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Short Communication

Two-dimensional GaSe by Liquid Phase Exfoliation

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Abstract

GaSe nanorods were synthesized by liquid phase exfoliation as a resistive switch memory device with a transverse graphene/GaSe/graphene structure.

Keywords: Liquid phase exfoliation; Nanorods

ISSN: 2576-8840

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Submission: October 02, 2019

Published: October 15, 2019

Volume 12 - Issue 1

How to cite this article: Ganlin C, Wanqiang C. Two-dimensional GaSe by Liquid Phase Exfoliation. Res Dev Material Sci. 12(1).RDMS.000779.2019.
DOI: 10.31031/RDMS.2019.12.000779

Introduction

The III-VI compound semiconductor GaSe belongs to a two-dimensional layered structure, and the p-type semiconductor has a band gap that varies from 2.1eV to 3.5eV as the number of layers decreases [1,2]. Based on two-dimensional GaSe, it has excellent nonlinear optical properties and optical response characteristics, such as high optical responsivity and high external quantum efficiency [3]. It has important applications in the field of photodetectors [4]. When the dimension of the material is reduced to two dimensions, it will exhibit many novel properties different from the bulk phase. The traditional liquid phase exfoliation will reduce the purity of the material device because the organic solvent has a higher boiling point [5,6].Therefore, controlling the growth of high-quality two-dimensional selenide crystals has become a hot topic of research [7].

Results and Discussion

For analyzing morphology and structural properties of the synthesized GaSe nanostructures, SEM and TEM images were recorded. GaSe nanostructures obtained by liquid phase exfoliation and centrifuged at 6,000 rpm are shown in Figure 1. The nanoflakes are stacked on a plane with nanorods of 3-5µm in length [8]. Figures 2 show bright-field TEM images for the nanostructures and nanorod with a higher magnification. The SAED pattern of the single nanorod shows only one set of diffraction spots of six-fold symmetry, which conforms to the space group P-6 of hexagonal GaSe.

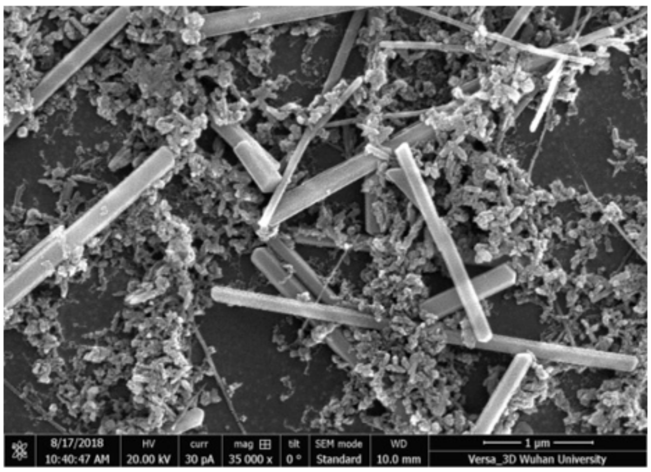

Figure 1: SEM images of GaSe nanostructures obtained at centrifugation speeds of 10000rpm.

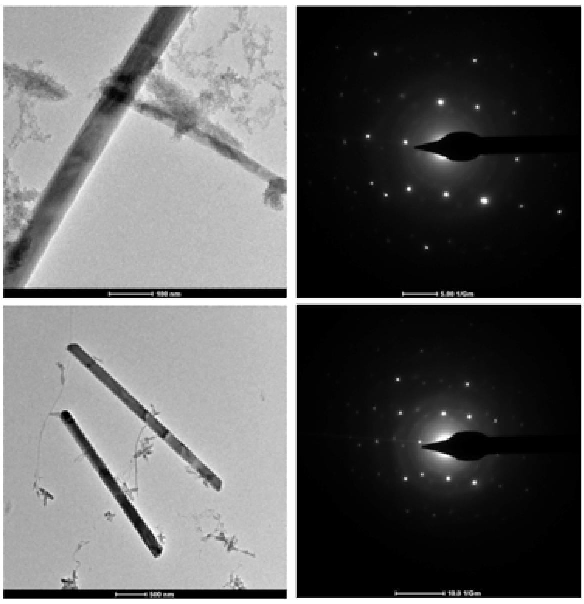

Figure 2: Bright-field TEM images of GaSe nanostructures and a specific nanorod obtained at centrifugation speed of 6000rpm.

