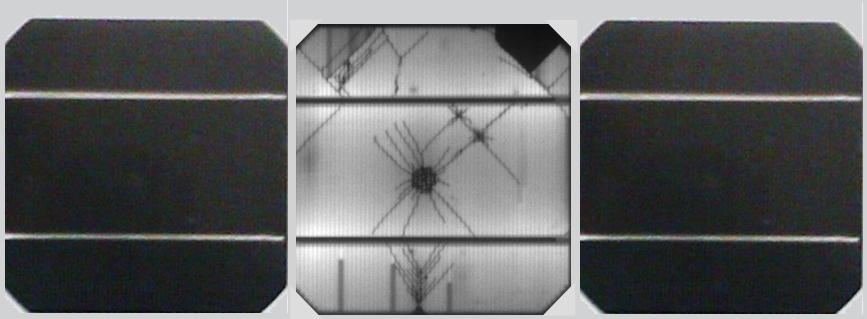
Multi-field and multi-scale Computational Approach to design and durability of Photovoltaic Modules



Marco Paggi
IMT Institute for Advanced Studies Lucca

Workshop ”ERC grants for the excellence of European research”
IMT Institute for Advanced Studies Lucca, Italy
November 11, 2015

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Frontier research

Frontier research:

"… classical distinctions between 'basic' and 'applied' research have lost much of their relevance at a time when emerging areas of science and technology often embrace substantial elements of both. The report therefore adopts the term frontier research, rather than basic research, to reflect this new reality. Frontier research, because it is at the forefront of creating new knowledge, is an intrinsically risky endeavour that involves the pursuit of questions without regard for established disciplinary boundaries or national borders." (European Commission, 2005)

Features:

- World class excellence
- Uncertain but potentially high impact outcomes
- New trajectories
- Sufficient mass and scope to address interdisciplinary topics
- Impact on business and society

