Structure of Atomically Clean Si, GaP and GaAs Surfaces and Epitaxy of Ag Thin Films

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Atomistic and crystallographic studies on the metal-semiconductor interface are very important because of the influence on the performance of a semiconductor device. In this study, atomically clean surfaces of Si, GaP and GaAs single crystals were prepared by the heat-treatment in ultra-high vacuum of $\sim 2\times10^{-10}$ Torr.

Structural changes in the early stages of the growth of Ag films evaporated onto these clean surfaces were observed in-situ by a new reflection electron diffraction method using a micro channel plate. The Si (1 1 1) clean surface consisted of 7×7 superstructure. Ag thin films evaporated onto the surface at room temperatures showed preferential orientation with the [1 1 1] axis normal to the substrate surface, and Si (1 1 1) $\sqrt{3}\times\sqrt{3}$R $-30°$--Ag reconstructed structure at the substrate temperature above 200°C. The GaP (1 1 1), ($\bar{1}\ \bar{1}\ \bar{1}$), (0 1 1) and (0 0 1) clean surfaces showed 1×1, 1×1, 1×1, and 2×1 structures, respectively, and the GaAs (0 0 1) clean surface indicated c(8×2) superstructure. The GaP (1 1 1), ($\bar{1}\ \bar{1}\ \bar{1}$) and (0 0 1) surface heat-treated above about 650°C were rough and composed of {1 1 0} facets, while the GaP (0 1 1) surface was relatively flat compared to the other three surfaces.

Ag thin films evaporated onto the GaP (1 1 1) and ($\bar{1}\ \bar{1}\ \bar{1}$) surfaces at room temperature were polycrystalline, and showed epitaxial growth above 200°C. Those evaporated onto the Ga (0 0 1); (0 1 1) and the GaAs (0 0 1) at room temperature composed of one dimensional lattice along the [1 1 0] direction of substrate, and showed epitaxial growth at about 250°C. It was suggested that the formation of such 1D lattice of Ag atoms are due to the disorder of substrate surface lattice.