TA05

Bulk Nanocrystalline $SmCo_5$ Permanent Magnet Prepared by Spark Plasma Sintering

Zhang Dongtao*, Yue Ming, Zhang Jiuxing, and Pan Lijun

College of Materials Science and Engineering, Beijing University of Technology, Beijing 100022, P. R. China

*Corresponding author: zdt@bjut.edu.cn, Phone: +861067391760, Fax: +861067392840

Nanocrystalline $SmCo_5$ permanent magnet with $CaCu_5$ crystal structure, which has a coercivity of up to 3~5T, has been investigated by many researchers [1,2]. However, the obtained magnets are only ball-milling powders or melt-spun ribbons, which arelack of value in practical application. Therefore, Spark Plasma Sintering (SPS), a novel fast solidification technique, has been applied in present study to fabricate bulk nanocrystalline $SmCo_5$ permanent magnet.

$SmCo_5$ alloy was prepared by induction melting with 15% excess Sm to compensate for the weight loss due to Sm evaporation. The ingots were crushed and ball milled for 10h at 700r/m under Ar in a high energy mill, then the as-milled powders were put into a Φ20 WC-Co mold to be densified in vacuum of 10^{-2} Pa using the SPS sintering machine. The sintering conditions are as follows: sintering temperature is 953-1023K; sintering pressure is 500MPa; heating rate is 50K/min; heat preservation time is 2 minutes.

XRD pattern shows that the sintered magnet exhibits a single phase with the $CaCu_5$ structures, indicating that the as-milled amorphous powders recrystallize into 1:5 structure after sintering process. The broad peak in the XRD pattern of the sintered magnetindicates a nanoscale crystallite size, which is calculated as 25 nm according to the Scherer formula. Further TEM observation (Fig. 1) shows that the microstructure of the magnet is composed of fine SmCo5 single-phase grains with anaverage grain size of about 30 nm. Under the optimal processing conditions, the density of the magnet reaches to 8.3 g/cm^3, which is over 98% of the theoretic density of the alloy. The thermomagnetic curve of the magnet shows that the Curie temperature is 1017K.

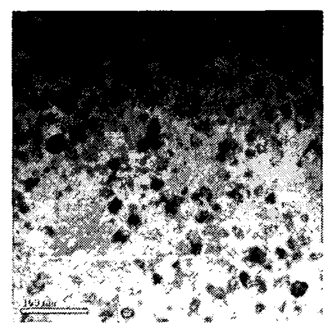

Fig. 1. TEM image of $SmCo_5$ magnet

Measurement of magnetic properties of the magnet is performed in a SQUID magnetometer at 300 K with a maximum magnetic field of 7 T. The high Mr/Ms ratio of 0.65 demonstrates the existence of strong intergranular exchange interaction among the nanograins in the magnet. The coercivity of the magnet reaches as high as 2.4 T. The strong anisotropy field of the $SmCo_5$ phase and its uniform nanoscale microstructure arethe origin of the high coercivity.

REFERENCES

[1] A.A. Kundig, R. Gopalan, and T. Ohkubo, Scripta materialia, **54**, 2047(2006).

[2] Ning Tang, Zhongmin Chen, Yong Zhang, and George C. Hadjipanayis, J. Magn. Magn. Mater., **219**, 173(2000).

TA06

Magnetic Microstructures of Phase-separated SmCo 2:17-type Sintered Magnets

Y. K. Fang[1, 2]*, H. W. Chang[3], Z. H. Guo[1], T. Liu[1], W. Li[1]*, W. C. Chang[2] and B. S. Han[4]

[1] Division of Functional Materials Research, Central Iron & Steel Research Institute, Beijing 100081 China

[2] Department of Physics, National Chung Cheng University, Chia-Yi, Taiwan, R.O.C

[3] Institute of Physics, Academia Sinica, NanKang, Taipei, Taiwan, R.O.C.

[4] State Key Laboratory of Magnetism, Institute of Physics and the Center for Condensed Matter Physics, Chinese Academy of Sciences, Beijing 100080 China

*Corresponding author: ykfang@126.com, weili@public3.bta.net.cn

Recently, $Sm(Co,Fe,Cu,Zr)_z$ (z = 7.0 - 8.5) permanent magnets with 2:17-type structure have been much attracted due to their high coercivity and high Curie temperature (~820°C) for high temperature application (>300°C) [1-2]. However, only few magnetic domain characterizations on SmCo 2:17-type sintered magnets [3] have been reported. In this work, magnetic domain structures of $Sm(Co_{bal.}Fe_{0.25}Cu_{0.07}Zr_{0.02})_{7.4}$ sintered magnets have been studied by using magnetic force microscopy (MFM) after the magnets are quenched from the four steps of heat treatment, including sintering, solid-solution, isothermal aging and slow cooling, respectively. In the specimens with nominal c-axis perpendicular to the imaging plane, the domain configurations change significantly from plate-like for the as-sintered magnet to corrugation and spike-like for the homogenized one, and then to a coarse, and finally to a finer domain for the 830 °C isothermally aged and 400 °C annealed samples, respectively. The finer domain (so-called interaction domain) is a characteristic magnetic domain pattern of the SmCo 2:17-type magnets with higher coercivity. The evolution of the magnetic microstructures was interpreted as the variation of the domain wall energy of the specimens together with crystalline microstructures. Moreover, domain walls in zigzag shape were firstly revealed by means of MFM in SmCo 2:17-type sintered magnets. The variation of domain patterns and width as well as the crystalline microstructures of the specimens can be used to characterize the evolution of their intrinsic coercivity.

REFERENCES

[1] Strnat K J 1988 *Ferromagnetic Materials* vol 4 (Amsterdam: North-Holland) pp 131-209

[2] Chen C H, Walmer M S, Walmer M H, Li S u, Kuhl E and Simon G 1998 *J. Appl. Phys.* **83** 6706

[3] Gutfleisch O, Müller K -H, Khlopkov K, Wolf M, Yan A, Schäfer R, Gemming T and Schultz L 2006 *Acta Mater.* **54** 997