Challenges of Graphene Growth on Silicon Carbide

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In this overview we consider issues and promising results obtained on graphene produced on SiC substrates by high temperature sublimation ambient Ar pressure. Heating of SiC to carefully decompose the surface to reconstruct and form a graphene layer has to consider the variations of the silicon to carbon ratio in the gas phase and particularly close to the substrate surface. At lower temperature the silicon escape is more pronounced at defects and the silicon to carbon ratio is rather high due to the large difference in the Si and C vapor pressures given by the SiC sublimation thermodynamics which results in C deficiency on the surface. The ratio of silicon and carbon containing species is decreased with increasing temperature providing more carbon in the growth cell and allowing more uniform and exact graphene layers, while the issue of homogeneous temperature fields over large area becomes more important. We have shown that by using a process temperature of 2000oC and 1 atm of Ar pressure under highly isothermal conditions, one monolayer graphene over a large area can be reproducibly fabricated [1,2].

The structural and electronic properties of graphene grown on SiC are substrate meditated. A major concern is the natural habit of silicon carbide to cause a step-bunched surface and is a factor to handle for large area graphene growth on silicon carbide wafers. We will further show the impact of the polytype of the SiC substrate on the quality of the graphene on top. Cubic SiC has the advantage of reduced step bunching which is substantial benefit for acquiring uniform step distribution of a Si-C bilayer size during sublimation. Having the advantage of fabricating own 3C-SiC substrates we will present a comparison of the graphene morphology for growth on 6H, 4H and 3C-SiC. We use spectroscopic ellipsometry mapping from 0.73 eV to 6 eV in order to probe the uniformity of the epitaxial graphene thickness and properties on a cm-scale. A good correlation between graphene morphology and transport properties has been observed. By surface potential mapping a geometrical tailoring of the surface topology is proposed.

Substrate supported graphene exhibits wrinkles. We have studied wrinkle geometry depending on the substrate crystallographic orientation and face (Fig.1). The issue of wrinkle reduction will be discussed.

The availability of large area monolayer graphene produced by our method has allowed demonstration measurements of quantum Hall effect with a high precision surpassing that for exfoliated graphene and being similar to the accuracy achieved in the established semiconductor resistance standards. These results are exceptionally promising for new findings in the metrology [3].

References

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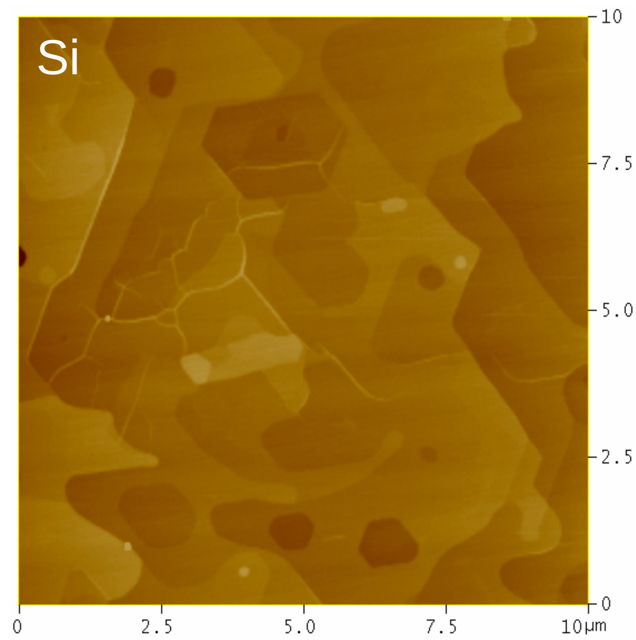

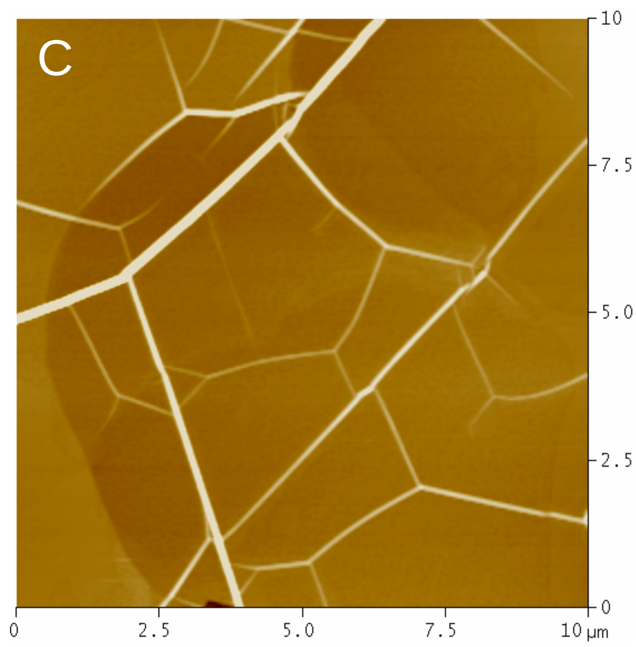

Fig. 1. Wrinkles on the Si and C-face of the same SiC substrate. Those on the C-face are much thicker.