1.15 Progress Report of Asia Pacific Research Collaboration 1999

CURRENT STATUS OF RESEARCH AND DEVELOPMENT ON MAGNETIC MATERIALS IN INDONESIA

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There have been some magnetic materials research activities in Indonesia. These activities are including national cooperation research and joint research between Asia-Pacific countries. The magnetic materials are covering permanent magnets (R-Fe_{17}-X and $Nd_2Fe_{14}B$ series) [1], magnetostrictive materials ((Tb,R)Fe_2 series) [2], Giant Magnetoresistance materials ((Sm,R)Mn_2Ge_2 series) [3] and nanocomposite RE-Fe,Co-B based permanent magnets. Most of activities of national cooperative research are financially supported by Government of Indonesia under RUT (Integrated Research) scheme, involving researchers from various research institutes like MSRC (BATAN), LIPI (Indonesian Institute of Sciences) as well as from university e.g University of Indonesia (UI). Research of magnetic thin films for magnetooptic materials application has also been reported [4].

Apart of national cooperation research, an intensive joint research activity in the field of neutron scattering under Asia-Pacific collaboration in the field of magnetic material, involving researcher from MSRC-BATAN, State Key Lab. for Magnetism, Chinese Academy of Sciences, Chinese Institute of Atomic Energy and also Japan Atomic Energy Research Institute has also been conducted. The research is mainly concerned with the structural investigation of $R_2Fe_{17-x}TM_x$ intermetallic compounds and their magnetic properties. High standard of research results have derived from these cooperative works and published in Scientific Journals such as J. Condensed Matter Physic and J. Phys. Soc. of Japan [5-10]. The resume of this activity result in the last four years has been reported in the last year meeting [11]. In this year, because of the limitation of HRPD beam time, there is only one sample could be measured using HRPD, i.e LaMn2O7 at 150 K. The pattern is given in the figure 1. For complete analysation, it is planned that the measurement will be done for several temperature.

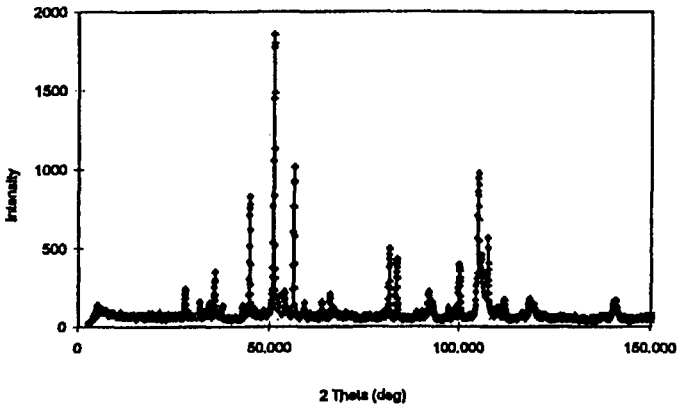

Figure 1. The high resolution neutron diffraction pattern of LaMn2O7 at 150 K

Research works on permanent magnet material based on $Nd_2Fe_{14}B$ series in nanocrystalline and nanocomposite system using meltspinning technique are being carried out intensively under an informal research coorporation between researcher of UI and National University of Singapore [12]. The effect of Fe atom substitution in the $Nd_2Fe_{14}B$ with Co atom on its Tc and grain exchange effects on magnetic properties of nanocomposite alloys is in progress. In figure 2, one of results showing progressive Tc enhancement in nanocomposite Nd-Fe,Co-B due to Co substitution is shown.

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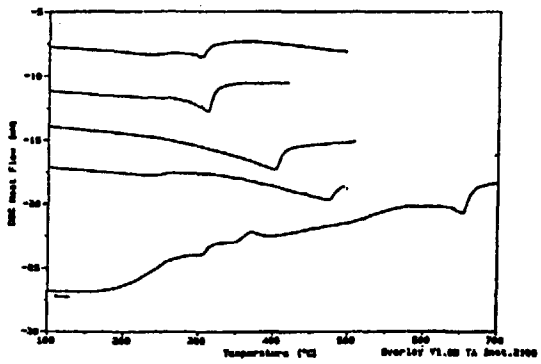

