# MAGNETIC FORCE MICROSCOPY ON THIN FILMS AND NANOSTRUCTURES

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Magnetic Force Microscopy (MFM) is a variant of the Atomic Force Microscopy (AFM) imaging technique. It records the magnetostatic forces or force gradients between a ferromagnetic sample and a small magnetized ferromagnetic tip. The main advantages of this technique as compared to other magnetic domain imaging techniques are the high resolution (better than about 20 nm) and its insensitivity to protective non-magnetic overlayers [1].

In this work we will apply the MFM technique to study magnetic domain patterns on magnetic thin films and nanostructures. The surface morphology and magnetic domain structure in our films has been observed by using a Multimode Microscope with a Nanoscope IIIa controller and a 120 μm x 120 μm magnet-free scanner (Model AS-130VMF) developed by Digital Instruments. We used a Co/Cr coated Si probe tip magnetized parallel to its long axis. The images were recorded by using the amplitude detection mode. Prior to measurements, most of the films were perpendicularly magnetized with the help of a small permanent magnet capable of producing a stray field of about 4 kOe. For specific measurements the samples were magnetized along various axes up to their saturation field, which may reach even the value of 20 kOe, with the help of a water-cooled electromagnet.

Pioneer works in ultrathin magnetic films have shown perpendicular magnetic domains in the demagnetized state. The source of this perpendicular anisotropy is the interface anisotropy developed at the interface. Similar domains could be observed in tetragonally distorted ultrathin films due to the magnetoelastic anisotropy. On the other hand, single-crystalline hexagonal close packed (*hcp*) Co films when grown epitaxially with the c-axis oriented perpendicular to the film plane may show perpendicular stripe magnetic domains even up to a thickness of about 500 nm. In that case the source of perpendicular anisotropy was the magnetocrystalline anisotropy of bulk Co, which favors the c-axis [2].

In this work, we have grown by radio frequency magnetron sputtering polycrystalline Co and alloyed CoPd films in the thickness range of 15 - 4500 nm. We have used various substrates, such as Corning glass, silicon wafers and Al-foil. Some of these films have been deposited on microstructured Silicon substrates [3]. The substrate temperature was about 350 K. The films have been found by x-ray diffraction experiments to present various structures and textures depending on the preparation conditions, mainly the Ar-pressure and deposition rate. Stripe- and labyrinth-like domain configurations are observed in Co films textured along the c-axis, and in Co films with a mixture of *hcp* and *fcc* grains, repectively. Co films which show mainly *fcc* or amorphous structure do not form perpendicular domains [4]. On the other hand, CoPd films with a strong *fcc*{111} texture exhibit perpendicular magnetic domains. The results are discussed with respect to magnetization loops recorded via a home-made newly established and fully automatic polar magneto-optic Kerr effect (MOKE) magnetometer and are compared to similar ones recorded on Co/Au and Co/Pt multilayers [5,6]. The possible formation of canted magnetic states is also considered [7]. The magnetic prehistory of the samples in terms of magnetization and demagnetization along certain axes is shown to produce stripes, labyrinths or bubble-domain structures. The results are analyzed with respect to the magnetic free energy of the films.

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