Experiment title:	Experiment number:
STRUCTURAL STUDY OF THE SURFACTANT ACTIVITY OF Pb LAYERS DURING THE HETEROEPITAXIAL GROWTH OF METALS	SI-58

ESRF

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Names and affiliations of applicants (*indicates experimentalists):

* JUAN J. DE MIGUEL..........Un. Autonoma, Cantoblanco, E-28049 MADRID, SPAIN
C. OCAL.................... "
R. MIRANDA................. "
* L. SPENDELER............... "
* J. CAMARERO................ "
J.E. PRIETO................ "

Report:

The objective of this proposal was to study the surfactant activity of Pb during MBE growth] of *fcc*-{Co-Cu} superlattices on a single-crystal Cu(lll) substrate. It had been observed in a previous study of our group [1] that covering the Cu(lll) surface with a monolayer of Pb before starting the deposition of the (Co/Cu) layers resulted in the suppression of twins and in an overall improvement of the structural quality of the films relative to those grown without the surfactant. However, a detailed structural study was needed in order to determine the mechanism of actuation of the surfactant agent. The Surface Diffraction Beanline (1D7) at the ESRF is specially well-suited for this kind of experiments, and the high photon flllx of the ESRF allowed us to perform real-time measurements during growth. This aspect is specially important in growth experiments, due to the strong influence of kinetics,

The experiments were performed in February/March, 1995, and focused on the growth of Co films on a Cu(lll) surface, with and without using Pb as surfactant. First of all, we were able to obtain a structural determination of the p(4 x 4) superstructure of the Pb monolayer, and observe its segregation to the surface of the growing films by monitoring, in real time during (Co deposition, the intensity of the characteristic fractional-order peaks. An efficient segregation is a basical requirement for a surfactant agent, and these measurements demonstrate that the p(4 x 4) superstructure is never destroyed by the Co deposited on it, but rather floats on top as a whole. However, in the process of penetrating below the Pb layer, the structure of the Co film is substantially altered, as demonstrated by the data presented in Fig. 1: while a 6 ML-thick Co film grown on clean Cu(111) already contains a large fraction of hcp-Co (upper panel), another film of equivalent thickness grown on a Pb-covered surface remains fcc (lower pane]). Therefore, it appears that Pb extends the range of thicknesses over which fee-(Co films can be produced. As a cosequence also the twinning of Cu over layers is suppressed, because across a film of fee-Co the information about the correct stacking sequence is transmitted from the substrate to the capping layer. On the other hand, Co films grown without surfactant start forming stacking faults at a very early stage as the first step of the transition to hcp; this breaks the fcc stacking sequence and thus Cu deposited on top of faulted Co forms islands with either of the two twin-fee "structures.

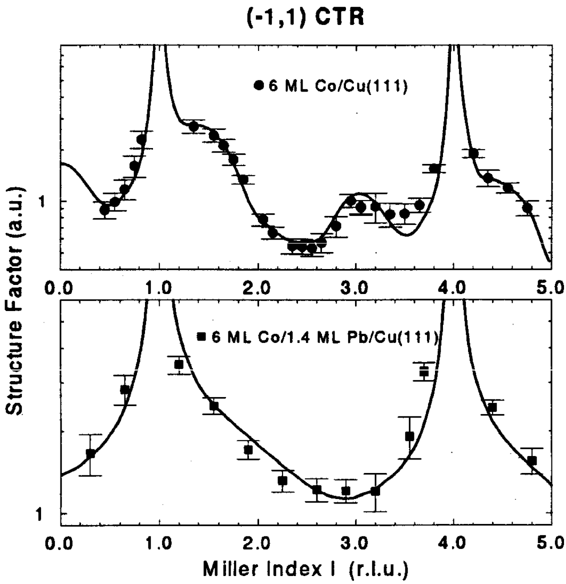

Figure 1: Perpendicular momentum scans ("rod scans") along the (-1,1) CTR for two 6 ML-thick Co films. Upper panel: when Co is grown on a clean Cu(111) surface, the features developing at L = 1.5 and L = 3.0 signal the appearance of the hcp phase of Co. Lower panel: these features are absent when the Cu(111) surface is covered with Pb before depositing Co. indicating that the film remains fee.

In order to obtain a full picture of the whole growth process, we performed a series of measurements for Co films of different thicknesses. In all cases we monitored the evolution of the film structure during growth by continuously sampling the diffracted intensity at several points in reciprocal space; then after stopping growth we did detailed structural characterizations of the films by measuring rod scans along several different crystal truncation rods (CTR's). Once that the structure has been completely determined for this set of thicknesses, the data collected in real time during growth allow us to extrapolate and decluce the structure for any intermediate coverage; thus, the special capabilities of the ESRF allow for a full structural characterization over an extended range of thicknesses in a very moderate time. At the present moment, the analysis of the data is nearly completed and will be published shortly.

References

1. J. Camarero, L. Spendeler, G. Schmiclt, K. Heinz, J.J. de Miguel, and R. Miranda, Phys. Rev. Lett. **73, 2448 (1994).**