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Indium Nanowires and Nanodots Grown on In/Si(111) Surface

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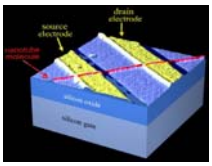
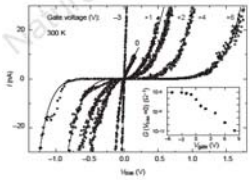
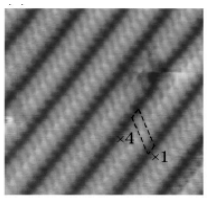
Introduction:

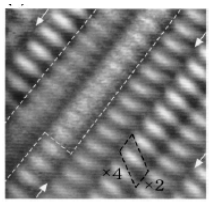
Low-dimensional nanostructures, like **nanodots and nanowires**, have been extensively studied due to their unusual physical properties (metal to insulator transition, quantum effects, and …) and potential applications in nanoelectronics (nanoscale electrodes, interconnections, single electron transistor, and …).





Carbon nanotube transistor
(Courtesy of Cees Dekker, Delft Institute of Technology, the Netherlands)



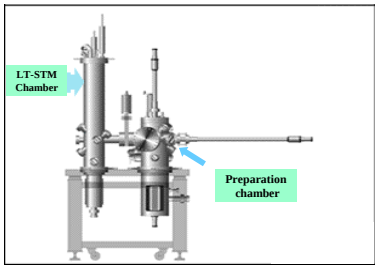


Charge density wave
in quasi-one-dimensional chains on Si(111)-In (4 × 1)[1]

Nanowires and nanodots on Si surfaces are of particular interest not only for their compatibility with Si-based device integration also for the possibility to be used as model systems to explore phase transition and interesting quantum effects. **In/Si(111) surface** is used as a substrate for the growth of **In nanowires and nanodots**.

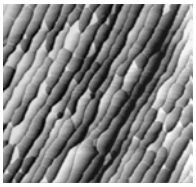
Experimental:

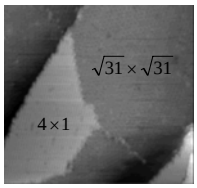
Experiments were carried out in **UNISOKU UHV LT-STM** system ($P \leqslant 1.5\times10^{-8}$ Pa, $T \leqslant 10$ K). Clean Si(111) surface was obtained after outgassing at ~600 °C followed by slowly heating to 850~900 °C and quickly flashing above 1200 °C. A resistant-heating evaporator is used to deposit In with a flux of 0.4~6 ML per min.



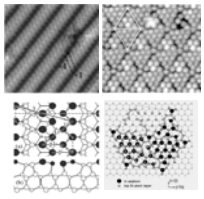
Results and discussion:

Si(111) - In (4×1) and $(\sqrt{31}\times\sqrt{31})$ surface



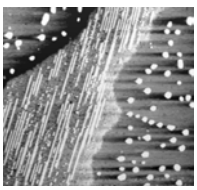


STM images of Inhomogeneous In/Si(111) surface

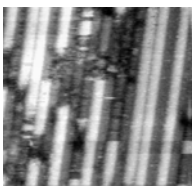


In - (4×1) and $(\sqrt{31}\times\sqrt{31})$ [1,2,3]

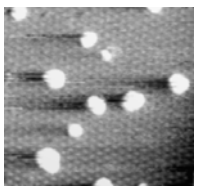
In nanowires and nanodots on In/Si(111) surface



Large-area STM image

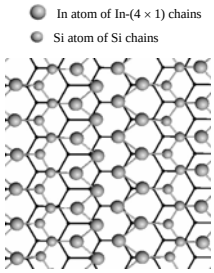


Nanowires on In - (4×1)

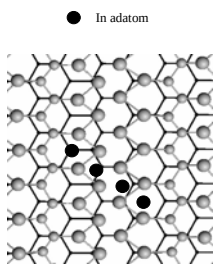


Nanodots on In - $(\sqrt{31}\times\sqrt{31})$

Adsorption sites favorable for In adatoms on In-(4 × 1)

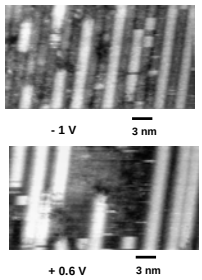


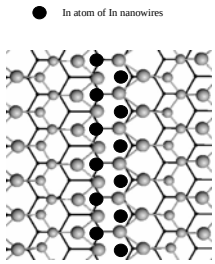
In-(4 × 1)



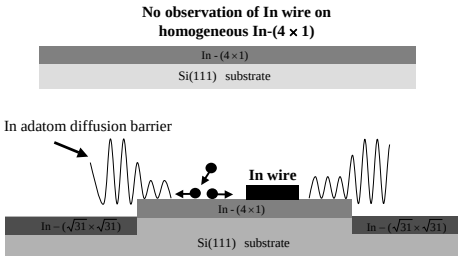
Favorable sites for In adatoms

Possible model structure of In nanowire

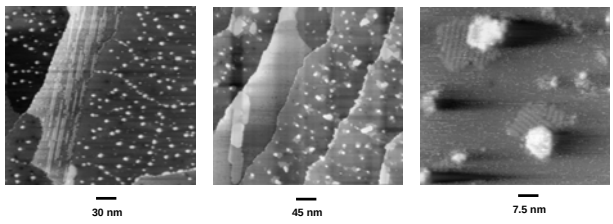




Nucleation and growth of In wires enhanced by step (Enrlich-Schwoebel) barrier



Shape transformation of In nanodots during annealing



In nanodots as grown

Flat In islands after annealing

Conclusion and outlook:

1) In nanowires and nanodots on In/Si(111) surface

- In nanowires and nanodots are grown on In-(4 × 1) and $\sqrt{31}\times\sqrt{31}$ surfaces, respectively.
- The formation of In nanowires is attributed to the *anisotropic diffusion barriers* caused by the structural anisotropy of In-(4 × 1) substrate.
- A possible model structure is presented for In nanowires.
- In nanodots transform into flat In islands during annealing.

2) Research plan for coming experiments

- Electron confinement by In nanowires and nanodots
- Phase transition in In nanowires

References:

[1] H. W. Yeom, S. Takeda, E. Rotenberg, I. Matsuda, K. Horikoshi, J. Schaefer, C. M. Lee, S. D. Kevan, T. Ohta, T. Nagao, and S. Hasegawa, Phys. Rev. Lett. **82**, 4898 (1999).
[2] O. Bunk, G. Falkenberg, J. H. Zeysing, L. Lottermoser, R. L. Johnson, M. Nielsen, F. Berg-Rasmussen, J. Baker, and R. Feidenhans'l, Phys. Rev. B **59**, 12 228 (1999).
[3] A. A. Saranin, A. V. Zotov, A. N. Tovpik, M. A. Cherevik, E. N. Chukurov, V. G. Lifshits, M. Katayama, and K. Oura, Surf. Sci. **450**, 34 (2000).