A high performance optical detector using TiS_3 nanoribbons

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Abstract. We report the fabrication and characterization of TiS_3 nanoribbons based detector. The TiS_3 nanoribbons were fabricated using CVT method and then TiS_3 nanoribbons dispersion was drop cast onto the standard electrode strip. The fabricated device was characterized by illuminating it by FCLB by varying its wavelength and power. The results shows good performance at 6.9 mW/mm^2 power density of 1064 nm wavelength.

Keywords: Titanium trisulfide (TiS3), Chemical vapor transport (CVT), Fiber coupled laser beam (FCLB).

1. Introduction

Over a decade ago there are various techniques as well as materials been developed to fabricate high performance and cheap optical detector. These materials include various thin films and nanostructures. Carbon nanomaterials and chalcogenides have been reported as highly efficient materials for optical detectors. The carbon nanomaterials used for the fabrication of optical detector include graphene and carbon nanotubes. The chalcogenides are the group 16 element of the periodic table which possesses sulphur, selenides, tellurides, and polonidesas one of the components in the chemical formula. The most common chalcogenides are WS_2, InSe, GaSe, In_2Se_3, MoS_2, TiS3 and TiS_2 etc. Although the reported techniques and materials provide good optical response characteristics but at the same time they also have several limitations and disadvantages. These disadvantages are tedious fabrication methods, required huge quantity of materials etc. Therefore, to achieve a simple assembly, highly accurate, better performance optical detector remained unexplored.

In this paper, we describe the fabrication and characterization of optical detector operating in the visible to near infrared region of electromagnetic spectrum. The optical detector was fabricated using TiS_3 nanoribbons. Then the fabricated device was characterized using the FCLB of typical three wavelengths viz. 635 nm, 785 nm and 1064 nm wavelengths. The power density of the laser beam varies from 0.69 mW/cm^{3}to 6.9 mW/cm^3.

2. Experimental

The experimental method includes two steps. First step includes the fabrication of TiS_3 nanoribbons and in the other step we have drop cast the dispersion solution of TiS_3 nanoribbons onto the standard electrode strip.

2.1. Fabrication of TiS_3nanoribbons

TiS_3 nanoribbons were fabricated using CVT. In this method, first a mixture powder was prepared using titanium powder and sulphur powder in a specified ratio. Then the solid phase reaction was carried out in a vacuum sealed ampoule by placing the mixture of Ti and S in ampoule. After approximately 24 h of growth reaction, the ampoule is cooled in ambient condition. In this way, TiS_3 nanoribbons were obtained.

2.2. Fabrication of Detector

For the fabrication of optical detector, the suspension of fabricated TiS_3 nanoribbons were prepared by adding an appropriate amounts of TiS_3 nanoribbons in ethanol followed by sonication for 5 min. The suspension was then drop cast onto the standard electrode strip. The strip was then dried in vacuum oven for about 1-2 hours. After drying, the strip is ready for characterization as photodetector in presence of fiber coupled laser beam and in dark conditions.

3. Results and discussion

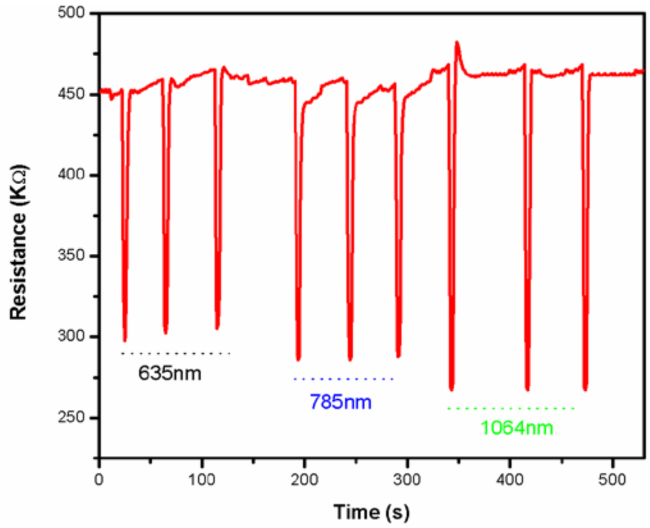

Figure 1. Variation of resistance with time for different wavelength of the laser beam.

To characterize the optical detector in terms of photoresponse, the experiments were carried out by illuminating the detector using FCLB of varying wavelength and power density. Figure 1 shows the variation of output resistance as a function of time for three different wavelengths viz. 635 nm, 785 nm and 1064 nm wavelength of the laser beam. It is noticeable from the figure that the change in photo resistance is found to be highest when the detector was illuminated with 1064 nm wavelength. This wavelength is assumed to be the optimized wavelength. Therefore, to further characterize the optical detector in terms of power density of the laser beam we have performed the same experiment keeping the wavelength of the laser beam fixed as 1064 nm and varying the power density from 0.62 mW/mm^2.

Figure 2 shows the variation of photoresistance of the optical detector as a function of power density of the laser beam at 1064 nm wavelength. In the performing experiments, the power density of the 1064 nm wavelength laser beam has been tuned from 0.62 mW/mm^2-6.9 mW/mm^2. It is clearly noticed in figure 2 that the change in resistance of the optical detector is fund to be highest for 6.9 mW/mm^2 power density of the laser beam of 1064 nm wavelength. It means that from the experimental observations, the performance of the optical detector is quite well at 6.9 mW/mm^2 power density of 1064 nm wavelength.

4. Conclusions

In summary, the fabrication and characterization of TiS_3 nanoribbons based optical detector have been carried out. The performance of the optical detector has been optimized in terms of wavelength and power density of the laser beam. From the experimental observations, it is concluded that the performance of the optical detector is quite better at 1064 nm wavelength and 6.9 mW/mm^2 density of the laser beam.

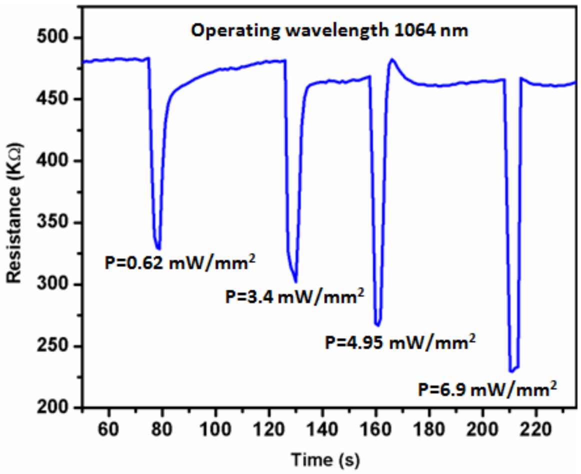

Figure 2. Variation of resistance with time for 1064 nm wavelength of the laser beam at varying power density.

5. Acknowledgments

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