

Materiales y tecnologías fotovoltaicas

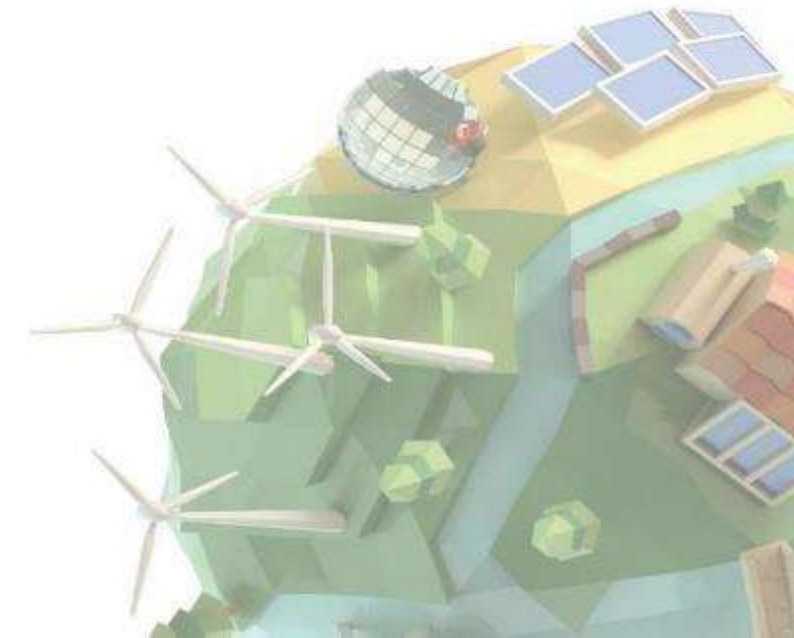
Amaru Palomino Töfflinger, Andrés Guerra, Rolf Grieseler, Roland Weingärtner

Grupo de Ciencia de los Materiales – Sección Física – PUCP



PONTIFICIA
**UNIVERSIDAD
CATÓLICA**
DEL PERÚ

HZB Helmholtz
Zentrum Berlin



PRIMER CONGRESO DE ENERGÍAS RENOVABLES Y
ARQUITECTURA BIOCLIMÁTICA | **CABER 2017**

"Reconstruyendo el Perú Sosteniblemente"



CABER
LIMA- PERÚ 2017

Materials Science Group Physics, PUCP



100 años
PUCP



Roland Weingärtner



Andrés Guerra



Amaru Töfflinger



Rolf Grieseler



Total: 23

4 Scientists (PhD)

6 Phd students

11 Master students

1 Bachelor student

1 Assistant

Deposition

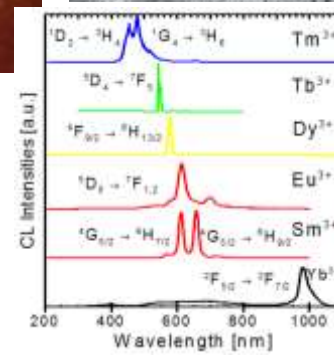
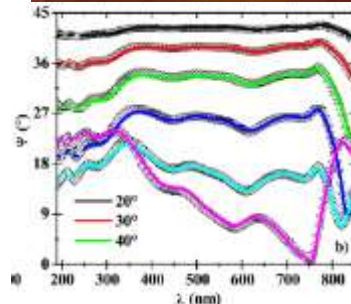
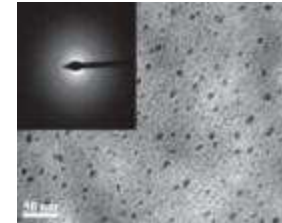
Magnetron sputtering



Thin-films: AlN, SiN, SiC, ITO
Rare-earth doping: Tb³⁺, Yb³⁺



SiC:Tb³⁺



Characterization:

Optical, electrical and structural

- Semiconductor thin-films
- Passivation of silicon surfaces
- Rare earth luminescence
- Soon: SiC:H for the photo-electrochemical water splitting

**Photovoltaics (PV)
Research**

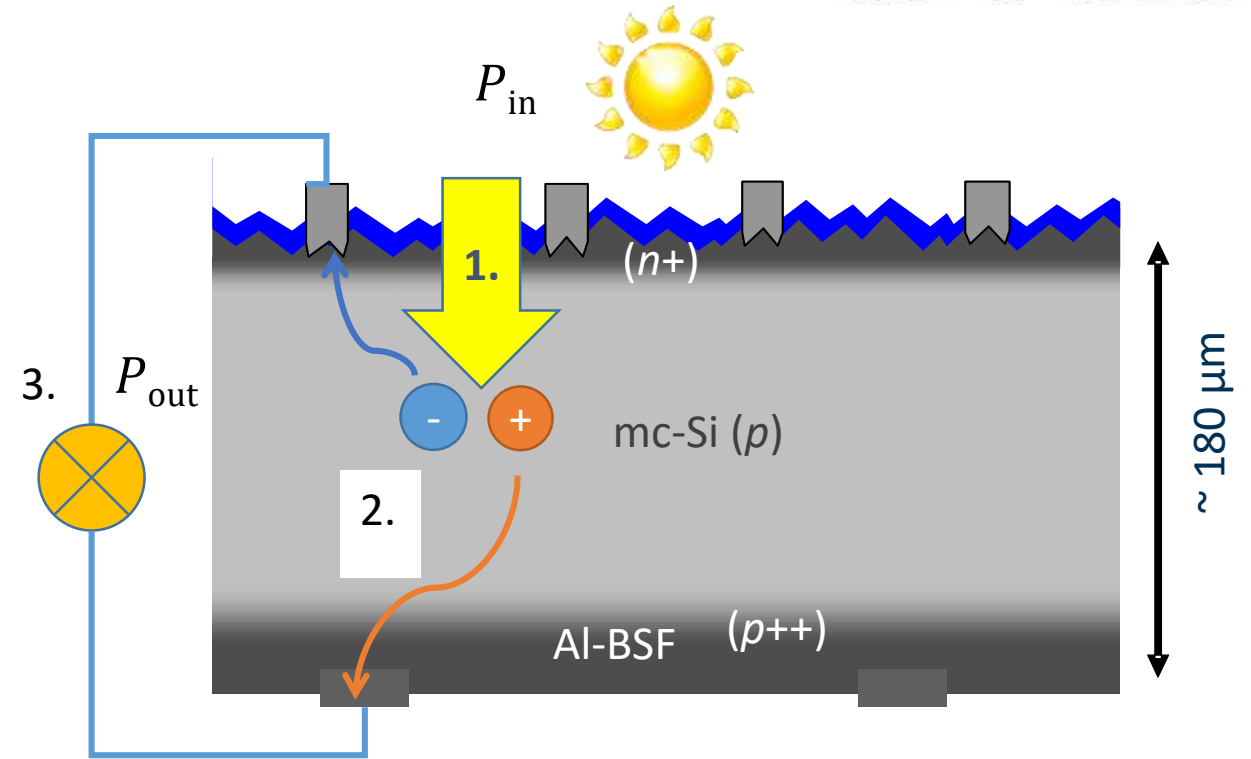
From a PV-panel to a solar cell



Commercial solar cell
Efficiency $\eta = 15-17\%$

Power conversion efficiency:

