GIAN COURSE ON

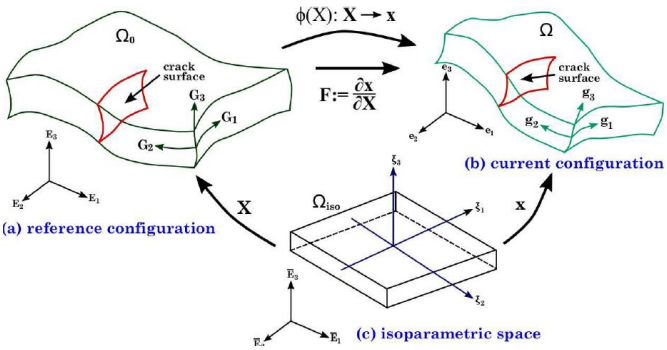
Computational Fracture Mechanics for Photovoltaic Reliability

Indian Institute of Technology Delhi

13 – 23 May 2019

Overview

Photovoltaic (PV) solar cells convert the solar energy into electricity. Solar energy is a renewable, sustainable, non-polluting, abundantly available and clean energy. Therefore, it is one of the fastest growing technologies in the World. Cell cracking is an important problem in the manufacturing of PV modules, which impacts the yield strength and hinders the progress towards the usage of thinner Silicon wafers. The micro-cracking leads to lower conversion efficiency and hence power losses in the range of 7-21%. Hence, novel technologies are required for the efficient design of solar cell architectures to avoid/tolerate fracture in brittle Silicon, apart from material savings, such that ultra-thin solar cells with enhanced operating life can be developed. As a result, significant fundamental and applied research is required, to achieve: (i) the improved durability and sustainability, (ii) integration into the building technologies and (iii) the evolution of smart cells suitable to new climate zones in the World. Furthermore, considering long service life of solar cells under varied environmental conditions, the related degradation phenomena also play a significant role on the performance. On the other hand, there is urgence to develop new qualification standards and accelerated degradation tests that are consistent with the climate zones of emergent countries, to open new markets for the PV industry.



The aim of this 2-module short course is to present the state-of-the-art and the most recent developments in the areas of computational fracture mechanics to simulate and study the influence of cracks in Silicon based solar cells on the current-voltage characteristics, under the action of mechanical, thermal, electrical, and chemical fields. To begin with relevant advanced computational methods to study crack growth in three dimensions will be discussed. This is followed by a review of relevant computational techniques to estimate the current-voltage characteristics under multiple fields. Later on the discussed technologies will be extended to study the influence of cracks in Silicon based solar cells on the power output characteristics. Some live demonstrations are also planned.

Objectives

The primary objectives of the course are as follows:

a) Expose the participants from PV companies, composite laminate producers, technicians working in public and private laboratories for material qualification, and researchers (PhD students, post-doctoral researchers and faculty members) to the problems of durability and reliability of Silicon-based photovoltaics.
b) Provide the knowledge on computational methods for laminates structures and fracture mechanics required to characterize PV modules, assess their durability, develop novel testing methods, and evaluate the impact of environmental loading and aging phenomena onto electric power-losses.
c) Provide the knowledge of experimental methods to assess the forms of degradation affecting PV modules in the field or in the lab, and understand their impact on electrical power-losses.
d) Enhance the capabilities of the participants to identify the proper computational schemes suitable for the study of nonlinear fracture mechanics problems in composites, under the action of multiple fields, which is a complex topic, but of paramount importance in materials for energy applications.

<table>
<tr><td>Modules</td><td>A: Computational Fracture Mechanics (13 – 17 May 2019)
This module covers fundamentals and advanced topics of nonlinear fracture mechanics including the phase field approach to fracture and the cohesive zone model; molecular dynamics; multi-scale formulations; finite element implementation strategies for statics and dynamics; coupled problems due to heat transfer and moisture diffusion.

B: Photovoltaic Reliability (18 – 23 May 2019)
This module covers silicon cracking, electric models of silicon semiconductor in the presence of cracks, impact loading effects; modelling, simulation and experiments of accelerated and environmental ageing effects; viscoelasticity and ageing of polymers; fracture and fatigue of materials composing photovoltaic modules.</td></tr>
<tr><td>Venue</td><td>Indian Institute of Technology Delhi</td></tr>
<tr><td>Who should attend</td><td>▪ Executives, engineers and designers from industries and government organizations including R&D laboratories.
▪ Student at all levels (BTech/MSc/MTech/PhD) or Faculty from academic institutions and technical institutions.</td></tr>
<tr><td>Course Registration Fees</td><td>The participation fees for the course is as follows:
<table>
<tr><td></td><td>One module</td><td>Both modules</td></tr>
<tr><td>Research scholars/ Students</td><td>Rs. 5,000/-</td><td>Rs. 7,500/-</td></tr>
<tr><td>Faculty</td><td>Rs. 10,000/-</td><td>Rs. 15,000/-</td></tr>
<tr><td>Working professionals</td><td>Rs. 15,000/-</td><td>Rs. 20,000/-</td></tr>
<tr><td>Participants from abroad</td><td>US $500</td><td>US $750</td></tr>
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The above fees (inclusive of GST) include the use of all instructional materials assigned for the course and laboratory equipment usage charges.</td></tr>
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The Faculty

