ESRF

Experiment title: STUDY OF THE EFFECT OF SURFACTANTS ON THE INTERFACIAL ROUGHNESS OF CRYSTALLINE SUPERLATTICES	Experiment number: HS-448

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Report:

In our experiments performed at beamline ID01, we studied the crystalline structure of two metallic superlattices grown by Molecular Beam Epitaxy with the aid of Pb as a surfactant agent. Sample No. 1 was a $\{Cu_5/Co_7\}_{25}$ multilayer grown on a single-crystal Cu(111) substrate. The second sample (denoted No. 2 in the following) was a $\{Cu_6Co_7/Cu_6\}_{22}$, also grown on a Cu(111) surface. Both samples showed good crystallinity with sharp interfaces, and a small amount of roughness well correlated across the multilayer. Fig. 1 shows a representative example of the data obtained: it displays a high-angle scan across the substrate (002) peak of sample No. 2. Several intense multilayer reflections can be observed, indicating that the superlattice periodicity is well defined. The interference fringes (also known as Kiessig fringes) that can be seen between the multilayer peaks constitute an additional proof of the structural quality of this sample. It must be kept in mind that the magnetic layers consist of a mixture of Co and Cu with a large fraction of this latter element, which is the same used for the spacer layers. Therefore, the contrast is strongly reduced and the interfaces cannot be expected to be flat. Despite this limitation, the observation of the diffracted peaks demonstrates the coherence of the superlattice periodicity throughout the sample.

The epitaxial growth of Co and Cu layers on Cu(111) substrates has been a subject of continued interest due to the small lattice mismatch between both materials and their bulk inmiscibility, which makes them almost ideal candidates for the growth of magnetic heterostructures. However, samples prepared by the usual methods contain a large amount of structural defects, due to the following intrinsic characteristics of these materials[1,2]:

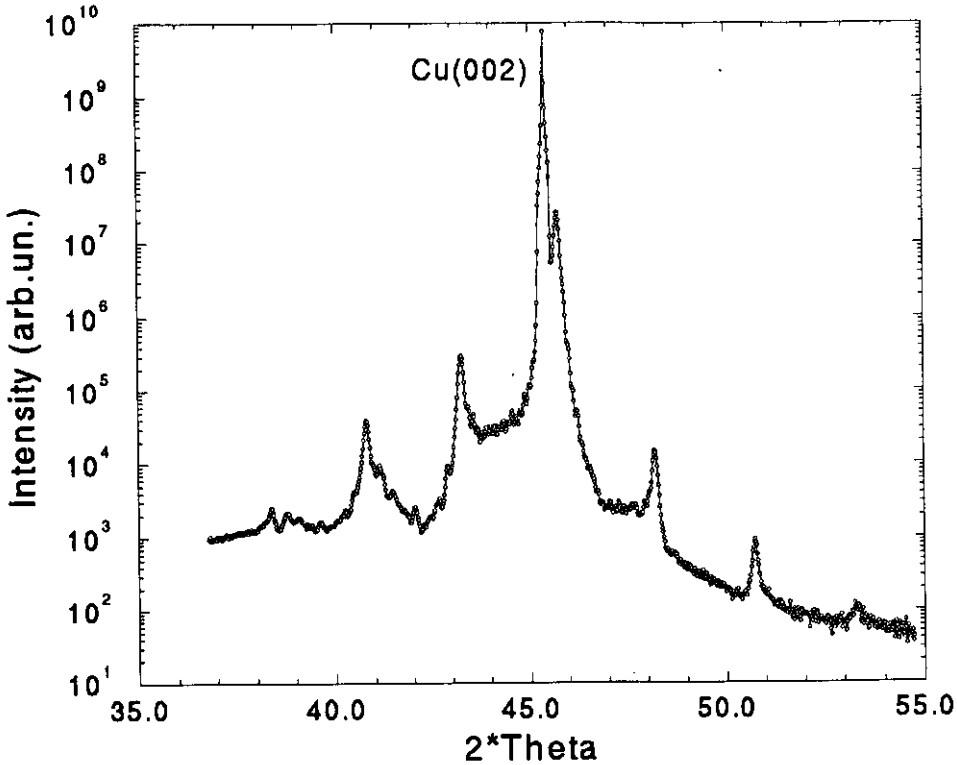

Figure 1: High-angle scan measured on Sample No. 2, showing peak (002) of the Cu(111) substrate together with the Bragg reflections corresponding to the superlattice periodicity.

- The existence of a large energetic barrier at atomic steps, hindering interlayer diffusion and thus suppressing layer-by-layer growth, and
- The existence of two different three-fold adsorption sites at the Cu(111) surface, which facilitates the formation of stacking faults and the appearance of the hcp phase of Co.

As a result, layers grown by vapor deposition are very rough and contain pinholes that establish direct contacts between consecutive layers. On the other hand, the use of a surfactant such as Pb greatly improves the structural quality of these samples, as the data obtained in these experiments show.

It must also be stressed that the obtention of these results has been made possible by the special characteristics of the ESRF and in particular of beamline ID01. Co and Cu are two elements of similar atomic number, and therefore their contrast for X-rays is very small. The sensitivity of our experiments was enhanced by tuning the energy of the X-ray beam to the Co absorption edge. Additionally, the large dynamic range of the diffractometer employed allowed us to detect a large number of diffracted satellites. This is important because it facilitates the analysis of the data, which is currently under way.

REFERENCES:

[1] J. de la Figuera . *et al.*, Phys. Rev. B **47**, 13043 (1993).
[2] J. Camarero . *et al.*, Phys. Rev. Lett. **73**, 2448 (1994).