International Journal of Physics and Research (IJPR)
ISSN 2250-0030
Vol.2, Issue 2 Dec 2012 9-14

CHARACTERIZATION OF PANI/ZnS/GLASS MULTILAYER SYSTEM

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ABSTRACT

We have used absorption and reflection spectra for band gap measurements using Tauc relation, taken by HITACHI spectrophotometer U-3400. Dark conductivity and photoconductivity is taken with digital electrometer (Keithley model 610), also I-V characteristics taken for PANI/ZnS/Glass multilayer system is observed, which indicate that ZnS thin film works as backbone to reduce the band gap.

It is observed that PANI/ZnS/Glass multilayer system is a typically of a heavily doped heterojunction. In PANI/ZnS junction the conduction of charge across the junction is typically a mixture of electron from n-ZnS side and polaron and bipolaron from p-Pani side. In addition to observe a thermionic emission, Schottky I-V characteristic also observed a pool frankely and trap assisted field emission with a non linear behavior. Also PANI/ZnS/Glass heterostructure shows promise of being an active device.

KEYWORDS: PANI, Vacuum Evaporation, Heterojunction, I-V Characteristics

INTRODUCTION

Polyaniline (PANI) has been emerged as an important conducting polymer for its wide usage in different fields e.g. in microelectronic sensors, anticorrosion coatings, electro chromic devices, electroluminescence devices, low noise field effect transistors and for electromagnetic shield and non linear devices etc. PANI exhibits insulating to metallic state or vice-versa, transition on doping with different protonics and inorganics. This transaction property of polymer has enabled it for use in large number of practical applications [1].

Organic semiconductor exhibits inferior charge transport properties and low chemical stability. At applied voltages, a large injection current passing through such a system, made of organic semiconductors can cause joule heating and damage the organic thin film/substrate interface. This seriously affects the stability and the operational lifetime of organic semi-conductor device [2].

In this investigation we report on characterization and fabrication of an inorganic-organic hetero structure using vacuum evaporation technique. A thin film of plane PANI was used as the hole transporting layer as well as the emitter layer and a thin film of ZnS coated on to PANI layer formed the electron transporting layer [3, 4].

EXPERIMENTAL DETAILS

A pure 1μm thickness ZnS thin film was first coated by vacuum evaporation on to highly cleaned glass substrate at room temperature in a vacuum of 2×10^{-5} torr. Polyaniline used for evaporation was chemically synthesized by oxidative polymerization of aniline using ammonium per disulphate (NH4)2S2O8 under controlled conditions, this yielded the emeraldine salt. Treating the salt with ammonia solution produces emeraldine base powder.

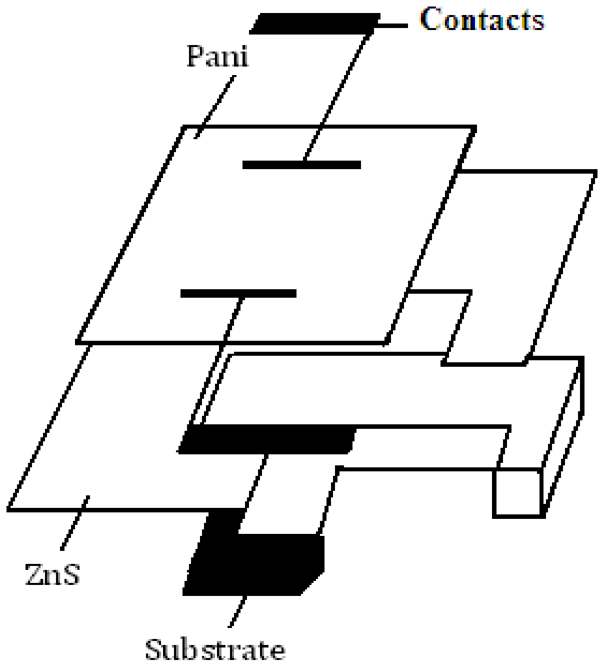

Fig. 1: Schematic Dig. of PANI/ZnS/Glass Substrate Thin Film

This was used for evaporation on to ZnS thin layer in a vacuum of 10^{-9} Pa for forming a thin film of Polyaniline [5]. The schematic diagram of vacuum deposited Polyaniline/ZnS structure is shown in fig. (1).

CHARACTERIZATION OF SAMPLE

A thin film of ZnS approximately 0.1µm is deposited on to glass substrate by vacuum evaporation technique and a layer of PANI is deposited by the same technique on to this ZnS film. Using Keithley electrometer I-V and EL-V electrical characteristics has been reported. The reflection spectra have been studied by using HITACHI U-3400 spectrophotometer, the energy band gap is determined by reflection spectra which indicates variation in band gap of PANI/ZnS heterostructure.

