

Micromagnetic study of coercivity in AlNiCo magnets

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AlNiCo offers high Curie temperature and magnetisation without rare earths, but limited coercivity remains a bottleneck. A method to improve the performance of AlNiCo is to achieve a tailored microstructure designed to resist magnetization reversal through controlled nucleation and pinning mechanisms. Coercivity arises from the shape anisotropy of the nanometer-sized FeCo rods. Using simulations we compute the hysteresis properties by progressing from micromagnetic simulations [1] of a small number of rods within the magnetostatic field of their neighbors [2] to large systems treated statistically based on the distribution of orientations of the rods [3]. We considered variations in geometric parameters, including rod dimensions, inter-rod spacing, and vertical shifts, guided by transmission electron microscopy observations. The distribution of rod orientations was derived from magnetic measurements. Ideal nanostructure of AlNiCo consists of perfectly aligned rods with diameter less than 20 nm, high aspect ratio and inter-rod spacing dependent on the diameter of the rods. Owing to the diminishing influence of the reversed demagnetized regions relative to the total rod volume, the coercivity remains nearly constant for aspect ratios above a threshold value of 6. Increasing the diameter of the rod beyond 20 nm and lowering the aspect ratio below 5 reduce the coercivity because of an increased relative importance of magnetostatic versus exchange energy. Decreasing inter-rod spacing lowers coercivity because of stronger magneto-static interactions. Tilted orientations of the rods with respect to the direction of the applied field reduce coercivity following the Stoner–Wohlfarth model. A vertical shift of a rod modifies the magnetostatic field pattern such that nucleation points of reversed domains are created in neighbouring rods.

References:

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