# Silver-ion implantation onto $TiO_2$ photoanodes for efficient plasmonic dye sensitized solar cells

Navdeep Kaur[1], Aman Mahajan[1#], Fouran Singh[2], D. P. Singh[1]

[1] Department of Physics, Guru Nanak Dev University, Amritsar-143005, India.
[2] Inter University Accelerator Center, New Delhi-110067, India.
#Email: aman.phy@gndu.ac.in

**Abstract:** Silicon based solar cells have ruled the light harvesting industry over last few decades, owing to its low cost leading to commercial viability. However, with saturation in the highest power conversion efficiencies being reported, extensive efforts are being done to explore its alternates like multi junction spectral splitting modules, organic material based solar cells and $TiO_2$ based Dye sensitized solar cells (DSSCs). [1] Among these alternates, low cost and easy chemical synthesis has made $TiO_2$ as front line material in the field of light harvesting, fuel cells and as electro photo catalyst. The porous structure of $TiO_2$ facilitate loading of ample amount of dye, causing high photo generated current in DSSCs. Multi prong approaches have been adopted to enhance the light harvesting.

However, widely used strategy to achieve the efficient light harvesting has been done by decorating $TiO_2$ matrix with metal nano particles (NPs) such as silver (Ag) and gold (Au). Ag NPs having strong localized surface plasmon resonance, arising due to the collective oscillations of electrons in metals and surrounding dielectric medium, and thus the local electric field generated helps in changing the spatial and energy distribution of trap states. Further, under the effect of this local field band tailoring can be achieved for favorable objectives like shifting of light absorption. [2, 3] The improvement in photocurrent on decoration with Ag NPs has also been attributed to formation of Schottky junctions of $TiO_2$ with NPs. Thus trapping of photo generated charges on the surface of metal NPs leads to extended life, which directly get translated into magnitude of photocurrent. Various research groups have attempted to decorate the $TiO_2$ matrix with silver NPs by chemical route, electro-deposition and even by LASER pulse deposition. But due to the complexity of chemical reactions, another alternative of ion implantation has been adopted in the present work. [4]

Here, Ag ions beam of energy 65 keV have been irradiated at a penetration depth of 17 nm (Measured by stopping and range of ions in matter (SRIM)) onto $TiO_2$ photoanodes at varying fluence from $1 \times 10^{15}$ to $9 \times 10^{15}$ $ions/cm^2$. The implantation has been confirmed through X-ray photoelectron spectroscopy (XPS) and X-ray diffraction (XRD) technique. The optical properties have been studied through UV-Visible and Raman spectroscopy. The DSSCs have been fabricated using Ag ion implanted $TiO_2$ as photoanodes and their photovoltaic performance (Figure 1) have been compared with $TiO_2$ based DSSC.



5th International Conference on Nanotechnology for Better Living (NBL-2019), Jointly organized by National Institute of Technology (NIT) Srinagar and Indian Institute of Technology (IIT) Kharagpur; April 7 – 11, 2019 at SKUAST, Shalimar Srinagar, Jammu and Kashmir, India; Editor: Dr. M. A. Shah and Prof. P. Banerji, ISBN:978-81-939516-0-6; Published by Applied Science Innovations Pvt. Ltd., Pune, Maharashtra, India.

