



**NCPRE**



# NewsLetter *Feb 2020*»

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## NCPRE *Profile*

The National Centre for Photovoltaic Research and Education (NCPRE) at IIT Bombay is one of the leading PV research center in the country. It was launched in 2010 with funding from the Ministry of New & Renewable Energy (MNRE) of the Government of India, soon after the launch of India's National Solar Mission. The broad objectives of NCPRE are to provide R&D and education support for India's ambitious 100 GW solar mission. NCPRE has 29 faculty members and over 120 research staff and students across 9 Departments at IIT Bombay. State-of-the-art laboratory facilities, with over 200 equipment spread across 12 laboratories, have been set up which are accessible to all researchers and Industries. The Centre is involved in both basic and applied research activities.

These research activities include silicon solar cell fabrication and characterization, new materials for PV devices, energy storage and batteries for PV, development of power electronic interfaces for solar PV systems, and module characterization and reliability. NCPRE has a strong programme of industry outreach. It undertakes projects and consultancy in its areas of expertise. It also provides services for characterization and measurements. NCPRE periodically conducts workshops and hands-on training in the field of photovoltaics for industry as well as academia.

*"NCPRE's solar photovoltaic research and education activities, and its collaborations with industry, over the last 10 years have been impressive and have contributed strongly to the growth of the solar PV ecosystem in India."*

*Armin Aberle,  
Professor, NUS & CEO,  
Solar Energy Research Institute of Singapore (SERIS)*

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# PV Module Reliability *Far reaching consequences*

With the increase in the development of new technologies in photovoltaics, it is equally important to understand the vulnerabilities of such technologies, as it is expected to have a consistently good performance and ability to maintain trust among the consumers. Since eventually, the energy generated by the solar plants matters more than simply the installed capacity, it is important to pay attention to the long term reliability of PV power plants.

## International status

Looking into the global aspect, we see that with the increase in PV installations, the cost per watt of PV installations has significantly reduced along with the decrease in the module prices, making it accessible like never before. On the other hand, the warranties on PV modules have steadily increased as now most of the leading module manufacturers offers 25 to 30 years of linear power warranty with an annual degradation rate of less than 0.7%/year, such less value of degradation rate signifies a good performance. In 2018, 580 TWh of electricity was generated from solar photovoltaics worldwide, exceeding the share of photovoltaics in global electricity for the first time, by 2%. By the end of 2018, the cumulative global installed capacity of solar photovoltaics crossed 512 GW mark.

Most of the places on earth receive ample sunshine also happens to have hot

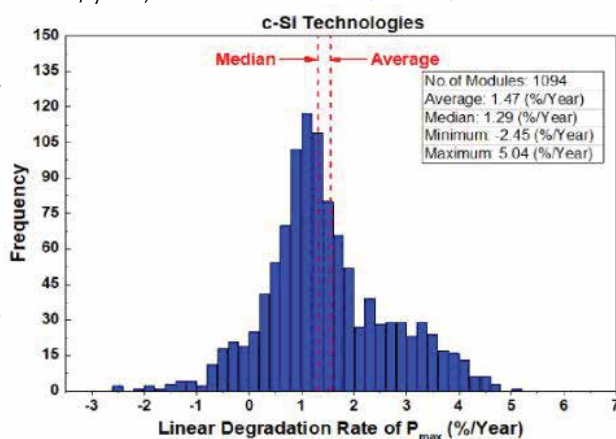
climates which include most of India, Middle East, Arizona etc. In such high temperature and otherwise extreme end-user environments, the PV degradation rates need to be carefully studied to optimize the deployment of solar photovoltaics in such areas.

## National status

Coming to the scenario in India, the initiatives taken by the government had lead to the solar industry significantly growing in our country. The target of solar photovoltaics installed capacity was targeted to 20 GW by the year 2022, which was achieved by 2018 itself. Most of the solar PV startups of the country focuses on the testing methods for reliability. NCPRE also has a significant role in this field. Initiated in the year 2013, NCPRE has conducted the All India Survey in the year- 2013, 2014, 2016 and 2018. The survey is conducted

extensively across the country, starting from Leh and Ladakh to Tamil Nadu, where the team performed detailed field characterization of PV modules along with the modes and mechanism of degradation in PV modules deployed. From the findings in the survey, as the module degradation in hot climatic zones is statistically higher than that in cold climatic zones, it is clear that it becomes crucial to have proper module quality

assessment in such hot climatic regions. Some of the research problems that are being explored for standards development are in the area of transportation and handling of PV modules, soiling and reliability of anti-soiling coatings, water quality for cleaning of PV panels etc. Soiling losses and degradation of modules are of prime interests in reliability. For proper standardization and adopted practices at the maintenance and monitoring level, there is a need to develop harsher yet relevant accelerated tests as mere qualification under IEC 61215 is not sufficient for in the hot climates. NCPRE is developing research and data-driven accelerated tests in consultation with the concerned industry stakeholders leading to new standards at domestic (Beauro of Indian Standards - BIS) and international (International Electrotechnical Commission- IEC) levels. The revised bypass diode test developed by NCPRE for modules in hot climates has been incorporated in the upcoming IEC TS 63126.

