Global Journal of Researches in Engineering: J
General Engineering
Volume 14 Issue 1 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

X-Ray Switching Study on Thin Film Silicon Photovoltaic Solar Panel

By Aditya Chaudhary & Kulvinder Singh
Guru Gobind Singh Indraprastha University, India

Abstract- Thin film silicon solar panels are subjected to switching study under high energy X-Rays exposures. Photo current of unbiased cell is recorded with time at short regular intervals (10 sec) at room temperature. These exposures develop reproducing photocurrents. Long exposures (Kilo second) are found to degrade the photocurrent almost linearly at a rate 2.4X10-14A/s. Solar panels are found to recover from the radiation damage in time spanning from 10-15 Hr. Trends of photo-currents at on-set and off-set are analysed in the light of trap-centers and reverse electric field at the electrodes. Variations of photocurrent with intensity of X-rays were also obtained. Results show that silicon based thin film solar cells are sufficiently stable and hard under the short exposures (10s) from high energy X-rays and can be used as X-ray sensors for space applications.

Keywords: solar cell, thin film photovoltaic cells, x-ray sensor, photoconduction.

GJRE-J Classification : FOR Code: 850504

XRAYSWITCHINGSTUDYONTHINFILMSILICONPHOTOVOLTAICSOLARPANEL

Strictly as per the compliance and regulations of :

X-Ray Switching Study on Thin Film Silicon Photovoltaic Solar Panel

Aditya Chaudhary [α] & Kulvinder Singh [σ]

Abstract- Thin film silicon solar panels are subjected to switching study under high energy X-Rays exposures. Photo current of unbiased cell is recorded with time at short regular intervals (10 sec) at room temperature. These exposures develop reproducing photocurrents. Long exposures (Kilo second) are found to degrade the photocurrent almost linearly at a rate $2.4X10^{-14}$A/s. Solar panels are found to recover from the radiation damage in time spanning from 10-15 Hr. Trends of photo-currents at on-set and off-set are analysed in the light of trap-centers and reverse electric field at the electrodes. Variations of photocurrent with intensity of X-rays were also obtained. Results show that silicon based thin film solar cells are sufficiently stable and hard under the short exposures (10s) from high energy X-rays and can be used as X-ray sensors for space applications.

Keywords: solar cell, thin film photovoltaic cells, x-ray sensor, photoconduction.

I. Introduction

In recent years many new systems were found suitable for making solar cells. This includes $CuInSe_2$, Dye-sensitized nano-structured materials, Bipolar AlGaAs/Si, Organic Solar materials etc. [1-5]. However technology of Silicon based solar cells is sufficiently developed and its commercialization has reached to heights much above than other materials. Solar panel arrays are commercially available for various applications ranging from house hold to the space applications. For long term usage of these panels, it is necessary to make them immune towards high energy radiations, especially for space applications. Degradation of structures is expected from high energy radiations including X-rays and high energy charged particles etc. In this regard it is planned to study the commercially available solar panels under the high energy X-Rays.

II. Experimental Details

Solar panel SC 1418I from TRONY was taken for the present work. It is a small panel of 18mmX14mm in size. There are 8 silicon thin film solar cells on ITO glass. Panel is encapsulated in a metallic chamber with black paper cover from the front side. This is ensured that no visible light can enter in to the chamber except X-Rays. Panel is mounted normal to X-Ray beam having circular cross section of 8mm diameter falling in the middle of the panel. Room temperature is kept between 18-20^{0}C for entire experimentation. X-Rays are obtained from Cu-Target tube (Philips Holland), operated at 30 kilo volt and plate current is kept between 2mA-10mA. Panels were subjected to basic switching studies. Firstly panel is given three shots of 10 second each with regular interval of 10 second. Process is repeated at changing intensity of X-rays. This is done by changing the plate current between 2mA to 10mA. Secondly the panel is given long exposure of 7 minute with a gap of one minute. Panel is taken as a photovoltaic source and is loaded by a series resistance of 99.3 kilo ohm. Set-up connections are shown in Fig.1. This high value insures the low current through the panel so as to avail almost the open circuit voltage. Photo-current obtained is recorded by a digital pico-meter (DPM 111 Scientific Equipment, Roorkee, India). Whole set up is electromagnetically shielded. All connecting wires are Teflon coated to minimize lead leakages.