Figure 2. DSC scanning result showing progressive Tc enhancement of nano composite Nd-Fe,Co-B as a function of Co content [13]

The cooperative research is now being extended to an intensive project aimed at developing high performance Rare earth- Iron-Boron, Nitrogen permanent magnets of nanocrystaline based materials by meltspinning and mechanical alloying routes. Several nanocomposite systems of permanent magnet will be investigated both theoretically and experimentally. These are including application of micromagnetism and nanomagnetism models to study magnetization process that are governed by interaction between intrinsic properties and crystallographic microstructure. With the involvement of researcher of MSRC-BATAN, investigation on crystallographic as well as magnetic structures could be progressed, employing sophisticated instruments including Neutron Spectrometer and an Oxford Instrument Vibration Sample Magnetometer (VSM). Technologycally, the project is to develop a new magnetic material for modern permanent magnet applications and scientifically is to open a new understanding on magnetism of modern magnetic materials.

As an alternative methode some preliminary studies of sample preparation by mechanical alloying have also been carried out. Preparation using conventional ball mill facility gives results in form of mixture of supersaturated solid solutions in a dominan amorphous material. Preliminary result of soft magnetic material based on Fe-Si-B [14] with various additive elements such as Ni, Ti, Al, V and Ta in similar milling condition is presented in figure 3. Under the guidance of Prof. Y. Hamaguchi (JAERI), cooperation and support of Prof. Y. Yamaguchi (Institute for Materials Research, Tohoku University, Sendai, Japan) magnetic properties of these materials have been measured using VSM in Tohoku University, Japan (see figure 4).

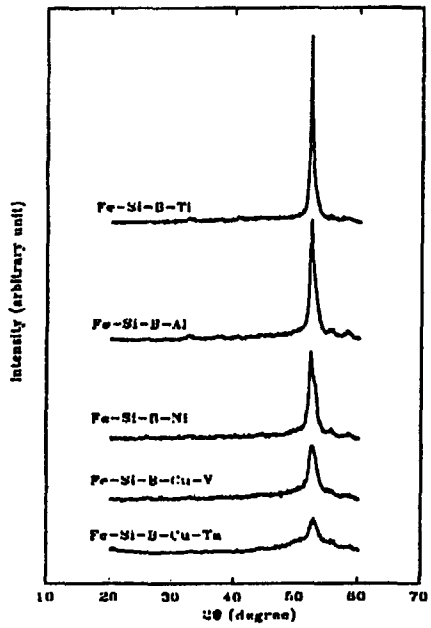

Figure 3. X-ray diffraction data of as-milled soft magnetic material base on Fe-Si-B with variety of additive element [14]

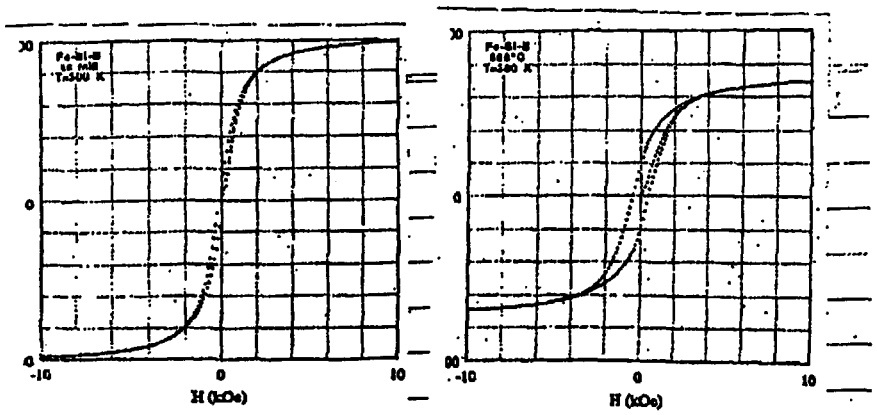

Figure 4. Hysteresis curve of amorphous material

The research of magnetostrictive alloy, which is covered by the program of Riset Unggulan Terpadu (National Integrated Research) deals with the development of the Terfenol-D magnetostrictive alloy. This research is done in the collaboration with University of Indonesia (UI) and Prof. Y. Yamaguchi. The synthesis of the Terfenol-D alloy uses the chemical route called "Reduction-Diffusion method" that is developped and optimised in the frame of this research. Once single-phase powder alloy is obtained, then composites are synthesised from this alloy mixed with a polymer resin (as a matrix). The characterisation techniques include:

- structural analysis using the X-Ray Diffraction technique
- micro-structural analysis using optical microscope and SEM,
- magnetic measurements using the VSM in Sendai, Japan
- magnetostrictive measurements, consisting of measurements of strain changes in magnetic field. The strain gages were supplied by N. Minakawa.

