High performance photo-detector based on few layer InSe

Zhesheng Chen[1,2], Johan Biscaras[1], Abhay Shukla[1*]

[1]Institut de Minéralogie et de Physique des Milieux Condensés, CNRS-UMR7590, Université Pierre et Marie Curie, Paris 75252, France
[2]School of Nuclear Science and Technology, Lanzhou University, Lanzhou 730000, PR China

* Corresponding author: abhay.shukla@upmc.fr

Abstract

Since graphene was first discovered in 2004, few layered materials have generated considerable enthusiasm in the nanotechnology and condensed matter physics communities because of the possibility of obtaining ideal two-dimensional (2D) materials with exotic properties [1-2]. For example, monolayer MoS_2 with direct bandgap has shown outstanding promise for applications in photo-detection and memory device [3-4]. However, monolayer Indium selenide (InSe) which is a III-VI semiconductor with an indirect bandgap is expected to make a transition towards a direct bandgap compound when the number of layers increases to five layers [5]. Moreover, it is expected that few layer InSe should also show promising photo-electronic properties.

We prepare few layer InSe using the anodic bonding method [6], and charcaterize it by transmission electron microscopy (TEM) and Raman spectroscopy to analyze the structure and polytype of samples. From the TEM data, the hexagonal structure is determined which corresponds to β or ε polytype. Combined with Raman data ($\Gamma^4_3(A''_2)$ mode at $199cm^{-1}$) the ε polytype is finally confirmed [7]. Eight layer InSe is then transferred to SiO_2/Si substrate followed by electron beam lithography and electrode evaporation to fabricate 2D photo-detector device. The response time, on-off ratio, responsivity as well as external quantum efficiency (EQE) are analyzed with a 532nm laser as the light source. The response time is less than 150ms with complete rise or decay, and on-off ratio is larger than 10^3 which shows fast response properties. In addition, the responsivity and EQE are 7.5×10^{-2} A/W and 17.5% under the source-drain voltage at 10V without back gate, respectively. Finally the back gate is applied to enhance the performance of 2D InSe photodetector. As a result the photocurrent increases with the responsivity and EQE higher than 2 A/W and 460% respectively when 50V back gate is applied.

References

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Figures

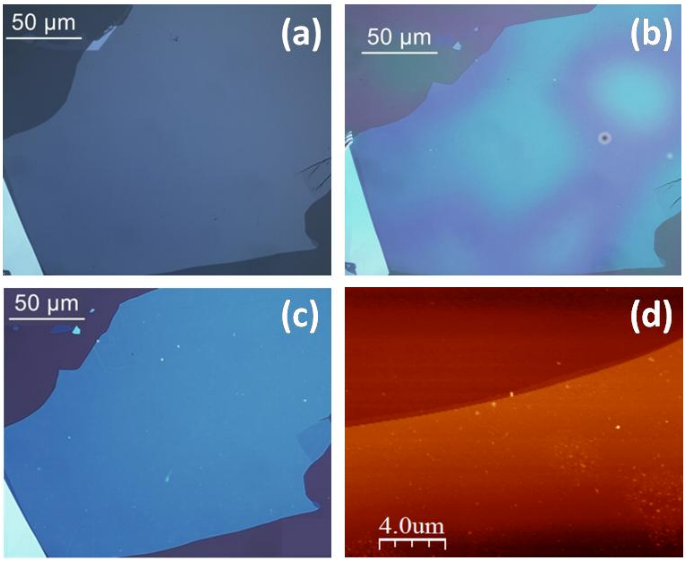

Figure 1. Optical images and AFM of few layer InSe during transfer process (a) on glass, (b) on SiO_2/Si coated with polymer after transfer (c) on SiO_2/Si after polymer dissolved and (d) AFM image of few layer InSe after transfer process.

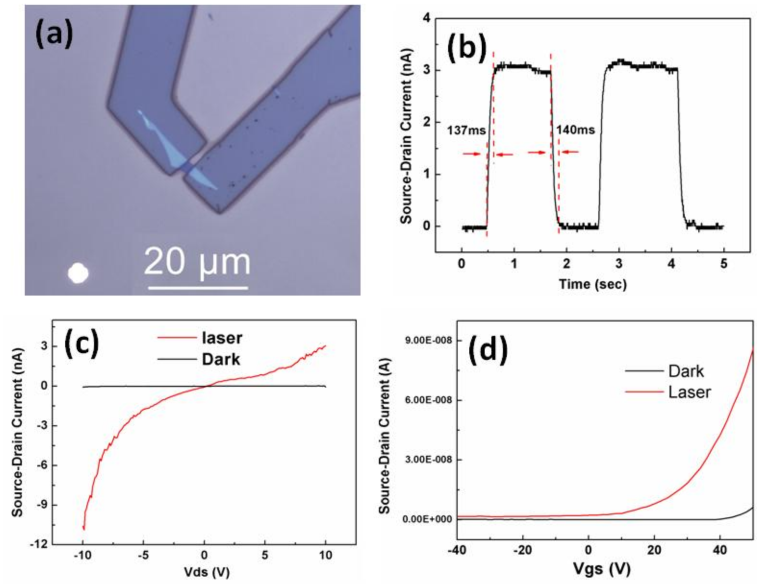

Figure 2. Eight layered InSe photo-detector performances on SiO_2/Si (a), (b), (c) and (d), respectively. (a) Optical image of InSe photo-detector prepared on SiO_2/Si (b) Photoresponse time during photocurrent rise and decay with laser switching on and off, and a bias voltage of 10V. (c) I_{ds}-V_{ds} characterization of InSe with source-drain sweep from -10V to 10V and no back gate voltage. (d) I_{ds}-V_{gs} characterization of InSe with back gate sweep from -40V to 50V and V_{ds} at 10V.