Abstract Andreas Michels:

Magnetic Neutron Scattering Studies on Nd-Fe-B Magnets

Nd-Fe-B-based permanent magnets have been continuously investigated for the last three decades due to their technological relevance as materials used in energy-related applications (e.g., motors and wind turbines) [1]. A crucial issue is the understanding of the magnetization-reversal process, which eventually may result in the preparation of dysprosium and terbium-free Nd-Fe-B alloys with characteristic magnetic parameters (coercivity, remanence, maximum energy product) that guarantee their performance also at the high operating temperatures of motors (up to 200 °C).

In order to achieve this goal, the combination of advanced characterization techniques such as aberration-corrected high-resolution transmission electron microscopy and three-dimensional atom-probe tomography with ab initio calculations and numerical micromagnetic modeling is required. Indeed, recent studies along these lines (e.g., [2-4]) have provided important information regarding the nature (chemical composition, crystalline structure, ferro- or paramagnetic) of the intergranular Nd-rich phases in Nd-Fe-B magnets (including nanocomposites), which decisively determine the coercivity mechanism of these materials.

Magnetic neutron scattering, in particular, small-angle neutron scattering (SANS) is another important technique for characterizing the bulk magnetic microstructure of engineering permanent magnets. Magnetic SANS provides information on variations of both the magnitude and orientation of the magnetization on a nanometer length scale (~ 1-300 nm). However, this method has only recently been employed for studying the spin microstructure of this class of materials (e.g., [5-10]). In this talk, we will discuss SANS data on both isotropic and textured sintered and nanocrystalline Nd-Fe-B magnets; specifically, the field dependence of characteristic magnetic length scales during the magnetization-reversal process is addressed, the exchange-stiffness constant has been determined, the observation of the so-called spike anisotropy in the magnetic SANS cross section (see figure below) has been explained with the formation of flux-closure patterns, and the effect of grain-boundary diffusion in isotropic Nd-Fe-B magnets has been studied.