

Lateral Ir-spaced superlattices of Fe, Co, and Ni on Ir(100)

A. Schmidt, A. Klein, C. Giovanardi, L. Hammer and K. Heinz

*Lehrstuhl für Festkörperphysik, Universität Erlangen-Nürnberg,
Staudtstr. 7, D-91058 Erlangen*

Email: andreas.schmidt@physik.uni-erlangen.de

The stable phase of clean Ir(100) exhibits a quasi-hexagonal top layer with six atomic rows fitting to five rows of the second layer (Ir(100)-(5×1)-hex). This leads to a surface buckling which amounts to more than a half of an Angström for the top layer and extends up to the fourth layer into the surface [1]. Exposure to hydrogen lifts this reconstruction by expelling the 20% extra atoms accommodated formerly in the top layer [2]. This Ir(100)-(5×1)-H phase is characterized by monoatomic, almost defect free Ir wires of up to micrometer length which reside in 5×1 long-range order on the unreconstructed substrate. As shown in fig. 1 they are almost equally spaced with a lateral distance of 1.36 nm, which corresponds to $5a$ with a the in-plane lattice parameter ($a = 2.72 \text{ \AA}$). Yet, also $3a$ and $7a$ spacings occur with statistical weight depending severely on preparation conditions. The buckling of the layers beneath the wires is dramatically reduced compared to the 5×1-hex phase. We show that this surface can be used as a template for lateral superlattices and layer-by-layer growth of magnetic materials. By deposition of Fe, Co or Ni the space between these wires can be filled, whereby the three elements differ by their in-plane growth modes as observed by scanning tunnelling microscopy (STM). Their final states at 0.8 ML coverage correspond to lateral superlattices, $\{\text{Fe}_4\text{Ir}\}$, $\{\text{Co}_4\text{Ir}\}$ and $\{\text{Ni}_4\text{Ir}\}$ as shown for Fe in fig. 2. The crystallographic structures of these three compounds as determined from the measurement and quantitative dynamical analysis of low-energy electron diffraction (LEED) intensities [3] are very similar, but differ in some parameters. In the case of iron, the adatoms being next to the Ir rows are shifted by about 0.05 \AA towards Ir, while Co and Ni atoms experience an only small shift in the other direction. This indicates a larger preference for homogeneous bonds for Ni and Co in contrast to Fe. For all three types adatoms intermixing with Iridium can be excluded.

The Fe_4Ir surface superlattice can also be obtained without the use of hydrogen as surfactant [4]. The deposition of 0.8 ML of Fe on Ir(100)-(5×1)-hex makes the surface restructure in the same way and a Fe_4Ir compound with the same local geometry is formed. Yet, this preparation procedure leads to a poor degree of long-range order.

Also, Fe-, Co- and Ni-films of higher coverages on the Ir(100)-(5×1)-H template are analysed. The growth is found to be layer-by-layer. For e.g. a deposition of 1.8 ML Ni, the Ni_4Ir superlattice is fully covered by pure Ni, with the chain like structure of the interface, preserved, as demonstrated in fig. 3.

Figure 1: STM image of the restructured Ir(100)-(5×1) after exposure to hydrogen at room temperature. The small picture shows the monoatomic Ir wires with a distance of $5a$.

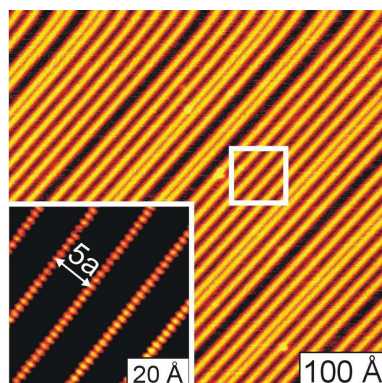


Figure 2: Left: STM image after deposition of approx 0.8 ML Fe on the Ir template (note that the Ir wires appear as dark lines). Right: Ball model of the Fe_4Ir superlattice on a STM image of the monoatomic Ir wires for visualization.

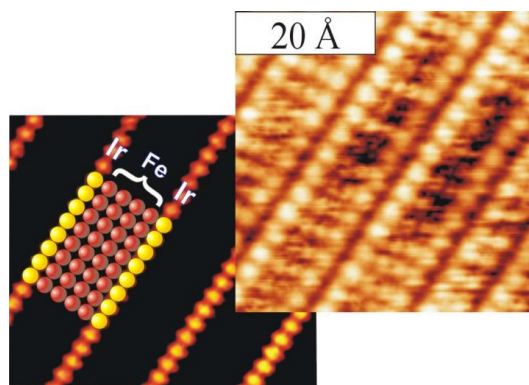
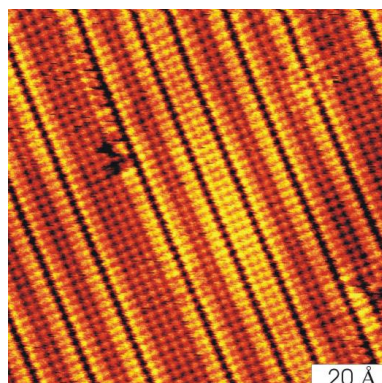


Figure 3: STM image after the deposition of 1.8 ML Ni on the Ir(100)-H showing the preserved chain like structure of the interface.



References

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