Surface enhanced Raman scattering of graphene

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Graphene, the one monolayer thick flat graphite, has been attracting much interest since it was firstly reported in 2004. Graphene has many unique properties which make it an attractive material for fundamental study as well as for potential applications. Raman spectroscopy has been extensively used to study graphene, i.e. identify graphene layer numbers; probe electronic band structure; determine type of edges (zigzag or armchair); measure the concentration of electron and hole dopants. In addition, using graphene as a substrate for probing vibrational information from target molecules has been paid more attention recently. Here, we present our results on the study of using graphene as a surface enhanced Raman scattering (SERS) substrate.

Firstly, gold (Au) films with different thicknesses were deposited on single layer graphene (SLG) and used as SERS substrates for the characterization of rhodamine (R6G) molecules. We find that an Au film with a thickness of ~7 nm deposited on SLG is an ideal substrate for SERS, giving the strongest Raman signals for the molecules and the weakest photoluminescence (PL) background. While Au films effectively enhance both the Raman and PL signals of molecules, SLG effectively quenches the PL signals from the Au film and molecules. The former is due to the electromagnetic mechanism involved while the latter is due to the strong resonance energy transfer from Au to SLG. Hence, the combination of Au films and SLG can be widely used in the characterization of low concentration molecules with relatively weak Raman signals.[1]

Following, we report a simple method to recover the SERS activity of aged graphene. We found that, for graphene samples fabricated and exposed in ambient for a period (several month or more), i.e., aged graphene, the SERS activities are vanished and no vibrational information of absorbed molecule can be detected. The SERS activity of aged graphene is dramatically increased after vacuum annealing and comparable to those on fresh graphene. Atomic force microscopy measurements indicate that residues on aged graphene surface can efficiently be removed by vacuum annealing, which makes target molecule closely contact with graphene. We also find that the hole doping in graphene will facilitate charge transfer between graphene and molecule. These results confirm the strong Raman enhancement of target molecule absorbed on graphene is due to the charge transfer mechanism.[2]

Finally, we compare the SERS activity of graphene, graphene oxide(GO), and reduced graphene oxide (rGO), to explore the impacts of local chemical groups and global π-conjugation network on the SERS effect of graphene. [3]

References

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Figures

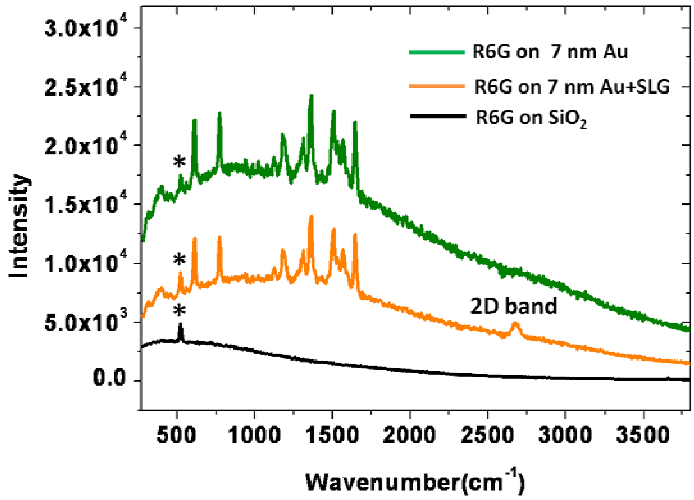

Figure 1. Raman spectra of R6G on SiO_2 substrate, R6G on Au/SLG substrate, as well as R6G on Au substrate.

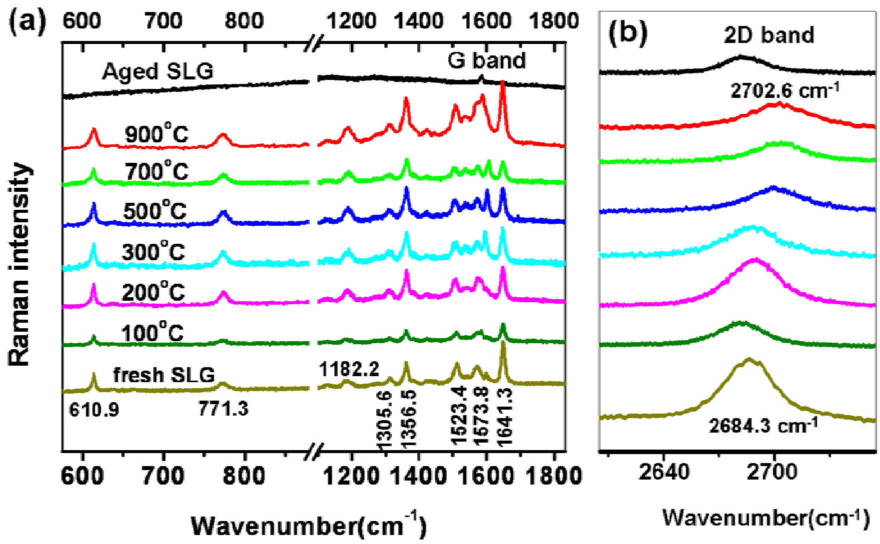

Figure 2. (a) Raman spectra of R6G adsorbed on aged SLG and annealed SLG samples. The Raman spectra of R6G adsorbed on fresh SLG is also included. (b) 2D bands of fresh SLG, aged SLG, and aged SLG annealed at different temperature.