Changing the domain structure of CoNi particles under mechanical stress

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The Villari effect (or the magnetoelastic effect – when the magnetic properties of a solid changes under mechanical stress) can be used for detection of a mechanical tension in the planar ferromagnetic particles or in a near-surface layer of the substrate where those particles are fabricated. The lateral resolution of this technique will be close to the lateral sizes of the particles. Usually the square planar particle has four-domain structure with equal domain sizes. In the presence of mechanical tension the area of domains with a magnetization perpendicular to direction of the tension were increased. The size increasing is caused by the negative magnetostriction of ferromagnetic material from which the particles were made. The length of the "bridge" between two antiparallel domains can be chosen for the characterization of the changing of the particle magnetic properties. The length of this "bridge" can be easily measured by magnetic force microscopy (MFM) and used to characterize the mechanical stress in the particle.

Studies were carried out on array of the planar CoNi (Co 18%, Ni 82%) particles with the size of $25\times25\ \mu m^2$ and $8\times8\ \mu m^2$. The particles were fabricated on a thin glass substrate. Heights of particles were varied for different samples in range 20-50 nm. Particles were prepared by electron beam evaporation under ultrahigh vacuum conditions by using a "Multiprobe P" setup (Omicron). An array of identical particles was formed by sputtering through a metal grid placed on the surface substrate. After sputtering, the sample was annealed at 300 °C during 15 min to reduce the stresses generated in the particles during sputtering.

To create the stressed particles substrate was elastically curved. For this purpose, the flat holder was used. The thin metal wire was placed under the center of a sample and the edges of a sample were clamped. The tension of particles was varied by changing the diameter of the wire under the sample's center. The scanning probe microscope (SPM) Solver HV and P47 (NT-MDT) were used. The magnetic cantilevers "Multi75M-G" (BudgetSensor) were used for MFM measurements. The obtained MFM images were compared with the computer modeling to determine a magnetic structure of the particles. The calculations were carried out by the OOMMF [1] and "Virtual MFM" [2] software. The size and shapes of particles obtained by SPM were used for modeling.

It has been shown that uncompressed 25-μm particles have a multidomain structure. Under the mechanical tension, the particle has quasi-uniformly structure with direction of magnetization perpendicular to tension. The uncompressed 8-μm particles have four-domain structure, with domains of equal sizes. A uniaxial tension of particle leads to increasing the sizes of domains with direction of magnetization perpendicular to the tension. The increasing of domain sizes leads to form a characteristic "bridge" between them, which is clearly observed on the MFM images. The direction of a bridge is perpendicular to the tension direction. The length of the bridge is directly proportional to the magnitude of the tension. Thus, the CoNi particles under study with the lateral size $8\times8\ \mu m^2$ can be used as the detector of the mechanical stress.

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1. M.J. Donahue, D.G. Porter: (http://math.nist.gov/oommf/).
2. D.V. Ovchinnikov, A.A. Bukharaev, *Technical Physics* **46**, 1014 (2001).