$$\eta = \frac{P_{out}}{P_{in}} = \frac{I_{mpp} * V_{mpp}}{P_{in}}$$



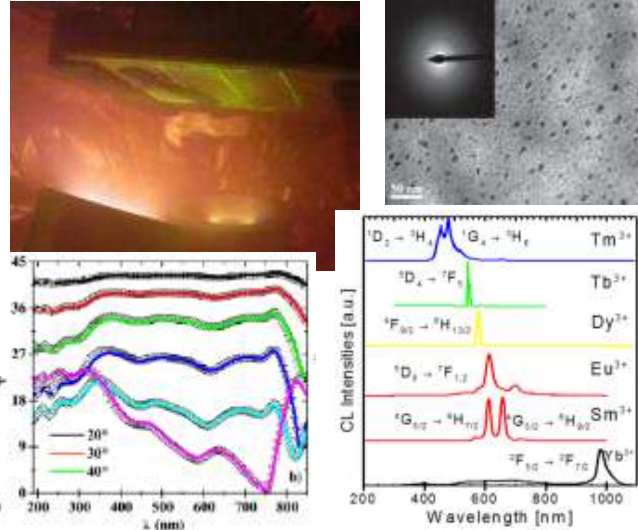
1. Absorption of light and generation of charge carriers
2. Separation of charge carriers (p/n-junction: E-field)
3. Extract photo-voltage and -current -> electric power P_{out}

Materials for PV applications

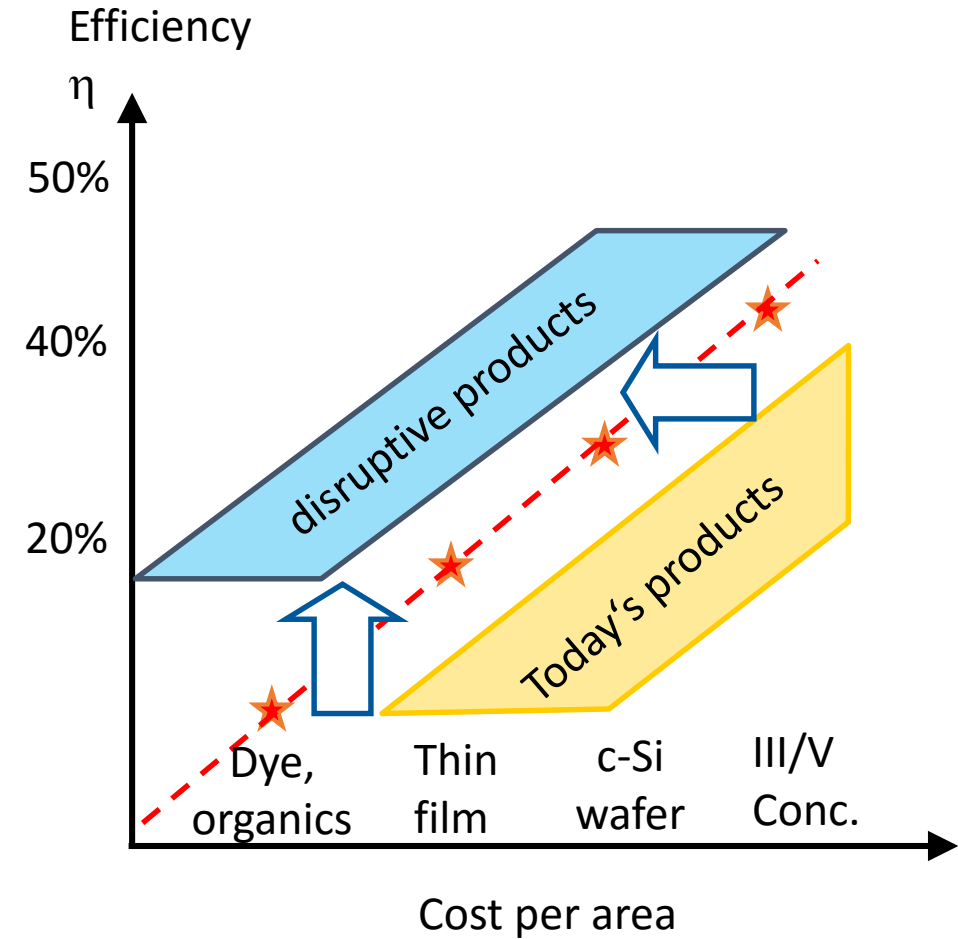
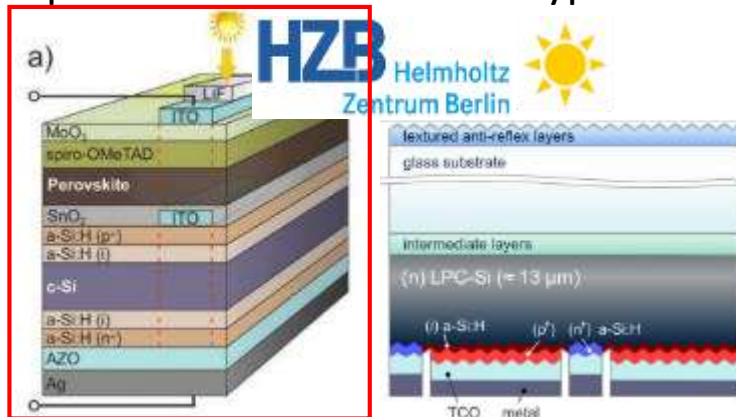
Fundamental research

