Depth profile analysis of magnetization in Nd$_2$Fe$_{14}$B grain exposed on the fractured surface of Nd-Fe-B sintered magnet by hard X-ray photoemission spectroscopy

A. Yasui$^1$, E. Ikenaga$^1$, Y. Kotani$^1$, N. Tsuji$^1$, W. Ueno$^1$, S. Hirosawa$^2$, and T. Nakamura$^{1,2}$

$^1$) JASRI / SPring-8, Sayo, Hyogo 679-5198, Japan.
$^2$) ESICMM / NIMS, Tsukuba, Ibaraki 305-0047, Japan.

Understanding of the magnetic properties in the several tens of nanometers range from the interface of Nd$_2$Fe$_{14}$B grain is important to elucidate the coercivity mechanism in Nd-Fe-B sintered magnets. In some recent studies [1-3], an intergranular grain boundary (GB) phase has been found to be ferromagnetic contrary to the previous belief that the GB phase is paramagnetic. Although these studies characterize the magnetic property of thin-film like GB phase of about 2-3 nm thickness, the distribution of magnetization across the deeper region from the surface of the Nd$_2$Fe$_{14}$B grain has not been uncovered, yet.

In the present study, we have, therefore, investigated distribution of magnetization as a depth profile from surface to inside of the Nd$_2$Fe$_{14}$B grain, which was exposed by fracturing of a Nd-Fe-B sintered magnet under ultra-high vacuum, using hard X-ray photoemission spectroscopy (HAXPES) at BL47XU of SPring-8 [4]. The angular-resolved analysis of magnetic circular dichroism (MCD) in HAXPES spectra enables us to obtain the depth profile of magnetization up to about 20 nm for 8 keV incident X-rays. In the experiment, we used circularly polarized micro-focused X-ray beams to get the information from an intergranular-fractured surface of a single Nd$_2$Fe$_{14}$B grain. The obtained MCD-HAXPES spectra show obvious angular dependences and suggest that the grain surface has the smaller magnetization with compared to the inside of the grain in the 20 nm range.

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References