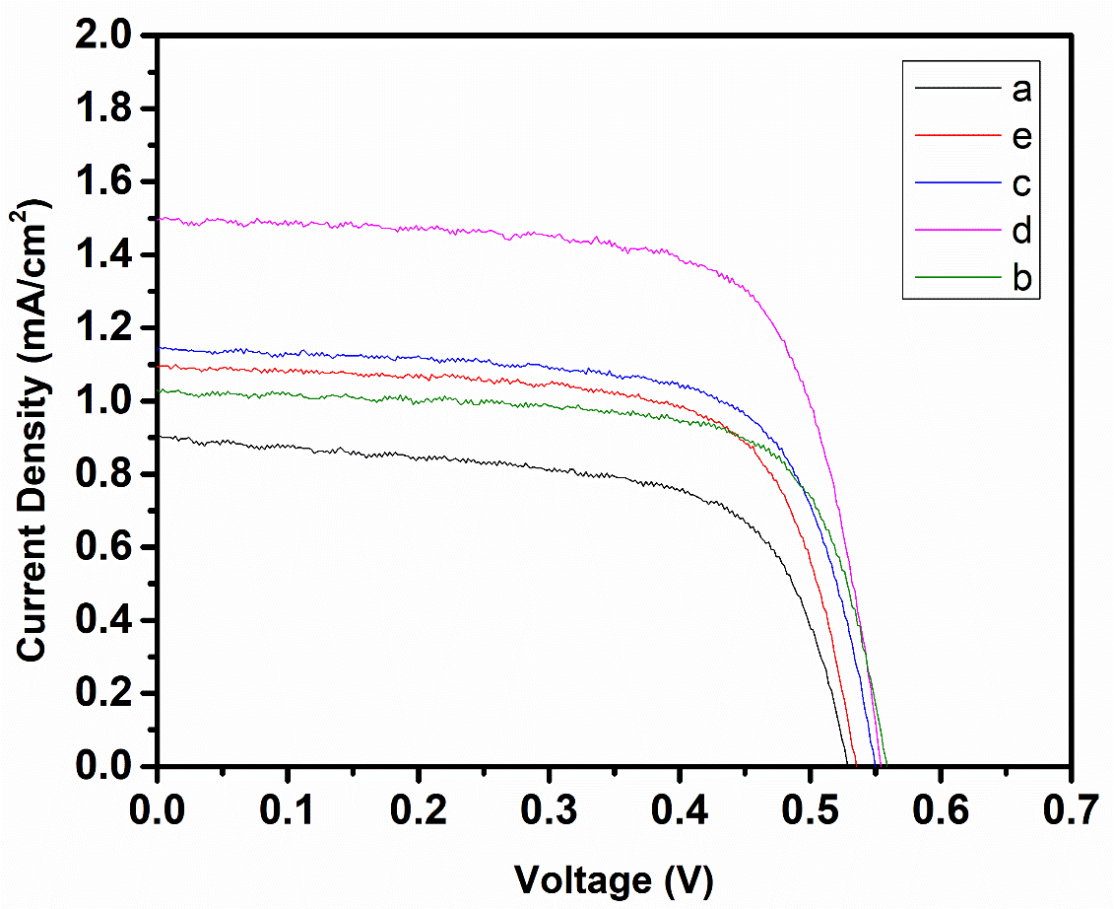


Figure 1: Current density Vs Voltage plots of fabricated (a) $TiO_2$ based DSSC and with Ag ions implanted based DSSCs at different fluences b) $1 \times 10^{15}$, c) $3 \times 10^{15}$, d) $6 \times 10^{15}$, e) $9 \times 10^{15}$ *ions/cm*$^2$

**References:**

[1] O'Regan, B., Gratzel, M. Nature (1991), 353, 737.

[2] Tanvi, Mahajan Aman, Bedi R. K., Kumar Subodh, Saxena Vibha, Singh Ajay and Aswal D.K., RSC Adv., (2016) Vol. 6, 48064-48071.

[3] Tanvi, Mahajan Aman, Bedi, R. K., Kumar, S., Saxena, V., Aswal, D.K. Journal of Applied Physics, (2015) Vol. 117, 083111-083116

[4] Jun Luo, Jiawei, Zhou, Haibo Guo, Weiguang Yang, Bin Liao, Weimin Shi and Yigang Chen. RSC Adv., 2014, 4, 56318.



5th International Conference on Nanotechnology for Better Living (NBL-2019), Jointly organized by National Institute of Technology (NIT) Srinagar and Indian Institute of Technology (IIT) Kharagpur; April 7 – 11, 2019 at SKUAST, Shalimar Srinagar, Jammu and Kashmir, India; Editor: Dr. M. A. Shah and Prof. P. Banerji, ISBN:978-81-939516-0-6; Published by Applied Science Innovations Pvt. Ltd., Pune, Maharashtra, India.