Influence of Dy_2O_3 and Sn on the Structure and Magnetic Properties of NdFeNB Magnets

Liya Li, Jianhong Yi Yuan Dong Peng

The State Key Laboratory for Powder Metallurgy, The Central South University,
Changsha 410083, China
llylucky@163.com

Abstract

Addition of 2.0wt%Dy_2O_3 or 0.3wt%Sn proved to be very effective in improving the permanent magnetic properties of NdFeNbB magnets. Dy_2O_3 additions result in the increase in the H_{ci} and temperature dependence due to formation of (NdDy)-rich phase and grain refinement of Φ phase. This improvement of the coercivity stability of the magnets from the addition of Sn is attributed to the smoothing effect of the Sn addition at the grain boundaries. The magnetic properties, the temperature dependence and Curie temperature of NdFeNbB with Dy_2O_3 and Sn combined addition were found to be considerably improved.

Keywords : NdFeNbB permanent magnets, magnetic properties, Dy_2O_3, Sn

1. Introduction

NdFeB permanent magnetic materials have enjoyed considerable attention because of their high magnetic properties. The NdFeNbB alloy was melted in vacuum induce furnace. The alloy ingot was broken and Dy_2O_3 and Sn was added before ball milling with gasoline to particle size of 3-5 μm. The powders were pressed in the 1.8T magnetic field. After isotropic pressing, the green compacts were then sintered at 1115°C for 1 hour in vacuum and subsequently heat treated at 580°C for 1h.

From Fig.1(a) we can see that the additions of Dy_2O_3 can be seen to result in a considerable increase of H_{ci} and H_{cb}. On the other hand, B_r slightly decreases with the addition of Dy_2O_3. The $(BH)_{max}$ slightly increases up to x = 1.5wt% and then decreases with subsequent addition of Dy_2O_3 content. The alloys of NdFeNbB+xSn in the rang x=0-0.6 have been investigated and their magnetic properties are shown in Fig. 1(b). The addition of Sn up to 0.3wt% causes the value of H_{ci} to increase, and further addition of Sn results in the decrease of said value. On the other hand, Br and $(BH)_{max}$ slightly decrease with the addition of Sn.The simultaneous addition of Dy_2O_3 and Sn to NdFeNbB shows the best temperature dependence, as shown in Table1. The temperature dependence of NdFeNbB with only Dy_2O_3 additions is greater than that of with Sn additions. According to the additions of Dy_2O_3 and Sn, the coercivity and the temperature dependence are greatly improved, as shown in Fig. 2(b).

It can be inferred that sintered NdFeNdB magnet is a multi-phase material consisting of *Φ* phase as matrix and $NdFe_4B_4$(η phase), Nd-rich constituents, α-Fe as minor phases as shown in Fig. 3. There are many small deposits distributed at the grain junctions and at the grain boundaries. From the EDAX analysis, we can deduce that Dy largely partitions to the Nd-rich phase, and less to the Φ phase. Sn mainly goes into the grain boundaries.

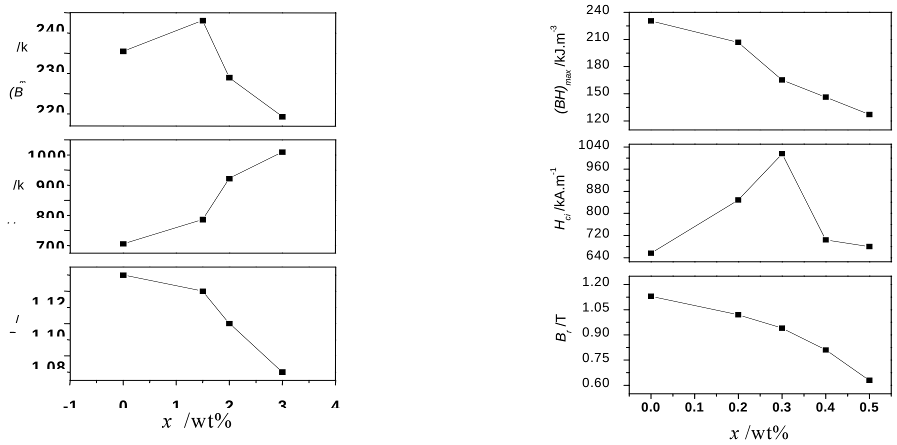
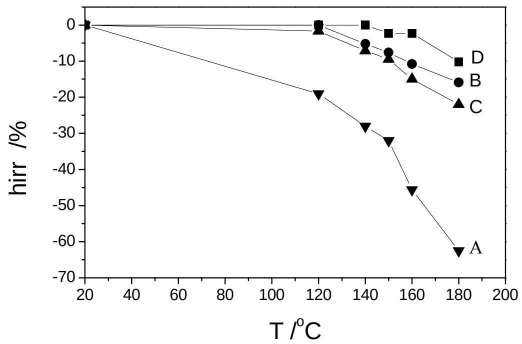


Fig. 1. Variations in B_r, H_{ci}, and $(BH)_{max}$ of NdFeNbB+ xDy_2O_3 and NdFeNbB+xSn as a function of Dy_2O_3-concentration(a) and Sn-concentration(b)

Table 1. The magnetic properties of the magnets at room temperature

Samples	B_r /T	H_{ci} / kA.m^{-1}	$(BH)_{max}$ / kJ.m^{-3}
NdFeNbB (A)	1.13	656.0	230.5
NdFeNbB+2%Dy_2O_3 (B)	1.11	824.0	221.8
NdFeNbB+0.3%Sn (C)	0.94	1016.0	165.1
NdFeNbB+2%Dy_2O_3+0.3%Sn (D)	1.09	1024.0	214.4



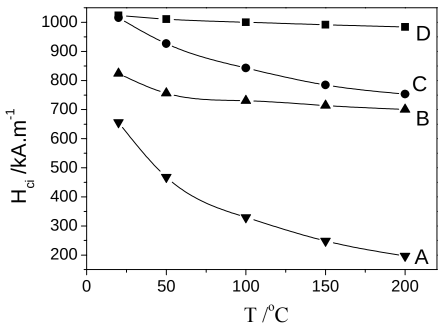


Fig. 2. The *hirr* and temperature dependence of coercive field of the magnets.

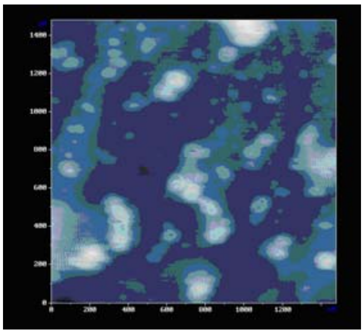


Fig. 3. MFM images of NdFeNbB+2%Dy_2O_3+0.3%Sn.

References

1. H J Engelmann, A S Kim and G Thomas, Scripta Materialia, 36[1],55(1997).
2. J Jiang, Z Zeng, J Wu, J. Magn. Magn. Mater, 214[1-2],61(2000).
3. Y Zhou, W Liu, X G Zhao, J. Magn. Magn. Mater, 278[1-2],1(2004).