Monodomain magnetization state at remanence in antidot lattices with inhomogenous perpendicular magnetic anisotropy

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Antidot-type lattice (ADL) magnonic crystals have been gaining interest due to its technological potential in high density data storage and signal processing [1]. Previous investigation of spin-wave (SW) dynamics in circular ADLs with perpendicular magnetic anisotropy (PMA) and the rims of reduced PMA around the holes, discovered strong interaction between bulk modes of the ADL and the rim localized modes [2-3]. This shows the potential of circular ADL as an SW waveguide. However, squircle-shaped ADLs (a superposition of a square and a circle) as an alternative geometry have not been explored.

Here, we run multiple simulations using MuMax3 micromagnetic solver to find the ground state of ADL based on Co/Pd multilayer with squircle antidots. We follow a scenario used in standard hysteresis loop measurements, i.e., we set the initial magnetization distribution to be at full saturation with strong external magnetic field ($\mu_0 H_{ext} = 1$ T) parallel to the PMA axis and reduce the external field strength in a stepwise manner to remanence. The material parameters are set following the Co/Pd multilayer [3], but we vary some parameters such as thickness of the thin film d, uniaxial anisotropy constant K_{u1}, and the lattice constant a. The simulations are then categorized into two-types of domain structures, monodomain (perpendicular magnetization component, $m_z > 0.99$ outside the rim) or multidomain ($m_z < 0.99$ outside the rim). The phase diagram is created from simulations varying the parameters mentioned, either with $a = 500$ nm or fixed thin film thickness of $d = 13.2$ nm. Our results show that there is no apparent dependence of the type of domain structure to the area of region with full PMA, i.e., a. On the other hand, we observed some dependence to the thickness of the thin film. This study provides guidance on the selection of material and geometric parameters for ADLs with a regular domain structure in remanence, and thus serves as a first step prior to simulating the SW dynamics in such systems.

References:

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