

# Stable p-doping in graphene using deep UV irradiation

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## Abstract

Graphene has been recognized as an important material for electronic devices due to its unique electronic properties such as ambipolar transport [1, 2]. However, due to its zero band gap it is essential to modulate the Fermi level, opening a gap in the electronic structure. It can be achieved by different methods [3], between them doping with various molecules. But often doping degrades the carrier mobility of graphene [4-6]. It is highly desirable to develop a way to tune the doping level without reducing the mobility of graphene. Theoretically, it has been described that oxygen molecules react with graphene in the presence of UV light to produce oxygen containing groups [7], these oxygen atoms form a stable structure on the sites of pristine graphene and induce p-type doping [8,9].

In the present work we used CVD grown graphene exposed to deep ultraviolet (DUV) light during different times up to 100 min. We analyzed the samples by Raman spectroscopy and transport measurements.

By Raman spectroscopy we analyzed the shift of G and 2D peak frequencies and the intensity ratios of these peaks as a function of DUV light exposure time, the blue shift of G and 2D peak positions increases with increasing the exposition time. This fact is interpreted as an increasing p-doping [10-12, 1]. The minor change of ratio of D/G peak intensity implies a negligible change in the defects before and after DUV light exposure, the small ratio peak intensity D/G indicates a low defect density.

The p-doping of CVD grown graphene is confirmed by transport measurements. The back gate voltage dependent resistivity for single layer graphene is analyzed as function of DUV light exposure time, the maximum resistivity corresponding to the Dirac point is shifted toward positive gate voltage with increasing the DUV light exposure time, see figure 1.

Figure 1(a) shows the resistivity as a function of the back gate voltage ( $V_g$ ), before and after DUV exposure for a different period of time. The Dirac point ( $V_{Dirac}$ ) of the pristine CVD grown graphene is found around zero Volt. After being exposed to DUV light for a desired time, the  $V_{Dirac}$  moves towards a positive  $V_g$ , increasing with increasing DUV exposure time, up to  $\sim 35$  V for 100 minutes of DUV exposure. The shift towards positive gate voltage, indicating p-type doping, is probably due to the formation of holes as the result of the photo-oxidation of graphene layer with DUV light exposure [13]. Figure 1 (b) shows the charge carrier concentration as a function of DUV light exposure time at different gate voltage, figure 1 (c) shows the mobility as a function of DUV light exposure time at different gate voltage. Inset shows the Dirac point shift as function of DUV light exposure time.

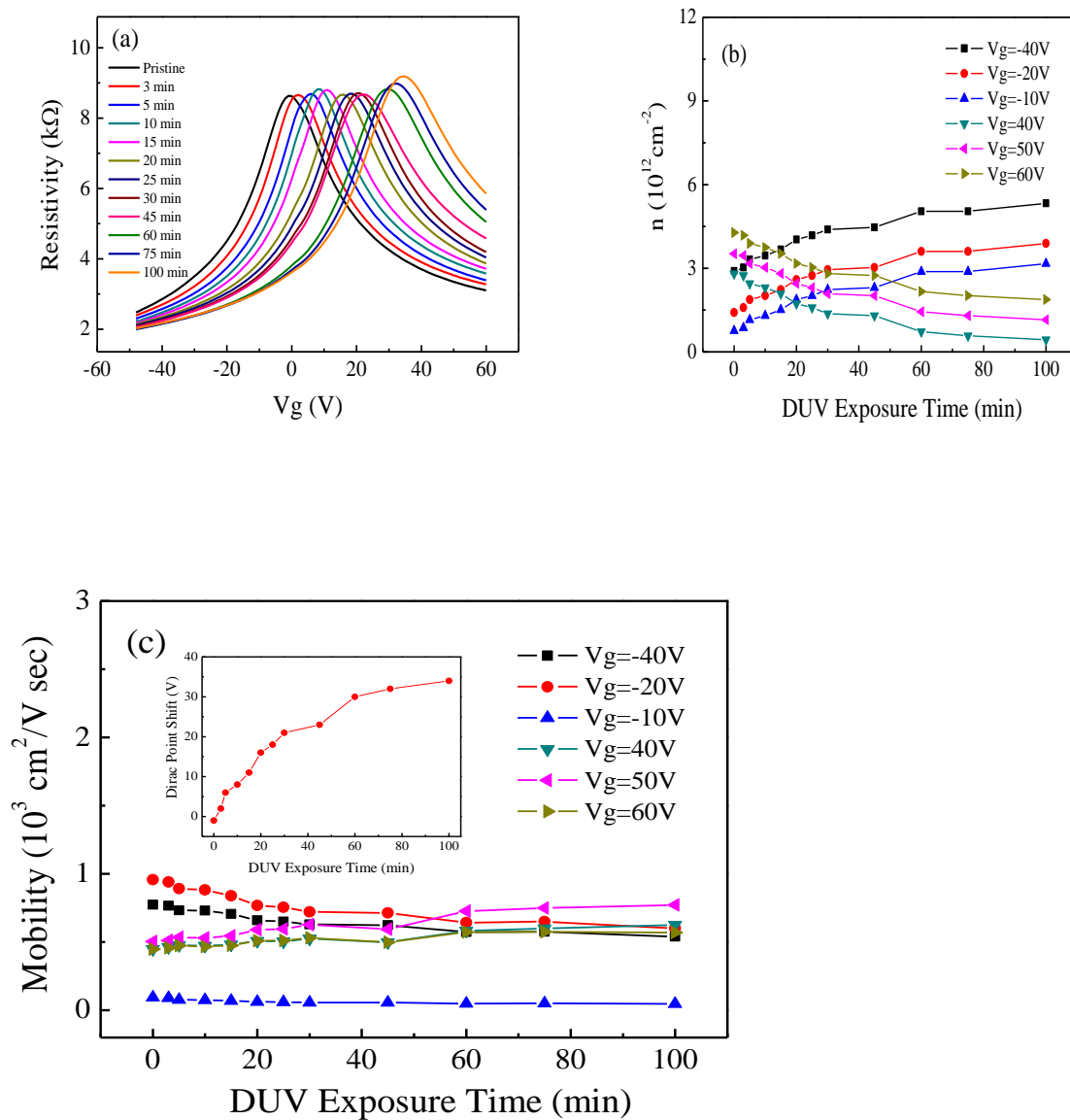
Our work demonstrates by Raman spectroscopy and transport measurements a strong and stable p-doping in CVD grown graphene film with deep ultraviolet (DUV) light.

## References

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## Figures



**Figure 1** (a) Resistivity as a function of back gate voltage ( $V_g$ ) for the single layer CVD grown graphene before and after DUV light for different exposure time. (b) Charge carrier concentration as a function of DUV light exposure time at different gate voltage. (c) Mobility as a function of DUV light exposure time at different gate voltage. Inset shows the Dirac points shift as function of DUV light exposure time.