Magnetic response of composites of magnetic nanoparticles in dielectric matrices to the alternating field of the microwave frequency range

English abstract of doctoral dissertation

mgr inż. Kacper Brzuszek

1 II 2024

The presented series of papers is devoted to the theoretical prediction of the dynamic response parameters of nanostructured magnets to alternating magnetic fields of very high frequency and high amplitude, analyzed as materials for magnetic cores. A potential field of application of so-called high-frequency magnetic nanocomposites is voltage microconverters for integration into micro-electro-mechanical systems. The key property of the analyzed magnetic structures, due to power losses (on eddy currents), is the high electrical resistance associated with the separation of nanoparticles and the small size of (metallic) nanoparticles. Using micromagnetic simulations, the time courses of the magnetic response functions (magnetization) of superferromagnetic and superparamagnetic systems (lattices of ferromagnetic nanoparticles in dielectric matrices) and an antiferromagnetic insulator were determined.

The possibilities of enhancing the dynamical response with a static ordering field, choice of the shape of magnetic nanoparticles, use of a rotating driving field instead of a linearly polarized one were considered. The difficulties of the simulations were the formulation of a model of a micromagnetic superferromagnet, the consideration of thermal fluctuations in the dynamics of superparamagnets, the consideration of complex anisotropy in the multi-domain structure of a two-lattice antiferromagnet. The results made it possible to conclude that

1. the frequency dependence of the response function of superferromagnet composite layers to a dynamic magnetic field is similar to the response of homogeneous ferromagnets, but the nonlinear effects of the dynamic response strongly depend on the structure of the composite;
2. the value of the magnetic permeability of superparamagnet composites in the microwave frequency range can be several times greater than the magnetic permeability of a vacuum, which justifies their potential use in power conversion;
3. the so-called *performance factor* (the product of magnetic susceptibility and frequency χf) of an antiferromagnet insulator, can reach values comparable to ferromagnet systems, justifying the consideration of antiferromagnets as magnetic materials for applications at extremely high frequencies.