Direct synthesis of a two-dimensional graphene grating on a dielectric substrate

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Abstract

Graphene has recently found a number of applications in photonic and optoelectronic componets including transparent electrodes, saturable absorbers, ultrafast transistors and optical modulators [1]. However, until now, incorporation of graphene into photonic and optoelectronic devices requires its transferring from metallic catalyst used for its synthesis to an insulator or semiconductor substrate. Moreover in order to achieve monolithic integration graphene should be deposited on the prescribed location on the Si/SiO2 wafer. Here we propose a technique for position-selective graphene growth directly on the pre-patterned dielectric substrate.

In the experiment, we formed an array of holes with diameter of about 4 µm and the period of 10 µm on a quartz substrate by femtosecond laser ablation. This pre-patterned substrate was covered by a 200 nm thick copper film and was employed as a substrate in the chemical vapor deposition (CVD) process (see Ref. [2] for details).

During the CVD process the Cu film liquidizes and forms a network prescribed by the morphology of the substrate and the temperature, while a few layer graphene will grow both on copper-vacuum and copper-silica interfaces [2,3]. Thus the graphene network will be “imprinted” on the silica substrate and can be revealed by removing copper by plasma and wet etching.

The fabricated graphene network was characterized by scanning electron microscope and Raman spectroscopy. In the Fig. 1 the Cu receding is presented without (1a) and with (1b) the surface modification. Without patterning the Cu layer is receded randomly, but on top of the hole grating the copper recedes by well controlled manner and form an uniform network structure. A typical Raman spectrum, measured from the graphene network revealed beneath Cu, shows that the quality of the graphene is comparable to the graphene samples reported in Refs. [2] and [3].

In conclusion we demonstrate a transfer free technique in order to deposit graphene to a prescribed location on dielectric substrate without post patterning. This technique can be extended by modifying the substrate by other means (e.f. by e-beam lithography or nanoimprinting). It can be also employed for introducing graphene elements into optical gratings or planar waveguides.

References

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[2] T. Kaplas, D. Sharma and Y. Svirko, Carbon, **50(4)** (2012) 1503-1509.
[3] C.Y. Su, A.Y. Lu, C.Y. Wu, Y.T. Li, K.K. Liu, W. Zhang, et al., Nano Lett., **11** (2011), 3612–3616.

Figures

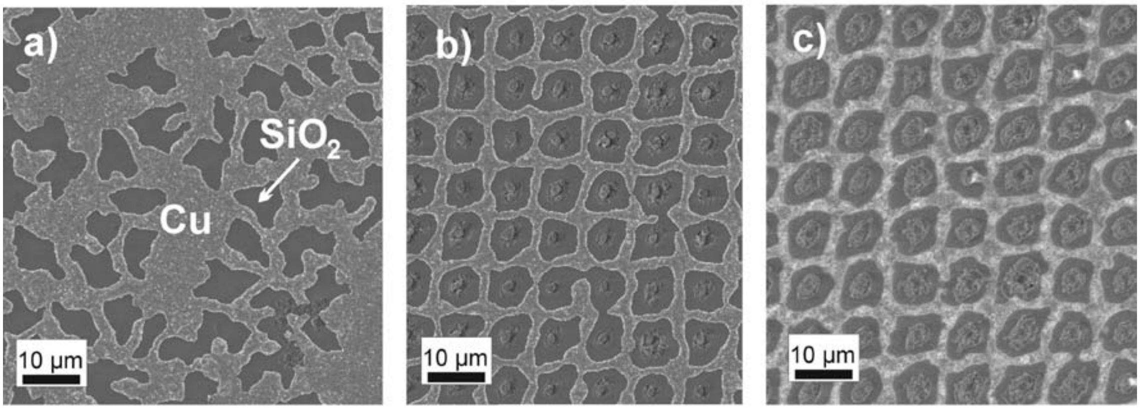

Fig. 1. A quartz sample, coated with Cu thin film, after the CVD process a) without patterning and b) with ablation holes. c) When the Cu remains are removed by wet etching the graphene network is revealed.

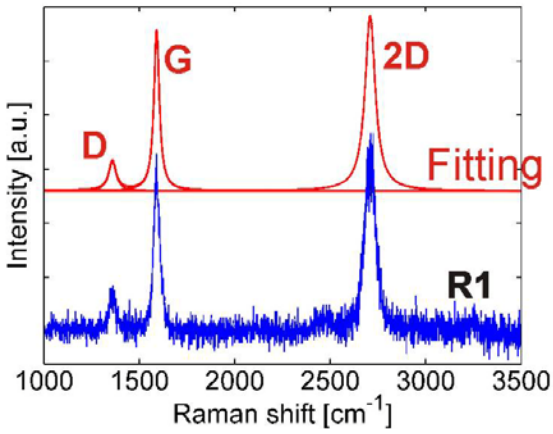

Fig. 2. A typical Raman spectrum measured from graphene network and Lorentzian peak fitting.