Investigation of the Ga films grown on Si(111)-√3x√3-Ga reconstruction.

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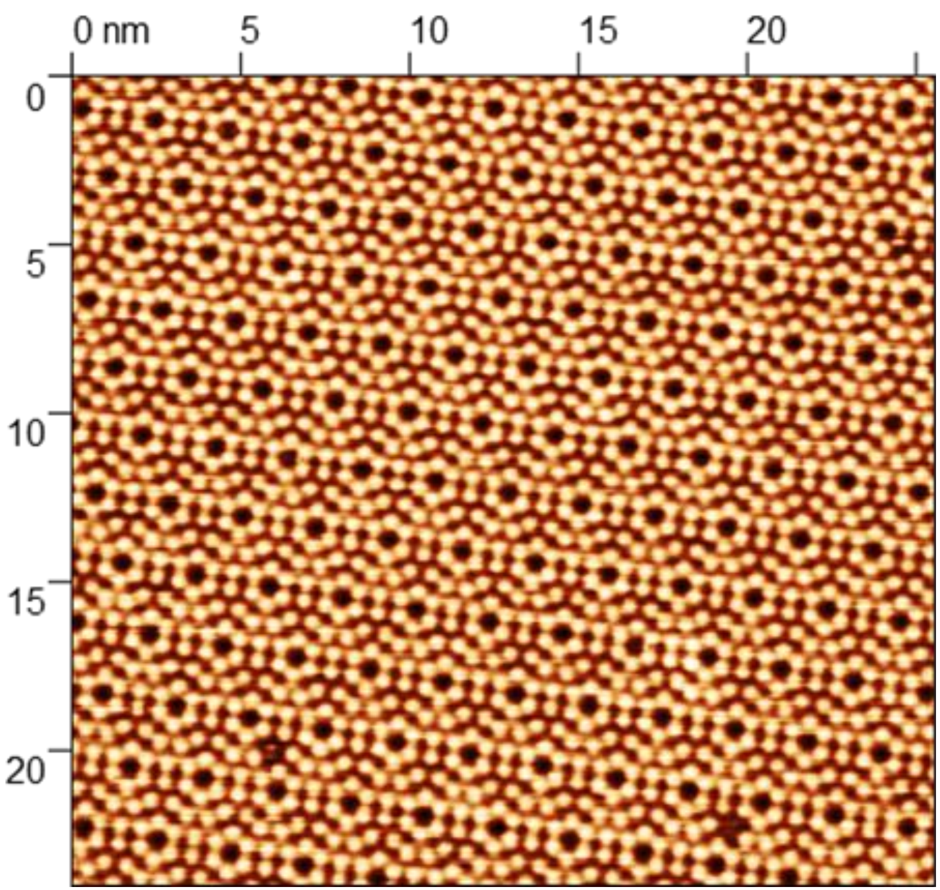
Introduction

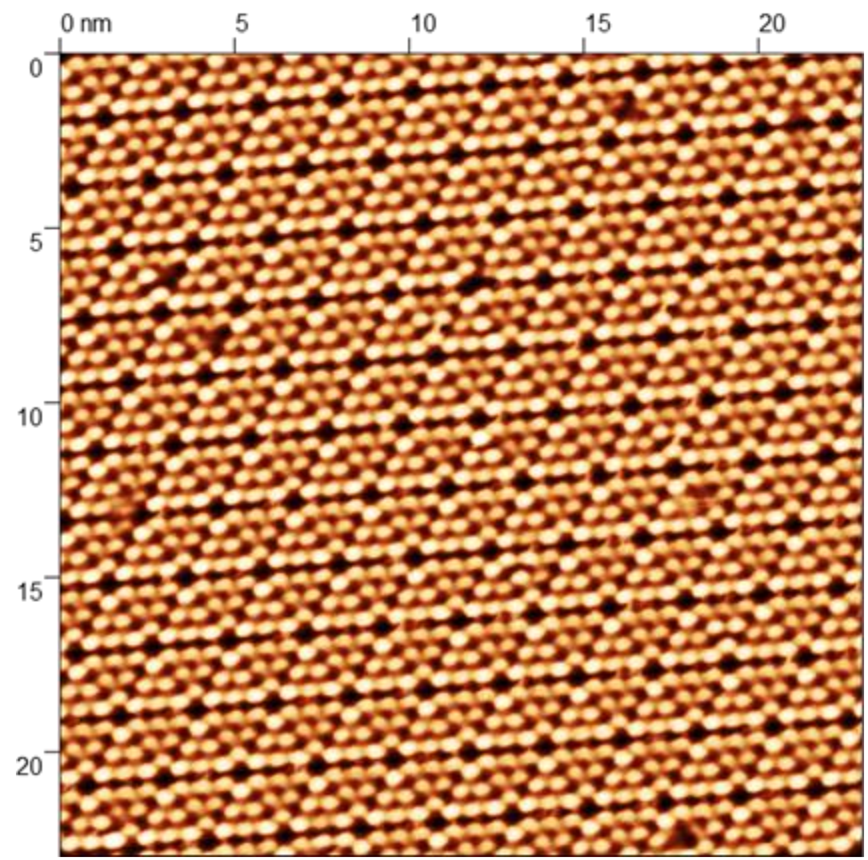
The formation of thin superconducting metal films on the silicon surfaces have attracted intense interest both for practical application in microelectronic devices and for fundamental research. One of the promising materials is gallium (Ga), because bulk Ga has several metastable phases. Thus, stable α-Ga passes into the superconductivity state at temperatures $T_c < 1.2$ K, while the metastable β-Ga has a critical temperature $T_c = 6.04(5)$ K. In this work, we studied the growth of gallium films on the Si(111)-$\sqrt{3}x\sqrt{3}$-Ga surface. The resulting structures were studied by scanning tunneling microscopy at room temperatures (RT), as well as by the 4 point probe method for superconductivity at temperatures down to 2 K.

