Abstract Thomas Schrefl:

Coercivity in RE and MnAl(C) magnets

Nucleation and pinning determines the coercive field of permanent magnets. Numerical micromagnetics is an excellent tool to visualize the nucleation of reversed domains and the pinning of domain walls in model systems. These model systems are constructed artificially on the computer using detailed input from the experimental characterization of the material. The finite element models are built in a way that accentuate the key microstructural features.

The magnetic state prior to the nucleation of reversed domains shows where reversed domains are likely to form. In figure (a) the dark blue areas indicate the regions where the magnetization rotates reversibly out of the alignment direction by more than 25 degrees. In Nd2Fe14B based permanent magnets, nucleation of reversed domains occurs within the weakly ferromagnetic grain boundary phase or at a thin defect layer at the grain surface. In Dy diffused magnets, where the grains are covered with a thin Dy containing shell, the regions with high reversible rotations of the magnetization are in the core of the grains. Consequently, the nucleation field is higher by more than 30 percent. Once a reversed domain is formed magnetization reversal proceeds by forming columns of reversed grains. The pinning field is lower for domains perpendicular to the c-axis than for domain walls parallel to the c-axis.

A structurally stable L10 phase forms in MnAl with small additions of C. This phase is a candidate for rare-earth free permanent magnets with intermediate properties. However, the coercive field is well below the anisotropy field owing to defects in the crystal structure. Using finite element micromagnetics we computed the nucleation field and pinning field at twin boundaries and at antiphase boundaries. The figure (b) shows the motion of a domain wall in MnAl(C) under increasing applied field. The walls are pinned at twin boundaries. The depinning fields, µ0Hp, are = 1.23 T, 1.5 T and 1.9 T. The nucleation field at anti-phase boundaries is µ0Hn = 1.4 T. These results clearly show that the presence of defects limits the coercive field in MnA(C) magnets.