Benchmarking for systematic coarse-grained micromagnetics

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Permanent magnets (PM) are integral to realize various green technology applications such as electric cars and wind turbines, etc. An important physical characteristic of PM is coercivity (H_{C}). As an extrinsic material property H_{C} depends upon microstructural features such as defects, local demagnetizing fields and thermal fluctuations. Phenomenologically, the magnetic microstructural parameters such as α and N_{eff} become crucial in defining H_{C} of a real PM [1]: $H_{\mathrm{C}} = \alpha H_{\mathrm{N}}$- $N_{\mathrm{eff}} M_{\mathrm{s}}$, where H_{N} is the ideal nucleation field, M_{s} is the spontaneous magnetization and α is the reduction of coercivity due to defects, intergrain exchange interactions and misorientation. The parameter N_{eff} is related to the effect of local demagnetizing field near sharp edges and corners of the microstructure. Ideal nucleation field (H_{N}) is the maximum coercive field when α = 1 and N_{eff} = 0. In this work, we show that for a single grain of $\mathrm{Nd_2Fe_{14}B}$ the numerical values of α and N_{eff} can be estimated both by finite temperature computation of coercivity and by neglecting the demagnetization fields selectively, which is not straightforward in experiments. On the one hand, many simulations are needed by feeding finite temperature intrinsic magnetic properties of $\mathrm{Nd_2Fe_{14}B}$ into micromagnetic model. On the other hand, only few simulations are needed corresponding to single temperature by including and excluding the effect of magnetostatics on demagnetization curve. We considered two shapes a cube and a thin film including defect. It is observed that very similar values of magnetic microstructural parameters can be obtained from both methods with advantage of less computation by switching off the stray fields within micromagnetic framework. This proof of concept is then extended to more realistic microstrucutre by considering multiple grains through the reduced order model [2] as shown schematically in Figure 1. Preliminary results for magnetic reversal processes and computed magnetic microstrucural parameters will be shown. Future work will encompass material inhomogeneities such as defects in multiple grains.

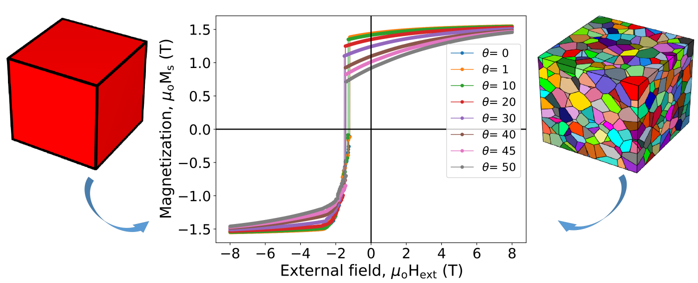

Figure 1: Schematic of using sinlge and multiple grains microstrucutre to compute demagnetization curve by using principles of micromagentics at different applied field angles ($\theta°$). The average grain size of polycrystalline structure is 7.3 μm.

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References

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