Supporting Information

Magnetic Anisotropy Axis Reorientation at Ultra Thin FePt Films

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Experimental details

Sample fabrication has been performed in an ultra-high vacuum (base pressure 1.5×10⁻⁹ Torr) magnetron sputtering system (AJA ATC-2200-V) in diode configuration. Commercially available monocrystalline (001) MgO substrates with surface roughness approximately 0.1 nm have been used for obtaining L1₀ FePt films with a (0 0 1) texture (i.e. c-axis perpendicular to the film plane) [J.-U. Thiele et al., Perpendicular magnetic anisotropy and magnetic domain structure in sputtered epitaxial FePt (001) L1₀ films, J. Appl. Phys. 84, 5686-5692 (1998)]. The substrates were kept at 500°C during deposition for promoting the conversion from the magnetically soft fcc phase to the magnetically hard fct phase with alternate stacking of (0 0 1) planes of Fe and Pt (usually called L1₀ phase) [D. J. Sellmyer et al., High-anisotropy nanocomposite films for magnetic recording, IEEE Trans. Magn. 37, 1286-1291 (2001)]. Higher temperatures were avoided for maintaining compatibility to microelectronics processes. Homogeneous deposition was ensured by rotating the substrates around their normal axis. The source material was a round 50 mm diameter Fe₅₀Pt₅₀ target. High purity Ar (99.999%) was used as sputtering gas at 3 mTorr pressure. The applied DC power was 2 W/cm², yielding a deposition rate of 0.041 nm/s. A pre-sputtering at the same conditions, for 1 min, with the shutter closed, was performed prior each deposition. All films were capped with a 3 nm thick Ta layer for protection against oxidation, deposited in-situ by DC magnetron sputtering, immediately after FePt deposition. All deposition rates were determined from X-ray reflectivity (XRR) measurements of test samples.

X-ray diffraction (XRD) structural analysis has been performed using a Siemens D500 diffractometer with Cu-Kα radiation, in steps of 0.03° and counting time 6 s/step. 0-2θ scans were obtained in the 18° to 120° range. Anomalous Hall Effect (AHE) measurements at room temperature have been conducted using a Quantum Design Physical Property Measurement System. Electrical connections were realized at the corners of each square sample using
silver-paint. The applied magnetic field was always perpendicular to the samples surface. A constant current of 0.1 mA was used for all measurements. Atomic Force Microscopy (AFM) and Magnetic Force Microscopy (MFM) have been performed using a Bruker Dimension Icon microscope and commercial probes from Bruker (TESPA tips for AFM and MESP-HM for MFM). Probes were magnetized along their axis which is perpendicular to the sample surface; thus, the obtained magnetic contrast originates from magnetic domains with perpendicular magnetization. The samples were demagnetized using an alternating out-of-plane field with decreasing amplitude prior imaging. AFM images were obtained using the Tapping Mode, whereas MFM images were obtained using the phase imaging double-pass tapping-mode: surface topography was recorded during the first pass and then the tip was lifted at a certain height above the sample and the magnetic contrast was recorded. All microscopy images have been processed using the WSxM software [I. Horcas et al., WSXM: A software for scanning probe microscopy and a tool for nanotechnology, Rev. Sci. Instrum. 78, 013705 (2007)].

**X-ray diffraction diagrams**

Below we show the XRD diagrams and the corresponding pseudo-Voigt least-squares fits to the data.

Figure 1. Pseudo-Voigt fits to the data for the FePt (001) Bragg peak. Black symbols are experimental data and solid red lines are fits to the data.
MgO(001), FePt (200), and FePt (002) pseudo-Voigt fits

Figure 2. Pseudo-Voigt fits to the data for the FePt (200) and FePt (002) Bragg peaks. Black symbols are experimental data and solid red lines are fits to the data.

Figure 3. Pseudo-Voigt fits to the data for the FePt (200) and FePt (002) Bragg peaks: 1 nm thick FePt film. Black symbols are experimental data and solid red lines are fits to the data.
Figure 4. Pseudo-Voigt fits to the data for the FePt (200) and FePt (002) Bragg peaks: 1.5 nm thick FePt film. Black symbols are experimental data and solid red lines are fits to the data.

Figure 5. Pseudo-Voigt fits to the data for the FePt (200) and FePt (002) Bragg peaks: 2 nm thick FePt film. Black symbols are experimental data and solid red lines are fits to the data.
Figure 6. Pseudo-Voigt fits to the data for the FePt (200) and FePt (002) Bragg peaks: 2.7 nm thick FePt film. Black symbols are experimental data and solid red lines are fits to the data.

Figure 7. Pseudo-Voigt fits to the data for the FePt (200) and FePt (002) Bragg peaks: 5 nm thick FePt film. Black symbols are experimental data and solid red lines are fits to the data.