Si(111) – 7x7

Atomically-clean Si(111)-7×7 surfaces were prepared in situ by flashing to 1280°C after the samples were first outgassed at 600°C for several hours.



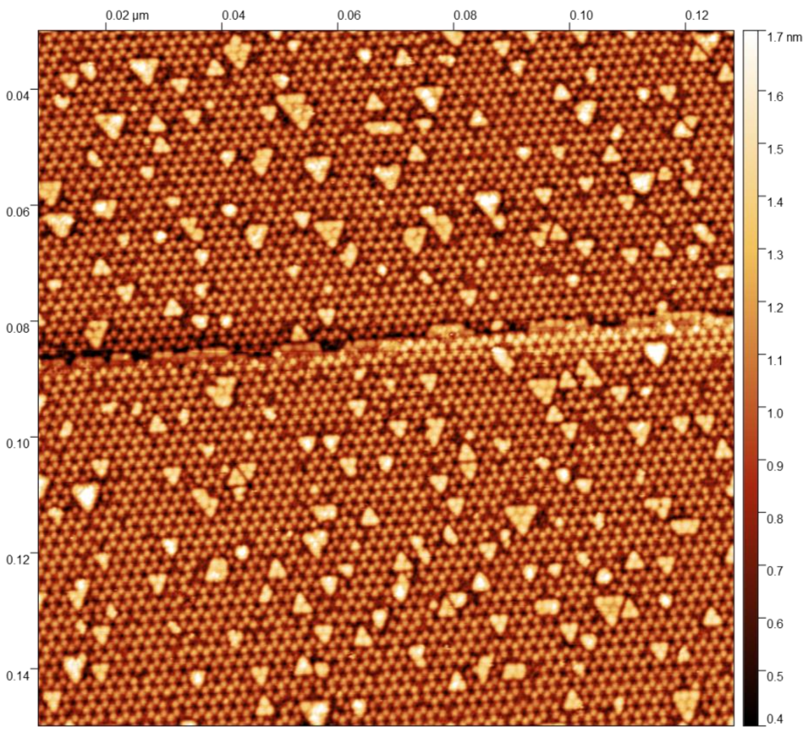
STM image at
+1.8V

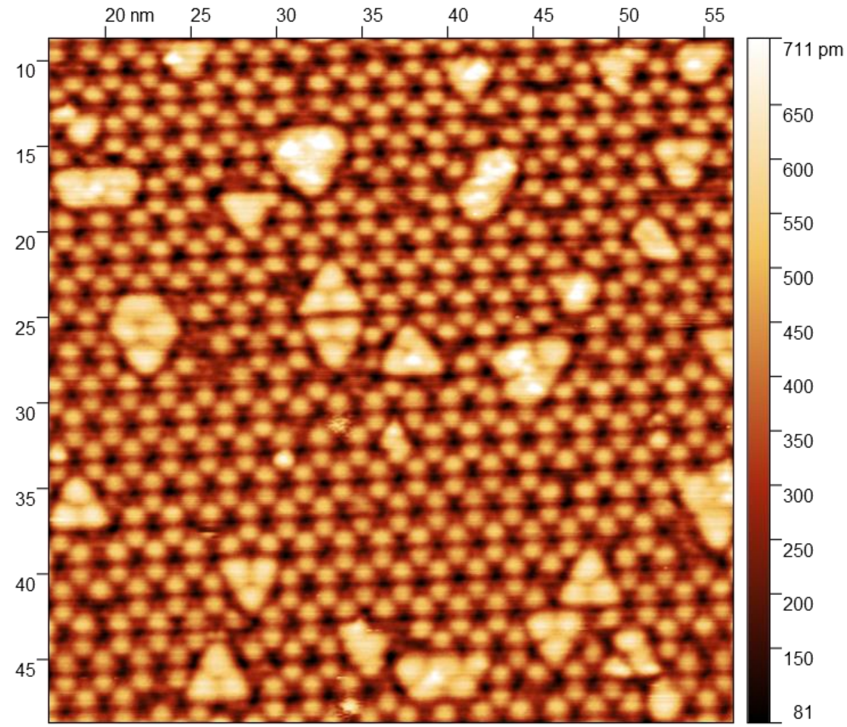


STM image at
-1.9V

Ga magic clusters

Gallium was deposited from a tantalum basket with a rate of 0.2 ML/min. The deposition rate was calibrated using the surface phase of magic clusters.

