Nanoobjects microscopy

Magnetic fine structure of implanted $Y_3Fe_5O_{12}$ films resolved by magnetic force microscopy

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Epitaxial yttrium-iron garnet (YIG) films offer a unique set of optical and magnetic properties enabling their potential applications in micro-wave devices, spintronic devices, planar waveguide structures, magneto-optical devices magnetometer sensors, etc.

Fig.1. MFM maps of initial (a) and Ne^+ implanted $Y_3Fe_5O_{12}$ (b) films. Implantation dose equal to 2×10^{14} ion/cm^2. Inserts show large-scale images.

The Dimension 3000 NanoScope IIIa scanning probe microscope operated in the two-path magnetic force gradient detection mode (MFM) was used to investigate the magnetic fine structure and influence of high-dose implantation on magnetic domains. YIG films grown by isothermal liquid-phase epitaxy. Samples were implanted by Ne^+ at the energy of 80keV up to the dose of 4×10^{14} ion/cm^2. To map magnetic stray field over YIG film with high lateral resolution the Nanosensors™ PPP-MFMR magnetic probes with coercivity of approximately 30 mT and effective magnetic moment in the order of 0.010–0.013 Am^2 chosen. These slightly magnetized probes provide us reliable detection of periodic large-scale stripe domains (inserts in fig.1) as well as ordering effects of sub-domains of nanometer scale.

The effect of polarity inversion for large-scale domain walls was revealed (black/ white stripes in fig.1) in samples implanted by doses 2×10^{14} ion/cm^2 and larger as well as reordering of sub-domains. Modeling allows us to calculate the gradients of magnetic forces measured under the MFM-scanning of an arbitrary ensemble of magnetic nano-objects. It was shown that the unusually high resolution achieved due to use of slightly magnetized probe is caused by some kind of "smart" or reverse-mirror response of probe on the local surface magnetization. The mechanism of the enhancement of the spontaneous magnetization due to high dose implantation Ne^+ is also proposed and discussed.