Comment on "Evidence for Dirac Fermions in a Honeycomb Lattice Based on Silicon"

In a recent Letter, Chen *et al.* [1], reported on the geometric and electronic characters of silicene on Ag(111) measured using scanning tunneling microscopy or spectroscopy (STM/STS). Based on interference patterns (IPs) observed by the mapping of differential conductance (dI/dV), they claimed that a linear dispersion relation appeared in the silicene band, which is a solid evidence for massless Dirac fermions. In this Comment, we point out that their conclusion resulted from an insufficient energy range in dI/dV mapping experiments, and thus was not correct. From the measurements in the wider energy range, we found that the dispersion relation must be described by a parabolic function and not a linear one.

Figure 1 summarizes our data. Figure 1(a) shows an STM image of silicene on Ag(111) taken at 6 K. The periodicity is essentially identical with that in Ref. [1]. Note that this phase, which shows $4/\sqrt{3} \times 4/\sqrt{3}$ with respect to the Ag(111) lattice [2], should be attributed to a bilayer silicene. Figure 1(b) is a typical dI/dV mapping (sample bias $V_S = 0.04$ V) showing the IP. The IP mainly originates from the electron scattering by silicene islands that do not appear in Fig. 1(a). In other words, the triangular boundary does not act as a major scattering center. The wave number of the IP is determined from the radius of the ring in the Fourier transform image of the dI/dV map [Fig. 1(c)]. Figure 1(d) shows the dispersion relation determined from the dI/dV mapping experiments.

One sees that the dispersion relation is *not* linear but fitted by a parabolic function that represents the quasifree electron band [blue curve in Fig. 1(d)]. This demonstrates that the pattern in the dI/dV map originates from interference of the quasifree electron and not from massless Dirac fermions. The lowest energy of the band was -0.098 eV. The electron effective mass determined from the band curvature was found to be $m^*/m_e = 0.14$ (m_e is the free electron mass). These values are close to those of the Ag(111) surface states [3]. Further, the IP did not appear when $V_S < -0.1$ V. These results do not indicate the massless Dirac fermion character but imply the quasifree electron one arising from the surface state of Ag(111) modified by Si covering.

By comparing our results and the ''linear dispersion'' in Ref. [1], one would see why they came to the wrong conclusion as well. Indeed, our experimental data between 0.35 and 1.1 eV follow both the linear and parabolic relation as shown in Fig. 1(d). Since we do not know their exact method for determining the wave numbers, we cannot further discuss the lateral deviation between our experimental data and theirs. Nevertheless, the present results clearly demonstrate that the limited energy range in dI/dV measurement brings us to a wrong conclusion about the band dispersion.

In summary, we draw a conclusion that the $4/\sqrt{3} \times 4/\sqrt{3}$ silicene does not acquire the Dirac fermion character.

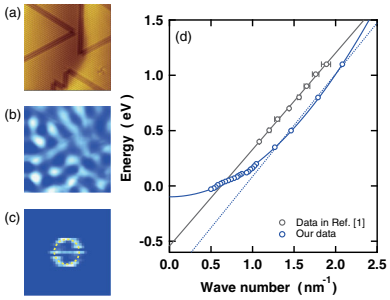

FIG. 1 (color online). (a) STM image of $4/\sqrt{3} \times 4/\sqrt{3}$ silicene on Ag(111) ($I_T = 100$ pA, $V_S = 350$ mV). The scan area is 284 Å $\times$ 284 Å. (b) dI/dV map for the same area shown in (a). $V_S = 40$ mV. (c) Fourier transform image of (b). Dotted yellow circle indicates the ring that determines the wave number of the IP. (d) Dispersion relation determined from the dI/dV map. Blue circles and curve represent our experimental data and the parabolic fit, respectively. Gray circle and line are the data taken from Ref. [1]. The blue dotted line is the linear fit only for the data between 0.35 and 1.1 eV.

Silicene may have fascinating electronic properties as graphene. However, the silicene in contact with Ag(111) is influenced by the underlying Ag substrate [4]. An approach to avoid undesirable effects from substrates is required to realize the exotic properties of silicene.

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