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Raman and phase shifting interferometry study of tear/fold structure on transferred graphene

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Applications & Keywords

Graphene production quality control

Techniques

Dispersive Raman

Phase shifting interferometry

Instrument Solution

XperRAM S Series

Xper-PSI

NanoSpectrum Software

Introduction

Graphene has been one of the most attractive materials in material engineering communities due to its structure and high electron mobility. Its unique electronic band structure enables Raman spectroscopy to identify a single layer of graphene and even distinguish variable numbers of layers.

Combined with phase shift interferometry (PSI), which investigates the height profile of 1 mm^2 area in 0.5 nm resolution, Raman spectroscopy is a powerful method to analyze the morphology of not only two-dimensional graphene, but also transition metal dichalcogenides. Those methods may be applied for quality control by detecting the defects, wrinkles, or torn parts of graphene sheets which can be generated from the transfer process during graphene fabrication.

Here, we have observed the folded parts on a bilayer graphene sample with Raman spectroscopy system - XperRAM S Series, and phase shifting interferometer (PSI) - Xper-PSI.

Materials & Methods

1 cm^2 of CVD graphene layer sample was fabricated by Graphene Supermarket. The graphene bilayer was transferred to 285 nm SiO2/Si (boron doped) substrate assisted by PMMA (poly-methyl-methacrylate).

Raman spectra and Raman images were obtained with Raman microscopy instrument XperRAM S Series. The Raman images were performed at those graphene's instinct Raman peaks of G band (~1580 cm^{-1}) and 2D band (~2700 cm^{-1}). Averaging of spectra were performed from those parts where the silicon substrate is exposed and where the graphene layer is folded (2+2 tetralayer).

The PSI images from the same parts were obtained via Xper-PSI using 532 nm excitation.

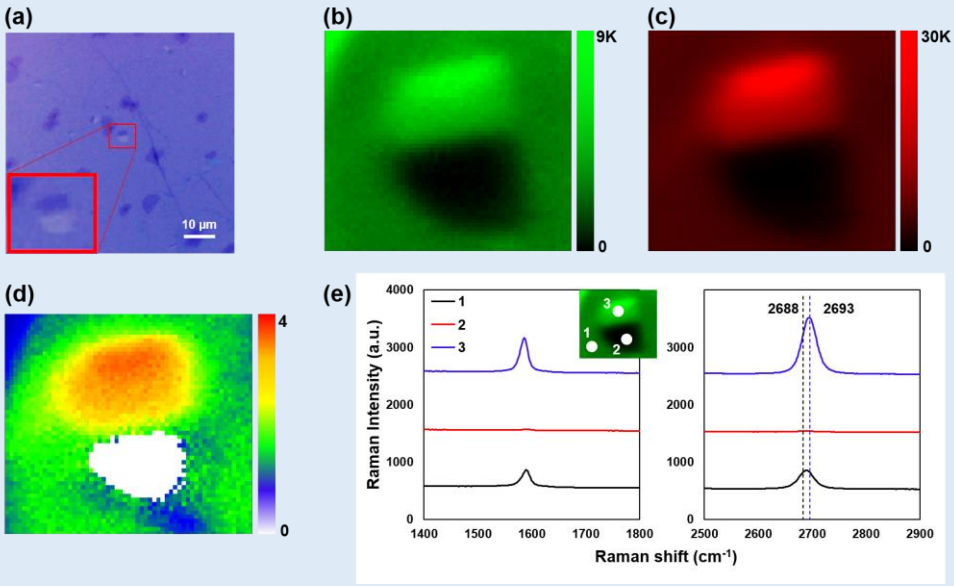
Results & Conclusion

During transfer of graphene on growth substrate to target substrate, it used to happen that a little of graphene area becomes torn and folded on the other side symmetrically [1, 2]. This phenomenon was also found through the microscope (*Figure 1. (a)*).

Raman mapping was used to investigate the layer of graphene sheet and the properties about tear/fold structure (*Figure 1. (b)-(d)*). Through 2D/G map (*Figure1. (d)*) and spectrum at point 1, it was confirmed that bilayer graphene sheet was grown on the substrate. In *Figure 1. (b)* and *(d)*, it was clearly seen that the two shapes were very similar. With Raman map images of G and 2D bands and spectra of point 2 and 3, the direction of the graphene being folded was indicated.

In addition, by comparing spectra of specific areas from the Raman image in *Figure 1. (e)*, intensity amplification of G, 2D band and the red shift (4~8 cm^{-1}) again confirms the graphene tear and fold morphology [2].

Figure. 1



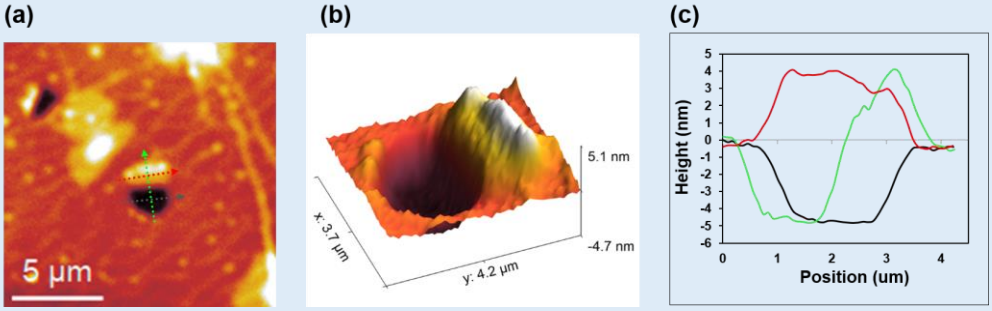
Results & Conclusion (continued)

PSI was used to observe the profile of tear and fold area. 2D PSI image and 3D-reconstructed images were shown in *Figure 2. (a)* and *(b).* Height profiles in *Figure 2. (c)* prove that the depth between graphene sheet and substrate was about 4 nm which was equal to the height of folded graphene sheets.

Furthermore, the height of several tear/fold graphene sheets was examined, and bilayer graphene had 4 nm height.

Thus, supported by the PSI method, Raman spectroscopy has the capability to analyze the surface structure of nanomaterials, such as graphene, two-dimensional materials, TMD, etc.

Figure. 2



References

[1] Ukjae, Lee, et al. "Facile Morphological Qualification of Transferred Graphene by Phase Shifting Interferometry" Advanced Materials (2020), 2002854

[2] Yufeng, Hao, et al. "Probing Layer Number and Stacking Order of Few-Layer Graphene by Raman Spectroscopy", Small (2010, 6) No. 2, 195-200