Fabrication of germanium-MoS$_2$ heterostructure for broadband photoresponsive device application

Nagoya Inst. Tech., Rakesh D. Mahyavanshi, Masaki Tanemura and Golap Kalita

E-mail: rmahyavanshi@gmail.com

Introduction: Heterojunction of two dimensional (2D) and bulk semiconductors has opened up new possibilities for next-generation photonic and nanoelectronic device applications. The combination of germanium (Ge) with transition metal dichalcogenides (TMDCs) can emanate new possibilities in the field of optoelectronic devices [1]. In this prospect, we demonstrate the fabrication of a Ge/MoS$_2$ heterostructure and observed photoresponsivity for wide wavelength range with a photovoltaic action.

Experimental: The MoS$_2$ layer grown by chemical vapor deposition (CVD) was used as a substrate to deposit the Ge thin film by thermal evaporation. The synthesized MoS$_2$ layer and Ge/MoS$_2$ heterostructure was analyzed by optical microscope, scanning electron microscope (SEM), Raman and X-ray photoelectron analysis. Current density-voltage (J-V) characteristics of the device was measured with a two probe system.

Results and discussion: Figure 1a-b shows the optical microscope and SEM images of the Ge and MoS$_2$ heterostructure. A thin interface was formed in-between the CVD grown MoS$_2$ and Ge film, considering the atomically smooth surface of MoS$_2$ layers. Figure 1d shows J-V characteristics of the Au/Ge/MoS$_2$/Al device for dark condition presenting the formation of a diode. The Ge/MoS$_2$ heterojunction showed a photovoltaic action with an open circuit voltage ($V_{oc}$) of 0.185 V and short circuit current density ($J_{sc}$) of 0.028 mA/cm$^2$ under illumination of light (figure 1e). The spectral response showed photoresponsivity for wide wavelength range (wavelength 350-1100 nm) signifying the possibility of developing self-powered broadband photo responsive device (figure 1f).

Figure 1 (a) optical (b) SEM images of Ge/MoS$_2$ heterostructure (c) Schematic diagram of the device. J-V characteristics (d) without illumination (e) under light illumination and dark and (f) spectral response.