EB01

High Magnetic Anisotropy Materials -From Bulk through Multilayers to Nano-scaled Particles-

Takao Suzuki*,†

Toyota Technological Institute, 2-12-1 Hisakata, Tempaku-ku, Nagoya, 468-8511, Japan

*Corresponding author: takaosuzuki(@toyota-ti.ac.jp, Phone: +81 52 809 1870, Fax: +81 52 809 1870

Magnetic anisotropy is one of the basic properties of magnetic substances. In particular, magneto-crystalline anisotropy is thought to be intrinsic for bulk materials, but the theoretical understanding is not satisfactory, as is often demonstrated. In multilayers and nano-particles where surface or interfacial magnetic anisotropy plays a key role, magnetic behavior is significantly influenced by extrinsic or induced magnetic anisotropy. Among many alloy systems, ordered alloys are known to exhibit high magnetic anisotropy; in particular the $L1_0$ ordered phase is of great interest because of applications in bit-patterned magnetic data storage.

Nano-composite particles with a high magnetic anisotropyphase, together with other magnetic anisotropies, are the subject of intensive research since they offer potential for various applications such as hybrid data storage, sensors, and bio-devices.

This tutorial lecture addresses the magnetism and structure of thin films and nano-composite particles with a high magnetic anisotropy ordered phase. An in-depth review of magnetic anisotropy in representative materials is given. Recent developments in high magnetic anisotropy of novel materials, multilayers, and nano-composites will be presented. Emphasis is placed on quasi-$L1_2$ structured alloy films [1] with very high magnetic anisotropy, on nanoscaled -FeRh particles[2], and on Ferro/Antiferro nano-composite systems[3].

REFERENCES

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EB02

Recent Developments in Rare Earth Permanent Magnet Materials

S. Hirosawa*

Magnetic Materials Laboratories, NEOMAX Co., Hitachi Metals, Ltd., 2-151-7 Egawa, Shimamoto, Osaka 618-0013, Japan

*Corresponding author: satoshi_hirosawa(@hitachi-metals.co.jp, Phone: +81 75 961 3118, Fax: +81 75 962 9690

Rare earth permanent magnets are one of basic materials that make possible for the highly automated modern society to function and run vigorously. Particularly, the $Nd_2Fe_{14}B$-based anisotropic sintered magnets have become indispensable not only in traditional applications such as hard disc drives and miniature audio devices but also in hybrid electric vehicles (HEV) that use the material in a much larger quantity than in the traditional applications. Eventhough rare earth elements are not rare in natural abundance, quick rise of such an enormous market creates a new concern about resources of certain elements such as Tb and Dy which is used in the high-coercivity grades of Nd-Fe-B sintered magnets used for HEV applications in an amount that surpasses the natural proportion of abundance in order to guarantee stability of magnetic flux at elevated temperatures. The function of these scarce elements do is to enhance magnetocrystalline anisotropy to which the intrinsic coercivity depends linearly. When a major improvement in coercivity is required without using this principle, one needs to understand the mechanism of coercivity comprehensively. One part of this presentation will give a brief review of current achievements in the sintered Nd-Fe-B type permanent magnet technologies and materials science on this background. Another possibility to reduce the rare earth usage in permanent magnets is to use nanocomposite type materials. These materials are isotropic in that the easy direction of magnetisation distributes randomly. However, by combining hard magnetic intermetallic compound such as $Nd_2Fe_{14}B$ with a ferromagnetic metal such as α-Fe, and by utilising the remanence enhancement effects that arise from strong ferromagnetic couplings between these two ingredients interwoven within a nanometer-scale microstructure. Another advantage of these isotropic nanocomposite permanent magnets lies in their relatively weak temperature dependence of the intrinsic coercivity. Beside that these materials can be used in conventional resin-bonded magnets, innovational usage of this type of magnets includes simultaneously molded two-colour rotors consisting of a powder iron core and nanocomposite magnet segments and binderless bonded magnets with considerably improved density and thermal stability which used to be a problem arising from the resin ingredient used as binder. To add these innovations, there have been considerable improvements in performances of anisotropic hard magnetic powders based on the hydrogen-processed Nd-Fe-B alloys with respect to the coercivity. Recent efforts in these directions are reported and positions of each material in the permanent magnet market are discussed in this presentation.