Stage M1 – Development of Spin Polarized Scanning Tunneling Microscopy (SP-STM) : A tool for the characterization of magnetism at the atomic level.

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Understanding the fine mechanisms of magnetism and spin dependent phenomena requires the determination of magnetic properties and interactions down to the atomic level. Combining the strength of Scanning Tunneling Microscope (STM) in imaging a surface with atomic resolution with spin sensitivity gives a new technique called Spin Polarized Scanning Tunneling Microscopy (SP-STM). The phenomenon of spin dependent tunneling can be traced back to 1971 from Tedrow and Meservey and 1975 from Jullière where those researchers were able to transfer by tunneling electrons from a magnetic material and a superconductor or an other magnetic material. Few years later, in 1987, Rhorer and Binning at IBM Zurich invented the STM and revolutionized the surface science at this time. We had to wait until early in the 1990 with Wiesendanger and Guntherodt to start seeing the first experiment based on the use of STM with magnetic tip and magnetic sample. The group "Nanostructures Magnétiques" at ILM studies the magnetism of small particles down to few nanometers in diameter. One of the latest study in our group is to go beyond performances of nowadays single magnetic phase magnets. A way to reach that goal is to combine soft magnetic nanoparticles with hard magnetic matrices like Co nanoparticles into a FePt matrix and control the microstructure of this system. Recently we were able to deposit Co nanoparticles of 6 nm into a FePt matrix where we observed coupling between the matrix and the nanoparticles (see figure 1). Using SP-STM would be of great help to understand the mechanisms at the interface between hard and soft nanomaterials which govern the performances of nanocomposite magnets. This internship is about the development of SP-STM onto an already existing STM at the Plateforme Lyonnaise de Recherche sur les Agregats (PLYRA). The work for the student will be to detect the spin polarized tunneling current with the set up (connect and set the right parameters) of a lock-in detection in the system. This lock-in will be the main tool in separating the topographic information from the spin polarized density of states of the probed samples. Then the student will start elaborating new STM tips used in SP-STM based on a magnetic material like Fe, Co or Ni, or by using a magnetic coating of W tips. The student will then measure the magnetic domain of ferromagnetic films of Fe or Co prepared by e-beam evaporation in the UHV deposition chamber at PLYRA and eventually probe the interface of the Co:FePt nanocomposite.

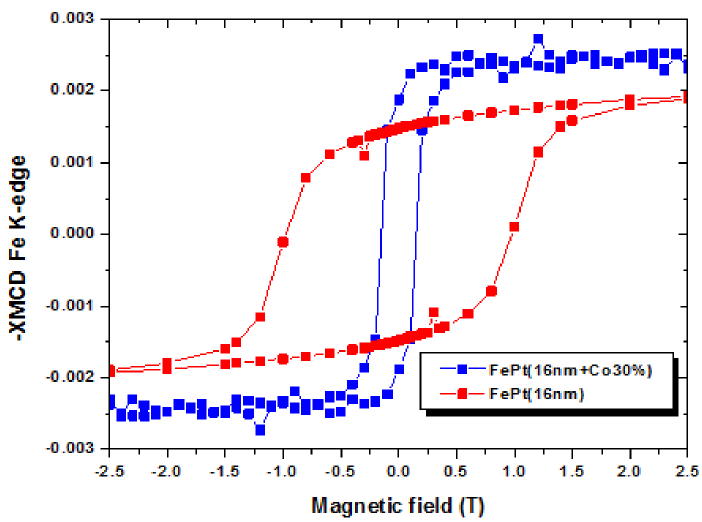

FIG. 1: Hysteresis loops on a FePt film (red) characterized by a large coercive field and on a Co:FePt nanocomposite. The coupling is visible by the increase of the magnetization at remanence (0 T field applied). The decrease of the coercive field is mostly due to a interface effect between Co clusters and the FePt matrix with a not perfectly controlled microstructure.