Prof. MARCO PAGGI is a Professor (December 2017-present) of Structural Mechanics at the IMT School for Advanced Studies Lucca, Italy. He is the Director of the Research Unit MUSAM - Multi-Scale Analysis of Materials, and of the experimental laboratory MUSAM Lab. He received his Ph.D. in Structural Engineering in 2005 from Politecnico di Torino, Italy. He has been appointed visiting or adjunct professor in a number of institutions, including the Laboratoire de Modélisation et Simulation Multi Echelle of the Université Paris EST, University of Trento, University of Pisa, Politecnico di Torino. He has been recipient of the Young Scientist Award by the European Structural Integrity Society in 2010. Since March 2013 he is a Fellow of the Young Academy of Europe. He is member of the Task 13 Committee on Performance and Reliability of Photovoltaic Systems of the International Energy Agency, Photovoltaic Power Systems Programme (IEA-PVPS) since October 2014. He has been principal investigator of two projects granted by the European Research Council on computational methods and reliability of photovoltaic materials.

Prof. Paggi is author of 3 textbooks on structural mechanics and thermoelasticity and of more than 150 publications in international refereed journals on computational methods for nonlinear partial differential equations, fracture mechanics, contact mechanics, material models for renewable energy applications, durability and ageing of polymers and adhesives, homogenization, numerical methods for coupled problems.

Dr. PATTABHI R BUDARAPU is an Assistant Professor in the School of Mechanical Sciences, IIT Bhubaneswar. He received his Ph.D. degree from Bauhaus University of Weimar, Germany, M.E. degree from IISc Bangalore, and B.Tech. degree from Sri Venkateswara University, Tirupati. Previously he worked as a postdoctoral fellow at IMT Lucca, Italy and as an Engineer at GE, Bangalore and scientist at DRDO Bangalore. His areas of interest include: adaptive multiscale methods for fracture, influence of cracks in photovoltaic solar cells and development of efficient materials for energy applications.

Dr. NARESH V DATLA is an Assistant Professor in Department of Mechanical Engineering at IIT Delhi. He received his Ph.D. degree from University of Toronto, Canada, M.E. degree from IISc Bangalore, and B.Tech. degree from NIT Warangal. Previously he worked as a postdoctoral fellow at Temple University, Philadelphia, and as a scientist at ISRO Bangalore. His current research interests include fracture and durability of multilayer structures that include photovoltaic modules and composite joints.

Registration Process

Step 1: GIAN web Portal Registration: Register in the GIAN portal i.e. http://www.gian.iitkgp.ac.in/GREGN/index by paying Rs. 500/- online. Registration to this portal is the one-time affair and will be valid for the lifetime of GIAN. Please note that course fee is separate.

Step 2: Login to the GIAN portal with the registered User ID and Password. Choose for the Course registration option. Select the course titled "Mechanical Design for Price Sensitive Markets" from the list and click the "Save" option. Confirm your registration by clicking the suitable option.

Step 3: Course Shortlisting: Candidates will be intimated through email regarding their selection.

Step 4: Course Fee Remittance: Once you receive the intimation from the Course Coordinator, the fee (as applicable) need to be paid.

Step 5: Mode of payment: The details of fee payment by Electronic Clearing Service/ RTGS/ Demand Draft in the name of "IITD CEP ACCOUNT". The bank details are as follows:

1	Bank Account No.	36819334799
2	Bank Address	State Bank of India, IIT Delhi, Hauz Khas, New Delhi 110016
3	Beneficiary	IITD CEP Accounts
4	IFSC code	SBIN0001077
5	MICR code	110002156
6	SWIFT code	SBININBB547
7	IITD PAN No.	AAATI0393L
8	Account Type	Savings

The participants are required to send the Demand Draft for the registration fee to the Course Coordinator.

Step 6: Fill up the registration form (**Given in Page no. 6 of this brochure**), by providing details of the bank transaction. Send the scanned copy of registration form to the Course coordinator at **datla.iitd@gmail.com** before **30th April 2019**.

Course Coordinator

Dr. Naresh Varma Datla, Assistant Professor
Department of Mechanical Engineering
IIT Delhi, Hauz Khas, New Delhi 110016
Tel: +91 11 26596071 (O)
Email: datla.iitd@gmail.com

GIAN COURSE REGISTRATION FORM

NAME : _____

DESIGNATION: _____

ORGANIZATION: _____

ADDRESS: _____

_____

_____

EMAIL ID: _____

MOBILE NO.: _____

COURSE NAME: **Computational Fracture Mechanics for Photovoltaic Reliability**

OPTED MODULE(S) (tick any one): A. Computational Fracture Mechanics (13-17 May'19)

B. Photovoltaic Reliability (18-23 May'19)

C. Both modules A and B (13-23 May'19)

Fees payable to "IITD CEP ACCOUNT", SBI, IIT DELHI

TRANSACTION NO. (e-transfer/RTGS/NEFT): _____

DEMAND DRAFT NO.(If paid by Demand Draft): _____

Place: _____

Date: _____ Signature of the Applicant: _____