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Investigation of Low-dimensional Si Structures on Ag(111) by Scanning Probe Microscopy

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Recent years, the progress of miniaturization of electronic devices stimulates a growing interest in low-dimensional materials. Among them, silicene, the allotrope of silicon equivalent of graphene, has attracted increasing attention owing to its superior electronic properties. Silicene has a honeycomb structure similar with graphene. The band structure of silicene, which forms 'Dirac cone' at the symmetric point K in the reciprocal space, indicates that the charge carriers in silicene sheet behave like massless Dirac fermions [1].

In contrast with the totally planar graphene, silicene has a buckled structure, which makes it difficult to determine the detailed structures of silicene. So far, scanning tunneling microscopy (STM) and low-energy electron diffraction (LEED) have been mainly used as characterization method for analysis of silicene structures.

Recently, it was reported that non-contact atomic force microscopy (nc-AFM) has a higher spatial resolution for (4×4) phase of silicene on Ag(111) than STM [2]. The high-resolution AFM imaging can even resolve all the constituent Si atoms, while STM resolves only the upper-buckled ones. Moreover, nc-AFM also for the first time identified the detailed atomic structures of (√13×√13)R13.9° phase of silicene on Ag(111) [3].

In this research, we carried out the AFM observation for T phase of silicene on Ag(111). All the constituent Si atoms including the lower-buckled ones are successfully resolved by high-resolution AFM imaging (Fig.1). The observation results also identified that there are two different types of ordering pattern of T phase [4].

During the synthesis of silicene of Ag(111), a new low-dimensional Si structure, silicon nano-ribbons (SiNRs) on Ag(111) (Fig.2), was also found. Under STM observation, SiNRs appear as two rows of bright protrusions. Based on the STM observation, DFT calculation was carried out to investigate its atomic structure. In the proposed structural model, SiNRs are composed of hexagonal and tetragonal Si rings.

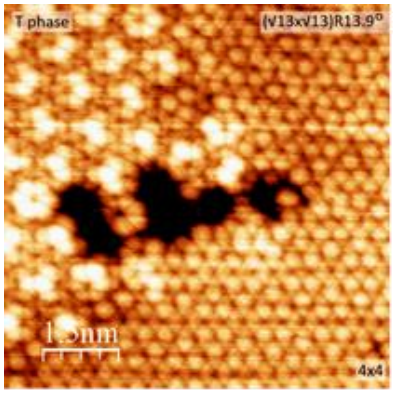

Fig. 1. High-resolution AFM imaging of silicene on Ag(111), on which T phase, (√13×√13)R13.9° and (4×4) phase coexist.

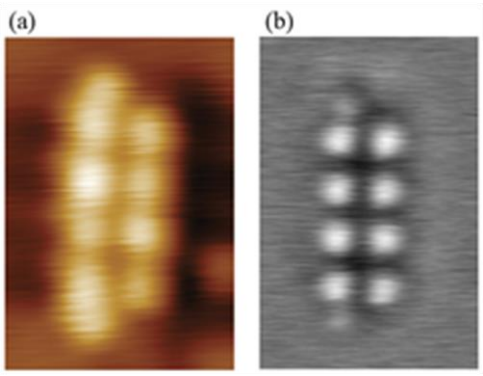

Fig. 2: STM image (a) and AFM image (b) of a SiNR on Ag(111).

References

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