JÜLICH
FORSCHUNGSZENTRUM

NEXTBASE
THE NEXT GENERATION BASELINE

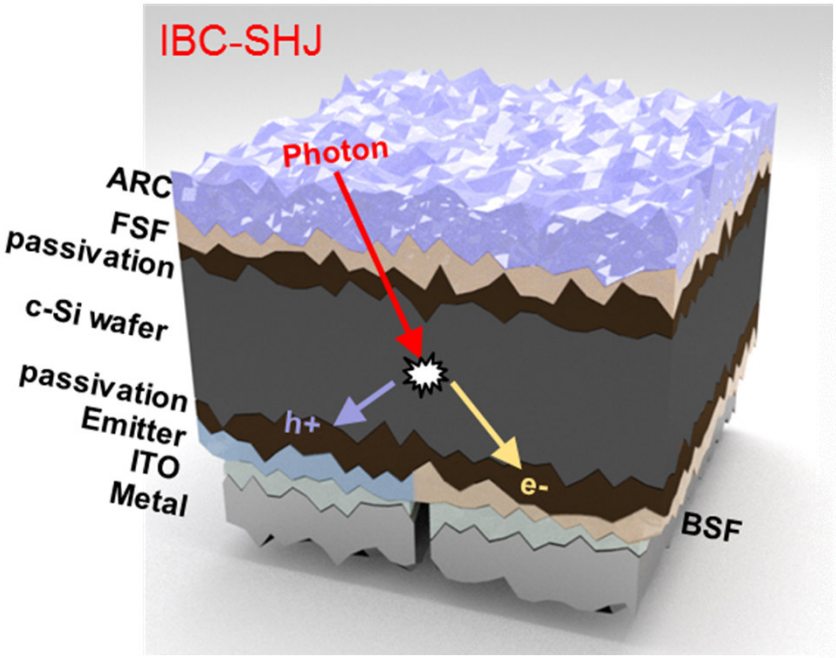
NextBase project (Next-generation interdigitated back-contacted silicon heterojunction solar cells and modules by design and process innovations)

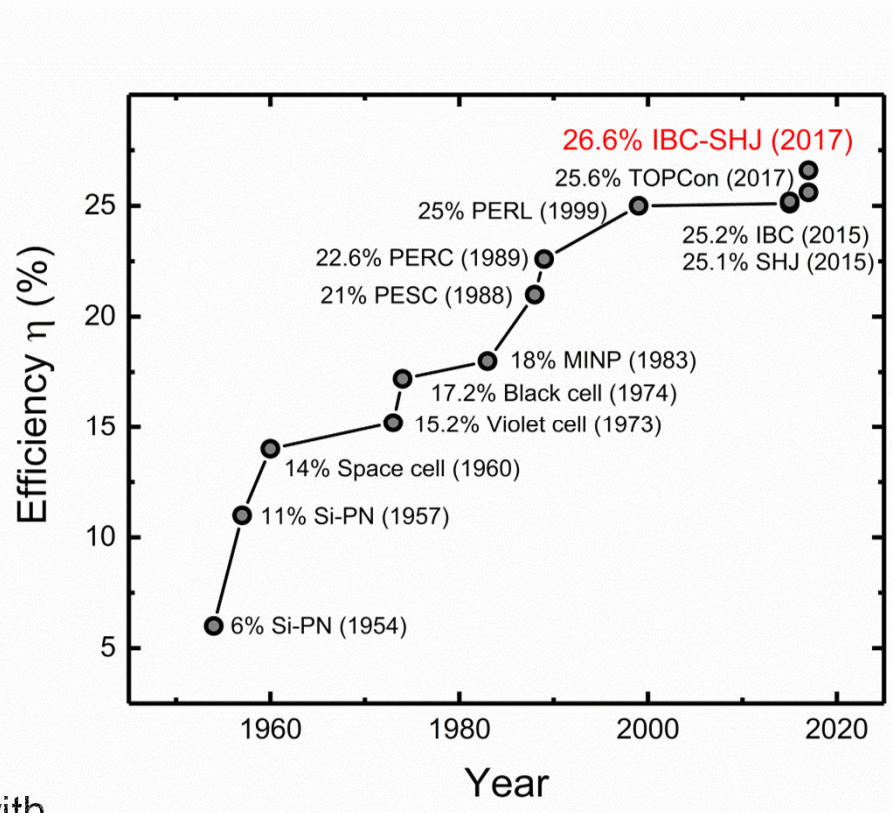
European workshop on nanotechnologies & advanced materials for PV & CSP, 24-25 October 2017, Brussels

