11th International Conference
on Advanced Materials

ICAM2009

Rio de Janeiro Brazil
September 20 - 25

Magnetic Behavior of Cluster-Assembled Materials

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Abstract – We present a project for the study of the magnetic behavior of small embedded clusters as a function of their size. The chosen strategy for the production of well characterized cluster-assembled materials as well as planned experiments are described and discussed pointing out the experimental difficulties and the scientific interest.

It is well known that new phenomena arise as the size of a system is reduced, however the understanding of these phenomena is often complicated by the great number of parameters that cannot be controlled simultaneously during sample preparation and by the need of new strategies for experimental analysis. A typical example is the determination of the magnetic moment per atom (MM) of supported clusters containing less than 1000 atoms. It has indeed been observed that the MM of such clusters in the gas phase is greatly enhanced with respect to bulk values and shows important size effects[1]; it is however unknown if this behavior survives when the particles are supported or embedded in a matrix. The difficulty of such experiment relies on sample preparation techniques that do not allow a fine control on the size, chemical composition and concentration of clusters, as well as on the failure of standard magnetometry tools such as SQUID or VSM due to the low signal to be detected. Therefore, in order to successfully determine the magnetic behavior of cluster-assembled materials, both experimental challenges have to be solved. In the following we discuss the strategy we plan to use.

A beam of cluster ions is produced in vacuum using a magnetron sputtering aggregation source[2]; it is then guided and charge selected through a system of electrostatic lenses, mass analyzed with a time of flight spectrometer and finally directed to a deposition chamber. The deposition chamber has being designed in order to allow the maximum versatility and to maximize the control on the sample: clusters are slowed down when reaching the surface for soft-landing; the matrix can be chosen to be of any solid material and the deposition rate is monitored with a crystal and varied according to the cluster current in order to maintain a stable cluster concentration; the temperature of the deposition surface can be regulated as well as the gas atmosphere in the chamber.

For what concerns the MM detection technique, we have chosen to perform transport measurements, i.e. magneto-resitance and Hall effect, as they have been proven sensitive to extremely low magnetization signals[3]. We are furthermore developing a magnetometry protocol based on the response of a quartz tuning fork to an alternating gradient field [4].

At present, the cluster source and the apparatus for transport measurements are both operational while the deposition chamber and the resonance magnetometry experiment are under construction.

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