UHV-STM Observation of Platinum Silicide Formation Process on Si (111) 7 by 7 Surface; Formation of a Novel Flat Surface in Atomic Order of Pt on Pt_2Si and Its Electrochemical Properties

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The Formation of metal silicides has attracted much attention as a Shottky barrier and an ohmic contact in semiconductor devices. Beside the interest as materials their epitaxial growth processes on Si(111) substrate are significant as fundamental analyses of solid state reaction chemistry and surface chemistry. In previous papers, we successfully observed the surface reaction processes of deposited Pd on a clean Si(111) 7X7bsubstrate by using the UHV-STM.

In this presentation, the dynamic transformation in the morphology of Pt-deposited Si(111) surface induced by therrnal treatment has been systematically observed by using the UHV-STM.

The remarkable changes were observed when the large amount of platinum was deposited over 2 ML (monolayer). After the deposition of Pt at room temperature, the platinum clusters without distinguishable atomic structure were imaged on the Si(111) 7X7 surface. Whereas the changes in the surface morphology was not observed up to 550 degree Celsius, two well-ordered structures were appeared after annealing at 600 degree Celsius as shown in Fig. 2. Interestingly, these structures had different periodicity. That is, one is a root 7 by root 7 structure versus the silicon lattice and the other is a root 7 by root 7 structure versus the silicon lattice. The root 7 by root 7 structure was totally disappeared over 650 degree Celsius and all the structure was the root 3 by root 3 structure, which was very stable even at the temperature higher than 800 degree Celsius. It is composed of six-fold symmetry lattice of protrusions.

As the assignment of the root 3 by root 3 structure, it is assumed that the formed material was platinum silicide, which has been result from the epitaxial grows of Pt_2Si with R30 rotation angle versus the Si (111) structure. For the structure with the longer periodicity, the obtained lattice parameter was fit well to the calculated value. If the root 7 by root 7 structure was formed versus Si (111) structure, the rotation angle should be 19 degree. The observed relationship in the STM images between the root 3 by root 3 structure and the root 7 by root 7 structure was the rotation of 11 degree.

To investigate the formation mechanism of the root 7 by root 7 structure, platinum was again deposited on the well-ordered root 3 by root 3 structure. After that, the surface was annealed again at 600 degree. As a result, it was found that the whole surface was covered with the root 7 by root 7 structure at 600 degree as shown in Fig. 3. From the result, it is expected that the root 7 by root 7 structure did not grow on Si(111) surface directly, but it grows on the root 3 by root 3 structure.

It was concluded that itself is forming the over-lattice of the rot 7 by root 7 structure by stabilized on the sites of the root 3 by root 3 plane of the Pt_2Si. The stp height of 0.17 nm is another evidence for this conclusion because it indicates that the over-layer is in an atomic level.

Fig 3 shows the well-ordered very flat surface of Pt having the root 7 by root 7 strucure, which was observed at 600 degree after Pt was deposited again on the surface of the root 3 by root 3 structure. As can be recognized from the flat surface of the Pt over-layer in Fig. 3, the present method should be utilized as a preparation method for a novel well-ordered very flat surface of Pt. The electrochemical behavior of the novel well-ordered Pt surface will be also presented.

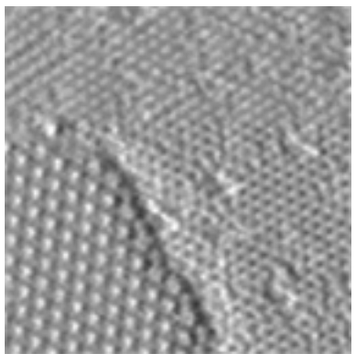

Fig 1. STM image of Pt-deposited Si (111) 7X7 surface after annealing at 600 degree Celsius**.**

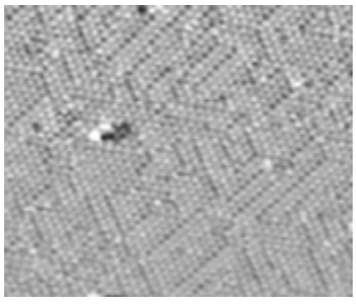

Fig. 2. STM image of Pt-deposited Si (111) 7X7surface after annealing at 800 degree Celsius.

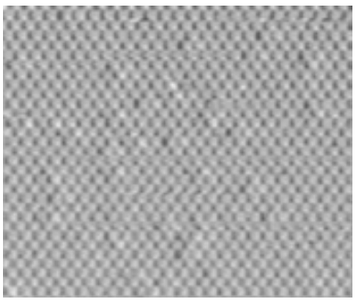

Fig. 3. STM image observed after Pt was again deposited on the surface of the root 3 by root 3 structure and annealed at 600 degree Celsius.