

HVL, Norway –PSG, India Collaborative Research

Dye Sensitized Solar cells & CZTS absorber layer based thin film solar cells

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India

Research Scholars

Ms. Prabavathy Nagarajan
Mr. Balaji Gururajan

PSG-HVL Collaborative Research Project (2016-2019)

Project Title: Efficiency and stability enhancement of natural dye Sensitized Solar cells (DSSC)

Name : Prabavathy Nagarajan

Position : PhD Research Scholar

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Principal Collaborator : Dr. Dhayalan Velauthapillai
Western Norway University of Applied Sciences, Bergen, Norway

Principal Investigator : Dr. R. Balasundaraprabhu
PSG College of Technology, Coimbatore, India

Period : January 2016 to August 2019

Project summary:

Titania nanorods with rutile phase are prepared by hydrothermal method. This functions as photo electrode for DSSC. The aim of the project is to utilize natural dyes as sensitizers for DSSC. This minimizes the cost of the solar cell and the preparation is also easier. But the stability of natural dye is very short compared to synthetic dye. The factors affecting the degradation of dye are studied and improvements are taken to increase the photovoltaic performance of the cell using natural dye. Dye from rose flower is used as a sensitizer. Platinum is used counter electrode and iodine/ iodide as liquid electrolyte for DSSC fabrication. The following strategies such as using citric acid as solvent to extract dye, adding algal buffer layers on the TiO₂ film to improve the dye anchoring, preparing Ca doped nanorods to reduce the photocatalytic activity and utilizing algal co-sensitization to improve the dye stability were the measures were performed to improve the solar performance of the cell from 0.67% to 3.09%.

International Publication:

- ▲ *N.Prabavathy*, R.Balasundaraprabhu, G.Balaji, Asitha Udhayanga, S.Prasanna, K.Sivakumaran, Gamini Rajapakse, G.R.A. Kumara, Dhayalan Velauthapillai , “Investigations on the Ca doped photoelectrodes for natural Dye sensitized solar cells”, Journal of Photochemistry and Photobiology : A Chemistry (2019).[Accepted]
- ▲ *N.Prabavathy*, R.Balasundaraprabhu, DhayalanVelauthapillai, Chapter title “Natural Dye Sensitized Solar cells - Strategies and Measures”, for Book titled “Rational Design of Solar Cells for Efficient Solar Energy Conversion, Wiley Publications, DOI: 10.1002/9781119437499.ch3 , (2018).
- ▲ *N.Prabavathy* ,S.Shalini, R.Balasundaraprabhu ,DhayalanVelauthapillai , S. Prasanna, G.Balaji.. N. Muthukumarasamy, Algal Buffer layers for enhancing the efficiency of anthocyanins extracted from rose petals for natural Dye sensitized solar cell(DSSC). Int. J. Energy Res, 42 (2), 790-801, (2018).
- ▲ S. Shalini , *N.Prabavathy*, R.Balasundaraprabhu, Sathish Kumar,S.Prasanna ,Dhayalan Velauthapillai, “Studies on DSSC encompassing flower shaped assembly of Na-doped TiO₂ nanorods sensitized with extract from petals of Kigelia Africana,” Opt. - Int. J. Light Electron Opt, 155, 334-343, (2018)

▲ *N. Prabavathy, S. Shalini, R. Balasundaraprabhu, DhayalanVelauthapillai, S. Prasanna N. Muthukumarasamy, Enhancement in the photostability of natural dyes for dye-sensitized solar cell (DSSC) applications: a review, Int. J. Energy Res, 41 (10), 1372-1396.(2017)*

▲ *N.Prabavathy ,S.Shalini, R.Balasundaraprabhu ,DhayalanVelauthapillai ,S. Prasanna, PravinWalk, N. Muthukumarasamy, Effect of solvents in the extraction and stability of anthocyanin from the petals of CaesalpiniaPulcherimma for natural dye sensitized solar cell applications, J Mater Sci: Mater Electron, DOI: 10.1007/s10854-017-6743-7, (2017).*

▲ *S.Shalini, N. Prabavathy, R. Balasundaraprabhu, T. Satish Kumar, PravinWalke, S. Prasanna Dhayalan Velayuthapillai, Effect of Na doping on structure, morphology and properties of hydrothermally grown one dimensional TiO₂ nanorod structures, J Mater Sci: Mater Electron 28 (4), 3500-3508, (2017).*

International Conferences/ Seminar Presented:

▲ *N.Prabavathy, R.Balasundaraprabhu, Dhayalan Velauthapillai, “Alum doped Dye sensitized solar cells”, International conference on “Advanced Nanomaterials for clean energy and health applications”, University of Jaffna, Srilanka ,(AMCEHA- 2019).*