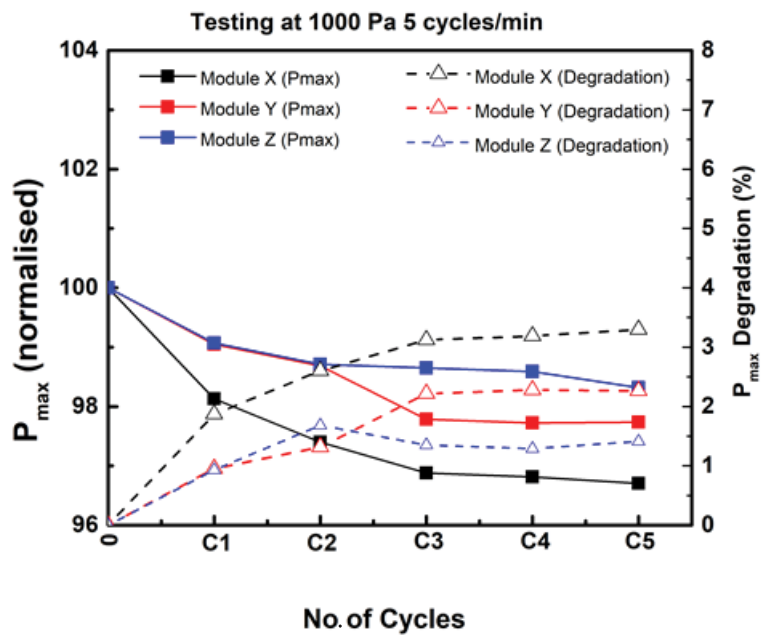


*Histogram of  $P_{max}$  Degradation rates of modules in %/year corresponding to the number of modules of crystalline silicon technology, showing the % degradation in  $P_{max}$  of modules in a year as a performance checking parameter. (Ref. : <http://www.ncpre.iitb.ac.in/ncpre/research/report.html>)*



## How much power do solar modules loose in their lifetime due to cell cracks?

Indeed. A crack in a solar cell may not be visible to the naked eye, but it may have adverse effects on PV module power output. The tricky issue about cell cracks is that they are a dynamic phenomenon, and they open and close more or less randomly as the module undergoes handling, transportation, thermal cycling, and flexing in the field. NCPRE has developed a particular Dynamic Mechanical Loading (DML) in situ-EL imaging setup (Page 9) which mimics the way modules are installed in the field. Also, NCPRE has developed a new accelerated test by optimizing the combination of variables like frequency of cycle, the number of cycles, the pressure applied. It was found that the PV modules reach a point where all cell cracks that tend to open up have opened and the module power loss reaches a maximum value and does not increase anymore. It assesses the vulnerability of different module designs to suffer power loss due to cell cracks. This would also be useful in evaluating the impact of existing cell cracks on the power loss which is often the case when the PV plants change hands.



*(The power loss from cell cracks becomes stable over the number of cycles)*

## Module transportation - NCPRE advises to pack it well!

Have you ever felt a bump or jerk while traveling on roads? Solar PV modules face this issue. These lead to vibration which in turn may lead to crack on the solar cells which may cause degradation in the long-term. So packaging becomes important for transporting PV modules from the manufacturing line to the installation site. The severity of vibrations experienced by the PV modules during transportation, manual handling and forklift handling was studied. Lateral vibrations experienced by the PV modules, which were placed vertically inside the pallet were immoderate. Manual handling of modules found to have high values of acceleration. It was found that the international standard is not suitable for Indian



road conditions primarily for the lower frequencies. Study shows, the standard pallets are safer for the transportation of PV modules through good roads. Few of the PV modules placed in the cassette packing developed micro-cracks which shows these are not sufficient to absorb the impacts of transportation. The road traversed in the experiment was one of the better laid and maintained roads in the country. Transportation to remote locations is necessary for devising an appropriate vibration test profile for Indian road conditions.