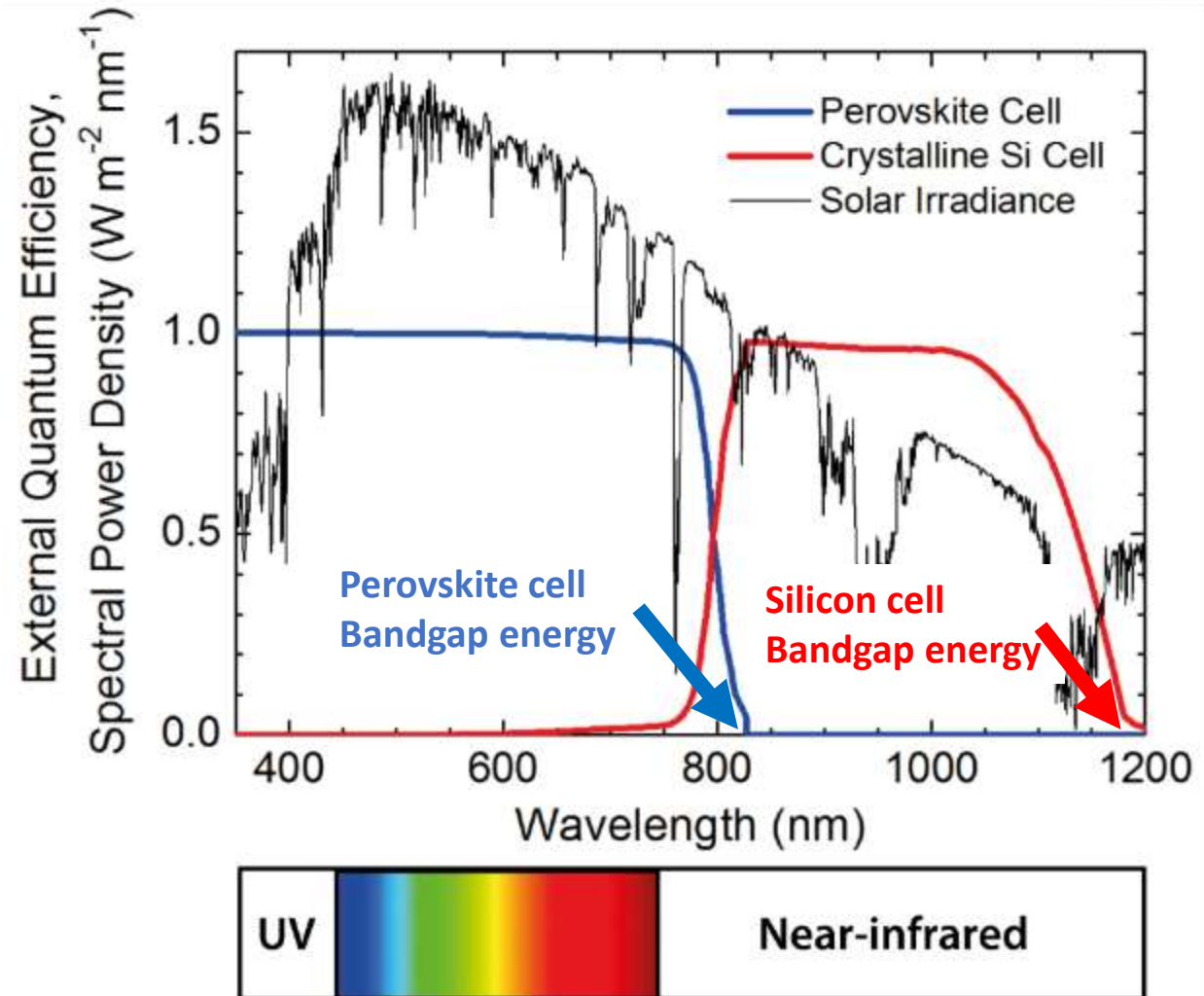
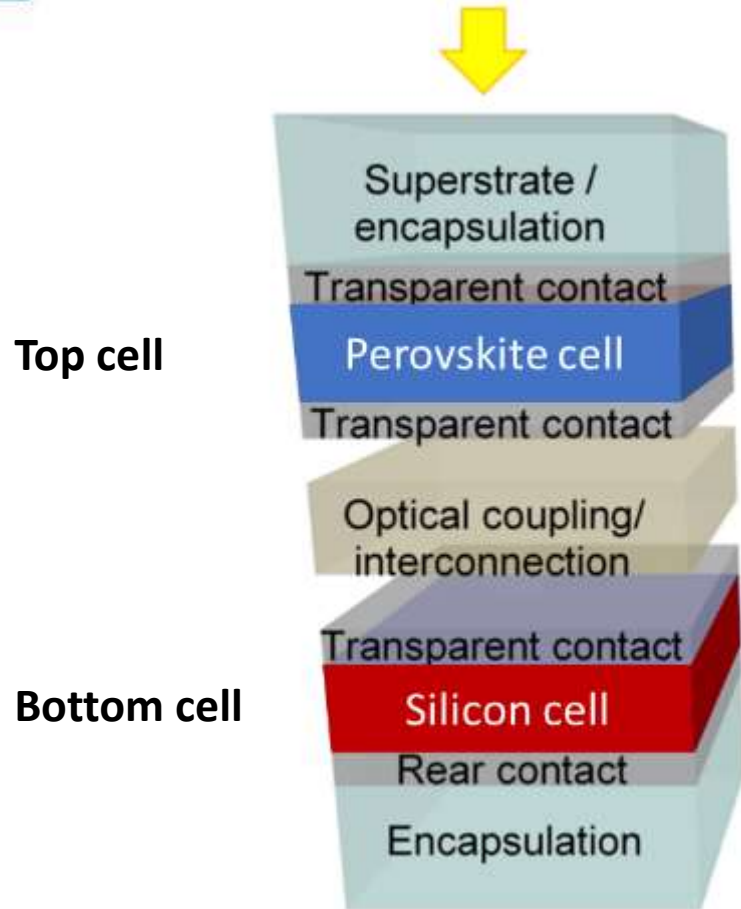
Optical + electrical properties:

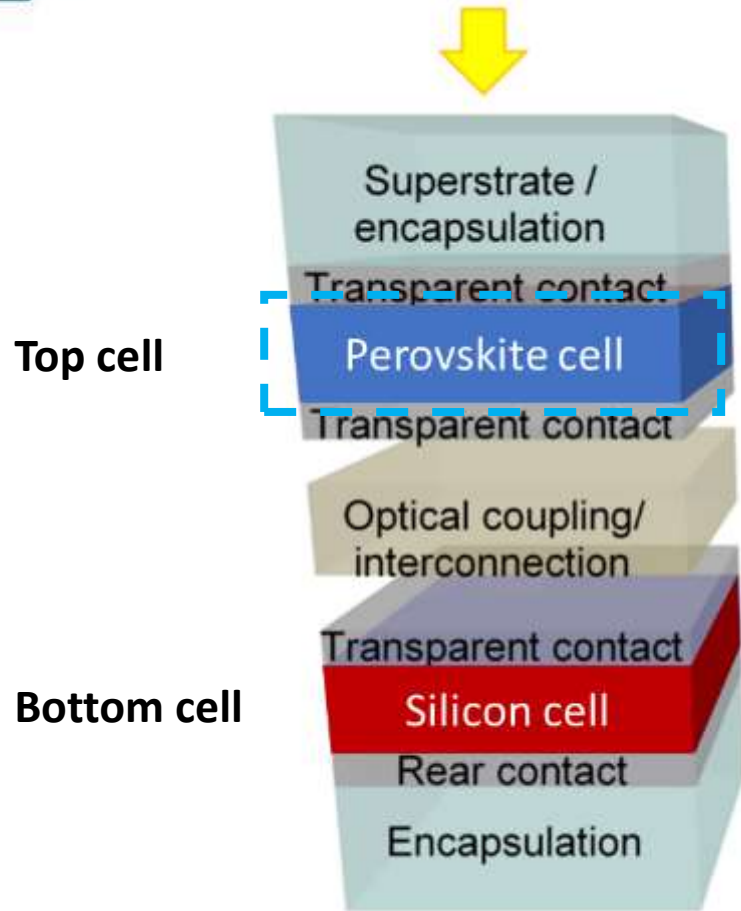
- Semiconductor thin films
- Passivation of silicon surfaces



