

Observation of Finite-Size Effects on a Structural Phase Transition of 2D**Nano-Domains**

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Abstract

The Pb-adsorbed Si(111) surface exhibits various kinds of phases depending on the coverage, temperature, and annealing history. At a coverage around one monolayer, there exists a 1×1 -Pb phase [1-3] at room temperature. The 1×1 -Pb phase has been found to undergo a reversible structural transformation into a $\sqrt{7}\times\sqrt{3}$ -Pb reconstruction at low temperatures [4]. With a variable-temperature scanning tunneling microscope (STM), we study the structural phase transition of Pb nano-domains on Si(111). Our STM observations indicate that no coverage change occurs across the phase transition, $1\times 1\leftrightarrow\sqrt{7}\times\sqrt{3}$. On the 1×1 structure, Pb adatoms are located at the T_1 site and the coverage is exactly 1 ML, which was also confirmed by Rutherford backscattering measurements. The $\sqrt{7}\times\sqrt{3}$ phase is basically a distorted 1×1 structure with some Pb adatoms slightly displaced from their T_1 site to form trimer rows (Fig. 1). Therefore, this phase transition may involve only small displacements of Pb atoms without breaking the Pb-Si bonds. Our STM observations also show that the transition temperature decreases with decreasing domain size (Fig. 2). Quantitative measurements of the transition temperature vs. the island domain size will be presented. The boundaries of the nano-domains are also found to have effects on the transition. At temperatures around the transition temperature, temporal fluctuations in structures can be seen, suggesting it to be a continuous transition. Careful examination of the change in the surface structure near the transition temperature reveals the fast dynamics associated with the thermal fluctuations.

REFERENCES

- [1] E. Ganz, I.-S. Hwang, F. Xiong, S.K. Theiss, J.A. Golovchenko, Surf. Sci. **257**, 259 (1991).
- [2] I.-S. Hwang, R. Martinez, C. Liu, and J.A. Golovchenko, Surf. Sci. **323**, 241 (1995).
- [3] I.-S. Hwang, R. Martinez, C. Liu, and J.A. Golovchenko, Phys. Rev. B **51**, 10193 (1995).
- [4] J. Slezák, P. Mutombo, and V. Cháb, Phys. Rev. B **60**, 13328 (1999).

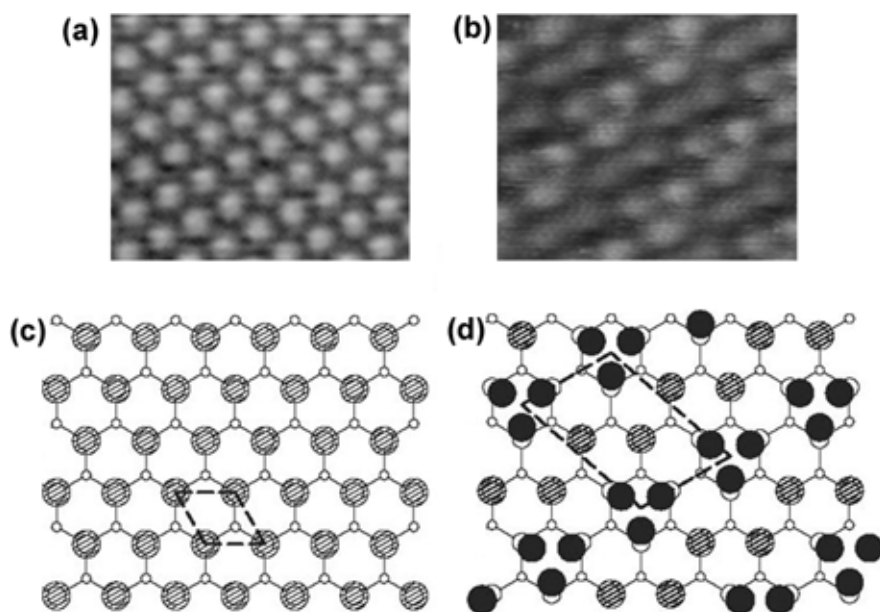


FIGURE 1. High-resolution STM images of the 1×1 phase (a) and the $\sqrt{7} \times \sqrt{3}$ phase (b). Atomic model for the 1×1 phase (c) and the $\sqrt{7} \times \sqrt{3}$ phase (d).

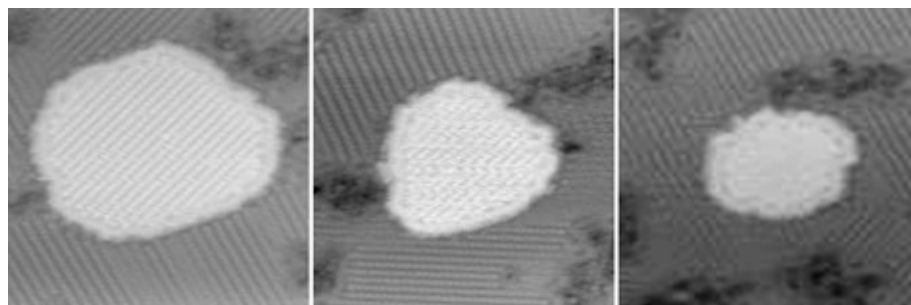


FIGURE 2. STM images showing finite-size effects on Pb-covered Si(111) islands taken at 212 K. The image size is $30 \times 30 \text{ nm}^2$. The bright lines correspond to Pb trimer rows.