Dr. Kaining Ding, Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung 5 - Photovoltaik


NextBase
Partners

IBC-SHJ solar cell



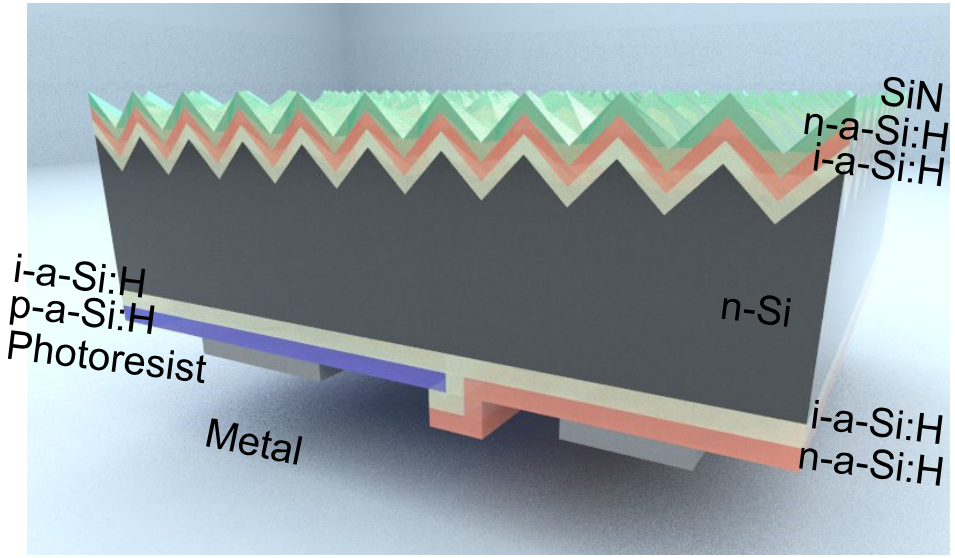


- Key advantage of IBC-SHJ solar cell

1. SHJ: excellent surface passivation with intrinsic a-Si:H → high *Voc*
2. IBC: No metallization shading loss and no front TCO → high *Jsc*
3. IBC + SHJ: combination of both advantages → high efficiency!

Fabrication of IBC-SHJ solar cell

- Patterning of rear side is complex and expensive
- Details of 26.6% record IBC-SHJ solar cell undisclosed



European effort to disclose the secrets of IBC-SHJ and to develop cost competitive and high efficiency IBC-SHJ technologies for European market