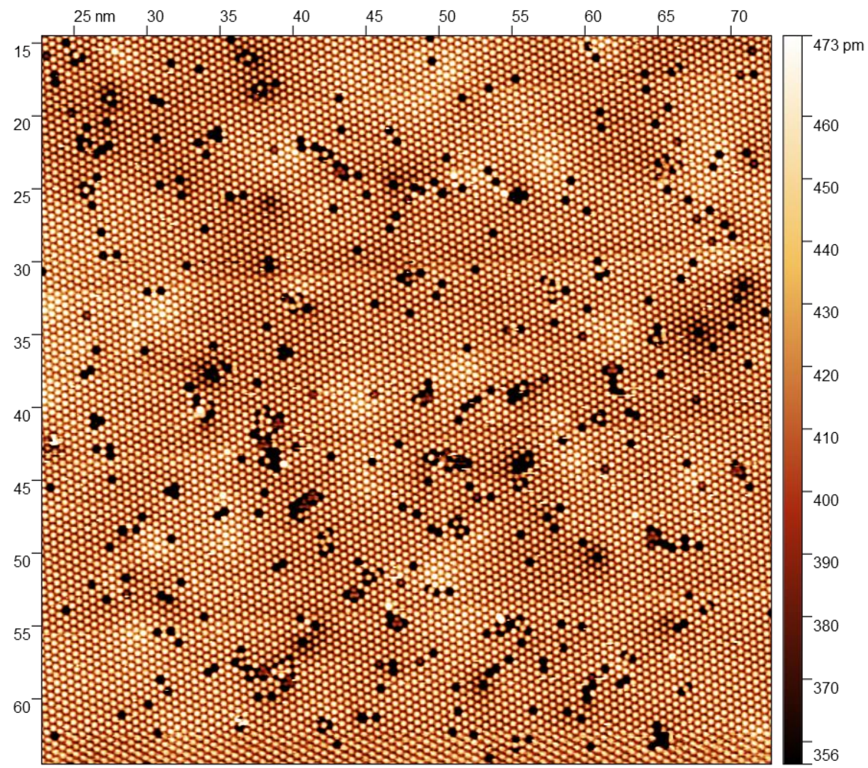




STM images at +2.8V. This reconstruction makes it possible to determine the amount of deposited coating with a high degree of accuracy. To do this, it is necessary to take into account the weight of magic clusters, as well as the area of the islands above them.

Lai M. Y., Wang Y. L. //PRB. – 2001. – T. 64. – №. 24. – C. 241404.