Cooperation with HZB: Prototype Solar cells





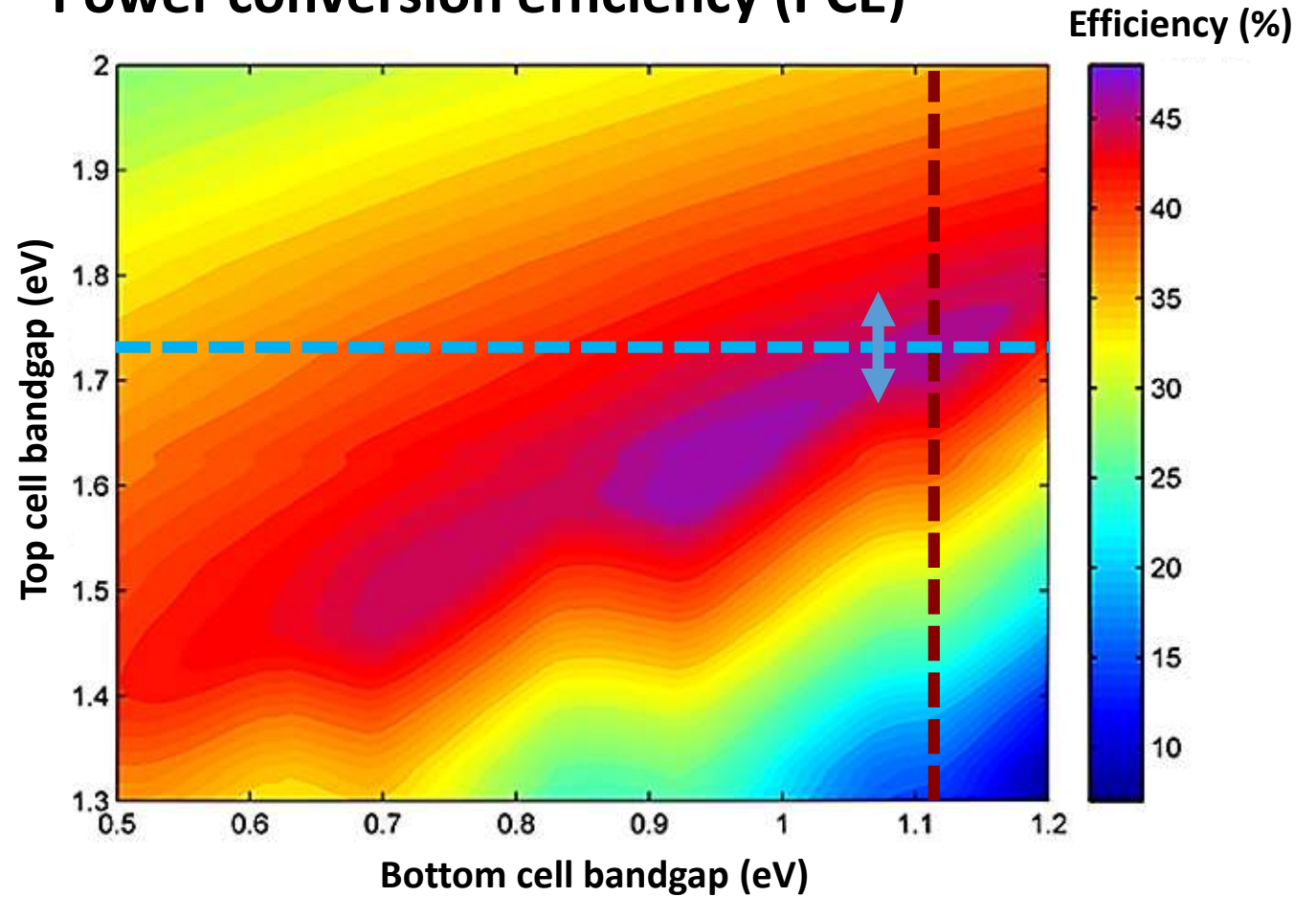


Optical parameters of Perovskite:
Complex refractive index \tilde{n} and bandgap E_g



- Device simulation + design
- Bandgap engineering

Power conversion efficiency (PCE)



S. P. Bremner et al, Prog. Photovolt. Res. App. **16** (2008) 225–33
<http://www.pveducation.org/pvcdrom/tandem-cells>
 HZB: S. Albrecht et al, *Energ. Env. Sci.* **9** (2016) 81-8

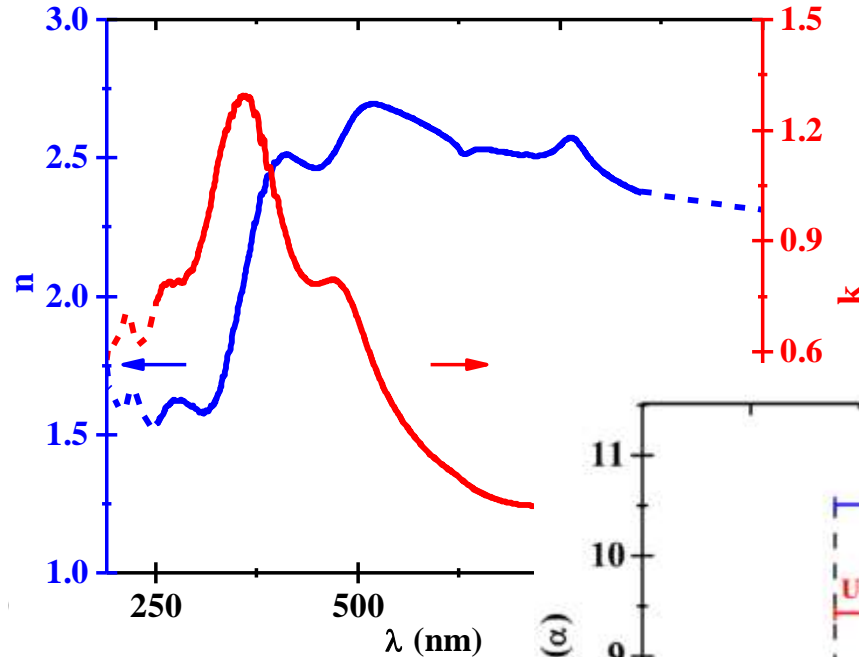
Variable Angle Spectral Ellipsometry (VASE)

Spectrophotometry (R & T)