General Information

Project acronym: NextBase

Grant agreement number: 727523

Work programme: LCE-07-2016-2017

Starting date: 01.10.2016

End date: 30.09.2019

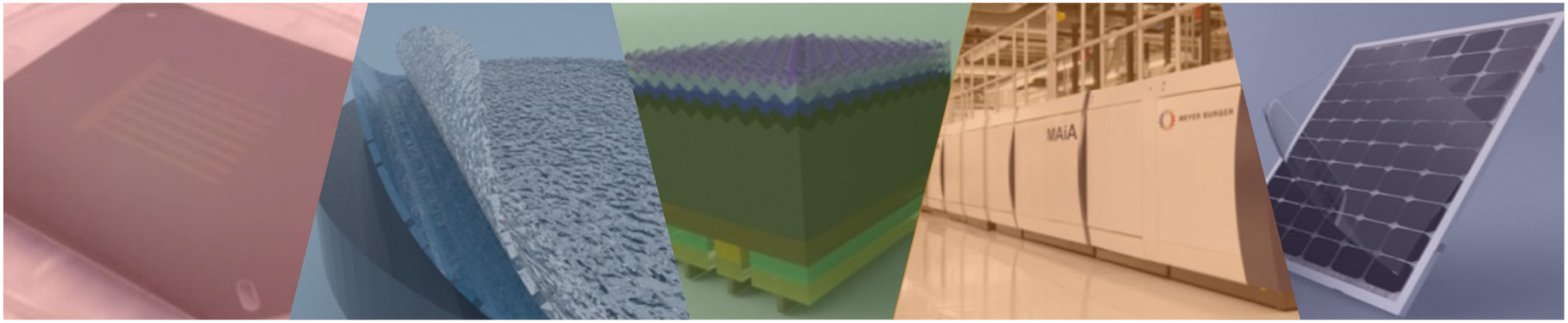
Budget: 5,7M€

Grant: 3,8M€

Coordinator: Dr. Kaining Ding (JÜLICH), k.ding@fz-juelich.de

Website: http://nextbase-project.eu/

Objectives



- Demonstrate IBC-SHJ solar cells with efficiency > 26.0%.
  - Production of highest quality wafers with lifetime over resistivity ratio > 2 ms/Ohmcm.
  - Introduction of transparent front stack and advanced light management for J_{sc} > 42 mA/cm²
  - Development of novel contact materials and contact designs for fill factor (*FF*) > 82% and V_{oc} > 740 mV.
- Demonstrate IBC-SHJ solar modules with efficiency > 22.0%.
  - Development of 60-cell interconnection and anti-reflection coating (ARC) for cell-to-module (CTM) ratio > 95%.
  - Implementation of encapsulation with relative power decrease <5% after degradation.
- Develop an industrial prototype PECVD reactor for IBC-SHJ solar cells.
  - Production of 6-in wafer with lifetime > 2ms with patterned doped layer.
  - Demonstration of minimum throughput of 10 wafers per hour.
- Develop processes that allow IBC-SHJ solar module cost of <0.35 €/W_p.
  - Development of high quality n-type wafers by low-cost multi-pulling process.
  - Development of various cost competitive patterning and interconnection techniques.

Work package structure

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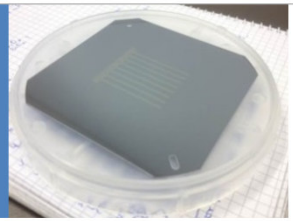
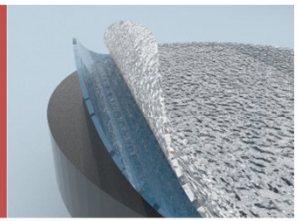
NEXTBASE THE NEXT GENERATION BASELINE

WAFER
- Wafer specification
- Thermal process
- Single-side texturing
- Advanced texture

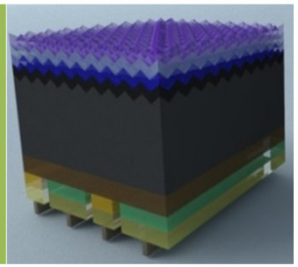


Cost & Life-cycle Analysis
- Cost assessment
- Scale-up analysis
- Environmental
- System impact

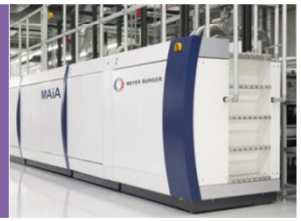
LAYER
- Rear contact material
- Transition metal oxide
- Front layer stack
- Electro-plated metal