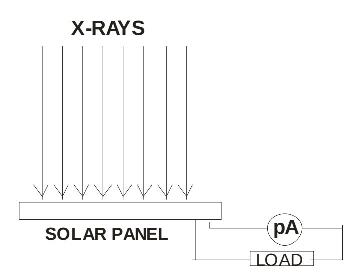

Figure 1 : Probe set up used for photocurrent measurements

III. Results & Discussions

Long exposure of solar panel to X-rays, clearly indicates the reduction of photocurrent with time. [Fig.2]. During these measurements it was insured that accelerating tube voltage, plate current and temperature remains constant. In order to check any variation due to instrumental setting, X-ray exposure is stopped for one minute. On the restart of exposure, photocurrent started from the last exposure value. Average current shows a trend of linear decrease at a rate around $2.4X10^{-14}$ A/s for a typical panel. When panel is left ideal for 10-15 Hr, it was found that photocurrent recovers to its initial value. This clearly indicates that the degradation is temporary. There are two possibilities of such a degradation viz. open circuit voltage decreases with radiation dose due

Author α: National Power Training Institute, Guru Gobind Singh Indraprastha University, Delhi. e-mail : aditya29power@gmail.com
Author σ: Deen Dayal Upadhyaya College University of Delhi, New Delhi 110 015, India. e-mail : kulvinder.physics@gmail.com

decrease in the carrier life time and secondly due to radiation induced charge trapping near the anode/cathode interface giving rise to a compensating electric field opposing the effect of the built in potential. [6].

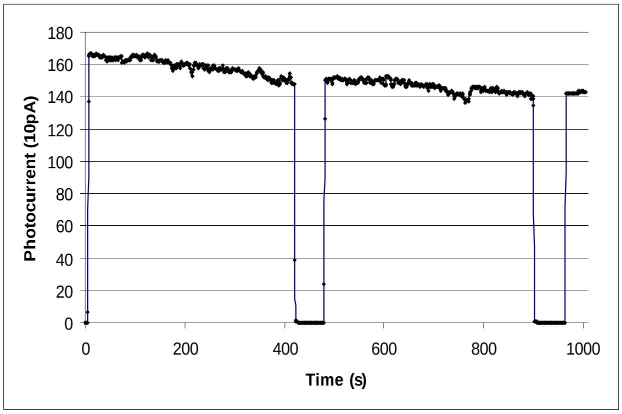

Figure 2 : Time degradation of solar panel

Decrease in carrier life time is due to enhanced scattering of charge carriers under high energy radiations. To under stand this effect we provided periodic shots of exposure at regular intervals of 10 second each. Process is repeated with increasing intensity of X-rays. It was found that with increasing intensity average photocurrent is increasing linearly with intensity of X-rays [Fig 3, 4]. It is expected as the photo-conversion also increases linearly.

