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Magnetic properties of $Nd_{12}Dy_2Fe_{73.2}Co_{6.6}Ga_{0.6}B_{5.6}$ magnets fabricated by current-applied pressure-assisted method

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I. INTRODUCTION

Nanostructed high energy Nd-Fe-B based bulk magnet can be prepared by hot-working process (hot press and die-upset) from melt-spun amorphous or nanocrystalline powder.[1] Recently, we have investigated a modified method, current-applied pressure-assisted (CAPA) process, to produce nanocrystalline isotropic and anisotropic NdFeB magnets. The process consists of current-applied pressing the melt-spun powders to obtain isotropic precursor subsequent current-applied deforming the precursor to obtain textured magnet.[2-3] The method uses direct current (DC) to heat specimens. Therefore, the high coercivity nanocrystalline magnets would be obtained due to the exposure time in short. In this article, we report the magnetic properties and microstructures of NdFeB magnets obtained from melt-spun NdFeB base hard magnetic powder by CAPA process.

II. EXPERIMENT

In this work, the isotropic MQU-G ($Nd_{12}Dy_2Fe_{73.2}Co_{6.6}Ga_{0.6}B_{5.6}$) powders poured in a graphite die were applied by 2000 A of DC through the upper and lower graphite punches while the pressure of 50 MPa was applied. The fully dense isotropic compact with size of 20 mm in diameter and 8 mm in length was obtained. Subsequently, a 1/4 piece of the compact reduced in length up to 60-70 % of its origin length in an open die through the method above-mentioned, which resulted in the textured anisotropic magnet. The magnetic properties were characterized by a pulsed magnetometer in magnetic field up to 8 T. The evolution of microstructures were detected by x-ray diffractometer and field emission scanning electron microscopy.

III. RESULTS AND DISCUSSION

Fig. 1 shows the demagnetization curves of the powder (a), isotropic (b) and anisotropic NdFeB magnets (c), respectively. The remarkably higher ${}_iH_c$ of 25 kOe was found in CA-pressed isotropic magnet. However, the reduction in coercivity of 28 % compare to that before deformation was observed for the CA-deformed magnet and the increase in remanence of 62 %. It is expected that the optimization of experimetal conditions and experimental conditions and compositional modification may improve the magnetic properties.

Fig. 2 shows the XRD patterns of the specimens shown in Fig. 1. The peaks obtained on surface perpendicular to the pressing direction for all samples correspond to the tetragonal structure of $Nd_2Fe_{14}B$ phase. In CA-pressed magnet, the peaks of (314), (410) and (210) planes are appeared as main reflections. After deformation, the dominant reflections are considerably reduced, and (00*l*) and (105) reflections grow as main peaks with the increase of remanence. It implies that textured structure is formed by the alignment of the crystallographic c-axis of the $Nd_2Fe_{14}B$ grains

along the pressing direction during plastic deformation.

Fig. 3 shows the microstructure of the fracture surface parallel to the press direction of CA-pressed isotropic magnet. It had randomly oriented fine structure with grain size in the range of 50-100 nm.

Fig. 4 shows the microstructure of the fracture surface parallel to the press direction of CA-deformed anisotropic magnet. The $Nd_2Fe_{14}B$ grains appear to be platelet with 50-100 nm in thickness and 300-600 nm in length, and the c-axes of the grains are well aligned along the press direction. It indicates that the *c*-axis texture is obtained by CA-deformation as well as by the conventional hot deformation.

Ⅳ. REFERENCES

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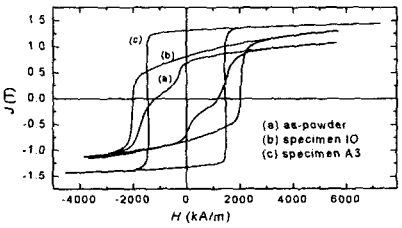

Fig. 1. Magnetic hysteresis curves of the raw powder, CA-pressed and CA-deformed magnets.

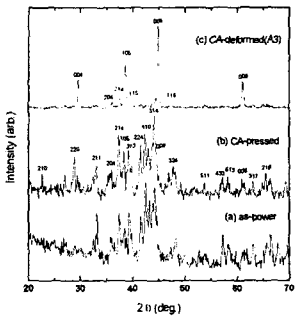

Fig. 2. XRD patterns of the raw powder, CA-pressed and CA-deformed magnets.

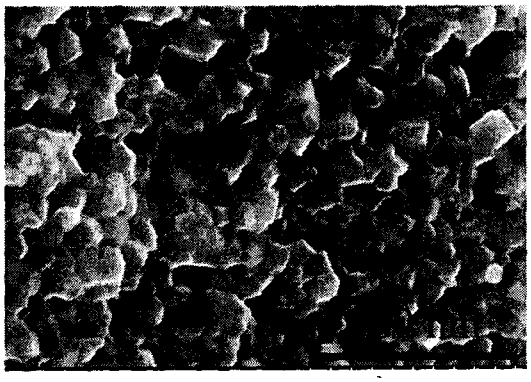

Fig. 3. The microstructure of the fracture surface perpendicular to the pressing direction for the CA-pressed isotropic magnet.

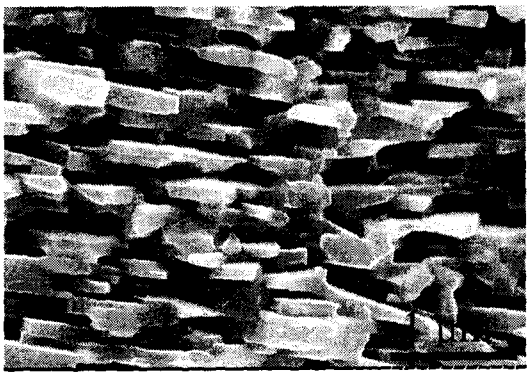

Fig. 4. The microstructure of the fracture surface perpendicular to the pressing direction for the CA-deformed anisotropic magnet.