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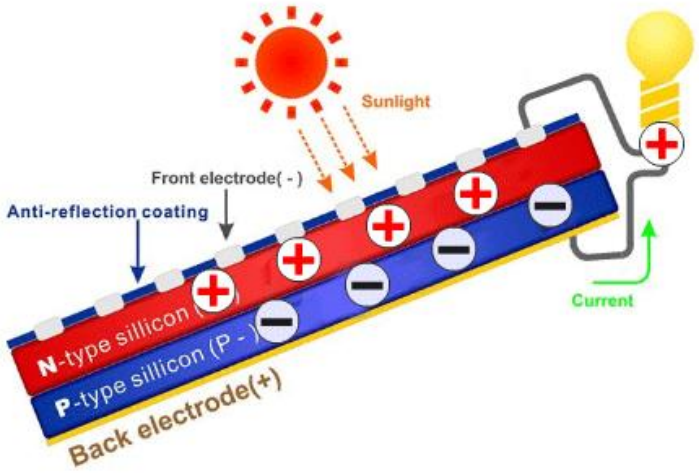
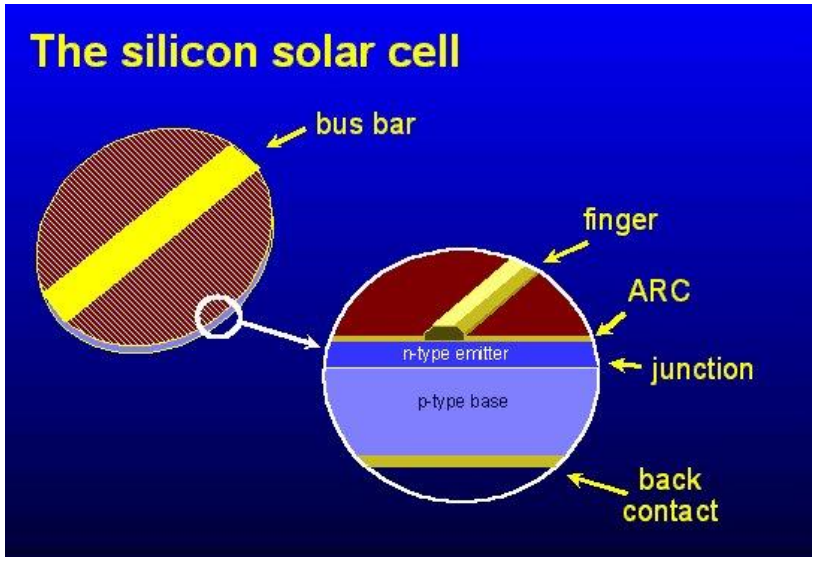
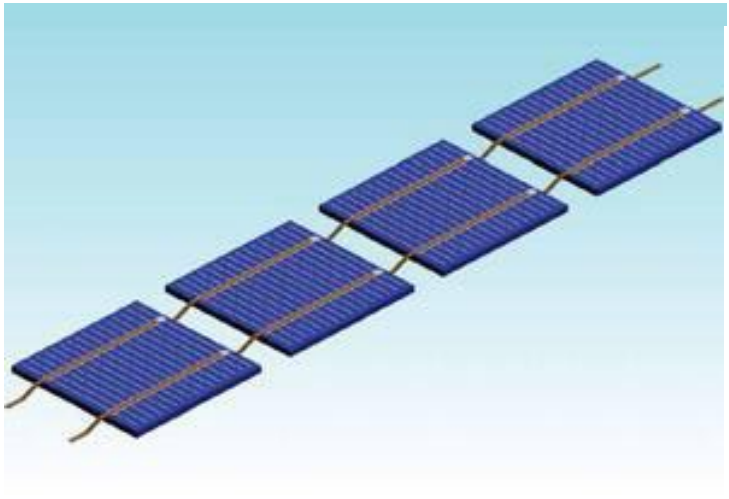
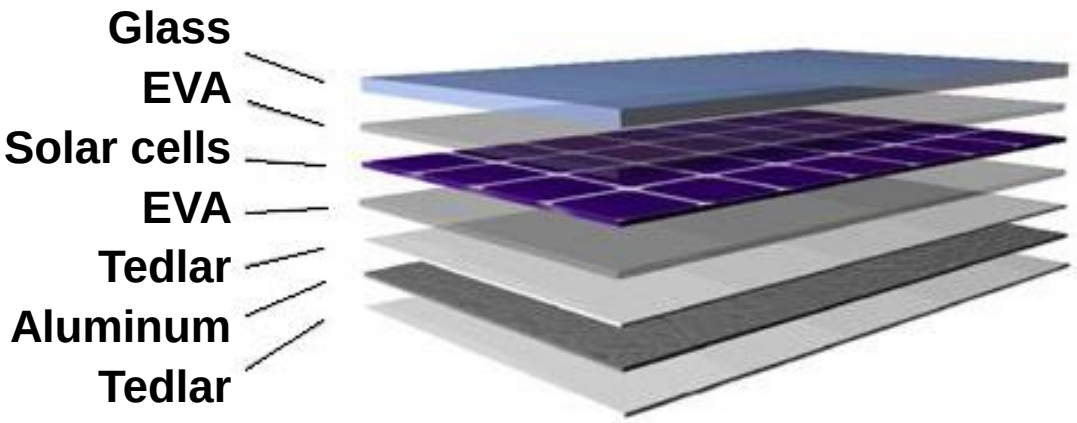
Photovoltaics (PV)









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Applications: from PV parks to building-integrated PV