CELL
- Patterning techniques
- Light management
- 26% cell processing



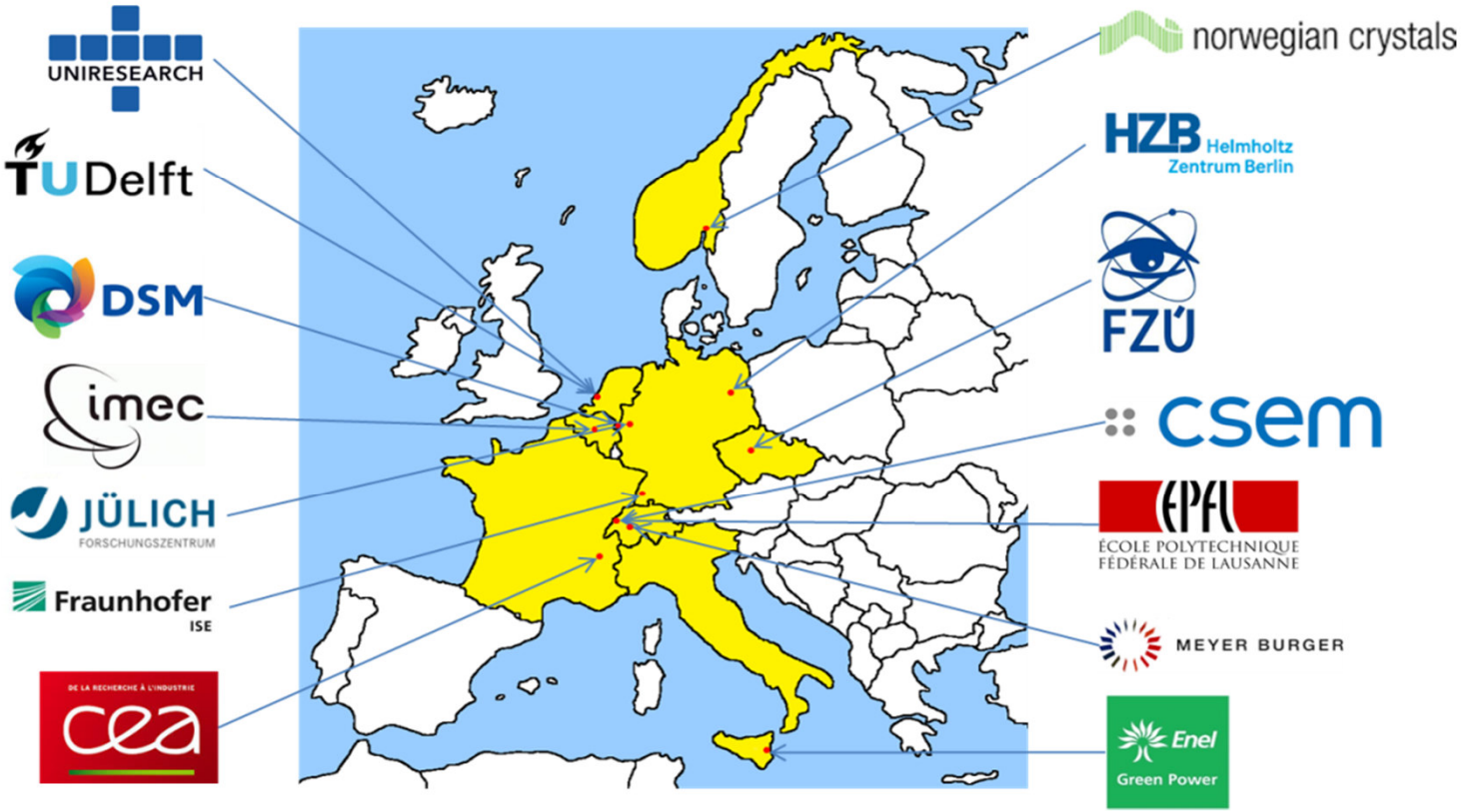
TOOL
- Tool specification
- System validation
- Pilot cell fabrication



Characterization & Modeling
- Loss analysis
- Device simulation
- Measurement setup
- Module testing

MODULE
- Interconnection
- Encapsulation
- Anti-reflection coatings
- 22% module processing

