Probing the Temperature Dependence of the Dysprosium-Silicon Interface.

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Summary. — Photoemission electron spectroscopic measurements were done on the Dy-Si interfaces prepared by Dy deposition onto cleaved Si(111) surface with the use of synchrotron radiation as a light source. Results show that an interfacial reaction takes place even at room temperature. Temperature dependence studies for Dy deposited on Si(111) demonstrate the importance of overlayer thickness and substrate temperature during deposition.

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1. - Introduction.

The understanding of the electronic structure and formation of rare-earth-semiconductor contacts has become an important issue for the development of new devices in microelectronics [1]. Rare-earth silicide/silicon junctions have the lowest Schottky barrier height of any metal silicide contact to n-type Si [2]. Rare-earth/semiconductor interface is a new type of metal/semiconductor contact which started to attract much attention. Up to now a large number of work has been done on the crystallographic and chemical characterization of rare-earth–semiconductor interfaces [3-5]. The electronic structure of rare-earth–semiconductor systems has recently been studied by using synchrotron radiation photoemission [6-9]. Changes in photoemission from the valence band of rare earths have given clear evidence of changes in the chemical state of the rare-earth atoms as a function of metal coverage.

In this paper we present the results of the photoemission electron spectroscopic study of the Dy/Si interface, in particular, the temperature dependence of Dy-Si formation. We found that the dysprosium silicide formation depends on the thickness of Dy overlayers and the substrate temperature during the deposition. Also annealing of pure Dy overlayers on Si(111) showed both Dy-silicide and pure Dy features.
2. Experimental procedure.

The photoemission studies were performed at the synchrotron radiation center of the University of Wisconsin-Madison, on the 6 m toroidal grating monochromator beam line. The ultrahigh vacuum system was equipped with low-energy electron diffraction (LEED), angle-resolved photoelectron spectroscopy and Auger electron spectroscopy. The combined photon and analyzer resolution varied between 0.18 and 0.4 eV. The vacuum system was pumped by a combination of turbomolecular, ion and titanium sublimation pumps and was equipped with a residual gas analyzer and the usual pressure gauges.

The sample was mirror polished-type silicon crystal Si(lll) with the resistivity of 200 Ω cm. Sample was cut (20 × 5 × 0.5) mm³ in size and mounted on a sample holder. The sample manipulator had an x, y stage, z motion axis and tilt mechanism (vacuum generators). The Si(lll) surface was cleaned before each Dy deposition by repeated argon ion sputtering, and subsequently annealed up to 1200°C in the ultrahigh vacuum by electric current directly passing through the sample. The surface of Si(lll) crystal exhibited the 7x7 surface reconstruction as demonstrated by low-energy electron diffraction (LEED). In addition to the LEED measurement, photoemission spectra taken at 22 eV photon energy from Si(lll) surface, showed no indication of oxygen contamination.

![Fig. 1. - Energy distribution curves (EDCs) for Dy/Si(lll) in the valence band region for 50 eV photon energy. EDCs of clean Si(lll)-7 x 7 taken with 22 eV photon energy. Coverages θ are given in Å and substrate temperatures during deposition T are given in °C. a) θ = 20; T = 20; b) θ = 20, T = 200; c) θ = 4, T = 20; d) θ = 4, T = 200; e) clean Si(lll).](image)