▲ *N.Prabavathy, R.Balasundaraprabhu, Dhayalan Velauthapillai, “Algal buffer layers for enhancing the efficiency of DSSC”, International Seminar on “Advanced Nanomaterials for clean energy and health applications” ,Coimbatore Institute of Technology , (2018), Coimbatore, TamilNadu, INDIA.*

▲ *N.Prabavathy, R.Balasundaraprabhu, Dhayalan velauthapillai “Algal buffer layers for enhancing the efficiency of DSSC”, Department of Biological sciences, University of Bergen, NORWAY, (2018).*

▲ *N.Prabavathy, R.Balasundaraprabhu, Dhayalan velauthapillai “Dye sensitized Solar cells – Cheap Flexible and Alternative”, International week seminar on Advanced nanomaterials for clean energy and health applications, Western Norway University of applied Sciences (HVL), Bergen , NORWAY,(2018).*

▲ *N. Prabavathy, S.Shalini, R.Balasundaraprabhu, S.Prasanna , Dhayalan Velauthapillai "Enhancing efficiency of DSSC using solvents for extraction of anthocyanins" ,International Conference on Advance in Functional materials (ICAFM- 2017), Central University of TamilNadu, Thiruvavur, TamilNadu,INDIA.*

Funding Details (PSG – HVL)

Research Fellowship- Ms.N. Prabavathy 1st Scholarship - Rs.2,00,000

2nd Scholarship - Rs 3,00,000

Travel Grant and Fellowship- Ms.N.Prabaavthy- (1st trip) - Rs 2,60,000

(2nd trip) - Rs 2,56,000

Research Fellowship - .Mr.G.Balaji 1st Scholarship - Rs 1,50,000

PSG-HVL Collaborative Research Project (2018-2019)

Project Title: Investigations of RF Magnetron Sputtered $\text{Cu}_2\text{ZnSnS}_4$ (CZTS) absorber layer for thin film solar cells

Name : Balaji Gururajan
Position : PhD Research Scholar
Address : Department of Physics
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Coimbatore- 641 004



Principal Collaborator : Dr. Dhayalan Velauthapillai
Western Norway University of Applied Sciences, Bergen, Norway

Principal Investigator : Dr. R. Balasundaraprabhu
PSG College of Technology, Coimbatore, India

Period : September 2018 to August 2019

Project Summary:

CZTS absorber layer based thin film solar cells will be fabricated on soda lime glass substrates, in RF magnetron sputtering. CZTS absorber layer will be studied for Structural, compositional, optical, morphological, electronic and electrical properties and necessary optimizations will be carried out. CdS buffer layer will be deposited using Hot-wall deposition system and all necessary studies would be carried out to study its properties. GZO transparent conducting oxide will be used as the window layer. It will deposited using RF Magnetron sputtering and all the properties will be studied and further optimizations would be carried out. Finally a thin film solar cell with the structure SLG/ Mo/ CZTS/ CdS/ GZO would be fabricated and will be studied for its efficiency and necessary optimizations will be carried out to enhance the solar cell efficiency.

Publications: (2019)

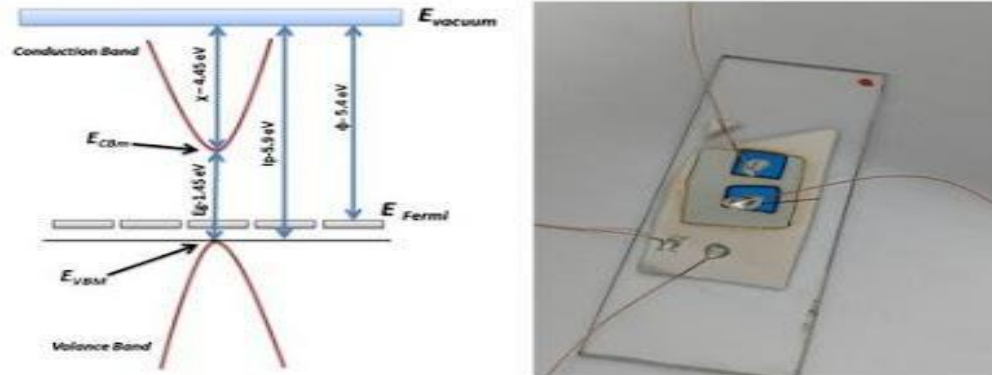
1. Influence of Sulphurization on the formation of $\text{Cu}_2\text{ZnSnS}_4$ (CZTS) absorber layer thin films deposited using RF Magnetron Sputtering, **Balaji Gururajan; Balasundaraprabhu Rangasamy**; Prasanna Sankaran; Prabavathy Nagarajan; Elena Echeverria, David N McIlroy; Sivakumaran Kaliappan; Kannan M D; **Dhayalan Velauthapillai**, *Under review, Thin Solid Films*
2. Study of RF Magnetron Sputtered stacked $\text{Cu}_2\text{ZnSnS}_4$ (CZTS) thin films using X-ray photoelectron spectroscopy for thin film solar cell, **Balaji Gururajan**, Prabavathy Nagarajan, **Balasundaraprabhu Rangasamy**, Prasanna Sankaran, David. N. McIlroy, Sivakumaran Kaliappan, Kannan M D, **Dhayalan Velauthapillai**, *Communicated to Materials (MDPI)*

