Structural and electrical transformations of Ag-implanted polyethylene terephthalate (PET) induced by swift heavy ion irradiation

J.J. Mboukam[1], D.C. Chilukusha[1,2], M. Madhuku[3] and M. Msimanga[1,3]

[1]*Photovoltaic NanoComposites R&D Platform*

Physics Department, Tshwane University of Technology, P Bag X680, Pretoria 0001, South Africa

[2]Department of Physics, Mulungushi University, Kabwe, 10101, Zambia

[3]*iThemba LABS, Tandem and Accelerator Mass Spectrometry Department, P. Bag 11, Wits 2050, South Africa*

Introduction

- IBA: important family of modern analytical techniques involving the use of MeV **ion beams** to modify the bulk properties of thin film materials through sputtering, bond breakings and ion tracks.
- IBA methods are based on principles of interaction of energetic MeV ions with the matter.

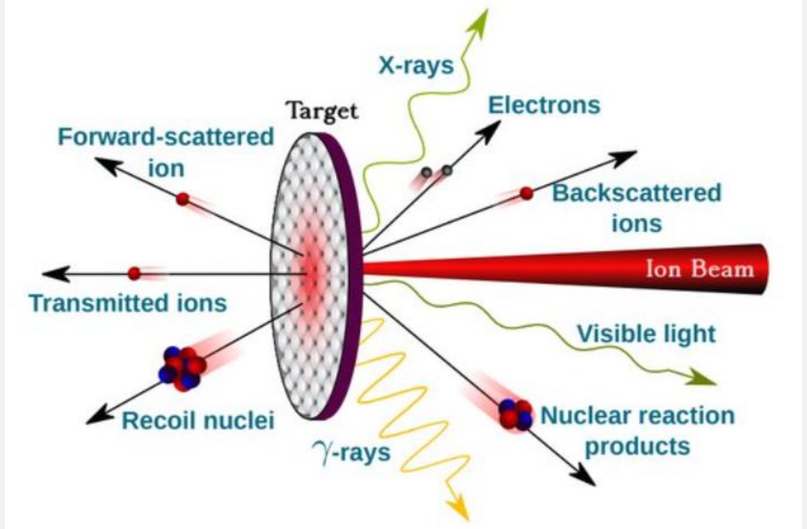


Fig. 1: **Ion interactions with matter.**

Polyethylene Terephthalate (PET) polymers exhibit unique behaviour due to high ratio of aromatic rings[1]. Implanted polymers are an important class of compounds due to their nonlinear optical responses, electrical conductivity and good thermal stability[2].

- ❖ Metal implantation + SHI irradiation: Ag propensity to nucleate and aggregate at high fluence
- ❖ sensors and flexible electronic devices: optical waveguides, picosecond optical switches, and other nano- and optoelectronic devices [3-5].

Experimental detail

Sample preparation

- PET cut into 1.2 x 1.2 cm^2.
- Washed in methanol and acetone bath.
- Rinsed in de-ionised water, blown and dried using nitrogen gas.
- 200-20A2F implanter was used for ion implantation.

Sample modification

- Ag^+ ion implantation fluences: $1x10^{17}$ ions/cm^2 with **150 keV Ag^+-ions.**
- Heavy Au^{7+}-ion beam of 30 MeV.
- Detector angle θ and the recoil angle β were kept fixed at 15^0 and 30^0, respectively.
- Presusre: 1.00 ✕ 10^{-6} mbar.

