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REAL TIME UHV-HRTEM OBSERVATION OF Si(111)$\sqrt{3}$x$\sqrt{3}$-Pd SURFACE AND DYNAMIC MOTION OF Pd CLUSTERS

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Recently, the development of advanced quantum devices requires the understanding of self-organized growth of metal or semiconductor nano-islands on semiconductor surfaces. For this purpose, the characterization and visualization tools for the surface growth with atomic resolution have been increasingly desired. Ultrahigh vacuum high-resolution transmission electron microscopy (UHV-HRTEM) has been a powerful tool to visualize atomic structure not only in a bulk but also on a surface. Moreover, well-established electron-diffraction and imaging theory can support the modeling of atomic structure. Individual atoms and clusters on a surface have often been imaged by HRTEM so far [1-2]. It is reported that Si(111)$\sqrt{3}$x$\sqrt{3}$-Bi was observed with HRTEM but image of surface atoms were overlaid with that of a substrate atoms [3]. A combination of HRTEM with computational process has provided clear atomic images of Si(111)5x2-Au and Si(111)7x7 surface without substrate image [4-5]. However, the atomic motions of atoms and/or clusters on the surface cannot be analyzed with such off-line processes.

This paper reports an atomic structure of a Si(111)$\sqrt{3}$x$\sqrt{3}$-Pd surface and the motion of Pd clusters on the surface with UHV-TEM in real time. Figure 1 shows a schematic drawing of Pd deposition. In-situ TEM observation was performed using a 200 kV UHV-TEM equipped with a field emission gun. Pd less than 1 ML was deposited onto a Si (111)7x7 surface using an electron beam evaporator attached to the microscope column at about 550 K. Figure 2A shows a conventional HRTEM image of the Si(111) surface, on which Pd exhibits the $\sqrt{3}$x$\sqrt{3}$ structure on the thin specimen (10 nm or less). Since the image was taken at near the Sherzer defocus, Si(111)1x1 lattice fringes (0.19nm) are dominantly observed and the surface structure is unclearly overlaid. From the image simulation, we found that the Si 1x1 lattice image disappears and the $\sqrt{3}$x$\sqrt{3}$ structure is enhanced when the convergent angle is larger than 1 mrad at the condition of over-focus of 20-50 nm and the thickness of 7.5-10.3 nm, and that the contrast enhancement of Pd clusters against the $\sqrt{3}$x$\sqrt{3}$ structure is maximized at the over-focus of around 34nm and the convergent angle of around 3 mrad. Furthermore, we introduced an objective aperture so that electron diffraction of 0.20 nm or less are filtered off. Figure 2B shows a HRTEM image of the same area, indicating that atomic arrangement of the $\sqrt{3}$x$\sqrt{3}$ structure is clearly seen without any Si(111)1x1 lattice fringes. At this condition, Pd clusters are visualized as a set of three bright dots as shown in Figure 3. We proposed two types of structure models for the cluster, e.g., Pd-trimer and silicide models, and the simulated image calculated using these models were compared with the experimental one. Figure 4 shows the each structure model and simulated images at 2 and 3 mrad convergent angles, indicating that the Pd-trimer model is consistent with our results rather than the silicide one.

References

[1] S. Iijima, Optik 48 (1977) 193.
[2] N. Tanaka, H. Kimata, and T. Kizuka, Surf. Sci. 386 (1997) 216.
[3] Y. Haga and K. Takayanagi, Ultramicrosc. 45 (1992) 95.
[4] L. D. Marks and R. Plass, Phys. Rev. Lett. 75 (1995) 2172.
[5] E. Bengu et. al., Phys. Rev. Lett. 77 (1996) 4226.

