Effective demagnetizing tensors in arrays of magnetic nanopillars

Abstract
A model describing the effect of magnetic dipolar interactions on the susceptibility of magnetic nanopillars is presented. It is an extension of a recently reported model for three-dimensional randomlike dispersions of nearly spherical nanoparticles in equilibrium [Sanchez et al., Phys. Rev. B 95, 134421 (2017)], to well-ordered arrays of nanoparticles out of equilibrium. To test it, a high-quality benchmark consisting of a two-dimensional hexagonal arrangement of quasi-identical parallel nickel nanopillars embedded in a porous alumina template was fabricated. This model is based on an effective demagnetizing tensor, which only depends on a few morphological parameters of the sample, as the nearest-neighbor distance between pillars and the volume fraction of pillars in the specimen. It allows us to obtain the nanopillar intrinsic susceptibility tensor from the magnetic response of the nanopillar ensemble. The values of the in-plane and normal-to-plane susceptibility of the sample are successfully predicted by the model. Furthermore, the model reproduces the susceptibility in the applied field direction, measured for different applied field angles. In this way, it provides a simple and accurate treatment to account for the complex magnetic effects produced by dipolar interactions. (AU)