## Soiling - Power Output disruptor

Soiling is a phenomenon wherein dust gets deposited on PV modules over a period of time. It causes significant energy losses thereby limiting us from harnessing the available solar potential. Soiling is a geographical phenomenon and studying it on the field is highly time consuming and expensive. It has been observed that Mumbai is facing 0.4% per day soiling loss. A need, therefore, arises to develop soiling chambers which can emulate the natural climatic conditions and deposit dust of varied composition and particle size on the test samples.



At NCPRE, the module reliability group led by Prof Narendra Shiradkar & Prof Anil Kottantharayil has developed two low-cost chambers to simulate 1. warm and humid & 2. hot and dry climatic conditions. A third chamber has been developed which simulates both the above climatic conditions. These chambers can deposit dust with uniformity of around 95% on samples of sizes ranging from 2.5 x 2.5 cm<sup>2</sup> & 22 x 22 cm<sup>2</sup>. Soiling losses can thus be studied in these chambers and better cleaning methods/ anti-soiling coatings can be developed.

## ALL-INDIA SURVEY OF PHOTOVOLTAIC MODULE RELIABILITY

In the past decade, NCPRE along with National Institute of Solar Energy (NISE) has conducted 4 pan India surveys to monitor reliability and durability of PV modules. Modules in different climatic zones across the length and width of the nation were monitored. Various tests such as measurement of I-V characteristics under light, infra-red (IR) thermography under light, electroluminescence (EL) imaging, interconnect integrity test, measurement of irradiance, etc are conducted in these surveys. Based on the data, the reports (available on NCPRE website) propose various recommendations for the photovoltaic community. These recommendations, if adopted with seriousness, will ensure that the installations coming up in future will show better overall performance than we have seen so far, and thereby ensure the success of the National Solar Mission.

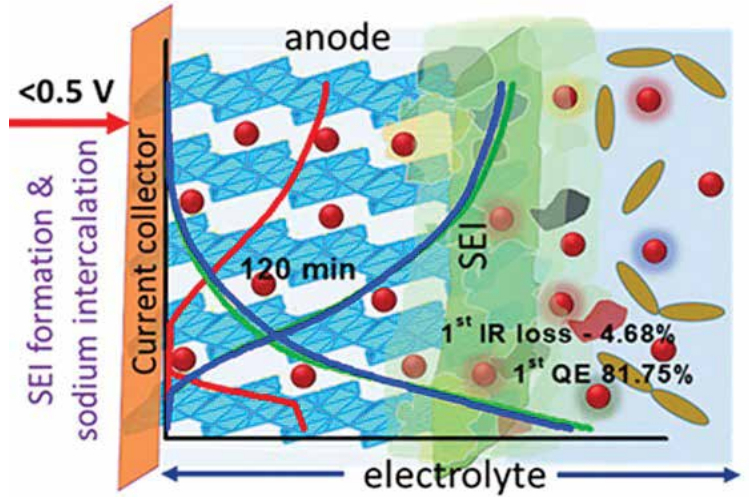




### Energy Storage Group

## A simple approach to mitigate the crucial losses in the sodium-ion battery

Sodium-ion batteries (SIBs) are one of the highly emerging battery technologies as a promising alternative to the lithium-ion battery for stationary energy storage applications due to their ultra-low-cost. The first cycle losses in the anode material of the sodium-ion battery are very crucial for its overall performance and efficiency. The Energy Storage Group at NCPRE has developed a stable (4000 cycles), high capacity (237 mAh g<sup>-1</sup>) and high rate capable and super stable anode material for SIBs. In this study, the 1st cycle loss was reduced significantly by utilizing an approach that has been shown to enhance the cyclability of the battery. The current understanding and the technique utilized here will provide a new direction to overcome the 1st cycle loss of sodium titanate anode and can be utilized further to develop sustainable rechargeable sodium-ion battery.



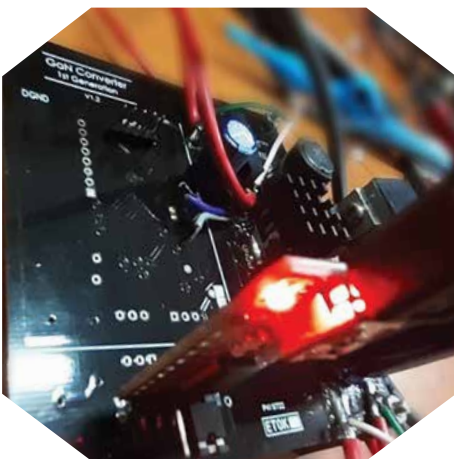
Solid electrolyte interphase formation and sodium intrcalation in Na-ion battery

### Did you know?

The Nobel Prize in Chemistry 2019 is awarded to John B. Goodenough, M. Stanley Whittingham and Akira Yoshino for their contributions to the development of the lithium-ion battery.