Conferences Attended: (2019)

1. Presented a paper titled "Investigations of RF Magnetron Sputtered $\text{Cu}_2\text{ZnSnS}_4$ (CZTS) absorber layer using X-ray photoelectron spectroscopy for thin film solar cell", at the International Conference on Advanced Materials for clean energy and health applications (**AMCEHA-2019**), University of Jaffna, **Jaffna, Sri Lanka, Feb 6-9, 2019**

Thin film Solar cells (CZTS AND DSSC)

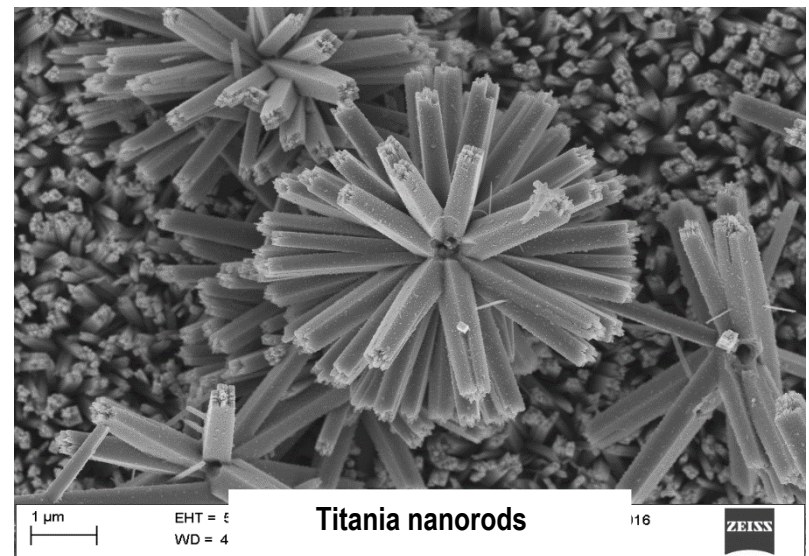
UPS Band diagram of CZTS absorber layer and CZTS thin film solar cell



Rose dye



Dye sensitized Titania film



Titania nanorods

Research Internship at HVL, NORWAY



Srilankan and Indian Research Group at HVL



PSG and CIT research Group at HVL



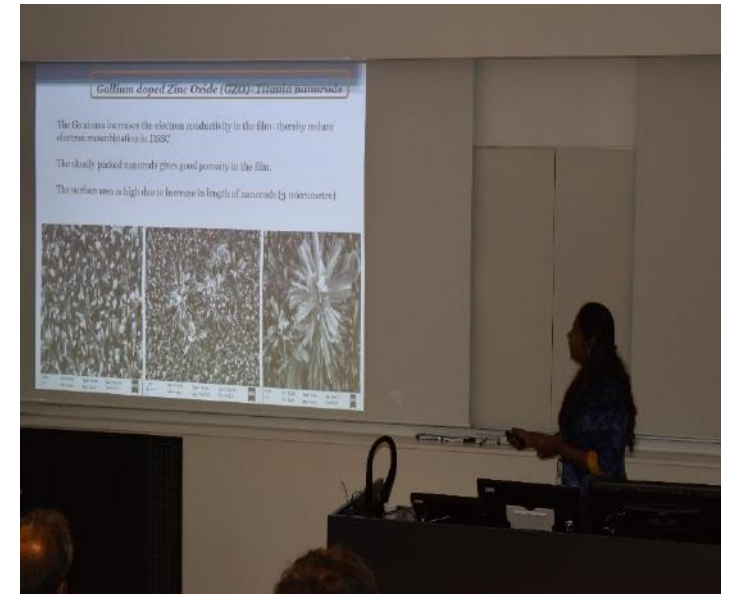
POD Cast on DSSC in Luftballlett



Dye extraction at HVL
Research Lab



Fabrication of DSSC at HVL Research lab



Presentation at UIB, Norway

Centre For Surface Science (CSS), PSG TECH, INDIA

<https://sites.google.com/view/psg-tech-css/home>



RF Sputtering in CSS



Solar Simulator in CSS



UV Vis Spectrophotometer in CSS



PSG Research group at University of Mumbai