Optical modeling
↓
Optical parameters
 $\tilde{n} = n + ik$

Band fluctuation model

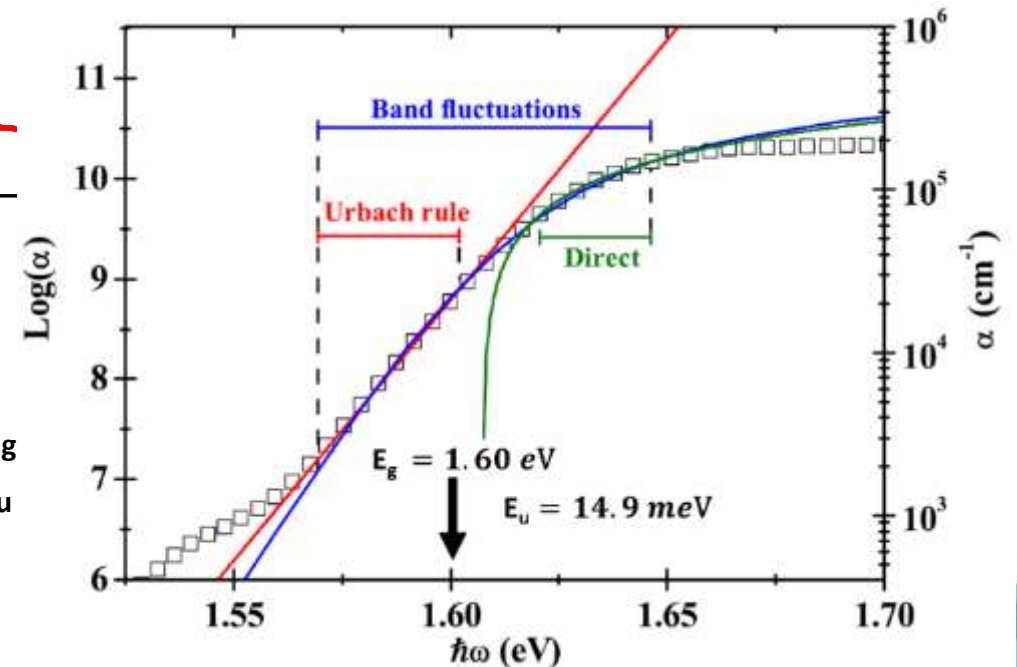
Band gap energy E_g
+ Urbach energy E_u



Andrés Guerra



Alvaro Tejada

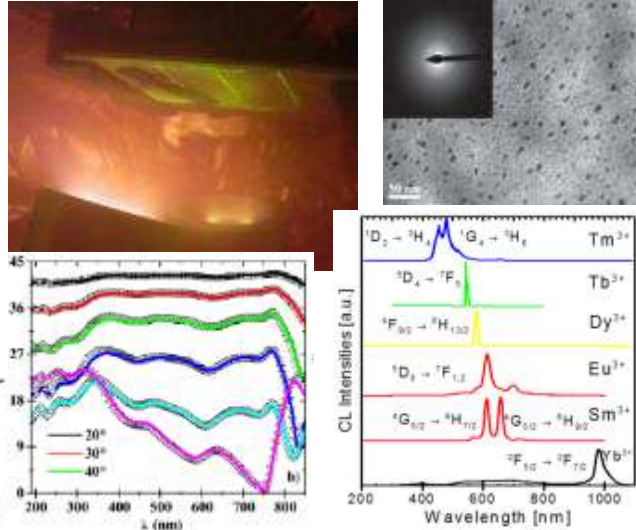


Materials for PV applications

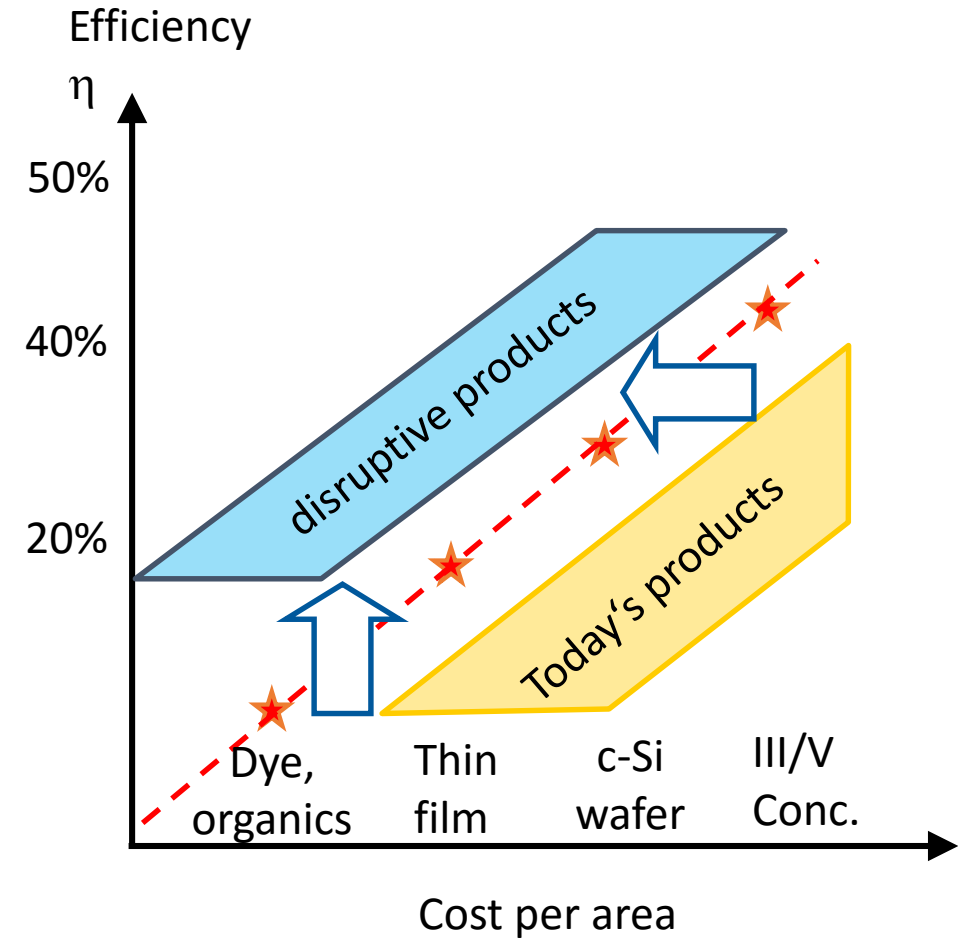
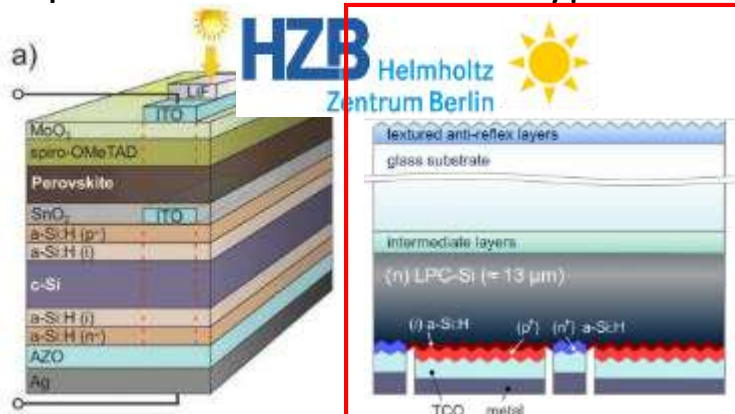
Fundamental research

Optical + electrical properties:

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Cooperation with HZB: Prototype Solar cells