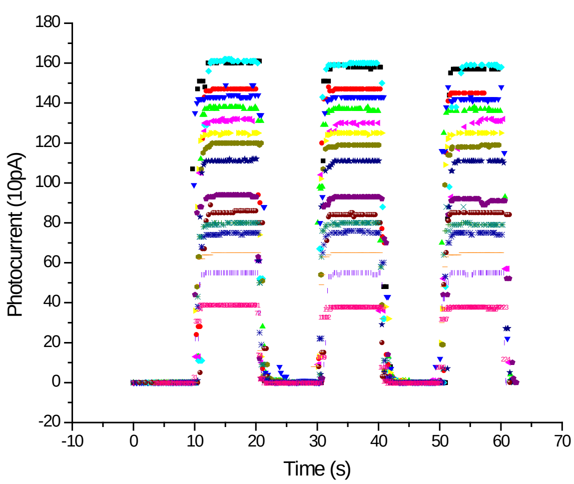

Figure 3 : Variation of photocurrent with switching time

This result indicates that decrease of carrier life time is not a prominent factor for degradation of solar panel. Possible factor which mainly seem to be responsible is therefore the charge trapping at the electrodes. This is also confirmed by the recovery of photo-current when sufficient time is given to the solar panel (10-15hr.) since the panel is left in close circuit for this duration. Our results of 10 second switching with 10 second recovery time clearly indicates that there is almost constancy in the photo-current with time.

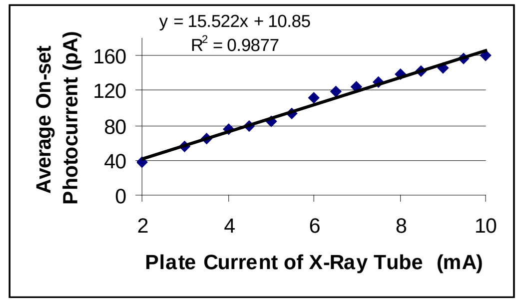

Figure 4 : Variation of average On-set Current with Plate current of X-Ray tube

In the recent study [7] degradation of a sample polymer solar cell was studied and it is found that with time active layer of the solar cell changed in the course of seven hours. The researchers at Helmholtz center Berlin [8] have studied the degradation of polycrystalline solar thin film panel and found that micro-voids existing within them are responsible for reduction of their efficiency by 10-15 percent.

IV. Conclusions

Time degradation of solar panel under the X-Ray exposure is mainly due to charge trapping at the electrode rather than reduction in the carrier life time. It however needs further direct experimentation for the measurement of trap charges at the electrodes. If sufficient relaxation time is given to the solar panel, degradation can be minimized. In such cases these panels can be used as X-ray sensing devices.

V. Acknowledgement

Dr. Kulvinder Singh is thankful to University Grant Commission (UGC), Government of India for providing financial assistance to carry out this research work under the project through F. No. 8-1(39)/ 2010/(MRP/NRCB). We are thankful to Suman Singh for useful discussions.

References Références Referencias

1. Michael Gratzel, Nature, Vol 414, 2001. p 388-344.
2. P. Peumans S. Uchida and S.R. Forrest Nature 425, 2003, p-158.
3. S. Uchida J. Xue B.P. Rand and S.R. Forrest. Appl. Phys. Lett. Vol. 84, 2004, p4218.
4. I. Brunder M. Karlsson F. Eickemeyer, J. Hwang, P. Erk, A. Hagfeldt, J. Weis and N. Pschier. Sol. Energy Mater. Sol. Cells Vol 93(10), 2009, p1896.
5. I. Brunder, S. Watanabe, J. Qu, i. B. Muller, R. Kopecek, J. Hwang, J. Weis and N. Langer, Organic Electronics doi 2010 10.1016/j.orgel 2009, 12 019.
6. Roderic A. B. Devine, Clay Mayberry, Ankit Kumar, and Yang Yang IEEE Transactions on Nuclear Science , Vol 57, No. 6, 2010 p3109-3113.
7. Deutsces Elektronen-Synchrotron DEYS "Solar cell degradation observed directly for the first time"

Science Daily 9december 2013 www.sciencedaily.com/releases/2013/12/131209105342.Htm.

8. Fehr, M., Schnegg, A., Rech, B., Astakhov, O., Finger, F., Bittl, R., Teutloff, C., Lips, K. (2014) Metastable defect formation at microvoids identified as a source of light-induced degradation in a-Si:H. *Phys. Rev. Lett.* (accepted) DOI: 10.1103/-PhysRevLett.112.066403.

This page is intentionally left blank