### Power Electronics Group

## Switching over to compact switches



The hardware of the 1MHz GaN-based converter

GaN-based devices are trending now-a-days because of their high switching frequency up to 1 MHz for power circuits which helps in high power density leads to compact design. GaN-based converters technology is advancing globally but the Indian industry is still far from its reach. NCPRE has developed a 1 MHz GaN-based DC-DC converter used for interfacing an ultracapacitor bank with a 48V DC bus in microgrids or battery storage or electric vehicles. The conventional design needs 4 layers of PCB design but we have developed 2 layers PCB design. Prototype has been tested for 100W of load and the measured efficiency is 97%. Next prototype of the synchronous converter will further improve the efficiency by replacing diodes with HEMTs.

### Did you know?

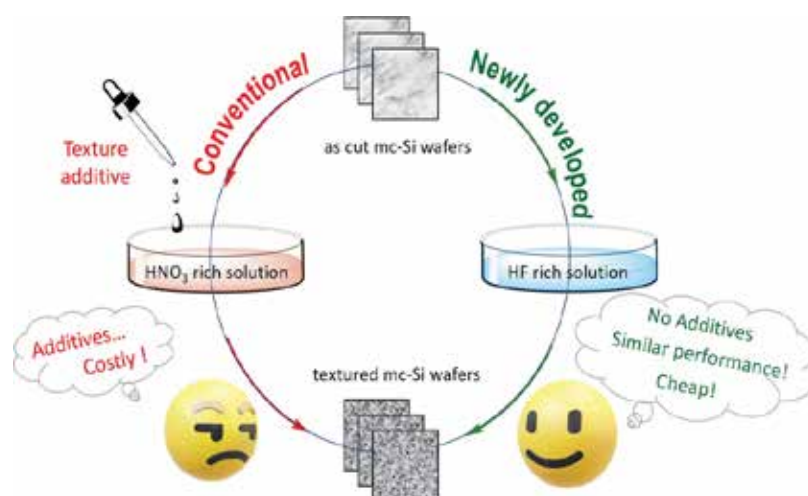
According to IPCC (Intergovernmental Panel on Climate Change) report in October 2019 on global warming the average temperature rise of the world has already increased by 1degree Celsius [1] <https://climate.nasa.gov/news/2878/a-degree-of-concern-why-global-temperatures-matter/>



## Silicon Group

# Low-cost additive-free acid texture process for commercial diamond-wire sawn (DWS) Multi-c Si wafers

Currently, industrial manufacturing of solar cells is dominated (62%) by the usage of DWS mc-Si wafers, owing to reduced kerf-loss leading to high through put. However, as a result, these wafers become highly polished, introducing a challenge in texture process. A team of researchers led by Dr Prabir K. Basu at NCPRE-crystalline silicon laboratory invented an additive-free and cost-effective chemical recipe, utilized in texturing of large area DWS mc-Si wafers. These additive-free acid-textured wafers and finally solar cells exhibited excellent optical, electronic and electrical properties compared to the existing additive-based acid textured wafers and cells. Detailed chemical cost analysis suggests that the additive-free acid texturing process can reduce the chemical cost involved in preparing the acid bath by 60% compared to existing additive-based acid texturing process. Successful demonstration of the texturing process was done at three solar cell manufacturing sites in India. Details of the invention have been featured in the form of patent, publications in reputed scientific journals and presentation in renowned conferences.



## Does the probing of silicon solar cells really matter?

Reliable measurement of the electrical performance of a commercial-grade Si solar cell is a great matter of concern for manufacturers, project developers and investors. Therefore, the International Electrotechnical Commission (IEC) has laid down the standard procedures for solar cell performance measurement listed in IEC 60904-1-10. However, shadow generated due to the fixed width of probing bars followed by difference in width of probe and bus bars introduce uncertainty in the short circuit current measurement and has not been standardized yet. A team of researchers led by Dr Ashok Kumar Sharma at NCPRE-crystalline silicon laboratory conducted a study focusing on the measurement uncertainty on solar cells carrying dissimilar dimension of bus bars. Investigation emphasized an essential requirement of correction known as shadow correction to minimize the measurement uncertainty. NCPRE researchers designed a set of kelvin probes to measure the short circuit current under the non-shadow condition and later used to apply the correction. "The proposed approach will help to mitigate the measurement uncertainties of solar cells efficiencies when tested at different laboratories or testing facilities, said Dr Sharma".