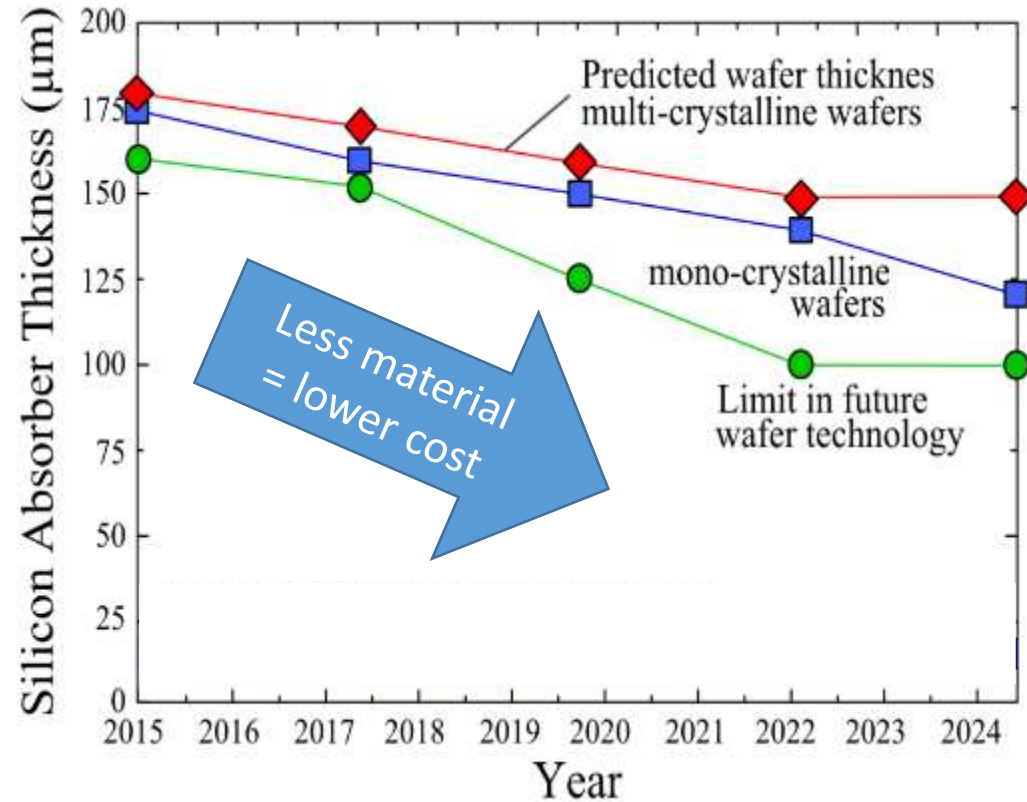
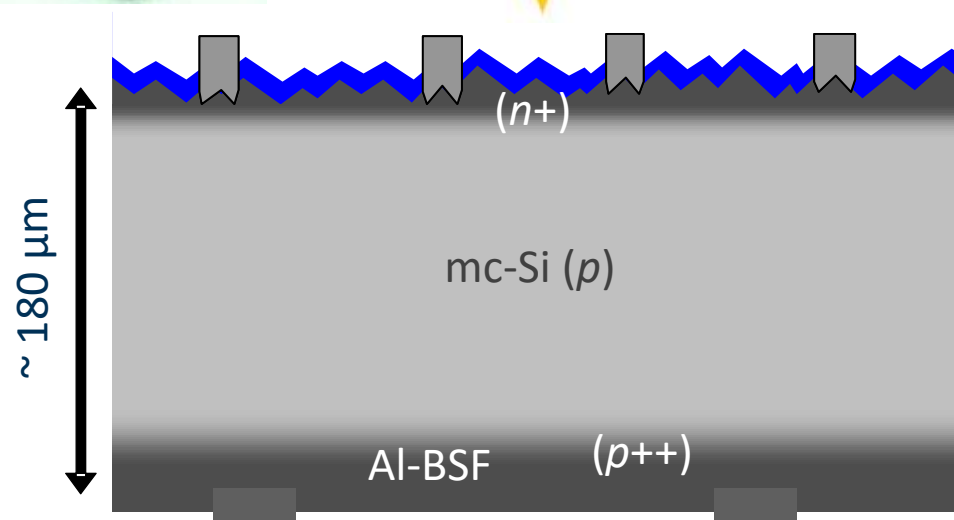


Reduce cost of silicon material

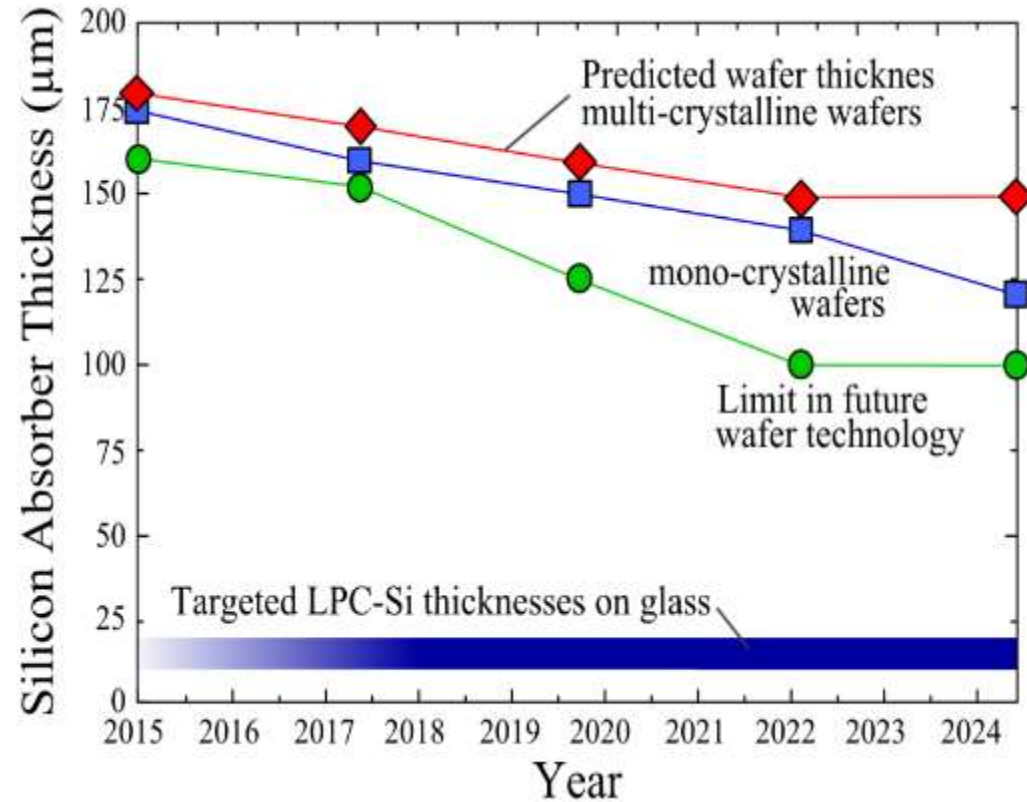
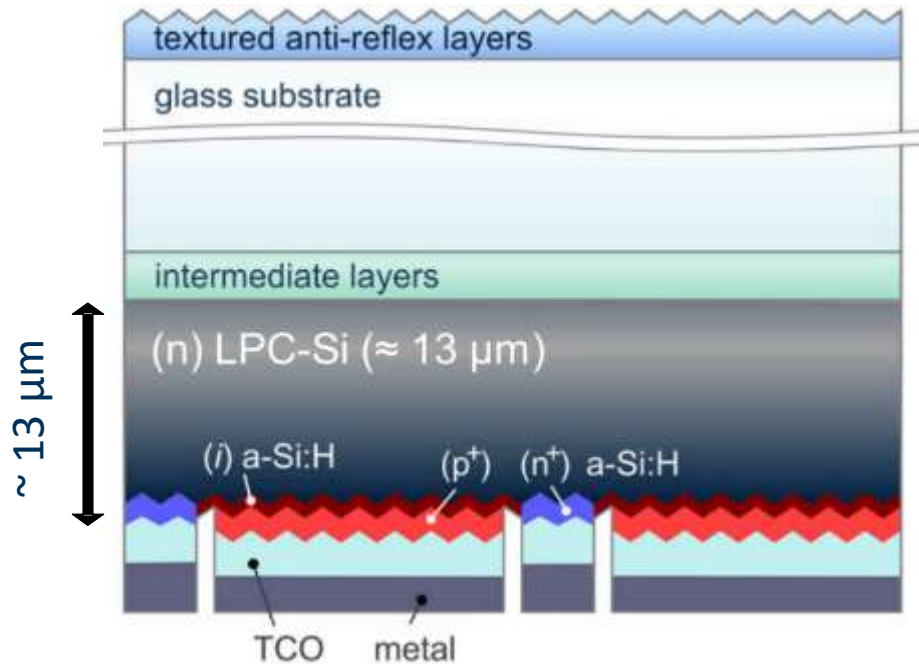
Silicon material: 30 – 40 % of PV module cost