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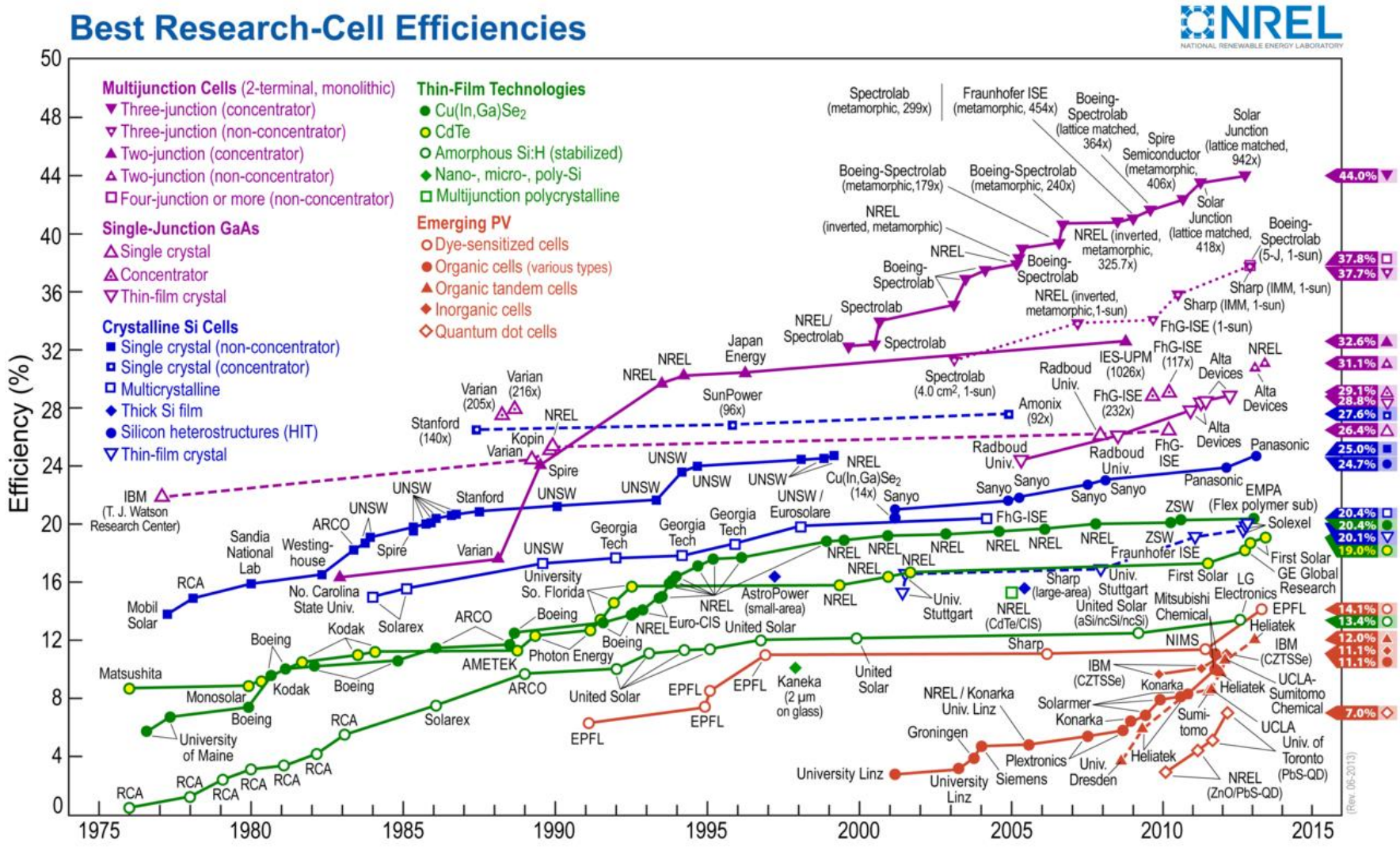
Main focus of the PV community: solar energy conversion efficiency



