Observation of magnetic domain decoupling in the HDDR processed Nd-Fe-B magnets with Dy-rich grain boundaries

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Grain refinement is required for a higher remanent magnetization of $Nd_2Fe_{14}B$ magnets. The hydrogenation-disproportionation-desorption-recombination (HDDR) process is a simple and low-cost process to achieve grain refinement through hydrogen penetration. However, HDDR processed $Nd_2Fe_{14}B$ magnets often exhibit a lack of coercivity. The coercivity is strongly related to the grain boundary structure and its chemical constituents. In order to achieve a higher coercivity, therefore, a grain boundary diffusion (GBD) process is employed to introduce non-magnetic phases such as Dy-rich phase at the grain boundary, which enhances the decoupling of magntization. However, it has not been directly observed yet the magnetization reversal in the Nd-Fe-B magnet with applied magnetic field depending on the grain boundary characteristics such as thickness, crystallinity, chemistry, continuity and others.

In this study, Dy was deposited by electrophoretic deposition (EPD) method on the HDDR processed $Nd_2Fe_{14}B$ samples. Then, the GBD process of Dy coated samples was carried out by annealing at 800 ℃ for 4 hours. The microstructure and chemistry of the grain boundaries were characterized by transmission electron microscopy (TEM) and energy dispersive X-ray spectroscopy (EDS), respectively. The magnetic domains of HDDR processed only and Dy GBD processed samples were observed and compared using the Lorentz TEM. We also observed the propagation of magnetic domains when a constant magnetic field was applied to each sample.

As a result, it was confirmed that the Dy-coated samples through the EPD exhibited less magnetization reversal (i.e. magnetization was locked by the decoupling) in a relatively strong magnetic field. From these results, we could better understand the mechanism of the magnetic decoupling and the influence of grain boundary structure on the improvement of the coercivity of the Dy GBD processed Nd-Fe-B magnets.