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Magnetic Properties and Microstructure of Sm_2Co_{17} Permanent Magnet

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The coercivity of Sm_2Co_{17}-based permanent magnets at high operating temperature gradually increased with increasing Cu and Zr content, but decreased as the Fe content increased. The magnet $Sm(Co_{0.7}Fe_{0.1}Cu_{0.16}Zr_{0.04})_{6.7}$ that was studied had a room temperature intrinsic coercivity of about 30 kOe. For this magnet, the temperature coefficient of coercivity $\beta_{RT\text{-}500^oC}$ and H_{ci} at 500^{o}C are -0.148%/^{o}C and 8.6kOe. The magnet is composed mainly by $RSm_2(Co,Fe)_{17}$ cell interior, $Sm(Co,Cu)_5$ cell boundary phase, as well as H $Sm_2(Co,Fe)_{17}$ lamellar phase. There is a maze- like domain structure in the magnet. The HRXRD evidence shows that the phase transformation at high temperature leads to the degraded magnetic properties of the magnets.

The Sm_2Co_{17} based magnets with the highest Curie temperature among the commercial rare-earth permanent magnets have attracted considerable interest as an attractive candidate for high-temperature applications.

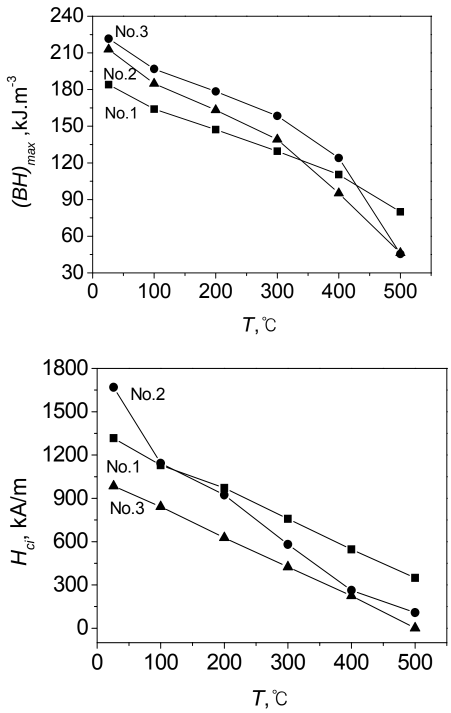

Fig. 1 Dependence of *(BH)$_{max}$*(a) and *H_{ci}*(b) on tempe rature(*T*) for Sm_2Co_{17}-based magnets

It can be seen from Fig.1that the magnet with 10.53wt% Cu-content has a room temperature intrinsic coercivity of 30.3 kOe. The temperature coefficient of coercivity $\beta_{RT\text{-}500}$ and H_{ci} at 500^{o}C are -0.148%/^{o}C and 8.6kOe. The coercivity of the sample with low Cu content decreases much faster than that with high Cu content. Sample B has a coercivity of 20.87kOe at room temperature, but only 1.36kOe at 500^{o}C. Sample A has a lower coercivity at room temperature(16.46kOe), but a coercivity of 4.37kOe at 500^{o}C. Higher Cu-content and lower Fe-content may increase the magnetic properties at high temperature.

Fig. 2 shows a typical TEM image of $Sm(Co_{bal}Fe_{0.197}Cu_{0.049}Zr_{0.026})_{7.5}$ magnet, respectively. The microstructure of the magnet consists of a perfect cellular microstructure with a cell size of 90nm and with a cell boundary thickness of 20nm. The cell interior is a $RSm_2(Co,Fe)_{17}$ phase, and the boundary is $Sm(Co,Cu)_5$ phase.

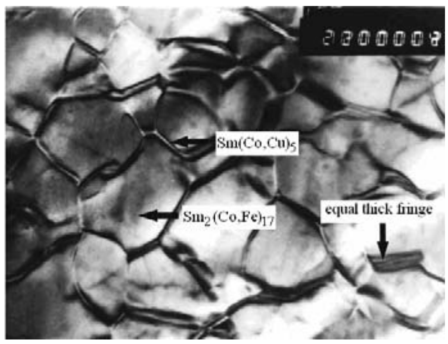

Fig. 2 Bright-field image(a) of the typical cellular mi crostructure of sample A

A fairly uniform maze-like domain structure is apparent in the magnet, as shown in Fig.3. A maze-like pattern is consistent with the formation of interaction domains consisting of many single domain grains of approximately uniform magnetization clustered together. In addition, there is a small number of stripe domain walls in the magnet. However, no distinctive domain wall pinning sites along the lamellar phase can be observed

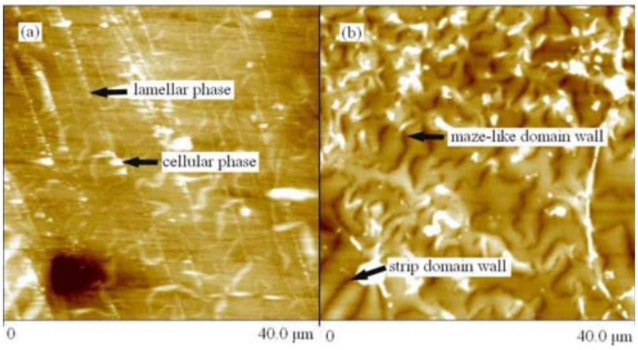

Fig. 3 A 40μm×40μm MFM image of (a) the typical microstructure and (b) the corresponding domain s tructure of sample A

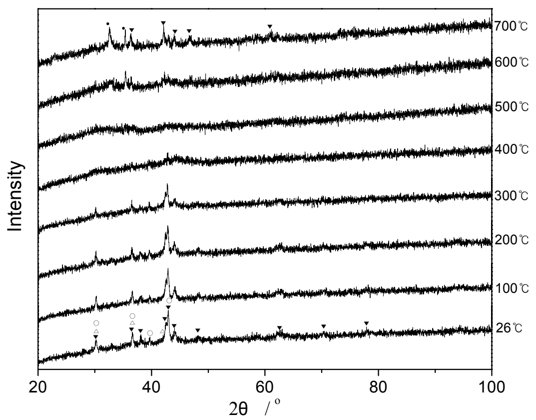

Fig.4 In situ high temperature XRD patterns of Sm_2 Co_{17}-based magnets from 293K to 973K

(▼—RSm2(Co,Fe)17 phase, △—Sm(Co,Cu)5 phase, ○—HSm2(Co,Fe)17 phase, ●—Sm2Co7 phase)

We can see from Fig.4 that high temperature X-ray diffraction suggests that following occurred:

RSm2Co17+SmCo5+H Sm2Co17→ amorphous structure (773K)

Amorphous structure → RSm2Co17+Sm2Co7 (873K)

Sm2Co7 phase grows (973K)

The results show that the phase transformation at high temperature leads to degraded magnetic properties of the magnets.

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