GeSe/MoS_2 heterojunction diode for optoelectronic applications

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1. Introduction

Heterostructure engineering of two-dimensional (2D) layered materials offers an exciting opportunity to take advantage of each building block for fabricating new electronic and optical devices. The p-n junction diode constructed by heterostructures of 2D layered materials (e.g., MoS_2/WSe_2, MoS_2/black phosphorus,) have been demonstrated to be excellent candidates for high-sensitive photodetectors with broad spectral response [1,2]. Recently, IV family monochalcogenides (e.g., GeS and GeSe) have been introduced as a new member of 2D material family and attracted much attention for the highly sensitive photodetector applications. The *p*-type semiconductor 2D GeSe has an orthorhombic structure with the band gap at around 1.1 eV. Accompanied by its strong light absorption property, the GeSe shows high-potential working as a photodetector with a broadband response from ultra-violate to near-infrared spectral regions [3]. By stacking n-type MoS_2 and p-type GeSe, the formation of heterojunction diode is highly promising with unique optoelectronic properties.

2. Results and Discussion

Here, the highly sensitive-photodetector based on GeSe/MoS_2 heterojunction has been demonstrated. We fabricated the multilayer GeSe flakes on PDMS film and few layer MoS_2 on silicon substrate by using the mechanical exfoliation method and then transfered GeSe onto MoS_2. The GeSe/MoS_2 heterojunction based field-effect transistors (GeSe/MoS_2 heterojunction-FETs) were prepared using the electron-beam lithography (Inset of Fig. 1(a)). Fig. 1a is the typical transfer characteristic behavior of GeSe/MoS_2 device. The GeSe/MoS_2 heterostructure FETs show obvious rectification behavior with rectification ratio larger than 5000, which was different from GeSe and MoS_2 FETs, indicating that the hetero-diode was forme d. obvious photovoltaic effect was also observed. This heterostructure FET show anti-ambipolar behavior and the typical on/off ratio ($I_{on/off}$) is larger than 10^5 (Fig. 1(a)). Furthermore, the GeSe/MoS_2 hetero-diode also exhibits strong (Fig. 1(b)) and broadband photoresponse with the photoresponsivity reaching 3 × 10^4 A/W at 500 nm. These excellent properties of high photoresponsivity and high rectification ratio indicate that the GeSe/MoS_2 heterojuction diode is a highly qualified candidate for the optoelectronic applications.

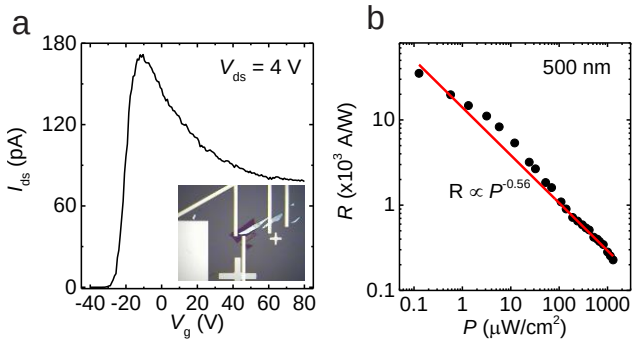

Fig.1 (a) Transfer characteristic of GeSe/MoS_2 heterojunction-FET. Inset shows the optical image of the FET. (b) Photoresponsivity under various light illumination conditions (500 nm) with V_g = 0.

3. Conclusions

Here we demonstrate highly sensitive-photodetector based on GeSe/MoS_2 heterojunction. Broad photoresponse and obvious photovoltaic effect was observed. Our results indicate that the GeSe/MoS_2 p-n heterojuction diode is a highly qualified candidate for the optoelectronic applications.

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