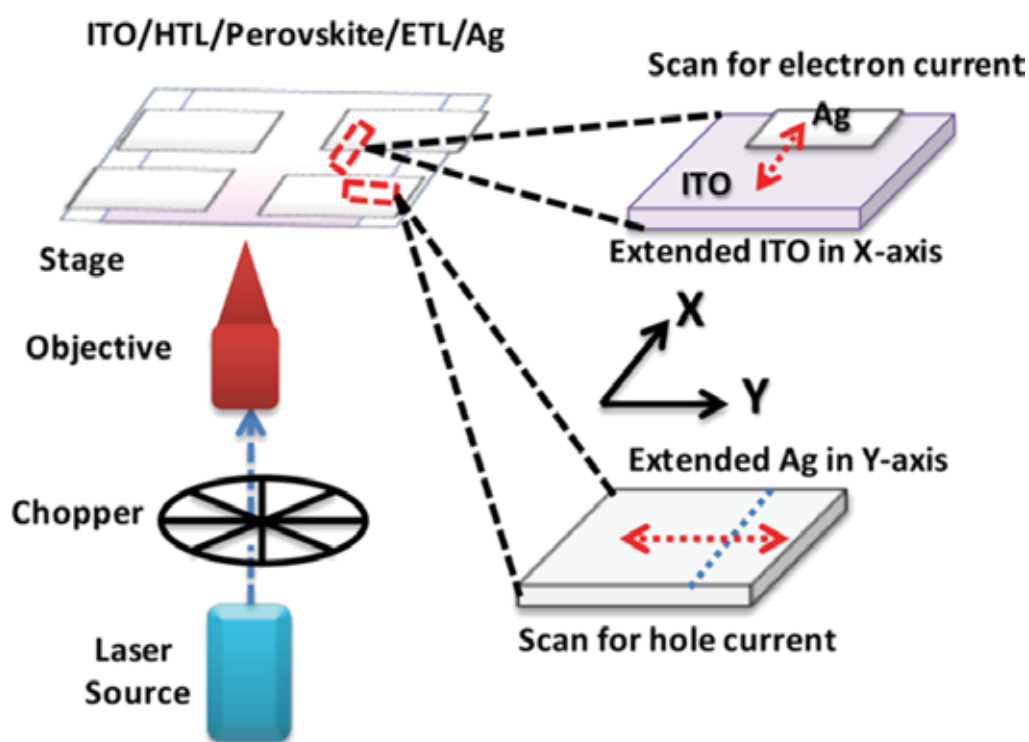


## Thin Film Group

## Understanding photophysics behind hybrid halide perovskite semiconductors

The charge transport and photophysics behind perovskite solar cells are still under study because of the exotic defect dynamics of these disordered semiconductors. Recently, NCPRE's thin-film group headed by Prof. Dinesh Kabra found that the various parameters like charge carrier diffusion length and dielectric relaxation decide the performance of various properties of optoelectronic devices particular in photovoltaics. A comparative study is carried out on charge transport length scale for passivated and pristine MAPI thin film-based perovskite solar cells through scanning photocurrent microscopy (SPM). The SPM study suggested an improved charge transport length ( $L$ ) and degree of ambipolarity of photogenerated charge carriers (electron and hole) is passivated as compared to pristine MAPI-based PSCs. These results were found to be correlated with frequency-dependent photocurrent measurement, which shows that the relaxation time of the charge carrier is relatively lower in passivated MAPI-based PSCs. This mechanism could be explained by trap-assisted recombination, where trap states are induced by ion migration in halide perovskite films. Furthermore, passivation of traps showed an increased degree of ambipolarity in the perovskite semiconductor thin film.

<https://doi.org/10.1021/acsenergylett.0c00120>



*Schematic of the scanning probe microscopy setup used to estimate the charge transport length of the photogenerated electron and hole, separately.*

### Did you know?

Perovskite PV is emerging as a viable competitor to silicon on accounts of phenomenal rise in efficiency in the past decade from 3.8% to 25.2%.





# Unique Dynamic Mechanical Loading (DML) facility

## *Helping design module with higher mechanical loads*

Dynamic Mechanical Loading tool helps us to understand the effect of cyclical loading on the PV module design. Current IEC 61215 standard has introduced the testing of PV modules under dynamic loading. In most cases, the Suction Cup tool is used for doing dynamic mechanical loading. This tool has several limitations, out of which non-uniform loading and blocking the front surface are the most challenging. Since it blocks the front side of the panel, it restricts any in-situ characterization on the PV module. Keeping the requirements of the latest IEC 61215 standard in mind, an innovative methodology and tool were needed to be developed which could overcome the limitations of the currently existing tools. After prolonged research by the joint team of professors and students at NCPRE IITB, an innovative state-of-the-art tool has been developed which can perform the entire mechanical loading test described in the IEC standard.

