Rubrene–Graphene Phototransistors in the Visible Regime

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The planar interfaces formed between monolayer graphene and semiconductor materials present unique opportunities for amplified detection of weak light signals. Phototransistors that combine graphene with organic semiconductors are particularly desirable owing to the gamut of complementary properties found in these systems.

Atomically thin materials such as graphene are uniquely responsive to charge transfer from adjacent materials, making them ideal charge-transport layers in photo-transistor devices. Effective Implementation of organic semiconductors as a photoactive layer would open up a multitude of applications in biomimetic circuitry and ultra-broadband imaging but polycrystalline and amorphous thin films have shown inferior performance compared to inorganic semiconductors. In this work, the long-range order in rubrene single crystals is utilized to engineer organic-semiconductor–graphene phototransistors surpassing previously reported photogating efficiencies by one order of magnitude. Phototransistors based upon these interfaces are spectrally selective to visible wavelengths and achieve responsivity as large as 10^7 A W^{-1} and a detectivity of 9 × 10^{11} Jones at room temperature. These findings point toward implementing low-cost, flexible materials for amplified imaging at ultralow light levels.

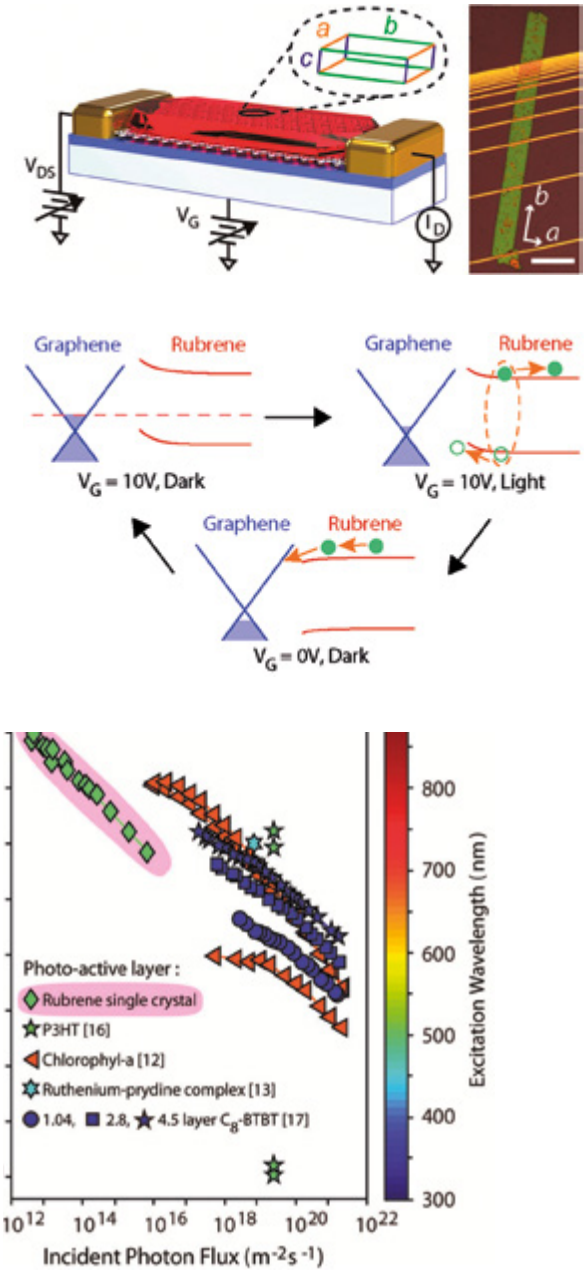

FIGURE 1
Schematic and optical image of a rubrene–graphene phototransistor on SiO2/Si. Schematic band diagrams illustrate the charge-transfer dynamics across at each stage of the light modulation cycle. Performance responsivity metrics of organic-semiconductor–graphene phototransistors.