MACROSCOPIC STUDIES OF MAGNETIC ANISOTROPY IN RARE-EARTH
INTERMETALLIC COMPOUNDS

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ABSTRACT

The Singular Point Technique and high pulsed field magnetometry have
been extensively utilized in order to study the composition and
temperature dependence of both the anisotropy field and the critical
field of first order field induced magnetic processes (FOMP) in
rare-earth Fe based intermetals. In particular, type I FOMP in
Nd_{2}Fe_{14}B and type II FOMP in Pr_{2}Fe_{14}B were investigated. High order
anisotropy energy constants are needed to account for the FOMP. Planar
anisotropy energy constants are also necessary to describe FOMP in
Nd_{2}Fe_{14}B. In conjunction with determinations of preferential site
occupations, the contribution and behaviour of 3d and 4f
magneto-crystalline anisotropy to the overall anisotropy have been
systematically investigated.

INTRODUCTION

The announcement in 1984 of the discovery of an Fe based Rare-Earth
intermetallic compound having excellent permanent magnet properties had
the effect of revitalizing Rare-Earth intermetallic research. Renewed
attention has been focussed on this field with a correspondingly large
number of both academic institutes and industries being involved in a
very active research and development effort. In addition to a substantive
effort in the U.S.A and Japan, Europe launched an intensive research
effort with the creation and support of the Concerted European Action On
Magnets (CEAM). Among the results produced by such an effort is the
realization that many binary intermetallic compounds which are not
interesting from the point of view of magneto-crystalline anisotropy
could be rendered most useful by forming isomorphous compounds of
suitable Rare-Earths with a stabilizing element.

The participation of MASPEC in the CEAM program was directed to a

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systematic study of 3d and 4f magneto-crystalline anisotropy, magnetization processes and preferential site occupations in numerous compounds with the tetragonal Nd$_2$Fe$_{14}$B structure and the new family of ternary Rare-Earth intermetallic compounds based on the tetragonal ThMn$_{12}$ structure.

MATERIALS PREPARATION AND EXPERIMENTAL TECHNIQUE

Materials preparation has consisted of a combination of in-house preparative techniques and various materials obtained in active collaborations with other CEAM partners. Materials at MASPEC were obtained by argon arc melting of appropriate elements followed by standard furnace annealing. Collaborations were performed with Laboratoire Louis Néel, Grenoble, Laboratoire de Crystallographie du CNRS, Grenoble, Philips Research, Eindhoven, Trinity College, Dublin and ICMA, CSIC-Univ. de Zaragoza. Sample monophasicity and homogeneity was controlled by thermomagnetic analysis and X-ray diffraction. Thermomagnetic analysis was also used to measure the Curie temperature in all compounds.

Magnetization curves of polycrystals and single crystals have been measured in a low field (up to 20kOe) vibrating sample magnetometer and in a high pulsed field magnetometer (up to 300kOe). The unique singular point detection technique (SPD, Asti et al, 1974) enabled precise measurements of the anisotropy field to be obtained from polycrystalline materials. The typical error in the determination of the anisotropy field $H_a$ is not more than 2%. Furthermore, exotic behaviour of the magneto-crystalline anisotropy such as First Order Magnetization Processes (FOMP, Asti et al, 1980) can be accurately quantified. The shape of the SPD peak is also often quite useful in that it allows an estimate to be made of the signs of high order anisotropy constants.

High resolution neutron diffraction has been used to investigate magnetic and crystal structures and to correlate this with the observed behaviour of the magnetic anisotropy. Particular emphasis has been placed