### Specifications and Capabilities:

Type of Test	Requirement as per IEC 61215	Requirement as per IEC+ protocol of NREL
Static Loading	Can be done at 5400 Pa pressure	Can be done till 8000 Pa pressure
Dynamic Loading	Can be done at 1000 Pa pressure	Can be done at 2500 Pa pressure

In this tool, we can perform the test on entire commercially available module sizes varying from 2m x 1m to 0.7m x 0.9m. This tool can test both glass-back sheet and glass-glass modules. On the biggest feature of this tool is that we can perform in-situ characterization on the PV module like electroluminescence and lighted I-V while the module is loaded (under mechanical stress). It is designed in such a way that it can simulate the effect of mechanical loading on different installation design. This allows a deeper understanding of the performance loss of PV module due to cell cracks. This will help the industry to design modules which can withstand greater mechanical loads.



## Industrial Collaboration *Success is best when it's shared*

- ▶ **A** team of researchers at NCPRE under the guidance of Prof. Sudhanshu Mallick, Department of Material science collaborated on a joint research project with Waaree Energies Ltd, India, one of the leading PV module manufacturing companies in India and Borealis Polyolefine GmbH, Austria, which has been a foremost provider of polyolefins to develop novel thermoplastic polyolefin (TPO) encapsulant, which is a newly developed non-crosslinking material for photovoltaic (PV) module lamination intending to demonstrate it as a potential replacement to ethylene-vinyl acetate (EVA).
- ▶ **N**CPRE and Applied materials U.S conducted a collaborative project partially supported by the UKRI Global Challenge Research Fund project, SUNRISE along with three other research institutes IITD, JNCASR and IISER-Pune under the guidance of Prof Dinesh Kabra, Department of Physics to develop novel high-performance nanogenerators using a lead-free organic-inorganic halide perovskite family of materials. IPO-Physics World is currently covering their collaboration.

### NCPRE *Services*

NCPRE has a very well equipped characterization labs with several scientists, engineers and students working on different projects which have been used by industry as well as academia.

- Renewsys solar PV Ltd. Hyderabad, India- Quality check of multi-crystalline Si wafers.
- Mundra Solar Photovoltaics Ltd, Mundra, Gujarat- Process troubleshooting in PERC Si solar cells.
- 3M India Ltd. Bengaluru- Failure analysis of solar-powered road reflectors.
- Websol Energy System Ltd, Kolkata, India- Wafer quality check and performance analysis of multi-crystalline Si wafer solar cell.





## NCPRE helps SSN college of Engineering Chennai make solar cells from India made multi-crystalline Silicon wafers

In the current photovoltaic (PV) market 95 % occupy the crystalline silicon (c-Si) solar cells. In that c-Si share demented by the multi-crystalline silicon (mc-Si) (62 %) solar cells due to low cost and high efficiency. 70 % of global sharing module production by China and Taiwan. In India, PV modules are produced by using external wafers only. At SSN College of Engineering, Prof. P. Ramasamy and his research group are growing boron-doped multi-crystalline silicon (mc-Si) ingot (22 cm\*22 cm\*12.5 cm) by using the directional solidification process. These ingots are converted to brick and then to wafers. The lifetime of the mc-Si wafer is 24 micro Sec and the resistivity of the wafers is in the range 3- 13-ohm cm. The SSN team had done a collaboration research work under Photovoltaic Users and Mentorship Program (PUMP) of NCPRE.



*G Aravindan, a PUMP User who was involved in this project work was in IIT from June 2019 to Feb 2019 learned how to fabricate multi-crystalline silicon solar cells in guidance of Prof. K. L. Narasimhan (left) and Prof. B. M. Arora (right). He expressed and acknowledged the support extended to him by NCPRE.*

His project was based on “Fabricating Solar cells from India-made multi-crystalline Silicon Wafers”. The aim of this project was to fabricate mc-Si solar cell using the wafers fabricated at SSN and process cell fabrication using facilities at student’s fabrication lab of NCPRE. They could successfully fabricate the silicon solar cells using NCPRE facility on the SSN grown mc-Si wafers. The best cell had a power conversion efficiency of ~9 %.