Ga √ 3 x √ 3

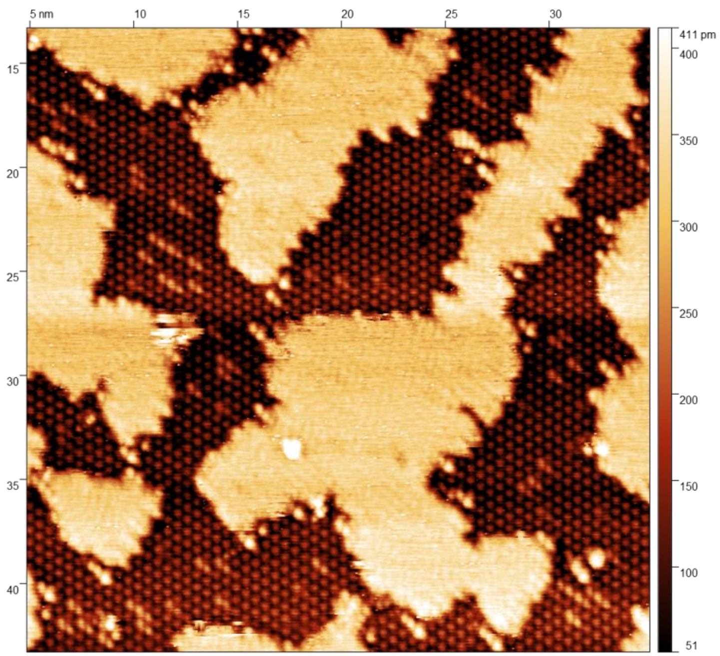


STM image at +1.8V

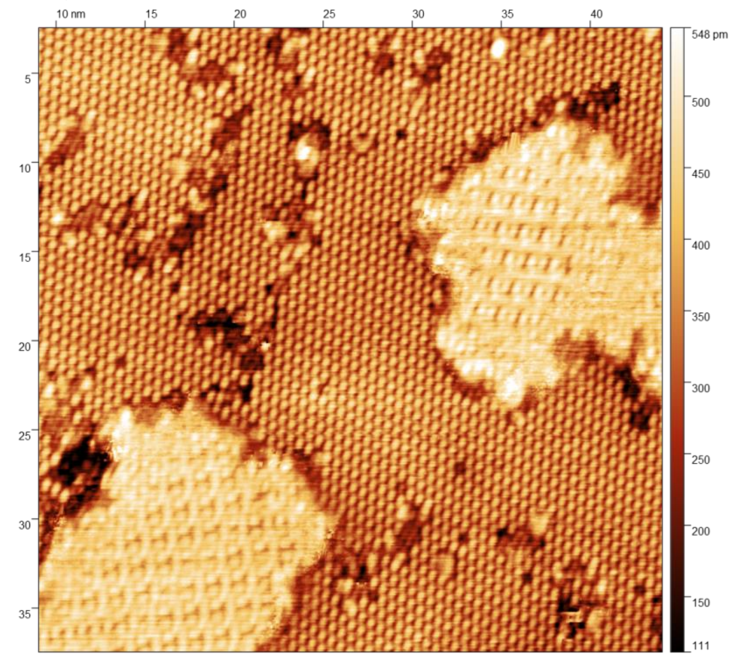
Leed √3x√3

To prepare the Si(111)-√3x√3-Ga surface, the 1/3 ML of Tl was deposited onto Si(111)-7×7 with subsequent annealing at 550°C. This phase is well resolved by the STM method and is characterized by the presence of a large number of defects.

Ga 4×√13



STM image at +1.8V
(0.4 MC Ga)



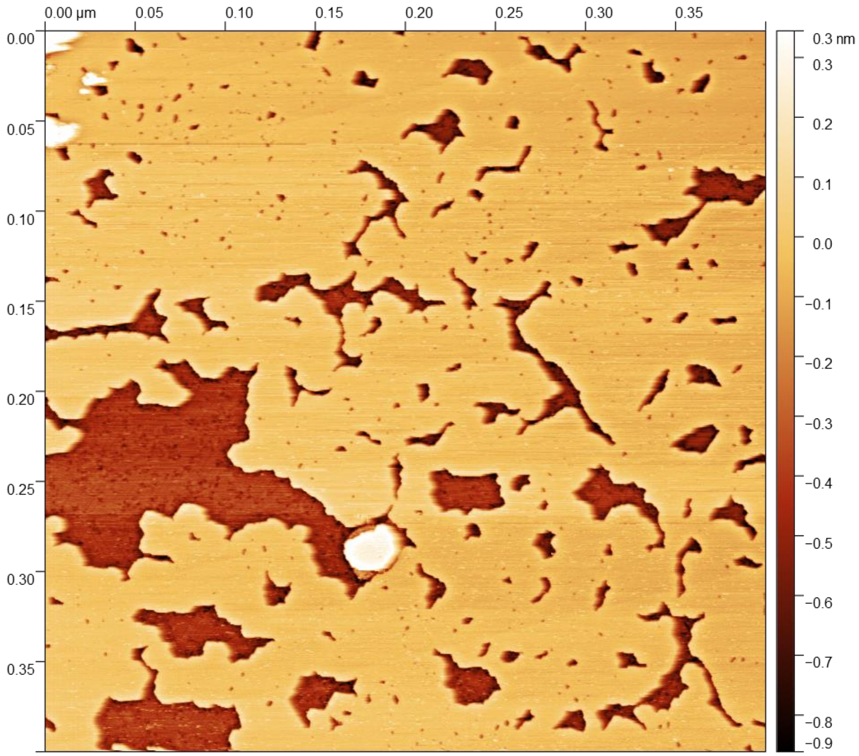
STM image at +1.8V
(0.4 MC Ga) after heat

