Transfer-Free Electrical Insulation of Epitaxial Graphene from its Metal Substrate

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Abstract

The remarkable properties of graphene, such as the very high carrier mobility at room temperature, tolerance to high temperature and inertness, make it the most promising candidate for future nanoelectronics. Several methods have been developed to produce graphene layers of various dimensions and quality, which, however, hardly match the requirements for mass production of electronic devices. Exfoliation-based techniques are very expensive, time-consuming and produce small flakes or graphene of poor quality. The most common way to obtain extended, high-quality, single graphene layers is the epitaxial growth on transition-metal surfaces. However, the graphene/metal interface has the disadvantage of a conductive substrate, that makes the conduction through graphene irrelevant.

In order to face this problem we have developed a novel transfer-free method to electrically insulate epitaxial graphene from the metal substrate it is grown on. This is achieved by growing in situ an insulating SiO2 layer of the desired thickness directly below the graphene layer, through a stepwise reaction between intercalated silicon and oxygen [1].

Firstly, epitaxial graphene is grown on a Ru(0001) crystal surface. Subsequent exposure of the sample to a flux of Si at 720 K results in Si intercalation and in the formation of a Ru silicide layer below graphene. Intercalation of oxygen [2] at T=630 K rapidly oxidizes the silicide producing a thin SiO2 layer over an oxygen covered Ru surface. By following the entire process by high resolution fast-XPS measurements we establish that graphene does not react with O_2 and that during the decomposition of the Ru silicide oxygen binds exclusively to Si [3]. At the end of the process, we proved electrical insulation of the graphene layer from the Ru substrate by performing lateral transport measurements with a microscopic 12 point probe, showing a resistance value characteristic of two-dimensional systems.

The transfer-free method developed in the present work shows that element intercalation can be exploited for the synthesis of materials below graphene, which might have wide application in graphene research and nanotechnology devices fabrication.

References

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