Direct growth of graphene film on Ge <100> substrate by low pressure CVD.

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Graphene has potential to play an important role in nanoelectronics devices due to its outstanding properties like carrier mobility, transparency, and one atom thick layer dimension. There are two different routes to employ graphene in devices: the first one is transferring the graphene to the device surface, and the second one is direct growth on the desired surface. One of the advantages of the direct growth can be a better integration between the substrate and the graphene sheet. This integration is essential for nanoelectronics devices on nonmetallic substrates [1,2,4]. Germanium is an intrinsic semiconductor material with higher carrier mobility than silicon, and their integration with graphene sheets is of high interest for both fundamental science and electronic device applications. Nowadays, however, this system remains relatively unexplored structurally and electronically, particularly at the atomic scale [3].

For this work, a low pressure CVD system with base pressure ~1 Pa (7.6 mTorr) was employed to the synthesis of a single-layer graphene. The substrate was a polished and crystalline Ge wafers <100>. After the base pressure was achieved, the Ge substrate was annealed in an Ar/H_2 atmosphere and sequentially to an atmosphere of $CH_4/H_2/Ar$ with pressure around $5x10^4$ Pa to promote the graphene growth. The amount of ratio-CH_4/H_2 used in the synthesis was in the range of 0.01 – 0.1. Raman spectroscopy and scanning tunnelling microscopy were employed to the samples analyses. Raman spectra show results typical of single layer graphene (Figure 1), evidenced by the ratio between the 2D and G band around 2, and an FWHM (Full Width of Half Maximum) of 2D band around 38cm^{-1}. The STM images show a typical graphene layer clearly indicating the success to direct growth on Ge substrate.

References

[1] Wang, G. et al. *Direct growth of graphene film on germanium substrate*. ***Sci. Rep***. 2013, 3, 2465.

[2] Lee, J. H. et al. *Wafer-scale growth of single-crystal monolayer graphene on reusable hydrogen-terminated germanium*. ***Science*** 2014, 344, 286−289.

[3] Kiraly, B. et al. *Electronic and mechanical properties of graphene-germanium interfaces grown by chemical vapor deposition*. ***Nano Lett*** 2015, *15* (11), 7414–7420.

[4] Pasternak, I. *et al. Graphene growth on Ge(100)/Si(100) substrates by CVD method*. ***Sci. Rep***. *2016*, ***6***, 21773.

Figures

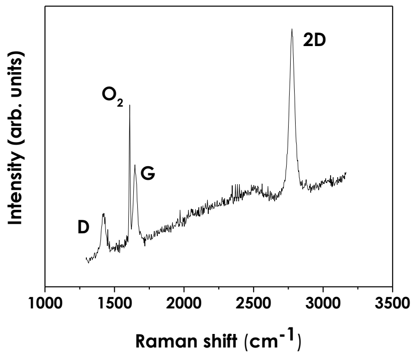

Figure 1: Raman spectrum of graphene deposited on Ge.