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ELSEVIER

Magnetization measurements on $\text{RE}_2\text{Fe}_{17}$ single crystals

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Abstract

Magnetization measurements on single crystals of $\text{RE}_2\text{Fe}_{17}$ (RE = Er, Ho and Y) have been performed in the temperature range 1.5–300 K and applied magnetic fields up to 12 T, along the hard (HMD) and easy (EMD) magnetization directions. In the $\text{Er}_2\text{Fe}_{17}$ compound a FOMP has been observed for temperatures of 1.5–110 K.

The $\text{RE}_2\text{Fe}_{17}$ compounds have been deeply studied from the magnetic point of view by several authors [1–3]. In these works magnetization measurements at 4.2 K have been reported and several sets of crystal electric field (CEF) parameters fitting the experimental results have been offered [1,4,5]. Nevertheless these sets of CEF parameters are quite different and they have not been tested at temperatures higher than 4.2 K. In this work magnetization measurements on several single crystals (SCs) of $\text{RE}_2\text{Fe}_{17}$ (RE = Y, Ho and Er) have been performed using a sensitive vibrating sample magnetometer using steady magnetic fields up to 12 T and temperatures ranging between 1.5 and 300 K.

The anisotropic and magnetic behaviour of the iron sublattice can be obtained from the Y_2Fe_{17} compound where the Y^{3+} ion is non-magnetic. In Fig. 1 we present the magnetization isotherms obtained when the magnetic field is applied along the c -axis (HMD) of the hexagonal structure. From these measurements a value of $2.11\mu_B/\text{Fe}$ at 4.2 K has been obtained for the magnetic moment of the iron atoms. This value is slightly higher than the one determined by other authors [2,6] but such a difference can be attributed to slight differences of stoichiometry in the samples [7,8].

The experimental magnetization isotherms show a well defined inflection at the anisotropy field (H_A) at which the magnetization reaches the HMD. The thermal dependence of H_A is reported in Fig. 2. H_A increases for decreasing temperatures and reaches a value of 4.2 T at 4.2 K. The anisotropy of this compound is large compared with the Y_2Co_{17} [2] for which H_A is five times lower than the one observed on Y_2Fe_{17} at the same temperature.

Fig. 1. Magnetization isotherms on a single crystal of Y_2Fe_{17} . The magnetic field is applied along the c -axis.

The EMD direction for the $\text{Ho}_2\text{Fe}_{17}$ compound is along the b -axis within the basal plane of the hexagonal structure. The spontaneous magnetization measured along such direction is 72.1 emu/g at 4.2 K. Assuming that the magnetic moment of the Ho^{3+} ion is $g_J J\mu_B = 10\mu_B$ and

Fig. 2. Thermal dependence of the anisotropy field H_A [(+) Y, (Δ) Ho and ($\square$) Er] and the critical field H_{CR} [(O) Er] for the $\text{RE}_2\text{Fe}_{17}$ compounds. The lines are visual guides.

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considering that the iron and Ho sublattices are antiferromagnetically coupled, a value of $2.15\mu_B/\text{Fe}$ is obtained. This value is very close to the magnetic moment obtained for the iron sublattice in the Y_2Fe_{17} compound.

The magnetization isotherms obtained in the hard c -direction are shown in Fig. 3. From the inflection of the experimental curves, H_A has been obtained. The H_A (see Fig. 2) measured is larger than in Y_2Fe_{17} , indicating that the RE sublattice is the main responsible for the anisotropy in this compound.

For the $\text{Er}_2\text{Fe}_{17}$ compound, the value of the spontaneous magnetization along the EMD (a -axis of the basal plane) at $T = 4.2$ K, is 82.5 emu/g and a value of $2.17\mu_B/\text{Fe}$ was obtained for the iron magnetic moment.

In Fig. 4 we present the experimental magnetization results obtained when the field is applied along the c -axis (HMD). Between room temperature and 125 K (Fig. 4a) the experimental curves show a normal behaviour and H_A can be obtained. For temperatures of 1.5–110 K a first order magnetization process (FOMP) has been observed (see Fig. 4b) and a jump of the magnetization from an intermediate direction to the HMD at a critical field (H_{CR}) takes place. The observed critical magnetic fields increase with decreasing the temperature and are in the range between $H_{\text{CR}} = 5.2$ T at $T = 1.5$ K and $H_{\text{CR}} = 3.6$ T at $T = 110$ K.

Such a process has been also observed in magnetostriction measurements [9] in which large jumps in the magnetostriction isotherms were observed as consequence of the FOMP phenomena.

The values of H_{CR} and anisotropy fields (H_A) for $\text{Er}_2\text{Fe}_{17}$ are very close to the H_A values measured in the Y_2Fe_{17} compound. This fact indicates that the FOMP transition observed in $\text{Er}_2\text{Fe}_{17}$ is induced by the iron sublattice.

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Fig. 3. Magnetization isotherms on a single crystal of $\text{Ho}_2\text{Fe}_{17}$. The magnetic field is applied along the c -axis.

Fig. 4. Magnetization isotherms on a single crystal of $\text{Er}_2\text{Fe}_{17}$. The magnetic field is applied along the c -axis. (a) between 290 and 125 K, (b) in the FOMP region ($1.5 \text{ K} > T > 110 \text{ K}$).

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