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Two-dimensional inter-metallic compound formation: Yb–Ni/Mo(110)

O Björneholm†, J N Andersen‡, M Christiansen§, A Nilsson†, C Wigren‡, J Onsgaard§, A Stenborg† and N Mårtensson†

† Department of Physics, Uppsala University, Box 530, S-751 21 Uppsala, Sweden
‡ MAX-lab, Lund University, Box 118, S-221 00 Lund, Sweden
§ Fysisk Institut, Odense University, Campusvej 55, DK-5230 Odense M, Denmark

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Abstract. The two-dimensional (2D) Yb–Ni on Mo(110) system has been studied with photoemission using synchrotron radiation from the MAX storage ring and LEED. Two 2D inter-metallic compound phases, Yb_2Ni and $YbNi_2$, were identified.

Much attention has been devoted to one-component two-dimensional (2D) systems. In the present paper, the two-component 2D system Yb–Ni on Mo(110) has been studied, and the formation of inter-metallic compound phases has been observed by photoemission and LEED. The combination Yb–Ni/Mo(110) was chosen since the systems Yb/Ni(100) [1] and Yb/Mo(110) [2, 3] have previously been studied, and the necessary surface sensitivity in the photoemission could be achieved by using a photon energy of 110 eV, close to the Mo 4d Cooper minimum.

Yb and Ni were co-evaporated onto a Mo(110) single crystal under UHV conditions. The amount of Yb was determined by the work-function change $\Delta\Phi$ [2], while the amount of Ni was determined by AES. To induce the compound formation, the sample was annealed at 520 K for 60 s. The compound formation was monitored by following the evolution of the Yb 4f doublets and by LEED. The development of a pure phase was indicated by the existence of one single Yb 4f doublet in the photoelectron spectrum, and the simultaneous observation of a characteristic LEED pattern.

Two LEED patterns associated with the overlayer were observed; a 7×2 pattern which was fully developed only in a small range around Yb and Ni coverages of 4×10^{14} atoms cm^{-2} and 2×10^{14} atoms cm^{-2} respectively and a 3×2 pattern which was seen for a wide range of Yb : Ni coverages and ratios. The fact that the 7×2 structure develops only for a very limited range of coverages means that the composition of this phase can be determined directly from the Yb and Ni amounts needed to yield a well developed 7×2 pattern. In this way the composition is determined to be close to Yb_2Ni. The 3×2 pattern is seen over a wide range of both Yb : Ni ratios and coverages, implying that the 3×2 structure forms islands and the excess Yb or Ni forms other phases on the surface. Therefore the composition of the 3×2 islands cannot be determined directly from the deposited Yb and Ni amounts without ensuring that the 3×2 phase is the only one present on the surface. This can be done by observing the quality of the LEED patterns and, in a more quantitative fashion, by photoemission.

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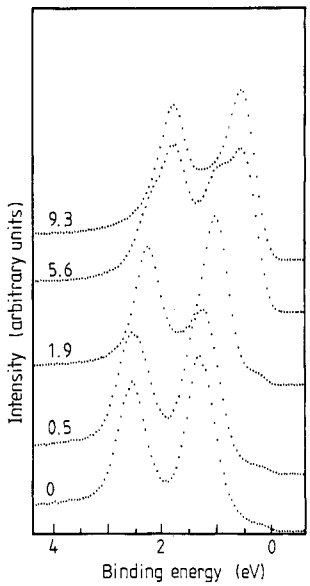

Figure 1. Development of the photoemission spectra of Yb–Ni on Mo(110), showing the formation of the two phases ($h\nu$ = 110 eV; Yb coverage, 4.3×10^{14} atoms cm^{-2}). The numbers on the curves indicate the Ni coverage (10^{14} atoms cm^{-2}).

The development of the photoemission spectra at a constant Yb coverage and increasing Ni coverage is shown in figure 1. Small amounts of Ni result in a broadening and a shift of the Yb 4f emission features. This is due to the simultaneous growth of a component with a Yb $4f_{7/2}$ binding energy of 1 eV and decrease in the intensity of the original component. At a Yb : Ni ratio of 2 : 1 the 4f emission is seen to regain its sharpness in the sense that only one Yb $4f_{7/2}$ can be identified. Thus the 7×2 Yb_2Ni on Mo(110) compound is characterised by a Yb $4f_{7/2}$ binding energy of 1 eV. Further deposition of Ni on the Yb_2Ni structure results in the growth of a component with a Yb $4f_{7/2}$ binding energy of 0.6 eV. When an amount of Ni corresponding to $YbNi_2$ is reached, a spectrum with only one 4f component is obtained. Further Ni deposition simply results in an increase in the Ni 3d intensity. The described behaviour is not limited to a Yb coverage of 4.3×10^{14} atoms cm^{-2} shown in figure 1. Rather, all depositions with a Yb : Ni ratio of 1 : 2 gave rise to this sharp 0.6 eV component in agreement with the island formation model suggested by the LEED results. Also the best developed 3×2 LEED patterns for a given Yb coverage were always seen close to this Yb : Ni ratio.

References

[1] Nilsson A, Eriksson B, Mårtensson N, Andersen J N and Onsgaard J 1988 *Phys. Rev.* B **38** 10357
[2] Stenborg A and Bauer E 1987 *Phys. Rev.* B **36** 5840
[3] Stenborg A, Björneholm O, Nilsson A, Mårtensson N, Andersen J N and Wigren C 1989 *Surf. Sci.* **211–2** 470