I-V characteristics and photo response properties of the device made by the GaSe dispersion at the centrifugation speed of 6000rpm are shown in Figure 3. The non-linear I-V curves indicates a Schottky barrier at the graphene/GaSe interface, and its band diagram before and after contact is shown in Figure 4.

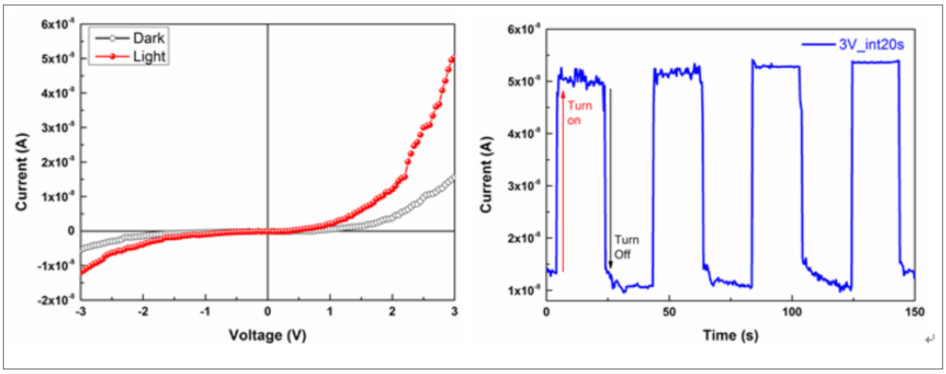

Figure 3: Figure 3: I-V curves of the device made by GaSe dispersions of 6000rpm in the dark and under white light illumination and time-resolved photoresponse measurements of the device at the biased voltage of 3 V under the white light illumination.

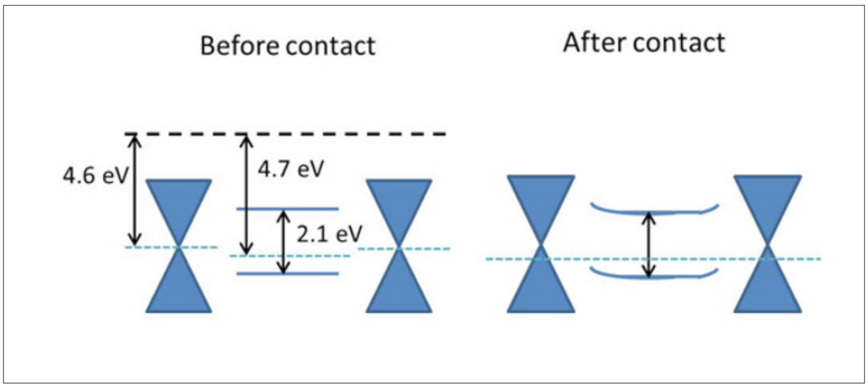

Figure 4: Schematic the graphene/GaSe nanostructure interface band alignment diagram before and after contact.

The work function of pristine graphene prepared by CVD method is 4.6eV deduced by the Raman. The few layers GaSe presents p-type doping and a work function of 4.7eV. The weak interaction between graphene and GaSe hardly induces the change of the gap size of GaSe, different from the phosphorene/graphene heterostructure. When graphene contacts GaSe, a dipole layer is formed at the interface and an accumulation region is formed in the GaSe region by upward band bending as shown in Figure 4. Under the white light illumination, photogenerated electron-hole pairs in GaSe are separated and swept into two graphene electrodes by applying an electric field leading to the photocurrents.

The photo response of graphene/GaSe device was explored at the biased voltage of 3V under the white light illumination shown in Figure 3. The response times of light are shorter than hundreds of milliseconds. The constant photocurrents under light illumination indicate a charging effect by deep traps associated to the defects and interface.

Conclusion

The ohmic contact GaSe nanorods with the graphene electrodes for the memory effect were prepared by the liquid phase exfoliation without organic solvents and impurities.

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