Modeling and experimental analysis of the hysteresis losses of magnetic nanodisks for hyperthermia applications

Riccardo Ferrero[1,2], Alessandra Manzin[1], Gabriele Barrera[1], Federica Celegato[1], Marco Coïsson[1], Paola Tiberto[1]

[1]Istituto Nazionale di Ricerca Metrologica, Torino, Italy

[2]Politecnico di Torino, Torino, Italy

Recently, magnetic nanostructures (MNs) obtained a lot of interest in cancer treatment, for both hyperthermia based therapies and induced cell apoptosis with the mechanical stimulation of cell membranes[1,2]. Focusing on hyperthermia applications, when an external ac magnetic field is applied to an ensemble of MNs dispersed in a tissue, different physical phenomena can concur to the heat generation, e.g. Néel relaxation, Brownian relaxation, hysteresis and eddy current losses. The relative contribution strongly depends on the size and physical properties of the used MNs[2,3].

Here, we present a micromagnetic modeling analysis and a comparison to experimental data, focusing on $Ni_{80}Fe_{20}$ nanodisks prepared via self-assembling of polystyrene nanospheres[4], for possible application in magnetically mediated hyperthermia. A parametric analysis is performed by varying disk diameter (100-700 nm) and thickness (15-30 nm), to find the optimal conditions for the maximization of the specific heating capabilities of the MNs. We focus on hysteresis losses, being the predominant heating contribution for such nanosystems. Hysteresis loops for nanodisks both arranged in 2D arrays (before detachment from the substrate) and free-standing (dispersed in a liquid) are calculated by means of a GPU-parallelized micromagnetic code[5]. The influence of interdot magnetostatic interactions and relative orientation with the applied field is analyzed.

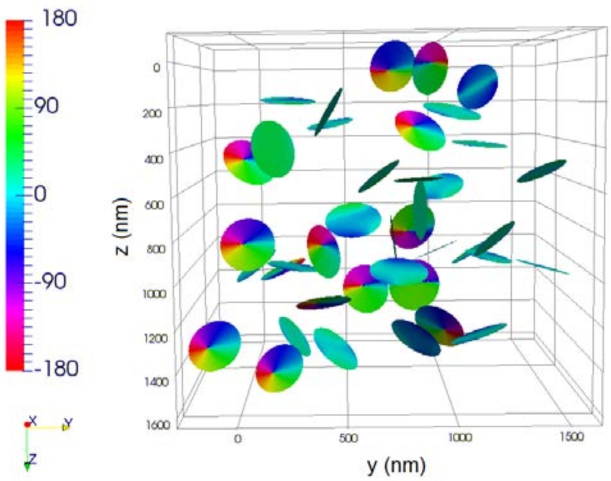

Figure 1. Magnetization configuration calculated at H_a = 30 kA/m (applied along *x*-axis) for an ensemble of 270 nm - diameter nanodisks with thickness of 30 nm, randomly dispersed with a concentration of 1%. Color scale refers to the magnetization direction with respect to the *x*-axis.

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