Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: CA20129

Grantee name: Michael Gater

Details of the STSM

Title: Solid Polymer Electrolyte memristor radiation sensors

Start and end date: 01/04/2024 to 19/04/2024

Description of the work carried out during the STSM

Initial characterisation was carried out on the devices fabricated at the University of Nottingham. The idea that the base reactance of the devices could be used as a reference. The devices were measured using a Agilent (Keysight) B1500A Semiconductor Device Parameter Analyzer, using two different batteries of tests: 1) A voltage sweep from 0 to V_{max} to $-V_{max}$ to 0, with $V_{max}=\{1.5, 2.0, 2.5\}$V; and 2) a retention time test, where a voltage pulse was applied and the change in time of the conductance was measured. In this last case, V_{max} was in the same range than before, and the conductance was measure by applying a 50mV bias during 30 s after the programming pulse.

Irradiation was done at the facilities of the Son Espases Hospital, with 6 MeV X rays using a Varian linear accelerator, at room temperature and at constant dose rate of 10 rad/s, to a total dose of 1 krad, measured by the embedded sensors in the Varian linear accelerator. Relative errors in total dose delivered to each sensor were below 1%.

Due to the time constraints and the ambitious goals of the mission, the study concentrated heavily on comparison between reference and irradiated PEO devices and double PMA physical barrier devices.

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

Description of the STSM main achievements and planned follow-up activities

Summary of STSM success:

The preliminary results of the work carried out point towards a successful STSM and the mission achieving it's expected outcomes, with the modulation of the electronic response as a product of irradiation. These results indicate two open routes as for development, the potential use of the device in personal dosimeters or introduction to the device fabrication process for improved memory applications. This clearly fits within the remit of WG1, in the area of radiation sensing and nanofabrication technologies.

Preliminary Results:

The devices were measured three times: 1) Before Irradiation; 2) 10h after 1krad irradiation; and 3) 10h after a second dose of 1krad, totalling 2krad. The measurement process included both a voltage sweep between 0 and 2.5V at low frequency, with a total time of 100 s per cycle. Results for a specific device are shown in Fig. 1 a) (lineal scale) and b) (log scale), which depicts the I-V sweep for the pre- and post-irradiation case at 1krad and 2krad. It is clear that the 1krad irradiated device have improved the difference between the on and off states, as well as a better conductance, as shown in Fig. 1 c) However, increasing the total dose up to 2krad destroys the memristive effect.

We believe that the explanation for these improved effects lies in the creation of new and deeper traps in the active PEO layer, as well as a possible curation effect of the polymers. These effects are positive up to a given point, when the newly created traps destroy the memristive effect, and also block the movement of the heavy Ca ions, thus stopping this second mechanism. In any case, we are performing additional research to find the causes.

Possible uses of these devices would be related to different paths. Firstly, we could include the irradiation as an additional step in the fabrication process to obtain improved characteristics. Second, these devices could be used as the sensing element in cheap, disposable personal dosimeters, as in [2].

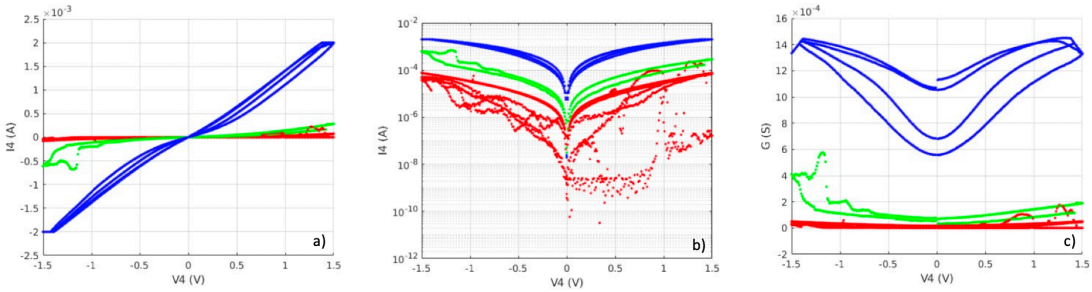

Fig. 1. Show the effects of irradiation of a double PMA physical barrier PEO device. a) Voltage-Current sweep of the device. Green symbols correspond to the virgin device, blue represent the 1krad, and red shows the 2krad measurements. b) Voltage-Current sweep (log scale) of the device. Green symbols correspond to the virgin device, blue represent the 1krad, and red shows the 2krad measurements. c) Conductance (G) vs applied voltage V sweep of the device. Green symbols correspond to the virgin device, blue represent the 1krad, and red shows the 2krad measurements.

Agreed Future work & Publications

We expect to write a conference paper and two journals papers related to this work with a poster presentation already accepted for presentation at the 1st Spanish Memristor workshop, Barcelona , 1st of July 2024.

Future work concerning the devices lies around optimizing the electronic response for sensing and optimisation of the irradiation as part of the fabrication process for better memory performance.

References :

1. [1] M.Gater,A.Adawi,andN.Kemp,"Enhancedswitchinginsolidpolymer electrolyte memristor devices via the addition of interfacial barriers and quantum dots," in *Proceedings of the 18th ACM International Symposium on Nanoscale Architectures*, pp. 1–4, 2023.
2. [2] E. Garcia-Moreno, E. Isern, M. Roca, R. Picos, J. Font, J. Cesari, and A. Pineda, "Temperature compensated floating gate mos radiation sensor with current output," *IEEE Transactions on Nuclear Science*, vol. 60, no. 5, pp. 4026–4030, 2013.