The development of ultra-fine anisotropic magnetic material by HDDR process

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Recently, Dy-free high coercivity Nd-Fe-B permanent magnets have drawn a great attention for hybrid electric vehicles (HEVs) or electric vehicles (EVs). To achieve high coercivity without heavy rare earth elements, the control of microstructures such as grain size and grain boundary is of significant importance. Hydrogenation-disproportionation-desorption-recombination (HDDR) process is one of the simple methods to obtain Nd-Fe-B magnetic powders with single domain-sized grains. Furthermore, the powders show anisotropic magnetic properties under optimal conditions, which have been focused on hydrogenation-disproportionation (HD) stage although desorption-recombination (DR) stage is also thought to be important for improvement of magnetic properties. In the present study, effect of master alloy and DR condition on the microstructure and magnetic properties of Nd-Fe-B powders prepared by HDDR process has been studied.

The strip ($Nd_{12.5}B_{6.4}Ga_{0.3}Nb_{0.2}Fe_{bal}$) and mold [$Nd_xB_{6.4}Ga_{0.3}Nb_{0.2}Fe_{bal}$ (x=12.5-13.5, at.%)] cast alloys were subjected to HDDR process after homogenization heat treatment. During desorption-recombination stage, dehydrogenation speed and time were systematically changed to control the speed of the desorption-recombination reaction. In the result, it was confirmed that the texture and Nd-rich distribution of HDDR powder was related to master alloy powder. Therefore the master alloy powders must have a single crystalline and uniform distribution of Nd-rich phase for higher magnetic properties of HDDR powder. Furthermore the higher Nd content resulted in higher coercivity of the HDDR powder due to the thicker and more uniform Nd-rich phase at grain boundaries. And it was also confirmed that the slow dehydrogenation speed could maximize the effect of high Nd content on the magnetic properties of HDDR powder. At the optimized dehydrogenation speed, the coercivity and remanence was 15.3 kOe and 13.0 kG, respectively, at 12.9 at.% Nd content, which resulted in a (BH)max of 36.8 MGOe.

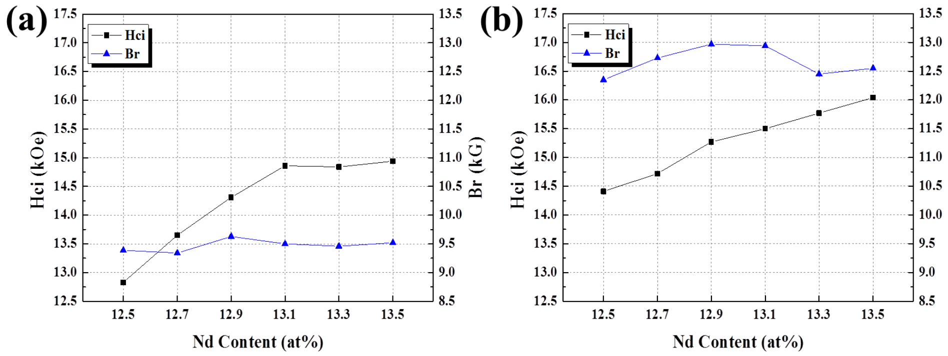

Fig. 1. Dependence of magnetic properties of HDDR powders processed by (a) fast-DR, (b) slow-DR process on the Nd content.