High Photosensitive Germanium Sulfide Photodetectors with Broad Spectral Response

Dezhi Tan,* Yuhei Miyauchi, Kazunari Matsuda

Institute of Advanced Energy, Kyoto University, Uji, Kyoto 611-0011, Japan
*E-Mail: tan.dezhi.63m@st.kyoto-u.ac.jp

1. Introduction

Since the first generation of graphene research, extensive research effort has been paid to two-dimensional (2D) layered materials owing to the interesting physics and various applications in nanoelectronics, optoelectronics, and energy conversion.[1,2] Especially, the high-sensitive photodetectors with broad response have been demonstrated based on the novel 2D materials, such as graphene, transition metal dichalcogenides and black phosphorus.[3] As a new member of 2D material family, metal monochalcogenides (e.g., GeS and GeSe) have attracted much interests for the highly sensitive photodetector applications. The *p*-type semiconductor 2D GeS with an orthorhombic structure has close direct and indirect optical transitions with small energy difference around 1.66 eV. Our previous report showed that the GeS exhibits strong light absorption in a broad range from visible to near-infrared spectral regions, which indicates that the GeS would work as a high-sensitive photodetector.[4]

2. Results and Discussion

Here, we study the highly sensitive-photodetector application of 2D layered material of GeS. For fabrication of photodetectors, the GeS nanosheets were prepared by the mechanical exfoliation method and then GeS-based field-effect transistors (GeS-FETs) were fabricated using the electron beam lithography (Inset of Fig. 1(b)). The photo-responses of GeS-FETs were measured with or without light irradiation, where the bias-voltage and light intensity were controlled. Figure 1(a) shows the photocurrent of GeS-FETs with changing the illumination light intensity. A nonlinear light-intensity-dependent response is observed (Fig. 1a). The GeS photodetectors exhibited high photoresponsivity R_λ of about 70 A/W under illumination of 0.66 μW cm^{-2} at wavelength of λ (= 400 nm) (V_g = 0 V, V_{ds} = 4 V). The specific detectivity, the key figure of merits of a photodetector, is as high as 4.8 × 10^{13} Jones. The photodetecting performance can be enhanced significantly with increasing the back-gate voltage (V_g) up to 80 V (Fig. 1(b)). R_λ can be reached to 600 A/W under illumination of 0.66 μW cm^{-2} (λ = 400 nm). Furthermore, we revealed that the GeS photodetector exhibits the broad spectral response in the wavelength range of 400-800 nm with high photosensitivity. These extraordinary properties of high photocurrent generation and broad spectral response promise that the GeS-FET photodetector is a highly qualified candidate for the optoelectronic applications.

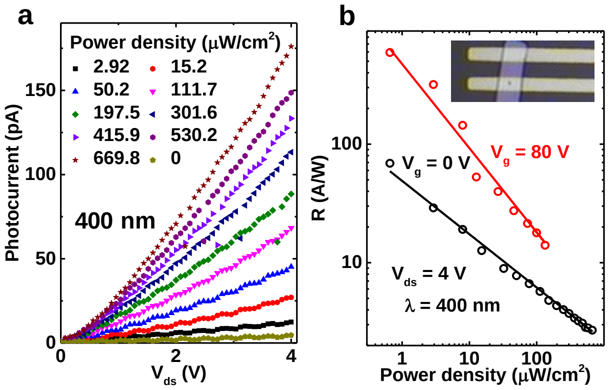

Fig.1. a, Photocurrent under light (400 nm) irradiation with different power density; b, photo-responsivity with V_g = 0 and 80 V. Inset shows the optical image of FET.

3. Conclusions

High photosensitive photodetectors with broad spectral response were fabricated by 2D layered material of GeS. High photoresponsivity (70 A/W), and specific detectivity (4.8 × 10^{13} Jones) were demonstrated for the GeS-FETs with under illumination of 0.66 μW cm^{-2} at λ = 400 nm. The GeS photodetector also showed broad response to the light in the range from 400 to 800 nm, and the photodetecting performance can be enhanced by increasing the gate-voltage.

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