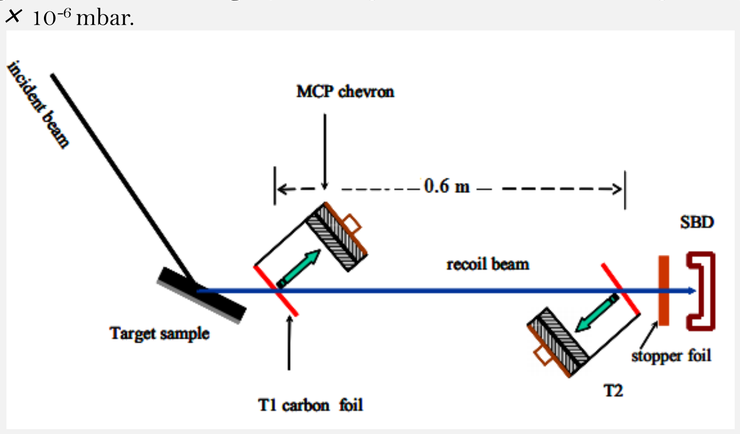


Fig. 2: ToF setup

- Faraday cup mounted on the beamline for measuring current
- Beam spot shape: 0.5 x 0.5 cm
- Ion fluence:

$$\phi = \int_0^t \frac{I}{neA} dt, \qquad (1)$$

Experimental detail and data analyses Cont…

Structural and Electrical characterizations

- Atomic Force Microscopy (AFM)
- Transmission Electron Microscopy (TEM)

