Raman scattering of suspended graphene enhanced by plasmonic Au nano-structures

Sebastian Heeg[†], Roberto Fernandez-Garcia[‡], Antonios Oikonomou[¶], Fred Schedin[§], Rohit Narula[†], Stefan A. Maier[‡], Aravind Vijayaraghavan[¶,§], and Stephanie Reich[†]

†Department of Physics, Freie Universität Berlin, 14195 Berlin, Germany
‡Department of Physics, Imperial College London, London SW7 2AZ, U.K.
¶School of Computer Science, The University of Manchester, Manchester M13 9PL, U.K.
§Centre for Mesoscience and Nanotechnology, The University of Manchester, Manchester M13 9PL, U.K.

sebastian.heeg@physik.fu-berlin.de

Abstract

Enhanced Raman scattering has become a spectacular application in the field of plasmonics. It combines the generation of highly localized light fields at metal-dielectric interfaces with the variety of properties that can be obtained by Raman spectroscopy. We demonstrate a graphene Raman enhancement of up to 10^3 arising from a nanoscale cavity between two closely spaced Au nano-disks [1]. Graphene is suspended between the two disks and partially extends into the cavity, which is schematically depicted in Figure 1. The suspended graphene is under tensile strain, which is induced by the double structure partially elevating the graphene. The resulting phonon mode softening allows for a clear identification of the enhanced Raman signals arising from the plasmonic hotspot (red spectrum) between the disks in comparison to unperturbed graphene (black spectrum) as depicted in Figure 2. Spatially resolved Raman measurements reveal that the enhancement in the cavity is localized in dimensions one order of magnitude smaller than the wavelength of the excitation. Upon rotating the polarization of the excitation, we switch from localized cavity enhancement to the dots acting as two approximately separate plasmonic particles. As a result, the near field localization in the cavity is lifted and the enhancement drops by a factor of 20. From a plasmonics point of view, graphene is used a Raman active, two-dimensional membrane that serves as a detection channel of the local near-field distribution. Raman enhancement in strained graphene can be used to characterize plasmonic enhancement arising from any variety of nano-structure geometries. From the perspective of Raman scattering of graphene, the nano-structures induce local strain and simultaneously provide the means of local detection. The induced strain configuration can neither be achieved by uniaxial nor biaxial strain.

Figures

Figure 1

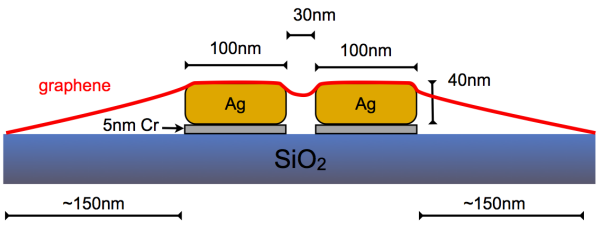
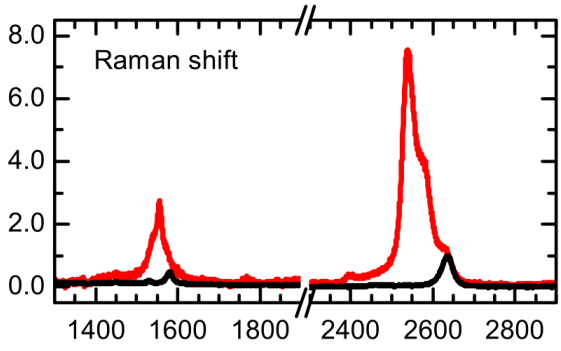


Figure 2



References

[1] Heeg, S. *et al.* Polarized Plasmonic Enhancement by Au Nanostructures Probed through Raman Scattering of Suspended Graphene. *Nano Lett.* **13**, 301–308 (2013).