グラフェン-Ga_2O_3 ヘテロ構造によるショットキー接合の作製とソーラーブラインドフォトダイオードへの応用

Fabrication of graphene-Ga_2O_3 Schottky junction for solar-blind photodiode application

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Introduction: Ultraviolet (UV) photodetectors are key component for various applications in the field of environmental monitoring, flame detection, astronomical studies, digital imaging, short-wave communication and other emerging technologies such as internet-of-things (IoT) sensors. Among, various oxide semiconductors monoclinic beta-gallium oxide (β-Ga_2O_3) with a direct band gap of 4.5-4.9 eV can be suitable for solar-blind UV photodiode applications. Here, we demonstrate formation of a suitable Schottky barrier potential in graphene/β-Ga_2O_3 heterojunction enabling fabrication of a deep-UV photodiode.

Experimental: Sn-doped single crystal β-Ga_2O_3 (thickness 650 µm, donor concentration 3.0×10^{18} cm^{-3}) purchased from Tamura Corporation, Japan was used for this work. A monolayer graphene film synthesized by the chemical vapor deposition (CVD) method was transferred on β-Ga_2O_3. Metal contacts were deposited by thermal evaporation technique using ULVAC VPC-260F for the device fabrication. Current density-voltage (J-V) characteristics measurements were carried out using a two probe system.

Results and discussion: Figure 1a shows the J-V characteristics of the device in dark condition for a voltage range of -2V to +2V at room temperature. The J-V curve presents the rectification characteristics with a nonlinear behavior at low voltage, and the current increases exponentially with the increase in voltage due to formation of a Schottky junction. Figure 1b shows the J-V characteristics under illumination of light with wavelength~254 nm, power~614 µW/cm^2 in comparison to dark characteristic. A photovoltaic action was obtained with an open circuit voltage (V_{oc}) of 10 mV and short circuit current density of 4.4 (J_{sc}) µA/cm^2 for DUV irradiation, attributing to possible self-powered operation of the photodiode. We also observed a bias dependent transient photoresponse for the fabricated device as shown in figure 1c. A faster photoresponse was obtained for self-powered mode of the solar-blind photodiode.

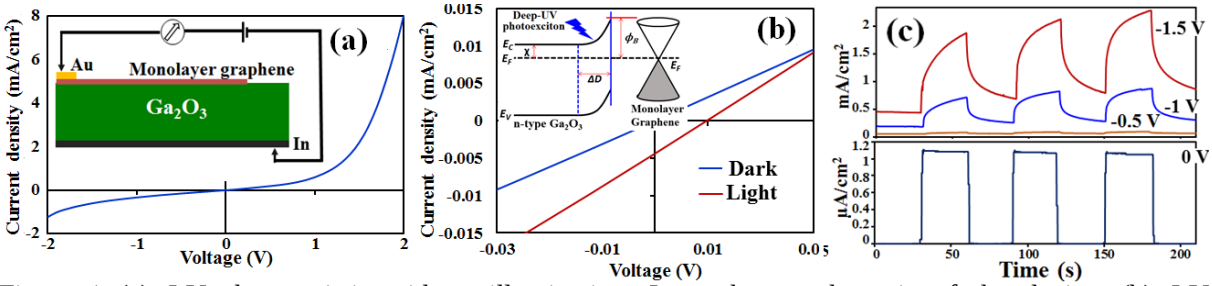

Figure 1 (a) J-V characteristic without illumination. Inset shows schematic of the device. (b) J-V characteristic for photovoltaic action. Inset shows corresponding energy band diagram of graphene/β-Ga_2O_3 heterojunction. (c) Transient photoresponse for the device at 0, -0.5, 1 and -1.5 V.