

Micromagnetic modelling of soft-in-hard FeCo-FePt nanocomposites

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The concept of exchange-spring (nanocomposite) magnets was presented in [1]. The basic idea is to combine the high magnetization of a soft magnetic phase with the high anisotropy of a hard magnetic phase and thereby designing a magnet with superior energy product $(BH)_{\max}$. It might also offer the potential to reduce the amount of critical materials used in permanent magnets for green energy applications such as the rare earth elements neodymium or samarium. In this study we present micromagnetic simulations of soft-in-hard FeCo-FePt nanocomposites prepared by e-beam lithography and thin film deposition and then analyzed at Institut Néel in Grenoble. Micromagnetic simulations were done using an energy minimization code presented in [2].

Fig. 1A and 1B show the geometric models used for the simulations ($700 \times 1100 \times 30 \text{ nm}^3$). 1A represents the as-deposited nanocomposite structure. 1B represents the sample after annealing where the soft magnetic FeCo rods diffuse into the hard magnetic FePt phase forming $(\text{Fe},\text{Co})_3\text{Pt}$ and creating voids at the original position of the nanorods. (a), (b) and (c) in Fig. 1C show the calculated demagnetization curves for the micro-patterned isotropic hard-magnetic FePt phase only, the structure as shown in 1A and the diffused structure 1B, respectively. Remanence enhancement but also reduced coercivity is observed compared to (a). (b*) and (c*) show the demagnetization curves of a simulation setup where the FeCo or $(\text{Fe},\text{Co})_3\text{Pt}$ nanorods were placed within a nonmagnetic matrix revealing a coercivity of 0.26 T and 0.15 T due to shape anisotropy, respectively. Once the nanorods are placed within the hard-magnetic FePt matrix this shape effect vanishes which can be seen comparing the respective demagnetization curves and magnetic states when the external field is turned by 90 degrees in the film plane. The same is also observed experimentally.

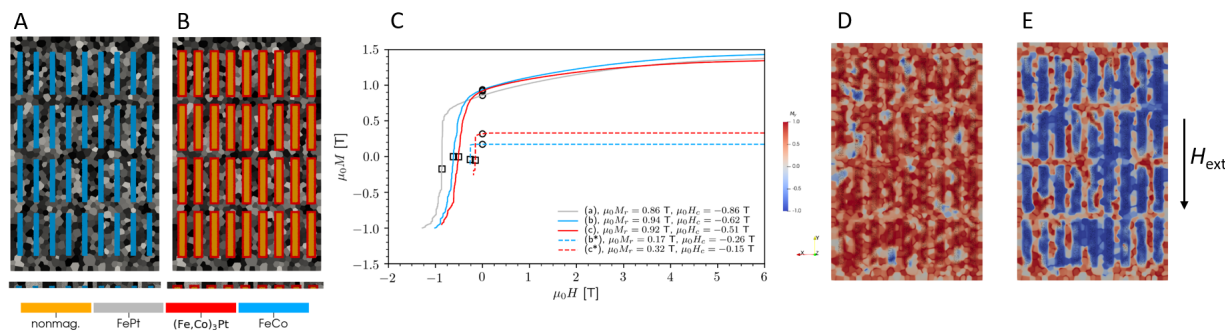


Figure 1: A and B depict the geometries used for simulations. C shows computed demagnetization curves. D and E show the magnetic states before irreversible switching and close to the coercive field.

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References

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