# Magnetic and chemical imaging by X-ray nano-probes in Nd-Fe-B sintered magnet

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Enhancing the coercivity without losing magnetization is one of the most important targets for improving the performance of permanent magnets. For Nd-Fe-B permanent magnets, researchers have been developing novel sintered structures with the optimized particle diameters and/or grain textures to further increase the coercivity. For achieving this, understanding and controlling of the magnetization reversal process is a key issue to provide the material design guidelines. In particular, how and from which grains does magnetic nucleation occur is still an open question. Magnetic properties of the grains are probably related to the chemical and structural properties of grain itself and of the neighboring textures. Microscopic observation in the magnetic and chemical states is indispensable for unveiling the nucleation process of magnetic domain.

We used a synchrotron-based hard X-ray nanoprobe [1] to study Nd-Fe-B sintered magnet. The technique offers a reasonable spatial resolution of 100 nm, element-selectivity, and non-destructive observation under a variable magnetic field up to 22 kOe. It also allows us to observe a non-flat surface with a bulk sensitivity (probing depth of ~2 μm) such that magnetic and chemical imaging at a fractured surface, in which the grain textures may be conserved as of the bulk sintered magnet [2, 3], would be possible. These capabilities are not simultaneously available from other magnetic microscopy techniques, such as Lorentz TEM [4], scanning X-ray transmission microscopy (STXM) [5], Kerr microscopy [6], spin SEM [3], and magnetic force microscopy. We demonstrate an evolution of the magnetic domain structure in the demagnetization process of a $Nd_{14.0}Fe_{79.7}Cu_{0.1}B_{6.2}$ sintered magnet. X-ray fluorescence micrographs are taken to correlate the elemental distribution of grain textures with the initial reverse magnetic domain structure created at the beginning of magnetization reversal. Segregated Cu located in the vicinity of the triple-junctions is shown to play a key role to determine the magnetic nucleation site. The performance of the soft-X-ray nanoprobe beamline, which has recently been completed its construction and ready for use, will be presented.

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