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THE MEASUREMENT OF THE MAGNETIC ANISOTROPY AND SOME RELATED PROPERTIES IN HARD MAGNETIC MATERIALS

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Abstract: Some methods developed at the MASPEC Institute for the measurement of the anisotropy field, texture and single or polydomain particle status in uniaxial ferromagnets are presented.

1. Introduction

The measurement of the magnetic anisotropy (H_A) is an important issue for the characterization of hard magnetic materials, either from a fundamental or applicative point of view. H_A is a relevant property which qualify these materials for different applications. In particular anisotropy is a necessary condition for the existence of the coercivity and it determines the occurrence of first-order magnetization processes (FOMP) and spin reorientations transitions (SRT). An important requirement is the possibility of measuring the anisotropy field directly in polycrystalline samples. Also the knowledge of some characteristics connected to H_A such as the single or polydomain status of the particles and the polydomain sample texture is particularly important for magnetic recording and permanent magnet applications respectively.

2. Experimental Methods

Transverse susceptibility. The reversible transverse susceptibility χ_t of a ferromagnet, having a positive uniaxial anisotropy, can be measured as a function of the applied magnetic field. The presence of peaks in the $\chi_t(H)$ curve of a polycrystal was predicted (1) on the basis of the Stoner and Wohlfarth model. An experimental method and apparatus (2) based on the measurement of the field dependence of the a.c. transverse susceptibility, has been developed and it allows for a precise determination of both the coercive and anisotropy fields in an uniaxial ferromagnet, provided it is made of single domain particles. This peculiarity allows for distinguishing between single or polydomain status of the particles in the sample. The absence of the peak at $H = H_A$ in the $\chi_t(H)$ curve of a polydomain particles sample is due to the shielding signal originated by: the domain walls motion (Fig.1).

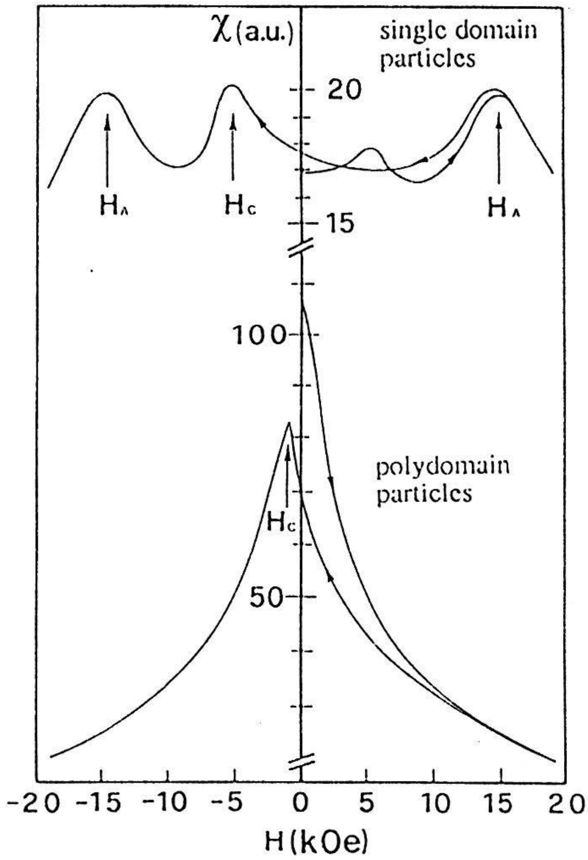

Fig.1 Transverse susceptibility χ_t as a function of the external bias field H

Singular Point Detection technique (SPD). In the magnetization curve of a polycrystal there are no indications for the determination of the anisotropy field (H_A) that is the field needed to saturate the sample along a hard direction. It has been demonstrated (3) that a peak, located at $H=H_A$ is observed in the nth derivative d^nM/dH^n of the magnetization with respect to the applied field. The order n of the derivative depends on the crystal symmetry and on the easy axis direction (n=2 in an easy axis ferromagnet). Such a peak is due exclusively to the grains having their easy axis at right angles with respect to the field. This implies:

1) the peak position is independent on any sample texture
2) the peak amplitude is proportional to the number of grains at right angles. Thus informations on the sample texture of oriented polycrystals are obtained by measuring the peak amplitude as a function of the sample orientation with respect to the field.

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