As a result, single-phase alloy (RD8 sample) has been obtained as it is shown by the XRD data (Figure 5) and the value of magnetisation at room temperature reaching $4\pi M_s$ = 9113 kgauss, as well as the value of the Curie temperature of 650 K. These values are comparable to those found in the literature for the same alloy made by more conventional techniques, such as arc-melting or induction melting.

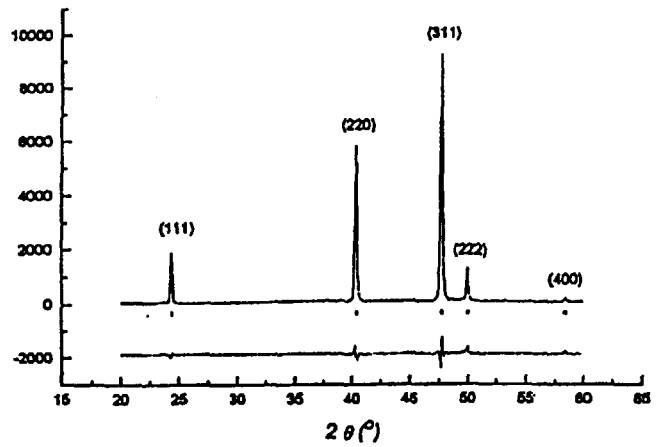

Figure 5. X-Ray Diffraction Data of Single-Phase Terfenol-D Alloy Made by the RD Technique

The composite made from this alloy and an epoxy resin as binder material showed a promising magnetostrictive properties. Figure 6 gives the curve of magnetostriction versus applied field for a composite sample with 23 % powder volume fraction, without biased field neither pre-loading stress applied to the sample, at room temperature.

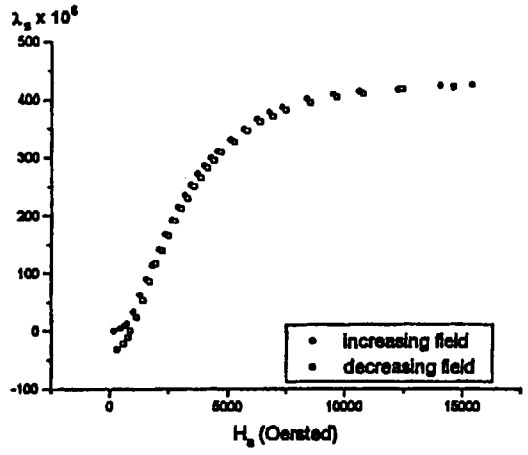

Figure 6. Magnetostrictive Data of 23 %-Terfenol-D Composite at Room Temperature

Beside the research activity, the Scientific meeting was also been held in the October 20-21, 1998, namely Materials Science Scientific Meeting. This is an annual meeting and this year was the third. It was assisted by approximately 200 persons : participants and invited guests, Indonesian and other nationalities (British, Japanese, Singaporean, French and Norwegian), from research centres, universities, private sectors and government. In this year, the topic of magnetic materials has a major opportunity to be discussed besides other materials such as polymer, ceramic, amorphous materials, metal and alloys. The role and strategic position of magnetic materials in industrial was comprehensively discussed by some of invited speakers [15-17]. Prof. H.A. Davies was highlighting research, development and applications of hard magnets in Europe. Discussion on soft magnets and their application was given by Prof. Peuzin from France. Prof. Tsushima and Prof. Y. Yamaguchi talked on the current research status of magnetic material in Japan. DR. A. Manaf presented the current status of magnetic research and development in Indonesia and Mr. S. Shimada from Sumitomo Co. highlighted the status and prospect of permanent magnets industry. These should provide us with strategic and important information on the magnetic materials and inspire a future development of magnetic exploration in our country.

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