Report for ESRF Experiment 25-01-1027 - XAS study of electrodeposited Cu-Bi nanowires for spintronics applications.

Introduction

Materials that may exhibit a giant Spin Hall Effect (SHE) have recently received attention due to the possibility of converting an electric current into a spin current without the need of ferromagnets [1]. Pure metals have a very small SHE, but there are different methods to enhance it, like impurity scattering or strong spin-orbit coupling In addition to the small intrinsic SHE in pure metals, scattering on impurities with strong spin-orbit coupling can contribute to an enhanced SHE. Several theorical calculations predict that some combinations of noble metals and impurities could lead to a very large SHE [2,3]. However, in order to attain large SHE values, two conditions are mandatory: (i) high quality samples and (ii) relatively large Bi concentrations [4].

In almost all experimental works published so far, Bi concentration is kept below 1% due to the difficulty of growing alloys with higher Bi content avoiding Bi clustering [4]. In our work we have grown electrodeposited CuBi nanowires with higher Bi concentrations and high crystalline quality.

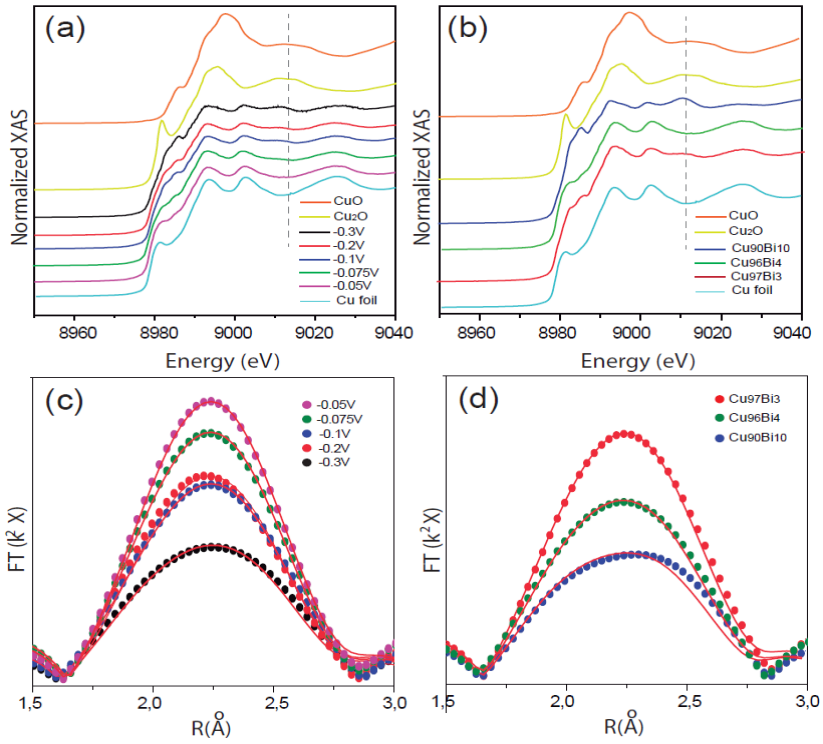
Experimental

CuBi nanowires have been grown by electrochemical deposition. Cu nanowires doped by Bi has been growth using organic-based electrolytes in polycarbonate membranes. Electrodeposition was carried out at room temperature, in a three-electrode configuration, using Pt gauze as a counter electrode and an Ag/AgCl reference electrode.

The morphollogy and the structural properties of the CuBi nanowires have been studied using different techniques (scanning electron microscopy, energy disspersive spectroscopy and x-ray diffraction and HR-Transmission electron microscopy). X-ray absorption experiments were performed on the SpLine beamline at the European Synchrotron Radiation Facility (ESRF). We carried out X-ray absorption near edge structure (XANES) spectroscopy experiments at the Cu K-edge (8.98 keV) and Bi L_3-edge (13.42 keV) in fluorescence mode at room temperature.

Results

We have electrodeposited CuBi nanowires and studied their composition and structural properties as a function of growth conditions and Bi content. We have performed XAS measurements on different set of nanowires with different composition and woth different growth conditions. We have also measured pure Bi and Cu foils as well as Cu and Bi oxides references. Fig. 1 shows the results obtained in the XAS measurements in the ESRF beamtime at Cu K-edge. In fig. 1.a., we show the XAFS signals at Cu K-edge for nanowires grow at different conditions. The comparison between the nanowires and the references provides us with information about the structure on the wires. As can be seen in the figure, when the growth potential is reduced, the shape of the spectra resembles that of the metallic Cu foil and the oscillation are better defined showing a better crystal quality. When the potential increase, a new oscillation appears, oscillation that can be related to an increase in the content of Cu oxide. Figure 1.b show the XANES spectra at the Cu-K edge for NWs with different Bi concentration together with the Cu foil, Cu_2O and CuO references. The spectra for the $Cu_{96}Bi_3$ and $Cu_{96}Bi_4$ NWs, is more similar to the one for the metallic Cu reference foil. However, for the $Cu_{96}Bi_{10}$ NWs, XANES profile changes, exhibiting some resonances resembling the one of the Cu oxide. Figure 1c and 1d show the analysis of the Fourier transform (FT) of the extended X-ray absorption fine structure (EXAFS) spectra for the measured Bi-doped Cu NWs.



References

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