

Investigation of mechanical strain of graphene by Raman spectroscopy

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Graphene is a unique material with a wide variety of applications due to its exceptional carrier mobility, transparency, and flexibility [1]. Mechanical strain of graphene is of importance for the optimization of flexible electronic devices as it can alter the electronic structure of graphene, even introduce a band gap. Raman spectroscopy is a powerful tool for analyzing the structure of graphene as it provides information regarding the number of layers as well as the presence of defects, doping, and mechanical strain [2]. This can then be extended by the use of polarized Raman spectroscopy to investigate the relationship between strain angle and the effect on the graphene lattice.

The use of chemical vapor deposition (CVD) to grow graphene creates a patchwork of small slightly rotated crystal domains [3]. These domains are each separated by domain boundaries which can affect the properties of graphene, particularly when combined with mechanical strain. In this work we have synthesized polycrystalline graphene by CVD on copper foil and transferred it to flexible elastomer polydimethylsiloxane (PDMS) substrates to create transparent, flexible structures, as seen in Fig. 1a. The presence of domain boundaries was found to cause an anomalous shift in the Raman peak position with mechanical strain when compared to exfoliated (monocrystalline) graphene, shown in Fig. 1b [4]. This was verified by growing large single domain graphene by epitaxial CVD which behaved in the same way as exfoliated single domain graphene. Theoretical calculations were used to support these experimental findings. Finally, polarized Raman spectroscopy was also used to investigate the graphene while under strain and compared to existing theoretical studies. Figure 1c shows the normalized I_{2D}/I_G ratio changing with regards to the relative angle between incident and reflected polarization, as well as the theoretical curve for unstrained single domain graphene [5]. Clearly as strain is increased we see an increased deviation from the expected theoretical values. By gaining a thorough understanding of the behavior of graphene under strain we can optimize the performance of flexible transparent electronic and photonic devices.

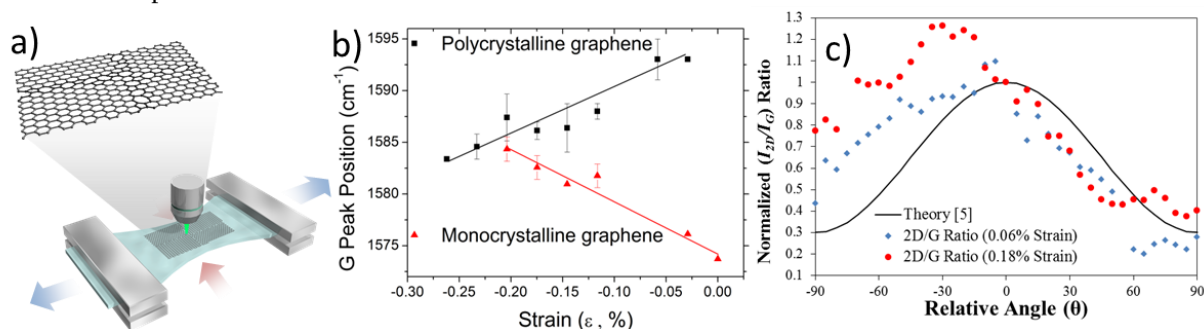


Figure 1. a) Schematic of polycrystalline CVD grown graphene after transfer to flexible PDMS substrate for strain experiment. b) Plot of the Raman G peak position with increasing strain showing opposite behavior for polycrystalline and monocrystalline graphene. c) Plot of I_{2D}/I_G ratio with changing angle between incident and reflected polarized light. The incident polarization angle is parallel to the mechanical strain axis. With increasing strain (0.06% to 0.18%) we see an increased deviation from the expected theoretical values.

References :

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