Thermomagnetic monitoring of nanocomposite formation in mechanically alloyed Nd-Fe-B alloys

H. W. Kwon, and I. C. Jeong

Schol of Materials Science and Engineering, Pukyong National University, Busan, 608-739, Korea

*Corresponding author: e-mail: hwkwon@pknu.ac.kr, Phone: +82 51 620 1641, Fax: +82 51 624 0746

Nanocomposite consisting of a hard magnetic phase ($Nd_2Fe_{14}B$) and a soft magnetic phase (α-Fe) are of great interest because of its enhanced remanence and it is considered as a promising material for bonded magnet applications. The nanocomposite materials are usually prepared by either rapid solidification or mechanical alloying process. In the mechanical alloying the starting materials (Nd, Fe and FeB) are extensively milled and then annealed. In the present study a Nd-Fe-B-based nanocomposites were prepared by mechanical alloying and subsequent annealing, and the nanocomposite formation process was monitored by thermomagnetic means. Alloys studied in the present work had composition of $Nd_xFe_{94-x}B_6$ (x = 5.5, 7, 8.5, 11). Elemental powders of Nd (~0.2 mm) and Fe (~10 μm), and crushed $Fe_{80}B_{20}$ alloy (~60 μm) were mechanically milled using a shaker mill. The milled materials were annealed at 550 °C – 800 °C under a vacuum of 10^{-6} mbar. A magnetic balance was used for the thermomagnetic monitoring of the nanocomposite formation in the milled alloys. The as-milled materials consisted of a mixture of an amorphous Nd-Fe-B phase and α-Fe nanocrystallites. Fig. 1 shows the thermomagnetic tracing of the as-milled $Nd_xFe_{94-x}B_6$ alloys (x = 5.5, 8.5). In the course of heating (Fig.1(a)) rapid magnetization reductions are observed at 544 °C and 505 °C for the alloys with x = 5.5 and 8.5, respectively. These magnetization decreases are attributed to the crystallization of $Nd_2Fe_{14}B$ phase. It can be seen that the crystallization temperature of the $Nd_2Fe_{14}B$ phase decreases with increasing the Nd content. The magnetization decrease appearing at around 770 °C corresponds to the Curie temperature of α-Fe. In the cooling tracing (Fig.1(b)) the magnetization increase due to the magnetic transition of α-Fe is greater for the alloy with lower Nd content, indicating that more α-Fe has been formed as expected from the composition. The magnetization increases at 310 °C are attributed to the $Nd_2Fe_{14}B$ phase which has been crystallized in the course of heating and cooling. The alloy with higher Nd content shows greater magnetization increase due to the $Nd_2Fe_{14}B$, and this indicates that more $Nd_2Fe_{14}B$ phase has been formed. In this article, the thermomagnetic monitoring results of the materials milled under various conditions are compared with XRD phase analysis and magnetic properties of the mechanically alloyed and annealed materials are also discussed.

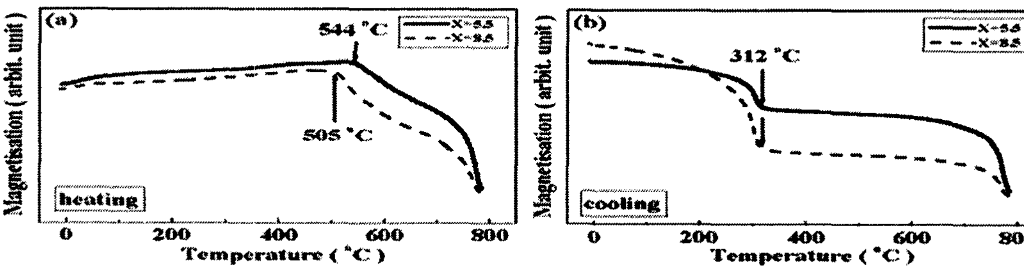

Fig. 1 Thermomagnetic tracing of the as-milled $Nd_xFe_{94-x}B_6$ (x = 5.5, 8.5) alloys.