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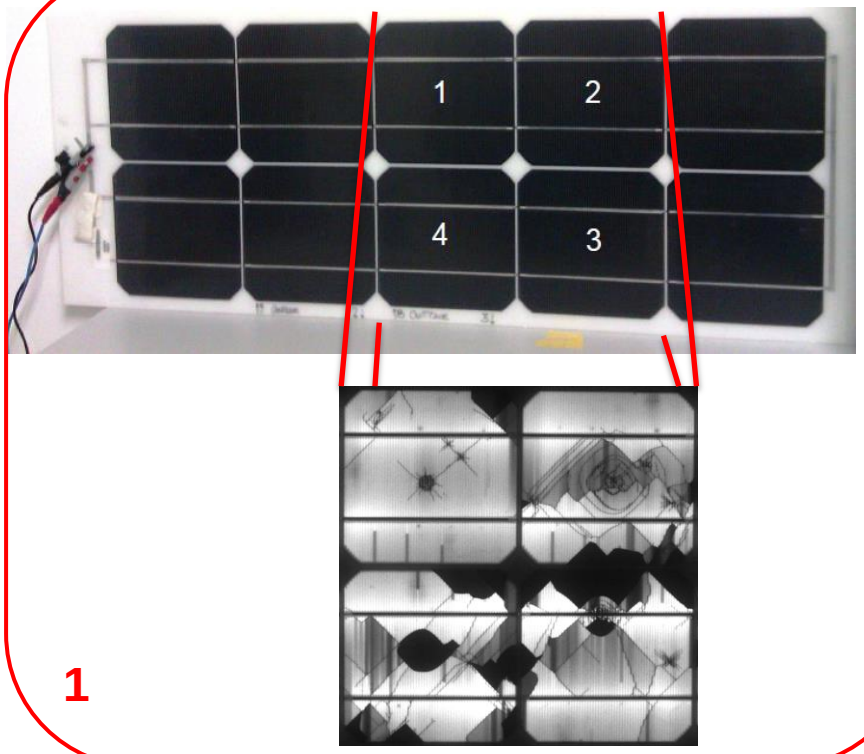
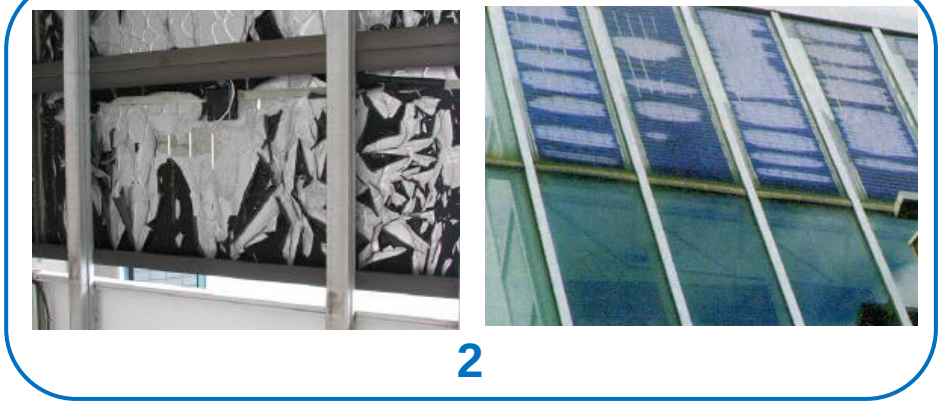
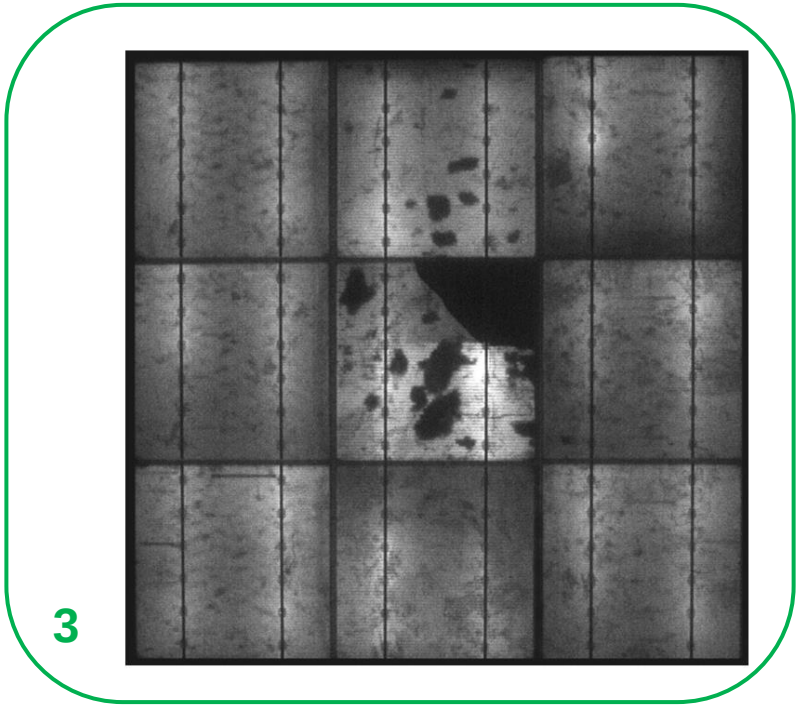
Durability