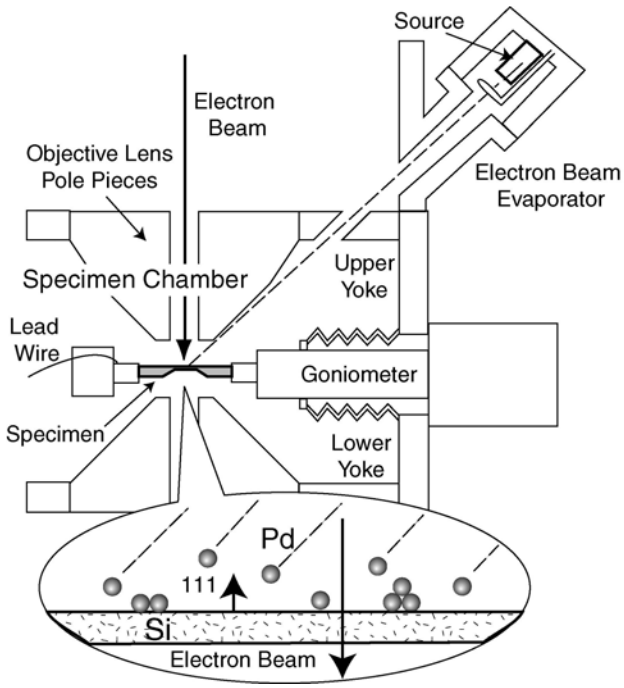

FIG 1. A schematic drawing of Pd deposition on Si (111) in the UHV-TEM

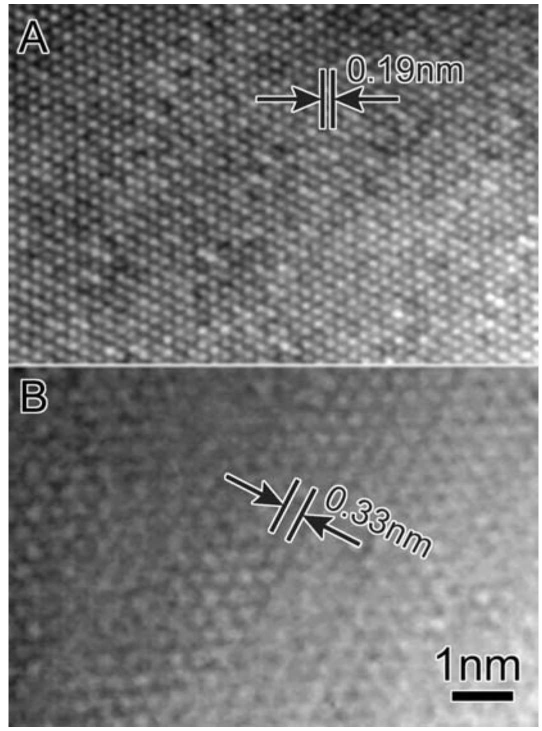

FIG 2. HRTEM images of Si(111)$\sqrt{3}$x$\sqrt{3}$-Pd taken by a conventional manner(A) and taken on the present experimental condition(B).

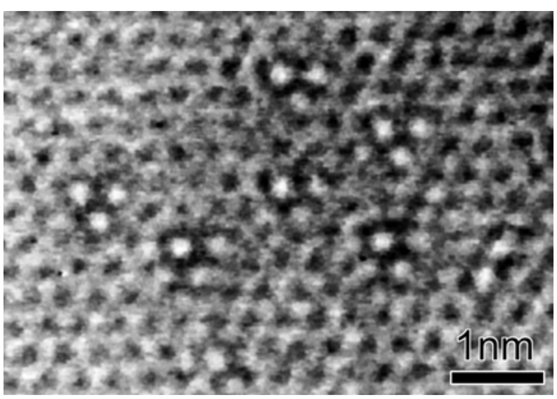

FIG 3. HRTEM image of Pd clusters moving around on the $\sqrt{3}$x$\sqrt{3}$ layer.

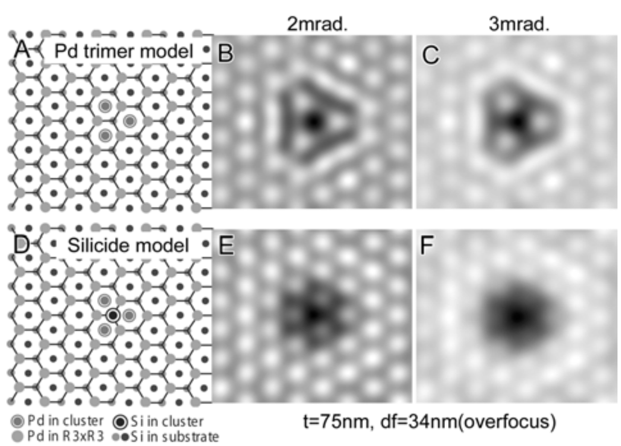

FIG 4. Structure models for a Pd cluster and their simulation images.

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