According to Tauc relation, the absorption coefficient is given by

$$h\upsilon = A\,(h\upsilon\text{-}Eg)^{n} \quad (1)$$

$$2\alpha t = \text{In}\,(Rmax - Rmin / R - Rmin) \quad (2)$$

Where R is the reflection for any intermediate energy photon (hυ). Constant A is different for different transition, Eg is the energy band gap and t is the thickness of the film.

RESULTS AND DISCUSSIONS

A graph is plotted between $(\alpha h\nu)^2$ or the square of hν In(Rmax – Rmin / R – Rmin), and hν (as abscissa) a straight line is obtained, the extrapolation of straight line to $(\alpha h\nu)^2 = 0$ axis gives the value of band gap.

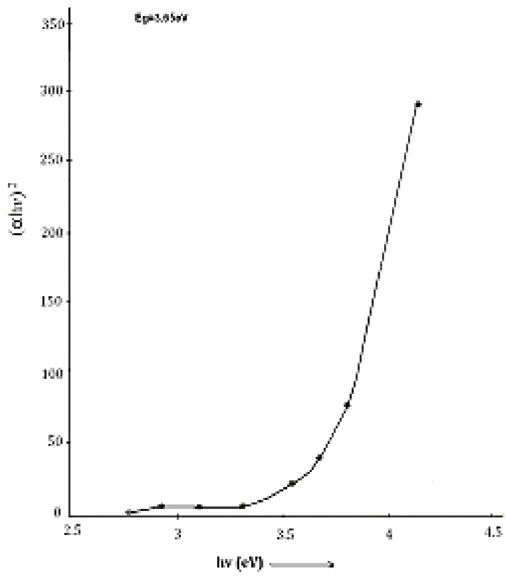

Fig. 2: Band Gap Measurement of ZnS/Glass Vacuum Evaporated Thin Film

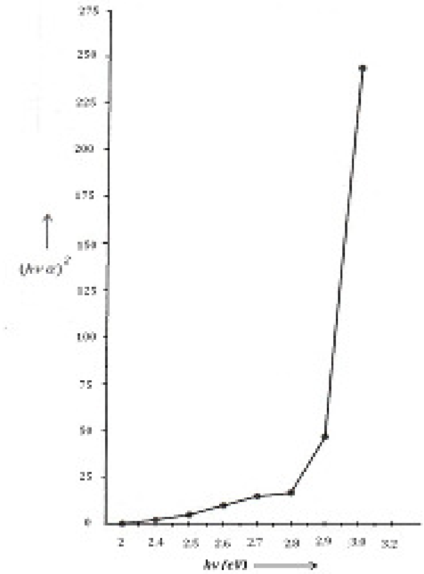

Fig. 3: Band Gap Measurement of PANI/ZnS/Glass Vacuum Evaporated Thin Film

Tauc relation as given in equation (2) is used for the determination of energy band gap of PANI/ZnS/Glass system. Fig.(3) shows the representative curve between hν In(Rmax – Rmin / Rmin)^2 and hν the extrapolation of straight line to $(\alpha h\nu)^2 = 0$ gives the value of energy band gap[6].

A composite study of Reflection spectra of ZnS/Glass with PANI/ZnS/Glass indicates that modification in Polyaniline structure is necessary to increase the durability; sensitivity and selectivity of the Polyaniline thin film growth characterization and addition of new material in to structure of Polyaniline are the new advance technology to reduce the band gap.

A reflection spectrum of PANI/ZnS/Glass is also observed which shows that reflection decreases with the decrease in wavelength and sudden fall present at a particular wavelength. From reflection spectra of vacuum evaporated ZnS thin film the preferred orientation in case of PANI/ZnS/Glass is observed, it is observed that there is an increase or decrease in such intensity [7, 8].

The Scanning electron Microscopy provides a direct structural evidence of growth and perfection of thin film. This is one of the most useful method for the investigation of the surface topography, microstructure etc. Fig. (4) shows the SEM image of ZnS/Glass and Fig. (5) shows the SEM image of PANI/ZnS/Glass. The secondary electrons are generated by the interaction of loosely bound electron of the surface atoms. The emission of secondary electron is sensitive to the incident beam direction and the topography of the surface layer.

The contrast hence depends on the rate of secondary electron [9, 10]. The surface morphology of such surface is investigated to access. The size and morphology of the electron beam of 5KV has been used. It is observed that the surface is smooth and grassy boundaries are widens as thick lines between the grain which are connecting together. A large surface area and comparative higher degree of crystallinity has been observed. On the other hand, the surface is substantially different and remarkable results have been obtained, when we characterize the sample containing Pani/ZnS multilayered thin film on to the same glass substrate as shown in fig. (5), a very interesting different type of morphology can be seen.