Some failure modes of PV modules:

1. **Cracks**
2. **Decohesion of the encapsulant**
3. **Moisture-induced degradation**







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Open issues, innovation, impact

Open issues

- Standard accelerated aging tests provide pass/fail criteria based on electrical output only; they reproduce failure modes never observed in the field
- Lack of simulation tools for durability
- Lack of guidelines for nondestructive monitoring in the field

Innovative methods

- Move from the solar cell to the whole PV module laminate
- Multi-physics framework requiring an interdisciplinary view
- New testing methods
- New design criteria for PV modules insensitive to cracking

Impact on society

- More reliable expectation on lifetime of PV technologies
- Better quality control and rating of PV productions
- Reduction of degradation rate from 1%/year to 0.5%/year is equivalent to an increase of the solar energy conversion efficiency from 25% to 27%

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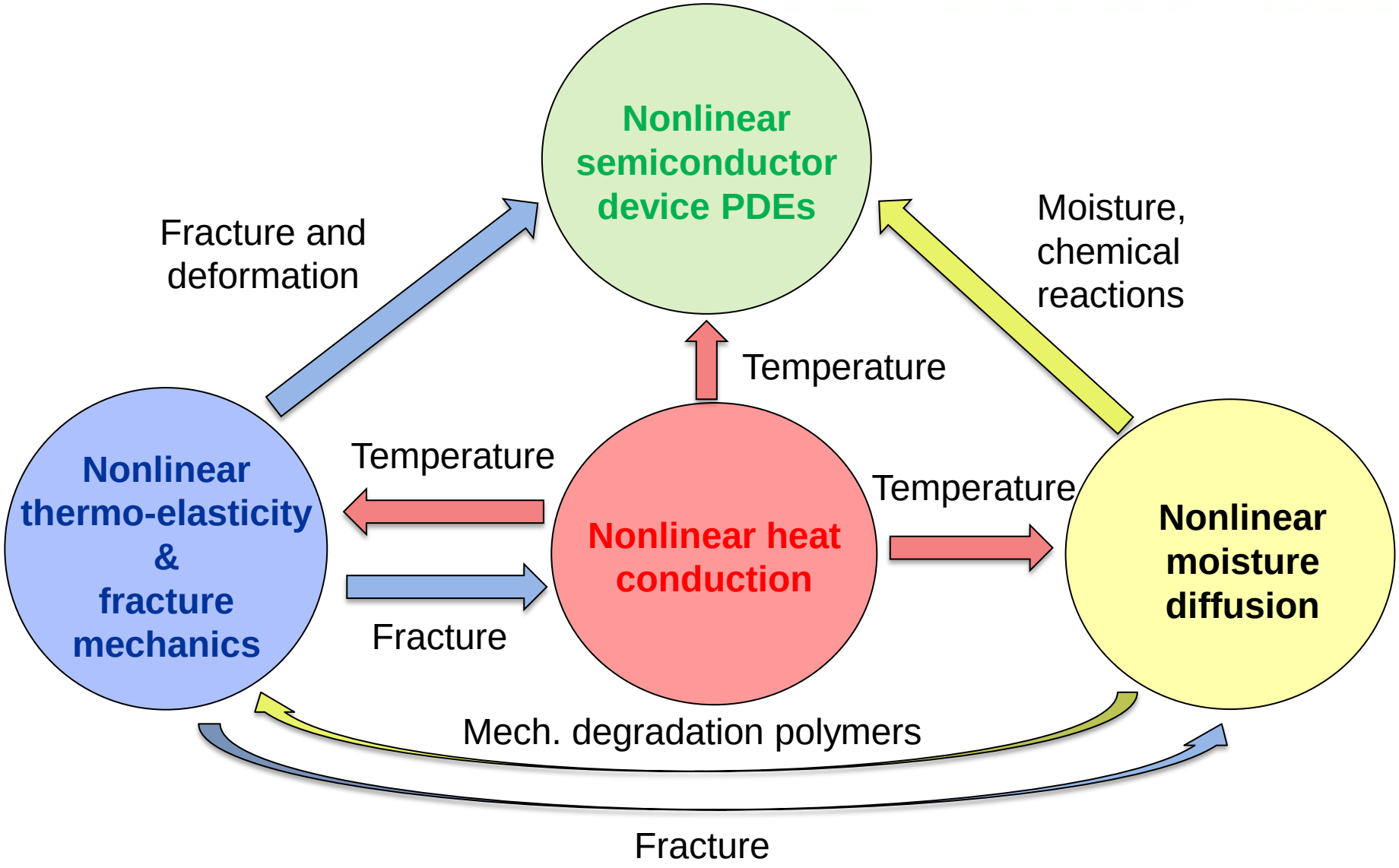
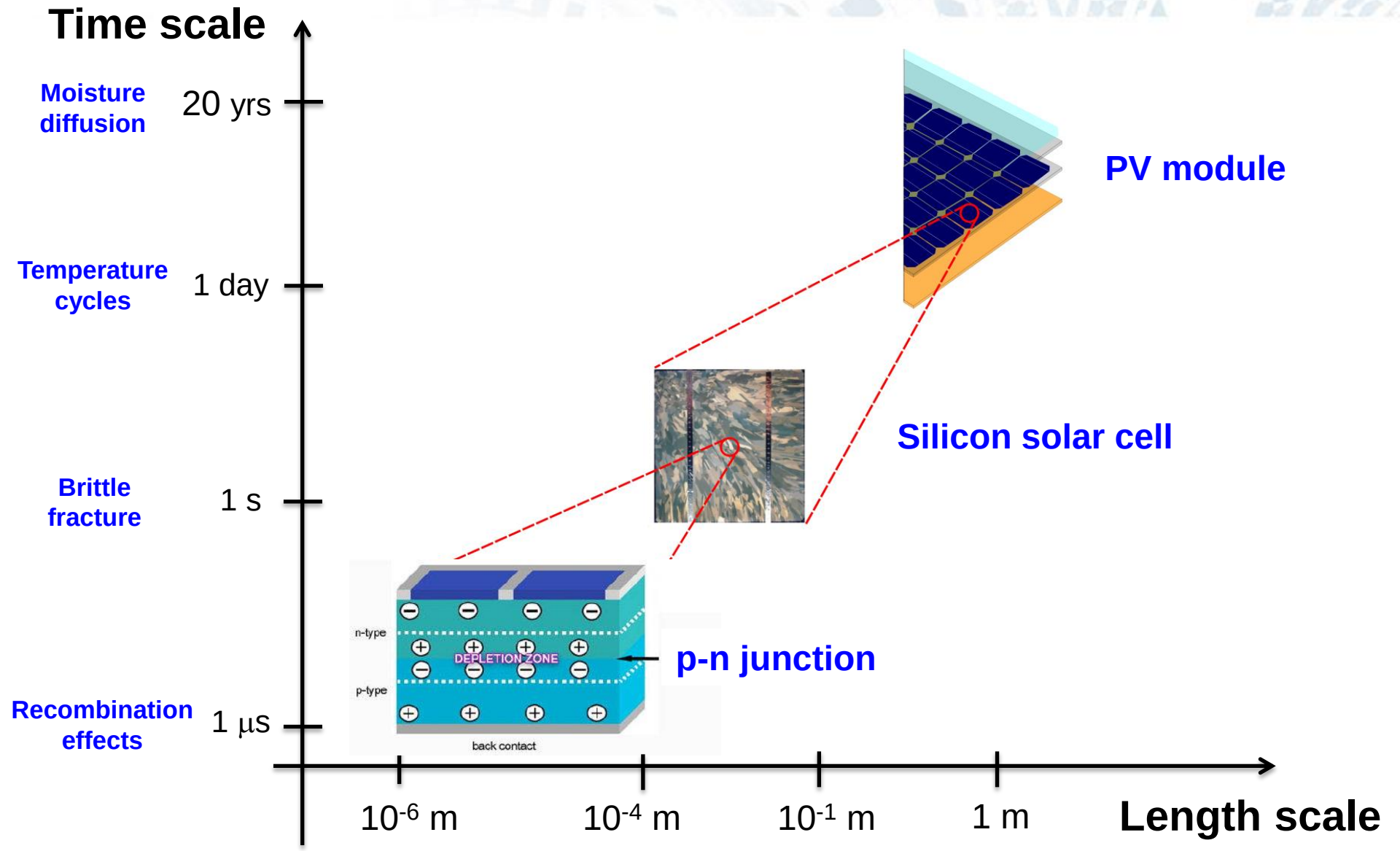
Multi-physics modelling & simulation



