Polymer Based Detectors: A Preliminary Study

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Introduction

Certain properties of organic semiconductors look alike to those of inorganic semiconductors, like Silicon and Germanium and as a result of which they can be treated as a substitute for Silicon and Germanium in many devices. Their main advantage lies in the relative simplicity of the technological implementation promising substantial economical benefits and opening scope for getting new semiconductor products. Organic FET, Organic LED, Organic Photovoltaic devices etc. are the outcome of this new generation research. Due to the differences in physical and chemical properties, organic semiconductors could serve as a starting material for new and improved sensors and detectors [1]. Semiconducting organic material may be subdivided into three categories viz. polymers, oligomers and small molecules depending on the length of the molecular structure that sets mechanical, chemical and electronic properties [2].

In this paper, we will focus on the possibilities offered by polymers in the domain of detection of ionizing radiation. By irradiating with ionizing radiations, conductivities in polymer materials [e.g. Polyanilene, Biaxially Oriented Poly Ethylene Terephthalate (BOPET) etc.] can be changed. This change was studied for alpha particles to carry out their detection. To be more specific, we will report some of our results on the changes in conductivity of BOPET films by alpha irradiation.

Experimental

A number of samples were made using thin sheet of BOPET and studied their current conducting behavior before and during exposure of the samples to alpha particles. Each of these samples comprises of two closely separated (12 micron) and 30 nm thick gold pads on a small piece of thin BOPET sheet of size 6mm × 2mm (approx.) which was mounted on a glass slide with the help of epoxy. Two single strand wires were held by silver paste on the two gold pads deposited on BOPET samples for electrical connection. A fixed voltage in the range of 40V to 90V was applied between the two pads and the current was measured over a period of 200-600 seconds (*I-t* characteristics). Then the sample was exposed to 5 MeV alpha particles from ^{241}Am – ^{239}Pu source keeping the bias same across the pads. It was observed that the current got increased. Similar measurements were carried out with samples made out of BOPET sheet coated with gold nanoparticles. But no change in the device current was observed before and during exposure of 5 MeV alpha. Some samples were also made with larger separation (330 micron) between the gold pads on a bigger size (15 mm × 6 mm) BOPET sheet. But extremely low value of current was observed and there was no change in the value of current before and during exposure of 5 MeV alpha particles. In another two samples, this exposure was done with the help of an alpha source of higher activity (0.5 mCi). In this study, these two samples were exposed to alpha periodically by placing the source on the sample for sometime, then withdrawing the source for some duration, again placing the source on the sample and so on. It was observed that the current also got increased and decreased periodically in the same fashion as the source was placed and withdrawn and the current increased by ~ 60 pA during alpha exposure as compared to its value before exposure. Before and during exposure the typical values of current observed were 320 pA and 380 pA respectively for an applied bias of 40 V. Fig.1 shows the variation of current through the BOPET sample with time when it was periodically exposed to 5 MeV alpha in air from a source of activity 0.5 mCi. Later on, one experimental set-up was used where an α- source and a sample can be placed inside a chamber kept under rotary vacuum. Initially the device current was measured in air for an applied bias of 90 V across the sample (placed inside the chamber) without exposing it to alpha and the variation of device current, plotted with time elapsed is shown in Fig.2. Then the sample and the α-source were kept under rotary vacuum and a clear jump of device current was observed (from 2.648 pA to 25.1 pA by using ^{241}Am – ^{239}Pu alpha source of activity ~ micro Curie (12108.19±32.79 Bq) and from 2.678 pA to 21.5 pA by using an alpha source of activity ~ nano Curie (2198 dpm) as shown in Fig.3 for the applied bias of 90 V across the sample.

Results and Discussions

From Fig.1 we can say that the base current was more when the measurement was carried out in air with a higher activity source. This may be due to the presence of adsorbed air on the surface of the BOPET sample which got ionized by alpha particles and subsequently under the influence of bias voltage across the pads, augment the device current contributed by charge carriers generated as a result of alpha particle interaction in BOPET material. Fig.1 also suggests that a BOPET sample can very

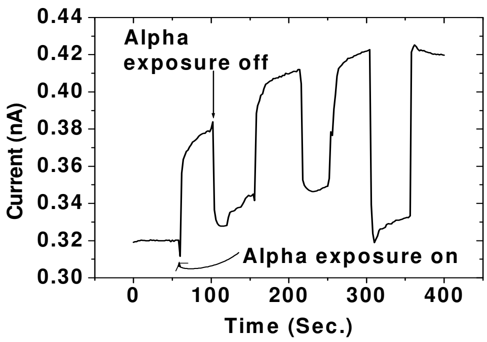

Fig.1. BOPET sample was periodically exposed to 5 MeV α in air from a source of activity 0.5 mCi and the device *I-t* curve was recorded.

well act as an α-sensor to give us information about presence of alpha particles. From Fig.3 we can see that higher the activity of the source, larger will be the current output from the BOPET sample. This may be due to the fact that, for alpha source of higher activity, more number of alpha particles will emerge out from the source and will interact with BOPET material. This in turn will cause more ionization in BOPET and under the influence of applied bias it will generate more current.

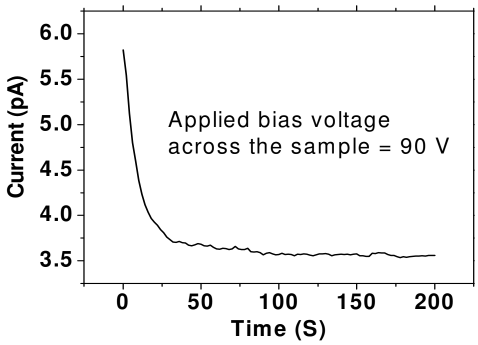

Fig.2. *I-t* characteristics of a BOPET sample in air prior to exposing it to an alpha source.

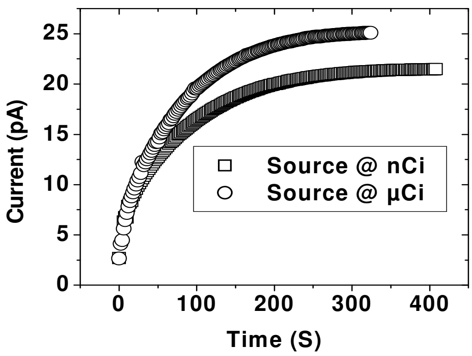

Fig.3. Same BOPET sample was exposed to 5 MeV α from two different activity sources under vacuum and the device *I-t* curve was recorded.

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References

[1] Matjaz Kozelj, Bruno Cvikl & D. Korosak, International Conf. on Nucl. Energy for New Europe (2006), pp. 306.1-306.10 [http://www.djs.si/port2006]
[2] Dario Natali and Marco Sampietro, NIM in Physics Research A 512 (2003) 419 - 426.