Development of high coercivity Nd-Fe-B magnet

Keywords: 3DAP, TEM, Permanent magnet, Micromagnetic simulation

Tadakatsu Ohkubo
Magnetic Materials Analysis Group
OHKUBO.Tadakatsu@nims.go.jp | http://www.nims.go.jp/mmu/

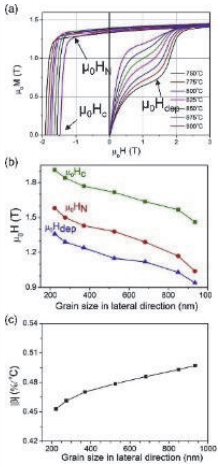
Background

Improvement of magnetic properties of permanent magnets became very important issue due to the need for resource saving and energy saving. Nd-Fe-B magnet now shows best properties among permanent magnets; however, further improvement of the properties is required.

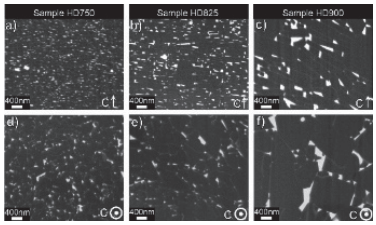
Aim

In the Nd-Fe-B magnets, in order to reduce the amount of the heavy rare earth elements such as Dy, the coercivity enhancement mechanism must be understood. So, multi-scale characterization by SEM, TEM and 3DAP have been applying to understand the relation between the magnetic properties and the microstructure[1].

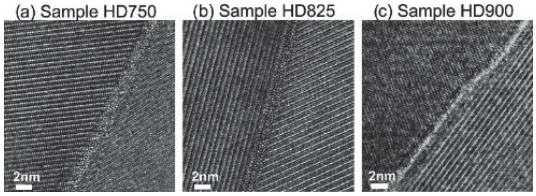
Advanced Research Topics



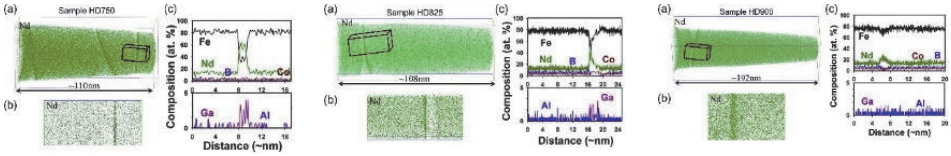
【Magnetic property】 Low hot-deformation temperature leads high coercivity and the small temperature dependency[2]



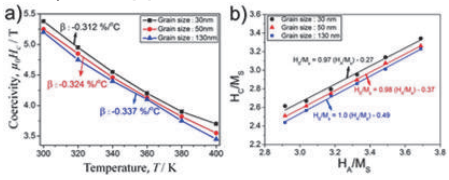
【SEM】 Grain size of hot-deformed magnet was decreased by decreasing the process temperature[2].



【TEM】 Grain boundary structure became amorphous when the hot-deformed temperature was low[2].



【Atom probe tomography】 Grain boundary phase has less Fe and more Nd by low hot-deformed temperature.[2]



【Micromagnetic simulation】 [3]
a) Smaller grain size shows better temperature dependency, smaller β, of coercivity.
b) Smaller grain size decreased effective demagnetization factor, N_{eff}, of equation $H_c = \alpha H_A - N_{eff} M_s$.

Publications

[1] T.T.Sasaki, T.Ohkubo, K.Hono, Y.Une, M.Sagawa, Ultramicroscopy 132(2013)222.
[2] J.Liu, H.Sepehri-Amin, T.Ohkubo, K.Hioki, A.Hattori, T.Schrefl, K.Hono, Acta Mater. 82(2015)336.
[3] H.Sepehri-Amin, T.Ohkubo, M.Gruber, T.Schrefl, K.Hono, Scr. Mater. 89(2014)29.

Summary

- Smaller grain size leads high coercivity and the low temperature dependency.
- Reason of high coercivity is due to high amount of Nd in grain boundary phase.
- Small temperature dependency of coercivity is due to decreasing the demagnetization field.

Research outcome

- Reducing Dy usage in a rare-earth magnet
- Improve high temperature magnetic properties
- Develop high performance magnets for hybrid/electric vehicles