## Pioneer Today *Leaders tomorrow*

**R**ajiv Dubey and Shashwata Chattopadhyay joined IIT Bombay in 2011, in the M.Tech. course in the Electrical Engineering Department and Energy Science and Engineering Department respectively. Both of them were involved with solar PV module reliability with NCPRE and had led the All-India Surveys in 2013, 2014 and 2016. Rajiv analyzed electrical performance data and has investigated the effects of dynamic mechanical loading on the generation of cracks in solar panels and its overall impact on solar panel power output. Shashwata worked on degradation modes in Hot climates and has performed accelerated tests on the EVA encapsulant used in solar panels in order to determine the activation energy for discoloration of the EVA. A significant outcome of the study is that the higher degradation rates of panels in the Hot climates as compared to Non-Hot climatic zones. Also, from 2014 survey data, it was quite evident that cracks in the PV module are one of the primary reasons for the high degradation rates. Hence it gave them an indication that there would be the need for an affordable, robust, and portable Electroluminescence (EL) system in the future. This system could be used by the installers or O&M persons to assure defect-free panels in the solar power plant. Rajiv with the help of Shashwata, has developed the portable Electroluminescence (EL) Tester under the guidance of the Professors from the NCPRE Module group. The EL tester can detect cracks, shunts, soldering problems, and other defects in the solar panels and can be used even in remote locations in solar power plants. Both Rajiv and Shashwata have multiple international publications and have presented their work in international conferences and workshops on solar PV module reliability and filed study.

Realizing the need for performing regular inspection and testing in the solar power plants for their optimal performance in the long term, the student duo have started a startup venture, SolarMarq Engineering LLP ([www.solarmarq.com](http://www.solarmarq.com)), for selling portable EL testers and other equipments at affordable rates, and also provide on-site testing services to the solar power plants.



**Shashwata  
Chattopadhyay**



**Rajiv  
Dubey**



**SOLAR  
MARQ**





## Chasing dreams *Prof. Sagar Mitra*

From my very initial research life, I was fascinated by the energy storage devices about their size, reaction mechanism, fast ions movement and their performance. The modern technological era has brought us all the electronic devices that are smaller, smarter and efficient but they still require high energy-dense storage devices to operate them. The research on the Lithium-ion battery came under my radar after my graduation from the Indian Institute of Science Bangalore. Shortly afterwards, I appealed to join world-renowned Scientist Prof. Jean Marie Tarascon group in France to understand the unique chemistry combinations and reaction mechanism of batteries and how to make it functional. After the successful completion of my postdoctoral study, I joined to a semiconductor industry in Sweden dealing with 45nm node of Cu via filling for backend IC processor processing.

The lithium-ion battery was calling back again and I joined Indian Institute of Technology Bombay in 2009 with a dream to make paper-thin and highest energy-dense Lithium-ion batteries. My vision started to shape into reality when NCPRE came up with the project to develop the in-house development of batteries; which helped me to grow and develop my lab with world-class battery prototyping, manufacturing, and testing facility. The lab with a team of more than 20 students and staff are now devoted to the battery research and technology development towards indigestion. The lab has produced more than 12 graduates in Lithium-ion battery and currently, they are serving in several Indian and overseas battery industries. A tropical country like us, need to develop a new engineered device with lithium or any other metal ions that can work efficiently, and the team is continuously working towards such goals.



