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Discrimination the Quality of Single layer Graphene transferred on Silicon Oxide substrate

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Abstract

We demonstrate in this application note that uRaman from Technospex Pte. Ltd. is a promising instrument to determine the quality of the transferred single layered graphene on a 300-nm silicon dioxide (SiO_2) substrate.

Introduction

Graphene is a unique two-dimensional material which is thin, strong and yet flexible[1]. Graphene possess extraordinary electric and optical properties that attract a lot of interest in graphene-based electronic and photonic devices[2]. However, it is crucial to determine the quality of the transferred graphene because it will significantly affect the performance of devices.

Raman spectroscopy, a high throughput and non-destructive spectroscopy method, can provide a quick and simple identification of the quality of the graphene on the device. Specifically, the disordered and defective carbon atom arrangement (D-band), and ordered sp^2 carbon arrangement (G-band) can be clearly identified and quantified from a vibrational Raman spectrum of a graphene sample

Experiment and Equipment

A monolayer of graphene (6×6 mm^2) was transferred from Cu foil to the 300-nm SiO_2 substrate according to the procedure documented in literature [3]. The Raman mapping was performed with uRaman Microscopy System (from Technospex Pte. Ltd., Figure 1) equipped with motorised stage for Raman chemical mapping, 532nm laser, spectrometer with thermoelectric-cooled CCD detector. 100X objective lens 0.95NA is used and the integration time for the Raman map is 0.5 s per spectrum and laser power was attenuated below the damage threshold for the graphene (< 4 mW).

Figure 1 uRaman-532TEC-Ci / uSight micro-spectroscopy system equipped with motorised stage and several objective lens

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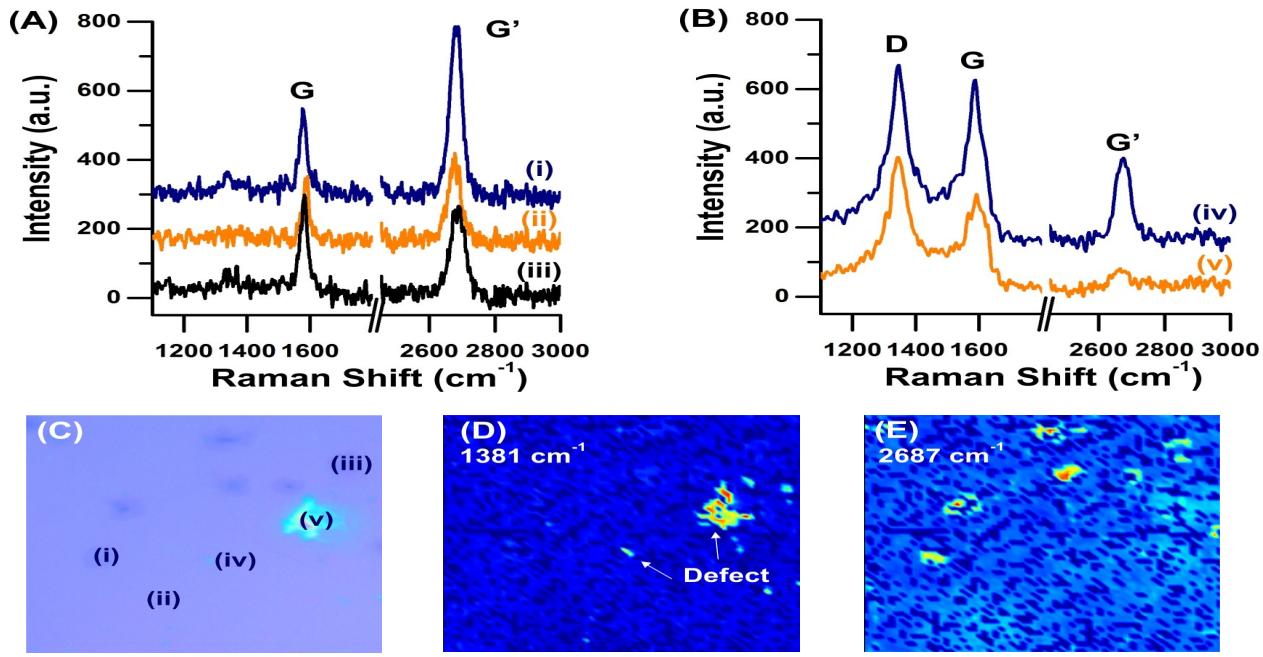

Figure 2 (A-B) Raman spectra of graphene on silicon dioxide taken from the different location from (C). (C) Optical image of single layer of graphene transfer to 300 nm of SiO_2. (D-E) Chemical images of D-band at 1381cm^{-1} and G' band at 2687cm^{-1} of the graphene layer.

Results and Discussion

The transferred graphene quality is investigated by Raman spectroscopy and its difference can be clearly discriminated from the chemical mapping of the sample. Main Raman feature from the spectrum (D, E) are D, G and G' band. All Raman spectrum present in Figure 2 (A-B) are taken from the region shown in Figure 2C. The typical single layer graphene spectrum has a large intensity G'-band relative to the G-band as shown in Figure 2(A)-(i)[4]. The ratio between G'/G bands is varied at different locations Figure 2A-(ii-iii) which indicated the triple resonance process in G'-band become hindered. For the region Figure 2B-(iv and v), a large disorder-induced D-band with intensity relative to G-band is observed. The D-band intensity is largely come from the fold boundaries due to the transfer process or residual PMMA on it. The disorder region on the single layer graphene can be clearly distinguished in the higher intensity area on the D-band Raman map on Figure 2B. Figure 2C shows the bright field image of the sample and the Raman mapping was measured over the area of interest. Figure 2D-E are the Raman map corresponding to the disorder-induced D-band (related to the defect peak) at wavenumber 1381cm^{-1} and ordered sp^2 carbon arrangement G'-band at wavenumber 2687cm^{-1}, respectively.

Conclusion

Raman spectroscopy is a high throughput and non-destructive method for quick and simple identification of the quality of the single layer graphene on the device. The uRaman -Ci microscope system from Technospex provides an ideal and low cost instrument for graphene characterization; alternatively the uRaman -M module can be easily mounted to existing upright microscopes in the lab to empower them for this measurement.

Reference

[1] Science **2009**, *324*, 1530.
[2] Nature Photon **2010**, *4*, 611.
[3] ACS Appl. Mater. Interface **2014**, *6*, 20464.
[4] Phys. Rep. **2009**, *473*, 51.

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