Correlation between Morphology and Transport Properties of Quasi-Free-Standing Monolayer Graphene

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Quasi-free-standing monolayer graphene (QFMLG) can be obtained by intercalating hydrogen at the interface of buffer layer and SiC(0001). It is efficiently decoupled from the substrate and a promising material for wafer-scale graphene-based nanoelectronics [1-2]. However, the mobility of QFMLG (~3000 $cm^2V^{-1}s^{-1}$) is limited to a value lower than that obtained with exfoliated graphene on SiO_2, and dominant carrier-scattering mechanisms have not been satisfactorily identified. Recently it was reported that the mobility of QFMLG depends on the substrate temperature during the hydrogen intercalation process, and that the highest mobility is obtained at 700-800°C [3]. These measurements suggested that carrier scattering should mostly stem from charged impurities at 600 and 800°C, while defects should induce additional scattering at 950°C. We used scanning tunneling microscopy (STM) to investigate the morphology of QFMLG formed at several hydrogen intercalation temperatures, and discuss here its relationship with transport properties [4].

Our STM observations reveal features in the QFMLG formed at 600°C and 800°C which have a diameter of 1.5 nm, a depth of 20-80 pm, and a density of 1×10^{13} cm^{-2} (see Fig. 1), and partially align with a periodicity of 1.8 nm, corresponding to the quasi-(6x6) reconstruction of the buffer layer. These features are attributed to Si dangling bonds at the graphene-substrate interface, they are due to incomplete hydrogen intercalation and are expected to contribute to carrier scattering as charged impurities.

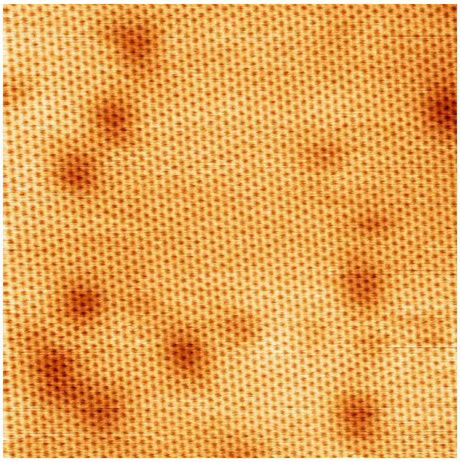

Fig.1 STM image of QFMLG after H intercalation at 800°C. Image size 12 nm × 12 nm.

Bilayer-deep voids in the SiC substrate (diameter 4-10 nm, density 6×10^{10} cm^{-2}, probably due to etching of the SiC by hydrogen) and wrinkling of graphene appear in samples formed at 1000°C, and they decrease carrier mobility significantly, despite a better H intercalation.

We conclude that a higher mobility of QFMLG can be obtained by optimizing the conditions for H intercalation while staying below the temperature at which voids and wrinkles appear.

References

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