

⁵⁷Fe NMR LINE SPLITTING IN SUBSTITUTED YIG¹

РАСЩЕПЛЕНИЕ ЧЕКИТЕП ЯМР ИЗОТОПА ⁵⁷Fe В YIG С ИМПРИМЕСИМИ

V. ANDÉRA*, M. BRABENEC*, J. ENGLICH*, Prague
H. LÜTGEMEIER**, Jülich

We have studied the NMR line-shape of the ⁵⁷Fe isotope in YIG in which a certain part of trivalent iron ions was substituted by diamagnetic ions Ga³⁺, Al³⁺ and In³⁺. In the region of small concentrations we may suppose the diamagnetic ions occupy only one type of the lattice sites. In this case we have found the characteristic ⁵⁷Fe NMR line splitting. The magnitude of the splitting depends both on the kind of the substituted ions and on the type of the lattice site, but it is independent of concentration. Supposing the random distribution of the substituent we have calculated the line shape taking into account the change of the transferred hyperfine fields and the dipol-dipol interaction caused by the replacing of Fe³⁺ ions in the nearest and the next nearest neighbourhoods of the measured ion.

The aim of this contribution is to show the applicability of the nuclear magnetic resonance (NMR) method for the study of the cation distribution in substituted yttrium-iron garnet Y₃Fe_{5-x}M_xO₁₂, where M = Al, Ga, In.

The yttrium-iron garnet (YIG) is a ferrimagnetic insulator with a rather complicated crystal structure, which belongs to the space group O_h¹⁰—Ia3d [1], [2]. The Fe³⁺ ions occupy two types of lattice sites, (octahedral 16a and tetrahedral 24d) which form two magnetic sublattices of the collinear ferrimagnet. According to the results of classical magnetic measurements [3] Ga³⁺ and Al³⁺ ions occupy preliminarily the 24d sites while In³⁺ ions occupy preliminarily the 16a sites, in the region of the small substituent concentration.

Our samples were prepared by the conventional ceramic technology. We used both powder and compact polycrystalline samples sintered at the temperature 1420—1450 °C. The phase purity, homogeneity as well as the composition parameter x were checked by the X-ray method.

NMR spectra were measured by the spin echo technique using both the coherent and non-coherent ferrimagnetic domains. We have detected the ⁵⁷Fe spin echo signal coming from ions inside the band width in the case of the non-coherent spectrometer and by the Fourier-transform method in the case of the coherent spectrometer.

The ⁵⁷Fe NMR spectrum in stoichiometric YIG consists of three rather narrow lines (see Fig. 1). The line at the frequency 65 MHz is due to the 24d sites. In the case of the 16a sites there are two magnetically inequivalent sites in the 1:3 distribution ratio, which have different values of the hyperfine field [4]. This difference is caused by a different dipol-dipol interaction and hyperfine field anisotropy.

¹ Contribution presented at the 6th Conference on Magnetism in Košice, September 2—5, 1980.

* Faculty of Math. and Physics, Charles University, Ke Karlovu 5, CS-121 16 PRAGUE.

** Inst. für Festkörperforschung der Kernforschungsanlage Jülich, D-5170 JÜLICH.

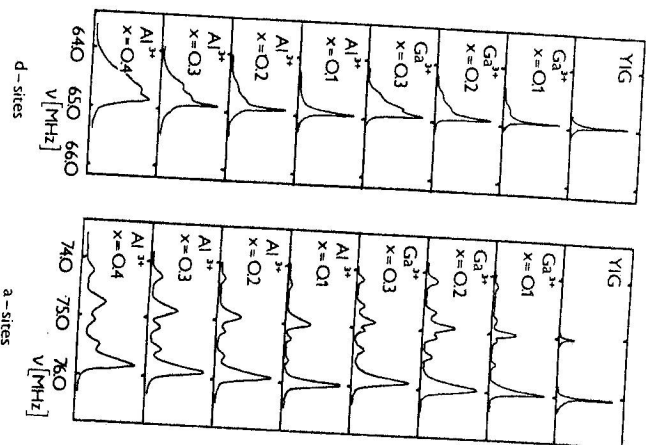


Fig. 1. ^{57}Fe NMR line-shapes of YIG substituted by Ga and Al at the temperature 10 K.

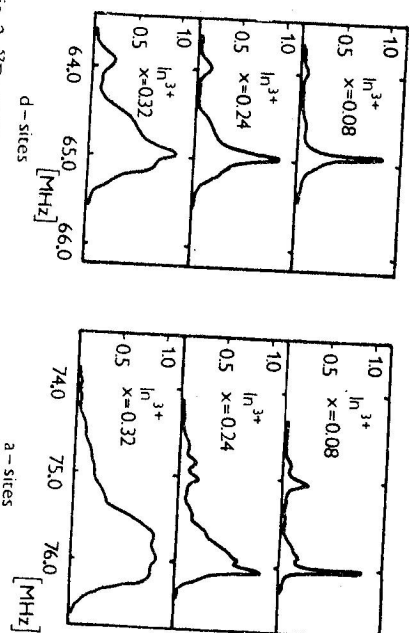


Fig. 2. ^{57}Fe NMR spectra of YIG substituted by In at the temperature 10 K.

The measured NMR spectra presented a very good possibility for the study of diamagnetic ions strongly the 16d sites NMR spectrum. For example Al^{3+} and Ga^{3+} substituents for $x \leq 0.3$ influenced very the other hand the influence of the In^{3+} ions on the NMR spectra is quite weak. On (Fig. 2). For higher values of x we observe the broadening of the 24d line in the case of the Al^{3+} substituent and the 16d line in the case of the In^{3+} substituent. These results correspond to the presence

of substituents in both types of lattice sites. Generally speaking we may say that our NMR cation distribution results are consistent with the above mentioned model based in classical magnetic measurements.

We calculated the theoretical form of the NMR spectra taking into account the dipol-dipol interaction and the supertransferred hyperfine field variation. It was found by comparison with the measured spectra that these two contributions were not sufficient to explain the shape of the measured spectra. To get a better agreement with the experiment it is necessary to consider some further contributions to the hyperfine field, e.g. the change of the hyperfine field anisotropy and the local crystal lattice deformation. A more detailed analysis is in progress and will be published later.

REFERENCES

- [1] Bertaut, F., Forrat, F.: *C. R. Acad. Sci.* 242 (1956), 382.
- [2] Geller, S., Gillet, M. A.: *J. Phys. Chem. Solids* 3 (1957), 30.
- [3] Gillet, M. A., Geller, S.: *Phys. Rev.* 110 (1958), 73.
- [4] Butron, F., Robert, C.: *C. R. Acad. Sci.* 253 (1961), 433.

Received October 20th, 1980