The subsequent deposition of gallium was performed on the Si(111)-√3×√3-Ga surface at room temperature (RT). From STM observations, the deposition of gallium on Si(111)-√3×√3-Ga at RT leads to the formation of flat disordered islands of irregular shape. Mild heating of the gallium film at a temperature of 50°C leads to the ordering of gallium atoms into a structure with 4×√13 periodicity. A gallium film with the same periodicity was observed by M.L. Tao et al. In this work, the authors deposited gallium on a heated Si(111)-√3×√3-Ga surface at 50°C.

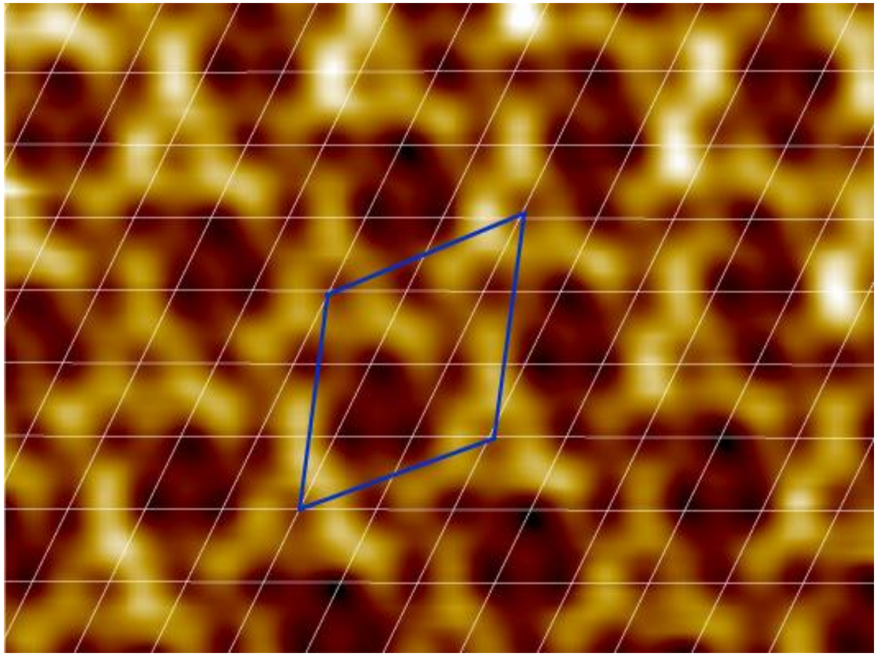
M. L. Tao , Y. B. Tu, K. Sun, Y. L. Wang, Z. B. Xie, L. Liu, M. X. Shi, J.Z. Wang. 2D Materials 5(2018)035009.

Ga $\sqrt{7}\times\sqrt{7}$

Further deposition of gallium both on an ordered film with $4\times\sqrt{13}$ periodicity and on a disordered one (before heating) leads to the formation of flat islands of the second gallium layer. As the coverage increases, the islands merge into a flat film at 4.14 ML Ga. The flat film looks like an ordered array of trimers with $\sqrt{7}\times\sqrt{7}$ periodicity.



STM image of flat islands of the second gallium layer



A cell $\sqrt{7}\times\sqrt{7}$ with an overlay grid 1×1

Conclusions

In this work, we studied the growth of gallium films on the Si(111)-$\sqrt{3}x\sqrt{3}$-Ga surface reconstruction. The deposition of 1.81 ML Ga leads to the formation of a flat disordered layer. Annealing of such a layer at 50°C forms a flat structure with $4\times\sqrt{13}$ periodicity containing 29 atoms per cell. Further deposition of gallium produces the next layer looking like an ordered array of trimers with $\sqrt{7}\times\sqrt{7}$ periodicity. Low-temperature measurements down to 2K did not reveal superconducting transitions.

Acknowledgements

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