Anisotropy dependent magnetic microstructure in perpendicular magnetized $L1_0$ FePt thin films

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The understanding and control of magnetic domains in thin films with perpendicular magnetic anisotropy is of fundamental interest for emerging spintronic, magnetic data storage, and magnetoelectric devices. We study the magnetic domains in 4 nm thin continuous $L1_0$ ordered FePt (001) films prepared on Pt/Cr/MgO(001) substrates by pulsed laser deposition. Kerr microscopy revealed a fundamental change in the magnetic domain pattern when varying the degree of $L1_0$ order by thermal activation. Large magnetic domains with fractal boundaries and non-equilibrium character are present at high $L1_0$ order, while small and stable dot like domains are found in films exhibiting lower $L1_0$ order. A roughness-induced contribution could be excluded by in-depth morphological and microstructural analysis (XRD, TEM, AFM). The evolution of the domain patterns can be directly explained by the change of the intrinsic uniaxial magnetocrystalline anisotropy (MCA). At high $L1_0$ order, because of the large uniaxial MCA, reverse domains only nucleate at a magnetic field exceeding the pinning field. At a lower $L1_0$ order and associated MCA, domain nucleation takes place at lower reverse magnetic fields, at which domain wall pinning is still effective.