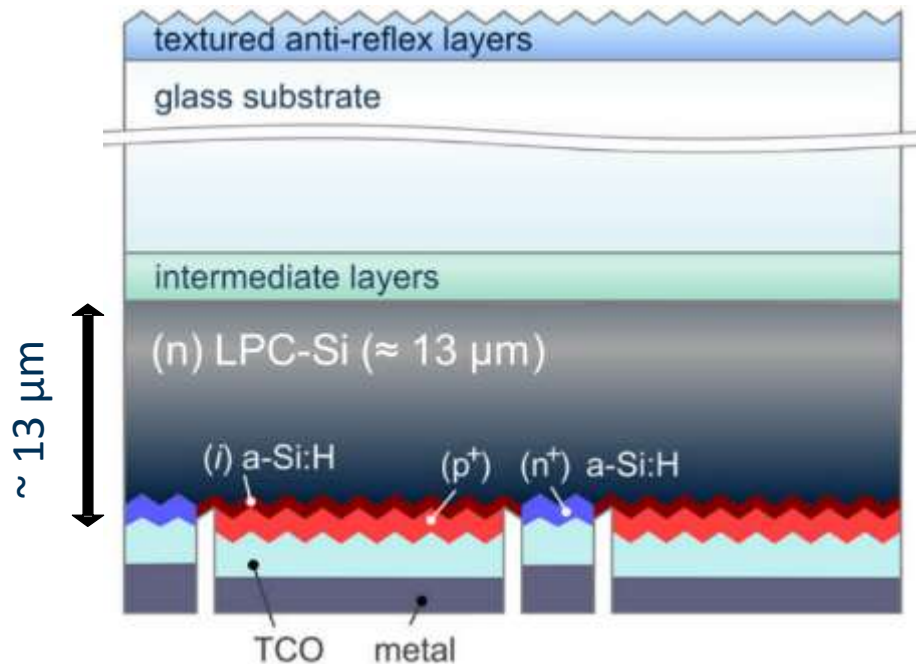
Commercial solar cell
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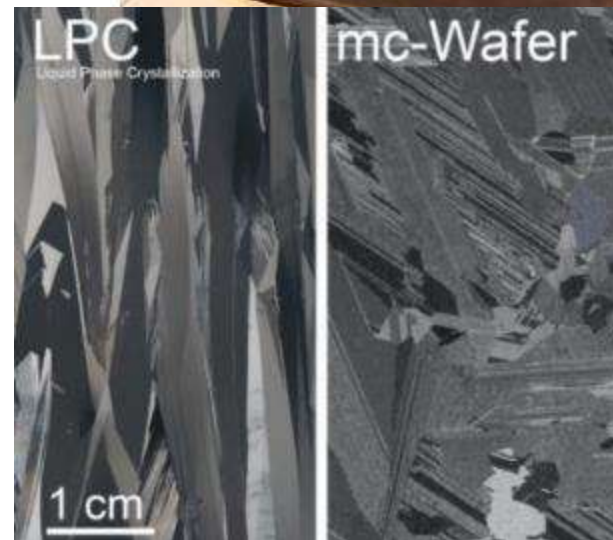
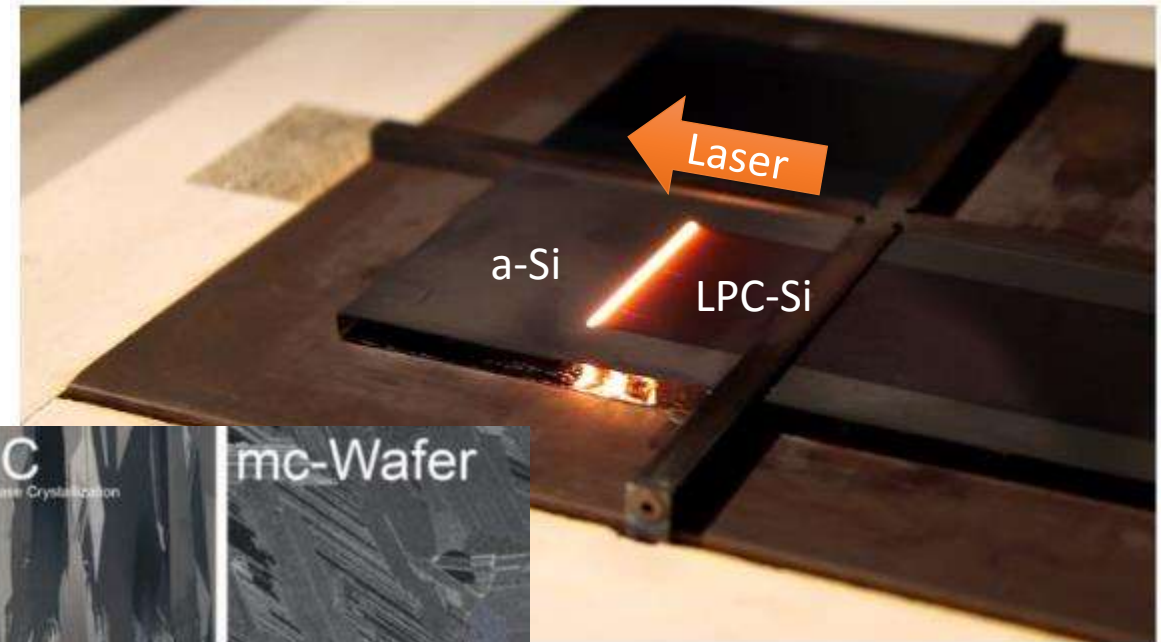
Liquid-phase-crystallized (LPC)-Si solar cells,
Efficiency $\eta = 14.2\%$



