14.2-02 IN-SITU REFLECTION ELECTRON MICROSCOPE STUDY OF METAL DEPOSITION ON CLEAN Si(111) SURFACE.

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UHV reflection electron microscopy(REM) was found to be very powerful for surface study, since it can reveal surface atomic steps, domains of surface and adsorbate structures, phase transition processes of them and so on (N.Osakabe et al., Surface Sci.(1980)97,393, (1981)102, 424, Jpn.J.Appl.Phys.(1980)19,L309, K.Yagi et al.,Proc. 4th ICSS(Cannes 1980)1007). In the present paper in-situ REM observations of metal deposition on Si(111) surfaces are described. For it a new double tilt REM holder and an evaporator were constructed. Fig.1 shows a cross section of our UHV electron microscope at the specimen position perpendicular to the optic axis. Evaporated metals from two W-filaments[5] in the evaporator[B], which has a quartz thickness monitor[8] and a shutter[6], pass through holes of liq.N_2[3] and liq.He[2] cooled cryogenic tips and of the side-entry REM holder[A] and reach a Si crystal[1]. The crystal with clean 7x7 Si(111) surface was prepared by heating to 1200°C by DC current fed through it in the microscope. An electron beam, which is nearly perpendicular to the figure hits the surface of the crystal with a small glancing angle and reflection electron diffraction(RED) patterns and REM images of the surface are continuously observed in-situ during deposition. Fig.2 shows a REM image from Si surface on which about 0.2 Å Au was deposited at 650°C. Dark areas are domains of the 5x1 structure nucleated along the wavy lines of surface atomic steps by Au deposition. From the determined sense of the steps it was concluded that the 5x1 structure nucleated preferentially on the upper side of the steps. The domains grow on the terraces in the direction indicated by arrows. An interesting finding is that during the Au deposition the steps move slowly in the direction indicated by arrow heads; opposite to the growth direction. This fact indicates that the 5x1 structure is not formed by Au atoms simply adsorbed on the Si surface. The step configuration changes when the 5x1 structure transforms to the $\sqrt{3}\times\sqrt{3}$ structure by further deposition. When the substrate temperature is low(~400°C) nucleation takes place also on the terraces between the steps. Ag deposition processes were also studied.

Fig.1

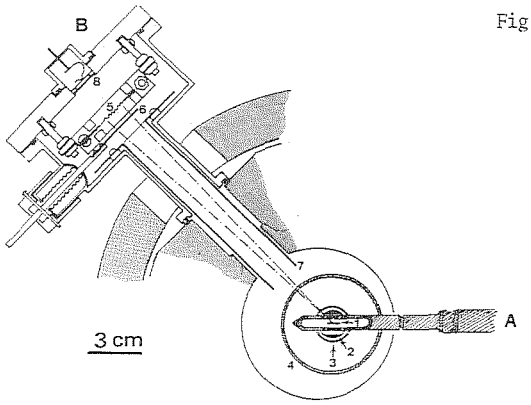
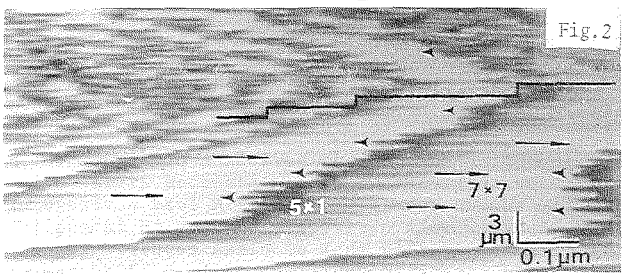


Fig.2



14.2-03 DYNAMIC PROCESSES OF MONOLAYER ADSORPTION STUDIED BY IN-SITU UHV-TRANSMISSION ELECTRON MICROSCOPE.

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Adsorption processes of metal atoms on foreign metal surfaces show quite specific features due to strong metallic bond between adatom and substrate. The adsorptions of monolayer level were observed by ultra-high-vacuum(UHV) transmission electron microscopy(TEM) and diffraction(TED). Combinations studied were Pb/Au, Au/Pb and Ag/Pb, which are to be compared with the previous study on Pb/Ag(111) (K.Takayanagi, Surface Sci. 104(1981) in press). The results are summarized in Table I.

In the case of Pb/Au(111), the reconstructed surface structure (22x1)(referred to rectangle unit mesh) seen in Fig.1a disappeared for a deposition of around 0.2ML (1ML=9.4×10^{14} atoms/cm^2). Then a new phase "I" (Fig. 1b, arrow) nucleated and transformed the surface to a (1x1) structure at 0.7ML. The twist structure initiated above 0.8ML and was completed at 1.2ML, forming the compressed (111) close packed layer with a strain ε=-3.3% and a rotation angle α=3.9° from the parallel orientation. Islands of alloy phase were seen to nucleate in the twist monolayer above 1.2ML. This observation contradicts the LEED study which reported layer by layer formation of an alloy phase above 1.5ML (J.Perdereau, et. al., J.Phys. F4(1974)798).

In the reversed case of Au/Pb(111), the alloy formation was started at surface steps of Fig.2a from the very beginning of the Au adsorption (Fig.2b, arrow). At the monolayer coverage of Au around 14×10^{14}atoms/cm^2, which is the density of Au(111) surface, the alloy phase covered the whole surface area.

In the case of Ag/Pb(111), Ag atoms did not form 2-dimensional layer, but islands, where an alloying effect between Ag-Pb was recognized.

In the reversed case of Pb/Ag(111),the ($\sqrt{3}\times\sqrt{3}$)R30°structure was initially formed. The twist structure appeared at 0.5ML and covered the whole surface area at 1 ML with ε=-2% and α= around 4.5°. Throughout the adsorption process no alloying between Pb and Ag was noticed.

The twist structure in Pb/Ag and Pb/Au is an incommensurate structure and was interpreted to be stabilized by interfacial misfit dislocations according to theoretical analysis of mass density wave(MDW), which has explained the phase transitions of oriented monolayers of rare gases adsorbed on graphite.

Table I

Pb/Au :	(22x1)→ "I"phase (1x1)→ TWIST→ alloy
Au/Pb :	2-dim. alloy nucleation at steps
Ag/Pb :	3-dim. nucleation & alloy phase
Pb/Ag :	random? → ($\sqrt{3}\times\sqrt{3}$)R30°→ TWIST

Fig.1 Pb/Au(111) Fig.2 Au/Pb(111)