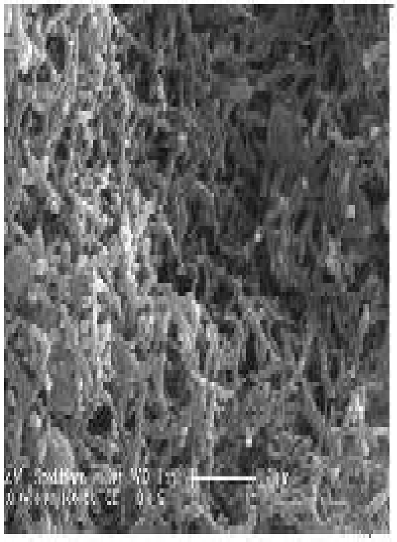

Fig. 4: SEM Image of ZnS/Glass

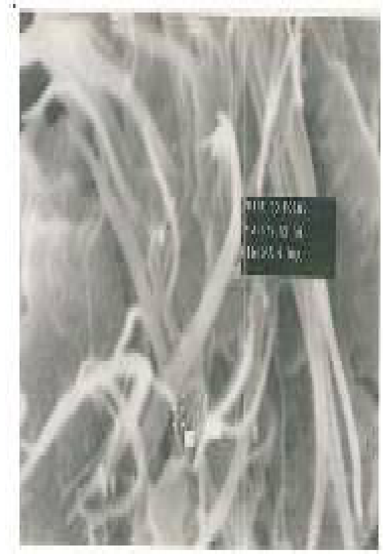

Fig. 5: SEM Image of PANI/ ZnS/Glass

In addition to above the PANI pallet/ ZnS junction have also been fabricated. Chemically prepared ZnS has been printed on a pallet of conducting Polyaniline. This pallet of ZnS coated conducting Polyaniline has been sintered at 150^0C for six hours. A different property of such function has been done in delaine, which indicates the thermal and environmental stability.

The I-V characteristic of such junction has been observed to be non – ohmic and also confirms that a good diode can be fabricated [11-15]. The I-V characteristic of ZnS/Glass and Polyaniline/ZnS/Glass substrate is shown in fig. (6) & (7) respectively.

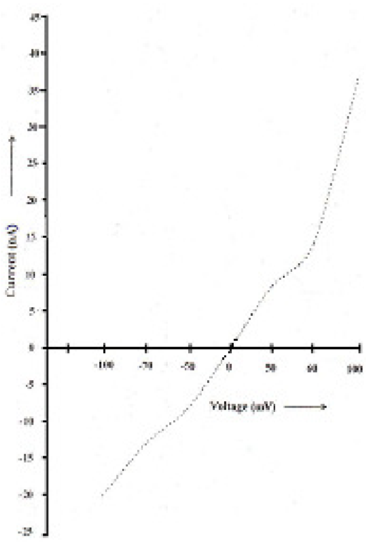

Fig. 6: I-V Characteristics of ZnS/Glass

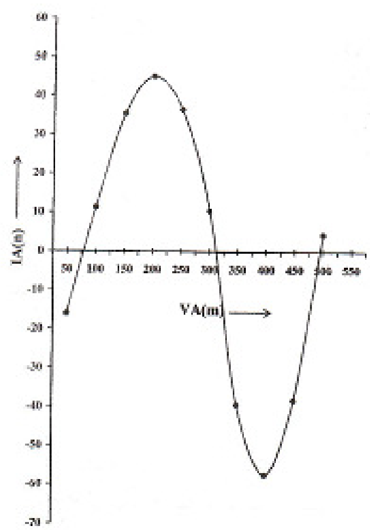

Fig.7: I-V Characteristics of PANIZnS/Glass

CONCLUSIONS

The variation in PANI/ZnS/Glass multilayer system is observed, which indicates that ZnS thin film work as back bone to reduce the band gap. It is observed that PANI/ZnS/Glass multilayer system is a typically of a heavily doped heterojunction. In PANI/ZnS junction the conduction of charge across the junction is typically a mixture of electron from n-ZnS side and polaron and bipolaron from p-Pani side. In addition to observe a thermionic emission, Schottky I-V characteristic also observed a pool frankely and trap assisted field emission with a non linear behavior. Also Al/Pani/ZnS/Glass heterostructure shows promise of being an active device. The size and morphology of the electron beam have been used. It is observed that the surface is smooth and grassy boundaries are widens as thick lines between the grain which are connecting together. A large surface area and comparative higher degree of crystallinity has also been observed.

ACKNOWLEDGEMENTS

All the persons directly or indirectly related with this investigation are highly acknowledged by the author.

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