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Laser Patterning of Epitaxial Graphene for Schottky Junction Photodetectors

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Abstract: Large-area patterning of epitaxial graphene for Schottky junction photodetectors has been demonstrated with a simple laser irradiation method. In this method, semimetal-semiconductor Schottky junctions are created in a controllable pattern between epitaxial graphene (EG) and laser-modified epitaxial graphene (LEG). The zero-biased EG-LEG-EG photodetector exhibits a nanosecond and wavelength-independent photo response in a broadband spectrum from ultraviolet (200 *nm*) through visible to infrared light (1064 *nm*), distinctively different from conventional photon detectors. An efficient external photo responsivity (or efficiency) of ~0.1 *A W*$^{-1}$ is achieved with a biased interdigitated EG-LEG-EG photodetector. The fabrication method presented here opens a viable route to carbon optoelectronics for fast and highly-efficient photoconductive detector.

Results and Discussion

❑ Synthesis of high quality epitaxial graphene (EG)

Thermal annealing of high purity semi-insulating SiC

Production of few layer (1-2 layer) EG

❑ STM, AFM and Raman investigations

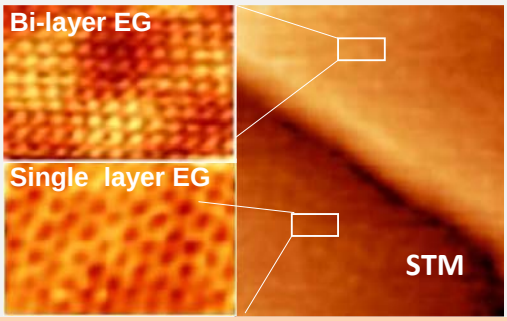

Figure 1. Atomically resolved STM images showing Single and Bi-layer EG prepared on semi-insulating Si-face SiC.

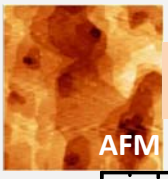

Figure 2. AFM image of EG prepared on semi-insulating Si-face SiC.

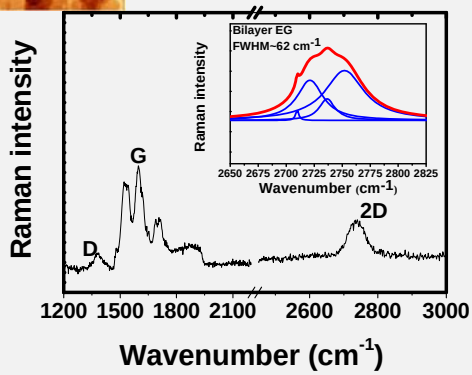

Figure 3. Raman Spectroscopy of EG (two layers) and Lorentzian fitted 2D-band (inset) of bilayer EG.

❑ Laser pattering of EG: EG based Schottky juction photodetector

EG was successfully modified using controlled laser irradiation method. The modified EG (say LEG) was found to have semiconducting properties similar to reduced graphene oxide and this selectively patterned EG results in formation of EG-LEG Schottky juction.

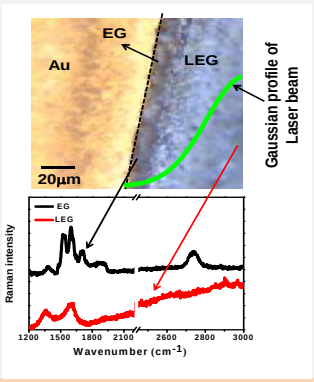

Figure 4. Raman spectra aquired on EG-LEG Schottky juction device.

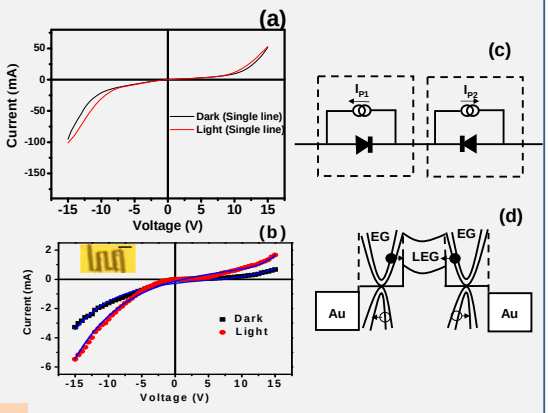

Figure 5. (a) I-V characteristics of the single-line EG-LEG-EG Schottky junction device. **(b)** I-V charateristics of interdigitated device. The solid curves (blue) are the modeling shown in **(c)** and **(d).** Estimated values of the two Schottky barrier heights: ϕ_1=0.75 eV, ϕ_2=0.70 eV.

➢ EG-LEG-EG Schottky juction photodetector

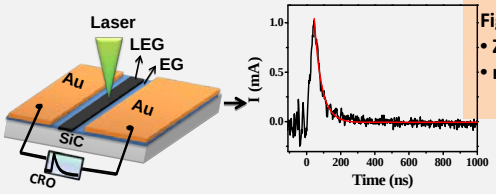

Figure 6.
- **Zero-biased** EG-LEG-EG photodetector
- **nanosecond** (τ_{decay}~10 ns) recovery time!.

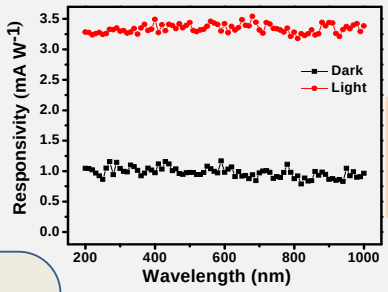

Figure 7.
- **Wavelength-independent** response with white light!!.

Summary:

We have demonstrated the fabrication of a large-area of EG-LEG-EG Schottky junction device on SiC substrates with a simple laser irradiation method. These zero-biased junction devices show nanosecond photo responses, making them promising for high-speed applications. More importantly, the devices exhibit a uniform broadband (200 *nm* -1064 *nm*) photoresponse, demonstrating that the EG-LEG-EG Schottky junction devices are not only excellent visible and infrared sensors, but they are also superior UV detectors, which is distinctively different from conventional semiconductor photon detectors whose photo response strongly depends on light wavelengths. An efficient external photo responsivity (or efficiency) of ~0.1 *A W*$^{-1}$ is achieved with a biased interdigitated EG-LEG-EG photodetector. The fabrication method presented here opens a viable route to carbon optoelectronics for fast and highly-efficient photoconductive detectors.

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