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A High Performance Visible-NIR Detector using Aligned TiS_3 Nanoribbons

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ABSTRACT

We report the fabrication and characterization of Titanium trisulphide (TiS_3) nanoribbons based optical detector. The (TiS_3) nanoribbons were fabricated using chemical vapour transport method (CVT) and then TiS_3 nanoribbons dispersion was drop cast onto the interdigitated electrode pattern and aligned in between the electrode using DEP. The fabricated device was characterized by illuminating it by fiber coupled laser beam by varying its wavelength and power and in dark conditions. The results shows good performance in visible to near infrared region of electromagnetic spectrum.

***Keywords*:** CVT (Chemical vapour transport), DEP (Dielectrophoresis), TiS_3 (Titanium trisulfide)

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

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polonidesas one of the components in the chemical formula. The most common chalcogenides are WS_2, InSe, GaSe, In_2Se_3, MoS_2, TiS_3 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 using TiS_3 nanoribbons.

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 interdigitated electrode for DEP.

Fabrication of TiS_3 nanoribbons

TiS_3 nanoribbons were fabricated using chemical vapor transport method (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 to the one end of the ampoule. After approximately 24 h of growth reaction, the ampoule is cooled in ambient condition. In this way, TiS_3 nanoribbons were obtained.

Fabrication of Detector

For the fabrication of optical detector, the suspension of fabricated TiS3 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 interdigitated electrode for DEP. The chip was then dried in vacuum oven for about 1-2 hours. After drying, the chip is ready for characterization as photodetector in presence of fiber coupled laser beam and in dark conditions.

3. RESULTS AND DISCUSSION

To characterize the optical detector in terms of photoresponse, the experiments were carried out by illuminating the chip using the fiber coupled laser beam 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. From Figure 1 we can see that the optical detector works well in the near infrared region of the electromagnetic spectrum.

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.

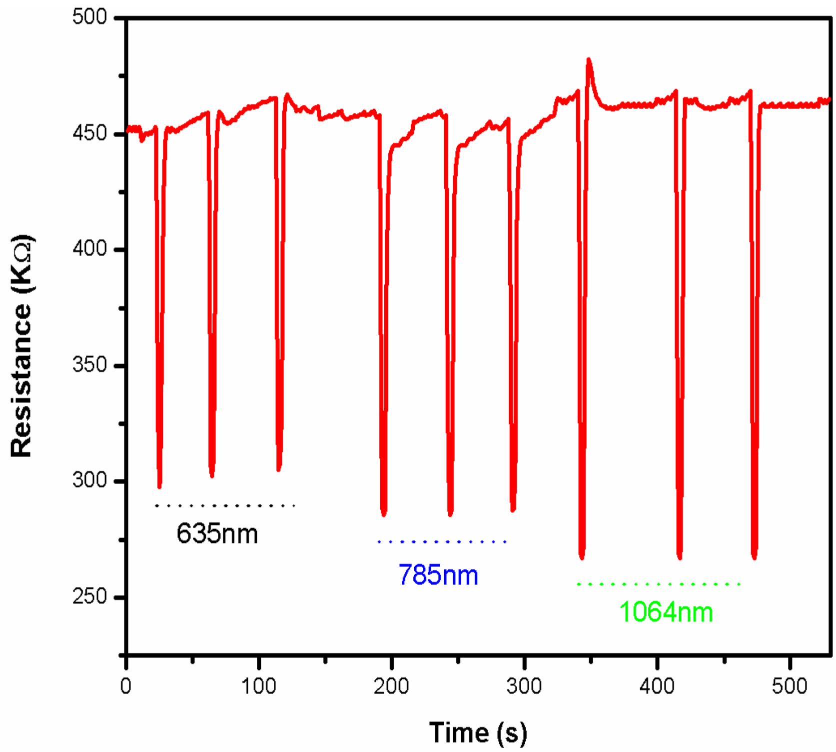

Figure 1. Variation of resistance with time for different wavelength of the laser beam.

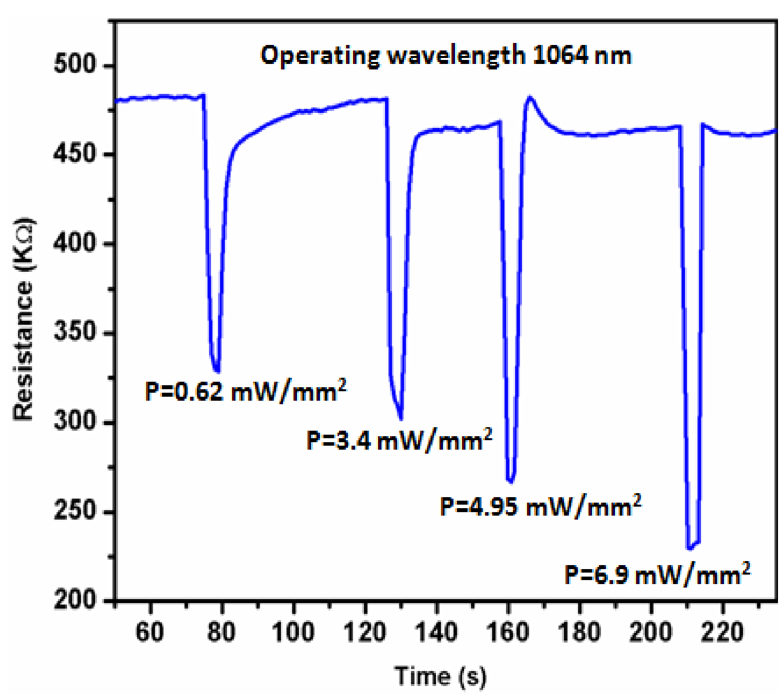

Figure 2. Variation of resistance with time for 1064 nm wavelength of the laser beam at varying power density

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. It is clearly noticed in Figure 2 that the change in resistance of the optical detector is found to be highest for 6.9 mW/mm^2 power density of the laser beam of 1064 nm wavelength.

4. CONCLUSIONS

In summary, the fabrication and characterization of the Titanium tri sulphide (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 in near infrared region of the electromagnetic spectrum typically at 1064 nm wavelength and 6.9 mW/mm^2 density of the laser beam.

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