Heusler alloy thin films for data storage and energy

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The more and more challenging requests of the data storage industry and new findings in the field of Spintronics have driven the interest of Magnetism research community towards the design and growth of thin films with high structural quality. Since the Nineties, several research groups have demonstrated the possibility to employ a sputtering apparatus to epitaxially grow, thin films of metallic alloys with different functional magnetic properties, e.g. huge magnetocrystalline anisotropy, ferromagnetic shape-memory, giant magnetoresistance. This demonstration has paved the way to the development of new devices, leading in some cases to important technological breakthroughs, as in the case of hard disk's reading heads based on the tunnel magnetoresistance effect. We have used a RF sputtering apparatus to grow epitaxial thin films or heterostructures of different magnetic metallic materials, exploiting the alternate deposition from three targets to obtain specific and variable compositions of the alloys. Using single-crystalline substrates with different lattice parameters, i.e., MgO, $SrTiO_3$, and LSAT, we have obtained epitaxial films (thickness from 10 to 200 nm) of two magnetic Heusler alloys: Ni-Mn-Ga and Mn-Ga. The films show a variety of different morphologies and microstructures, depending on substrate, film thickness and growth temperature. Our studies demonstrate that controlling structure and microstructure is crucial for tailoring magnetism. We have achieved a giant and anisotropic magnetization jump by microstructure engineering in magnetic shape-memory Ni–Mn–Ga films, which have a great potential for the fabrication of new-concept actuators, sensors and energy harvesters. We have also been able to epitaxially grow thin films of the metastable tetragonal phase of Mn-Ga (close to Mn_3Ga composition); these films possess exceptional magnetic and electronic properties, which make them promising as ferromagnetic electrodes in Spin-Transfer-Torque Magnetic RAMs. For both these Heusler alloys, we have realized nanodots by self-assembly nanolithography.

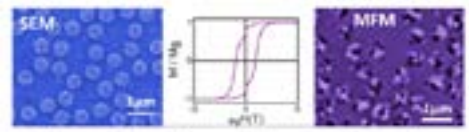

Figure 1: Scanning Electron Microscopy (left), perpendicular hysteresis loop (centre) and Magnetic Force Microscopy (right) of $Mn_{60}Ga_{40}$ nanodots obtained by self-assembly lithography

Biography

Francesca Casoli is a research scientist at the Institute of Materials for Electronics and Magnetism of the Italian National Research Council (IMEM – CNR). She obtained her PhD in Physics from the University of Parma in 2005, investigating magnetic thin films and multilayers with perpendicular anisotropy and exchange-spring properties. Her research is currently focused on Magnetic thin films, Nanostructures and Nanocomposites with new functionalities or multi-functionalities. She has published more than 60 peer-reviewed papers and 3 book chapters on magnetic materials for data storage, sensors/actuators and biomedicine. She has recently co-edited the book *Ultra-High-Density Magnetic Recording: Storage Materials and Media Designs*, edited by Pan Stanford Publishing in 2016.

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