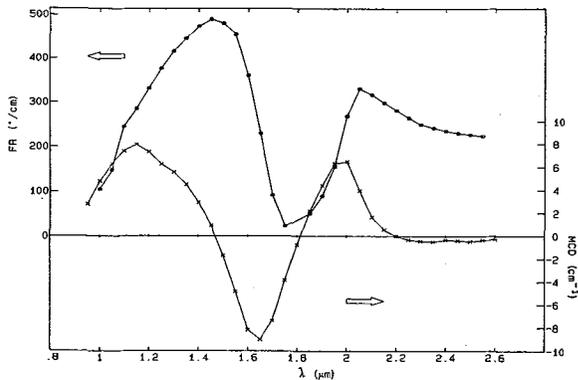


Fig. 4. - FR and MCD of the sample YIG(Sn) at 4 K versus wavelength. In this figure it is well evident the correspondence between the wavelengths of maxima and flexa of the two measurements.

the structure of the spectrum. As an example we report in figure 4, in the same graph, the 4 K results on the sample YIG(Sn) for both RF and MCD measurements. It is clearly evident that the wavelength values of the maxima and minima of MCD spectrum correspond with the flexa of FR results at 1.2, 1.6 and 2 μm , where the identified transitions are positioned. The same correspondence can be found in the results of the other samples where it is possible to observe small displacements in the transition's wavelengths depending on the different interaction energy between the doping ions and the magneto-optical centers.

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