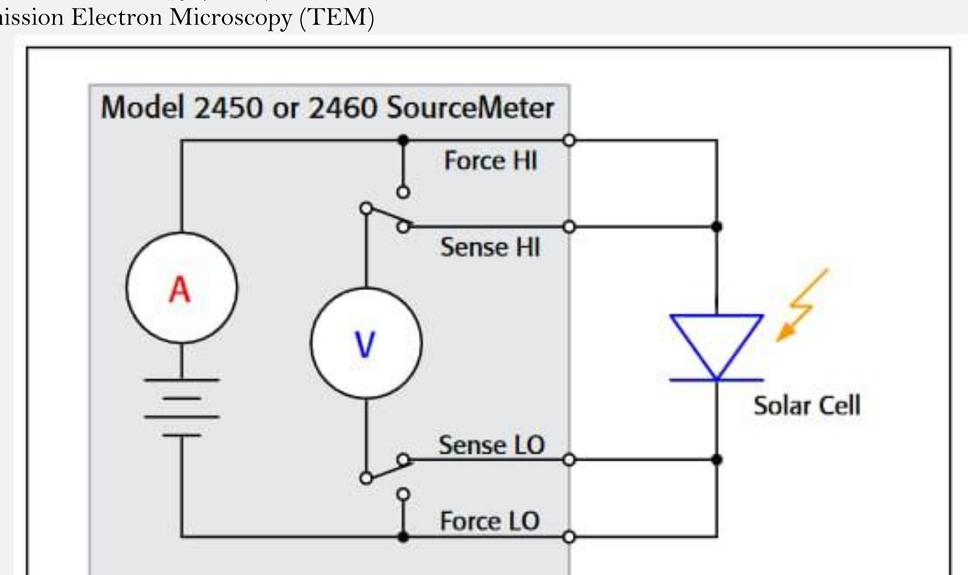


Fig. 3: Schematic diagram for electrical characterisation

Results

Structural analyses: AFM, TEM images and Raman spectra

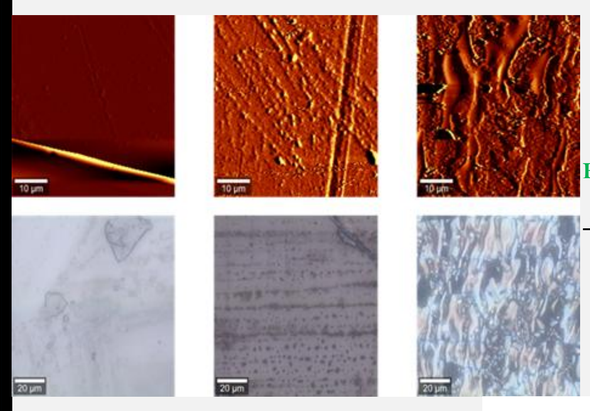


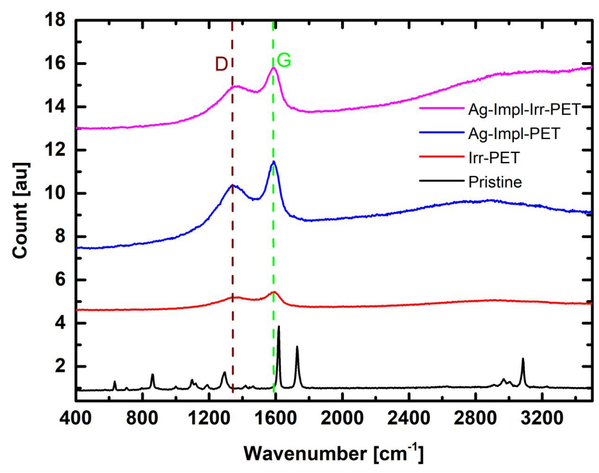
Fig. 4: AFM images of PET films and optical micrographs.

-blister: Conductive carbon cluster

Peaks: 857, 1286, 1613, and 1723 cm^{-1}
- ✓ C–C breathing
- ✓ ring C = C stretching,
- ✓ C=O stretching modes

I_D/I_G ratio = 0.25, 0.87 and 0.95

Fig. 5 Raman spectra



Results cont…

Electrical characterisation

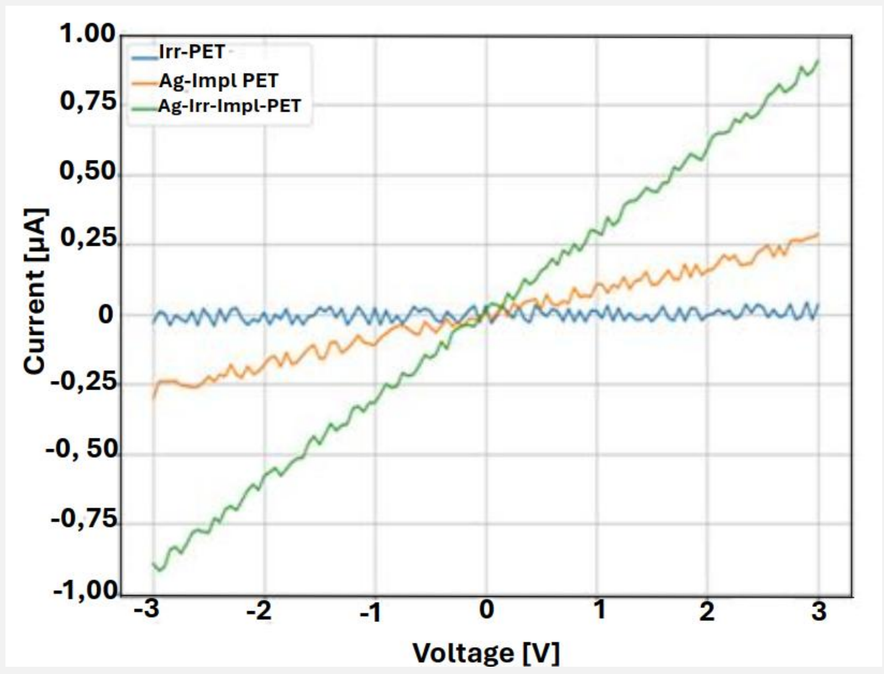


Fig. 6: I-V curves

Conclusion

- Structural and morphological transformation were observed.
- Formation of blister and conductive carbon cluster were also observed.
- Implanted and irradiated samples changed their electrical characteristics from insulator to semiconductors.
- Developed polymer-based nanocomposites with specific structural and electrical properties for cutting-edge technological applications.

Acknowledgements

The authors gratefully acknowledge the Tshwane University of Technology, iThemba LABS and NRF (Grant Number PSTD23042697816) for infrastructural and for financial supports.

References

[1] R. C. Ramola et al. Physica B:. **404**, 30 (2009)
[2] V. Popok Rev. Adv. Mater. Sci. **30**, 1. (2012)
[3] J. .J. Mboukam et al. Radiat. Phys. Chem. **223**, 111991 (2024)
[4] J. J. Mboukam et al. Physica B Condens. Matter. **695**, 416518 (2024)
[5] J. J. Mboukam et al. Nucl. Instrum. Methods. Phys. Res. B **546**, 165151 (2024)

69th Annual Conference of the South African Institute of Physics
UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG