	Experiment title: Grazing Incidence XRD study of the structure of magnetic nanoclusters in silica glass	**Experiment number**: HS-1268
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Names and affiliations of applicants (* indicates experimentalists):

F. Gonella, Physical Chemistry Dept., University of Venice, Italy

E. Cattaruzza*, INFM, Physical Chemistry Dept., University of Venice, Italy

F. D'Acapito, GILDA CRG, ESRF, Grenoble, France

C. Maurizio*, Physics Dept., University of Padua, Italy

F. Zontone*, ESRF, Troika Beamline, ESRF, Grenoble, France

Report:

The aim of the proposed experiment was to determine the crystalline structure of magnetic nanoaggregates formed within silica matrix upon either ion implantation or sol-gel routes, so investigating the role of different preparation parameters in giving rise to cluster structures with peculiar magnetic response. In particular, the magnetic properties of these composites depend critically on the clusters nanostructure and composition, in terms of magnetoelastic contribution related to lattice stress, or changes in the material magnetic response when a change in the crystalline phase occurs following the cluster size reduction. In the proposed experiment, fused silica slides were sequentially implanted with couples of ion species, namely, Co^+ and Ni^+, Co^+ and Cu^+, at total fluences in the 6 to $30*10^{16}$ ions/cm^2 range, and energies from 90 to 180 keV. Also, silica slides were coated via sol-gel dip-coating method, then annealed either in air or in reducing atmosphere at different temperatures. For each technique, different samples were prepared to cover the Co:Ni composition range. By these techniques, almost monodispersed nanostructures were obtained with particle size in the range from a few to several nanometers. Co:Cu (1:1) composites prepared by ion implantation exhibit a lower coercive force than single Co composites. With grazing incidence X-ray diffraction it was be possible to investigate the presence of Co clusters (hcp) and of Co:Cu alloy nanoclusters (fcc). A variation of the coercitive force has been observed with the change of Co:Ni alloys in the composites prepared by ion implantation at different doses. The sharp increase of the coercive in the case of 4:1 Co/Ni ratio in a sample

particle size. In order to understand and modelize the magnetic features of these Co:Ni composites, it is of critical importance to determine the cluster structure under the various preparation conditions.
Due to the dilution of the sample, grazing incidence geometry (about 0.1 deg) and extremely small beam were used, together with an image plate as detector in order to collect as much as possible of the diffracted beam. In the case of Co+Cu implanted systems, the presence of nanocrystals was detected, with isotropic orientation. The single implanted Co sample was found to exhibit hcp structure, whereas the subsequent Cu implantation gave riese to the co-presence of two crystalline structures, hcp and fcc, consistent with two different phases (Cu and Co nanoclusters), and no alloy formation was observed, in agreement with EXAFS measurements. Moreover, increasing Cu concentration determines an increasing of fcc structure. For Cu ($9*10^{16}$ ions/cm^2) implant followed by Co ($3*10^{16}$ ions/cm^2) implant and then annealed in hydrogen atmosphere, the sample exhibits only fcc phase. EXAFS analysis found that there are Co-rich fcc clusters. From these two observations, possible CuCo fcc alloy nanocrystals (not possible in bulk phase) are formed. This can be useful for tailoring (be', piu' o meno) the magnetic properties of the system for technological

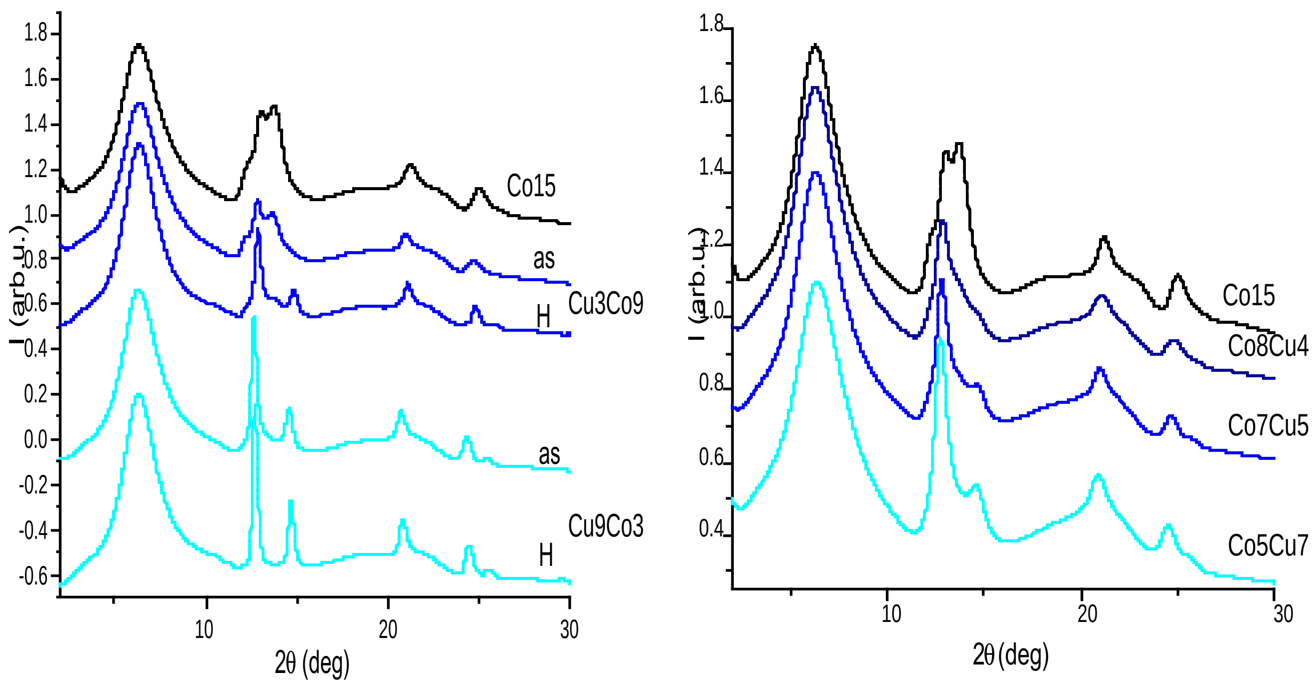

Fig. 1. Diffraction patterns for Co and Cu+Co implanted samples (left) and Co and Co+Cu implanted samples. The "H" indicates annealing in hydrogen atmosphere.

application. In Figure 1, diffraction patterns are shown for samples implanted and annealed at different conditions. The number indicates the implantation dose (in 10^{16} ions/cm^2) of the respective ion species, while the "H" indicates annealing in hydrogen-rich atmosphere. In the case of sol-gel prepared samples, randomly oriented crystalline structures were also detected. Work is in progress to determine the dependence of clusters families on the preparation parameters.

Publications

F. D'Acapito, F. Gonella, C. Maurizio, E. Cattaruzza, S. Padovani, G. Mattei, F. Zontone, in preparation.