Length and time scales



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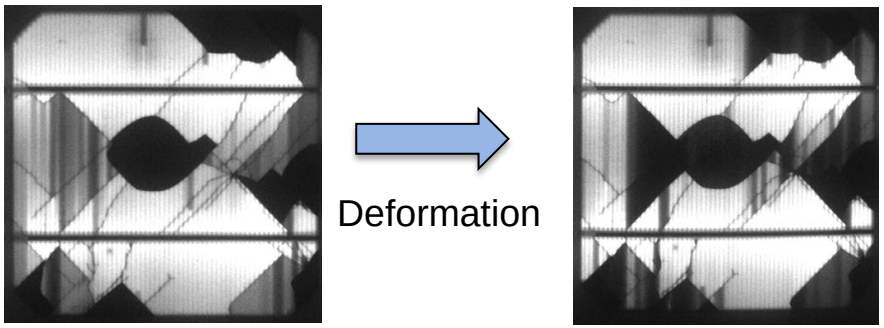
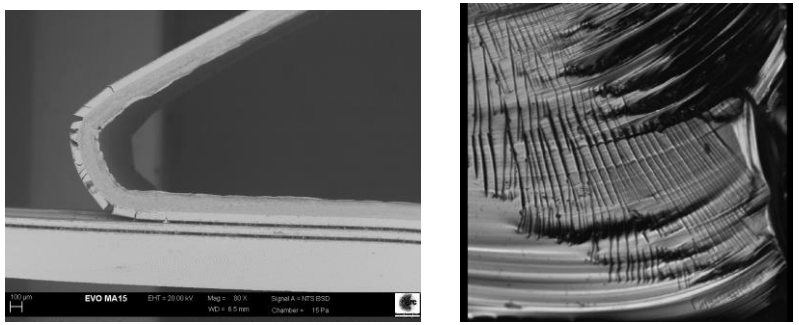
Multi-physics testing

www.imtlucca.it/research/laboratories/musam-lab



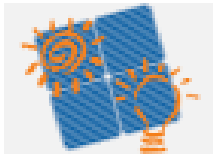
Effect of mechanical field on electric response



Peeling of Silicon thin films inside a SEM

Endorsement and collaborations

International Energy Agency
Photovoltaic Power Systems Programme (PVPS)
Task 13 on Performance and Reliability of Photovoltaic Systems



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Institute for Energy and Transport

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Avigliana, Italy

Applied Materials Italia S.r.l.
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http://musam.imtlucca.it

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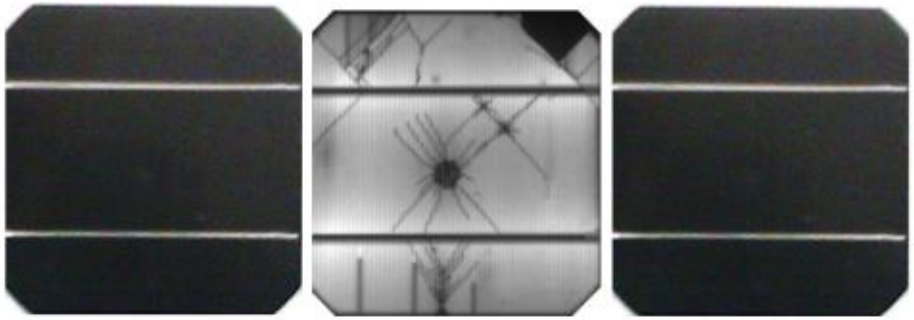

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IDEAS

http://musam.imtlucca.it/CA2PVM.html

Mid-term scientific report:
http://musam.imtlucca.it/Mid-term-report.pdf

MUSAM Annual Report 2014:
http://musam.imtlucca.it/Report_2014.pdf