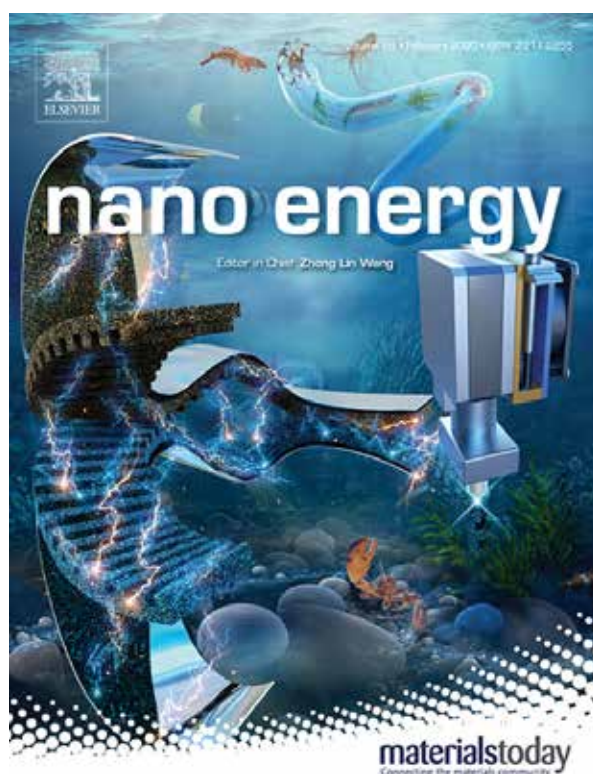


## NCPRE *Achievements*

- **D**urga Prasad Khatri, Research Scholar (NCPRE), IIT Bombay was awarded with the best poster award for his work on Critical Assessment of Firing Process for High Efficiency Screen Printed Industrial Crystalline Silicon Wafer Solar Cells in the International Workshop on Physics of Semiconductor Devices: IWPSD 2019 (December 17-20, 2019) held at Kolkata, India.
- **T**he recent advancement from the NCPRE (Thin-film group) is published in the Physics World by IOP (Institute of Physics). In this work, Prof. Dinesh Kabra and his student Richa Pandey (Thin film group) report a hybrid perovskite system with a very high piezoelectric charge density for applications in nanogenerators; while demonstrating a remarkable piezoelectric response and out-performing the leading hybrid perovskite. Their studies open up a new route to high-performance nanogenerators by the utilization of new materials. (<https://pubs.acs.org/doi/10.1021/acsenergylett.9b00323>)

## NCPRE *Publications*

1. Pandey, Richa, et al. “Microscopic Origin of Piezoelectricity in Lead-Free Halide Perovskite: Application in Nanogenerator Design.” ACS Energy Letters, vol. 4, no. 5, 2019, pp. 1004–1011., doi:10.1021/acsenergylett.9b00323.
2. Sarkar, Ananta, et al. “A Simple Approach to Minimize the First Cycle Irreversible Loss of Sodium Titanate Anode towards the Development of Sodium-Ion Battery.” Nano Energy, vol. 70, 2020, p. 104520., doi:10.1016/j.nanoen.2020.104520.
3. Sonia, Farjana J., et al. “Enhanced and Faster Potassium Storage in Graphene with Respect to Graphite: A Comparative Study with Lithium Storage.” ACS Nano, 2019, doi:10.1021/acsnano.8b08867.





## 5 Days workshop on Solar Off-grid Entrepreneurship Training Program (16<sup>th</sup> - 20<sup>th</sup> March 2020)

The Solar Off-grid Entrepreneurship training program aims to equip the participants with the theoretical, practical as well as commercial aspects required to make it a successful venture. The training is coordinated by Prof. Chetan Singh Solanki and will cover the concepts of world energy scenario, solar PV technology, practical aspects of using solar PV modules, battery technologies, technical details of DC appliances, PV system design, hands on training on PV system installation and maintenance, PV system cost estimations, payback period calculations, aspects of running off-grid solar business, etc. The training will consist of 50% teaching in the class room which will cover the fundamentals, technical specifications, standards, solar PV system design etc. and 50% hands on training. The certificate will be provided based upon the result outcomes of the 30 mins quiz that'll be taken every day.

## Advisory Committee Meeting and Industry Workshop

NCPRE has been meeting International Advisory Committee annually since 2011. NCPRE's 9<sup>th</sup> Advisory Committee meeting is scheduled to be held on Friday, February 21, 2020, followed by a one-day Workshop with Indian PV industry leaders on Saturday, February 22, 2020. The inputs are provided by the Advisory Committee such as Prof. Sir Richard Friend (Cavendish Professor of Physics, Cambridge University), Prof. Armin Aberle (NUS, & CEO- SERIS), Prof. Richard Corkish (Chief Operating Officer, Australian Centre for advanced Photovoltaics, University of New South Wales), Dr. William Tumas (Associate Laboratory Director, Chemical & Material Science, NREL), Prof. Gary Hodes (Department of materials and Interfaces, Weizmann Institute of Science), Prof. Ralph Gottschalg (Fraunhofer Centre for Si Photovoltaics (CSP), Germany & Professor, Anhalt University of Applied Science), Mr. Ardeshir Contractor, Founder and CEO, AA India and Professor of Practice, Ohio State University; other professors from IIT Bombay. Prof. Subhasis Chaudhari (Director, IIT Bombay) will be chairing the committee of this advisory meeting.



### Do You Want to Start Your Own Business In Solar?



Join

## SOLAR OFF -GRID ENTREPRENEURSHIP TRAINING

**Dates : March 16-20, 2020**  
**HANDS-ON TRAINING SESSION**

**The Courses Includes :**

- Theoretical Aspects
- Practical Aspects
- As well as Commercial Aspects

**Who are eligible:**

- ITI/Diploma in Electrical or Electronics with 2 years of experience
- Any engineering graduate

Only 20 seats per state !



Prof. Chetan Singh Solanki

Contact us : 022 2576 4475/80/76      Reg Link : [http://www.ncpre.iit.ac.in/ncpre\\_registration/trainingprogram\\_form.php?workspid=MjA=](http://www.ncpre.iit.ac.in/ncpre_registration/trainingprogram_form.php?workspid=MjA=)



### Contact details:

NCPRE website: [www.ncpre.iitb.ac.in](http://www.ncpre.iitb.ac.in)

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- All faculty, Students and Staff at NCPRE