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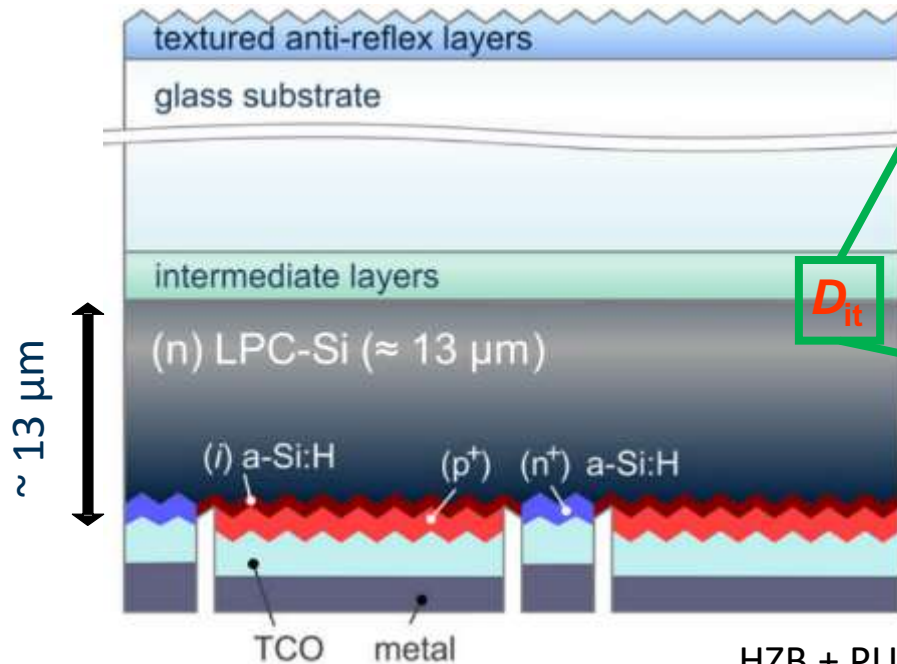


laser-crystallization



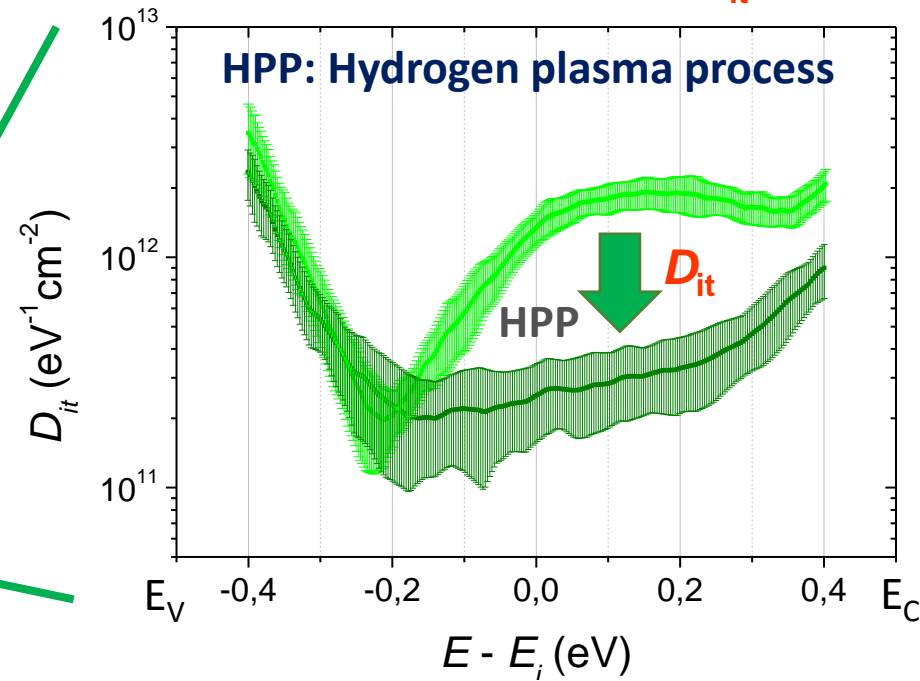
Liquid-phase-crystallized (LPC)-Si solar cells,
Efficiency $\eta = 14.2\%$

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Capacitance-voltage method:

Interface defects states D_{it}



Amaru Töfflinger



Jorge Dulanto

High quality LPC-Si interface passivation

HZB + PUCP joint publications:

N. Preissler, J. A. Töfflinger, et al. (2016) Phys. Status Solidi A 213 (7), 1697

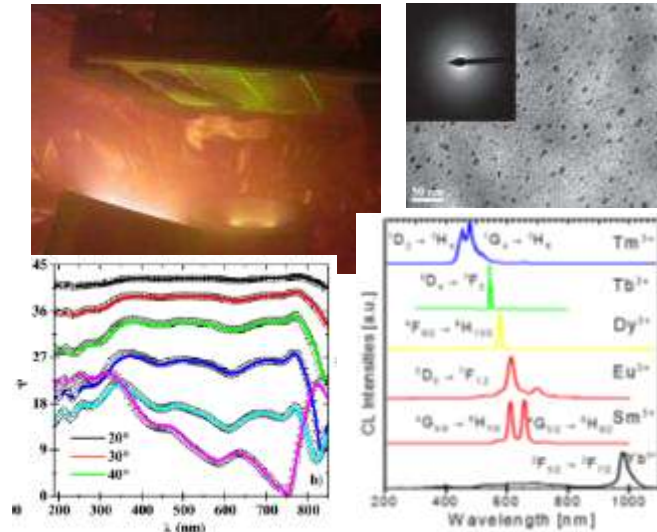
N. Preissler, J. A. Töfflinger, et al. (2017) Progress in Photovoltaics 25, (7), 515

Materials for PV applications

Fundamental research

Optical + electrical properties:

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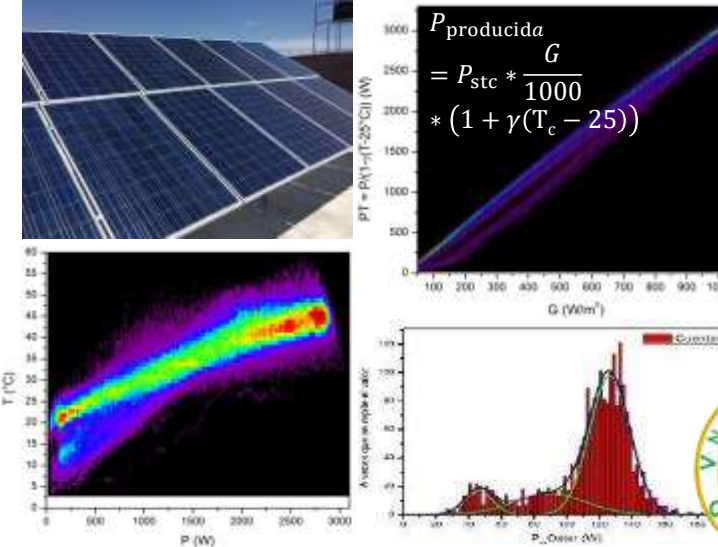
Cooperation with HZB: Prototype Solar cells



*HZB&PUCP: 3 joint publications since 2015

PV systems and technologies

Modeling and yield studies



To be presented by
Sebastian Gomez

Future project:

Quality control under real climate conditions





Acknowledgements



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HZB Helmholtz
Zentrum Berlin

*Institut für Silizium Photovoltaik
PVcomB*



UNIVERSIDAD DE JAÉN

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PNICP contract N° 274-PNICP-BRI-2015