Partners

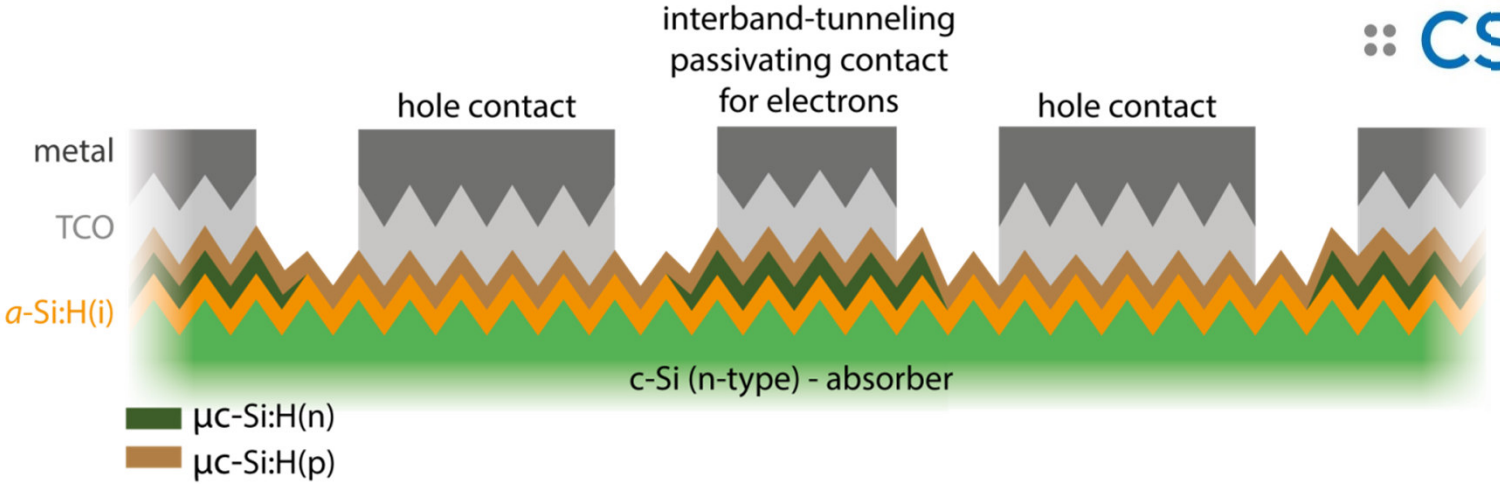


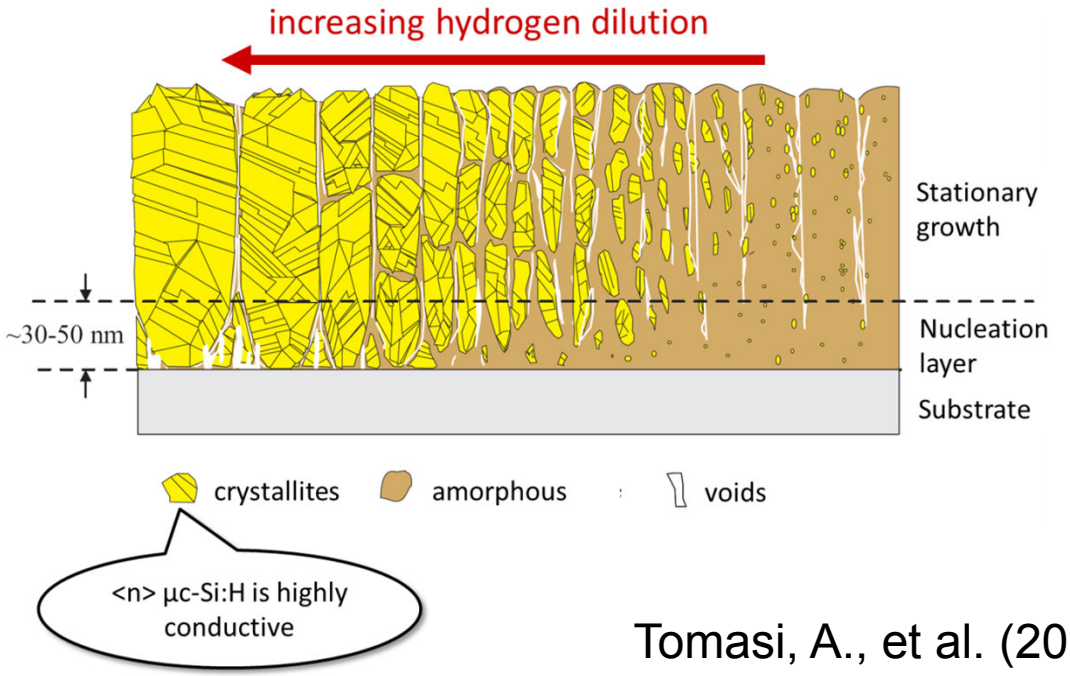
Brother/sister projects:

- **DISC: passivated contact, http://www.disc-project-h2020.eu/**
- **AMPERE: SHJ production, http://www.ampere-h2020.eu/**

Tunnel IBC with µc-Si

Shadow mask patterning with less alignment requirement



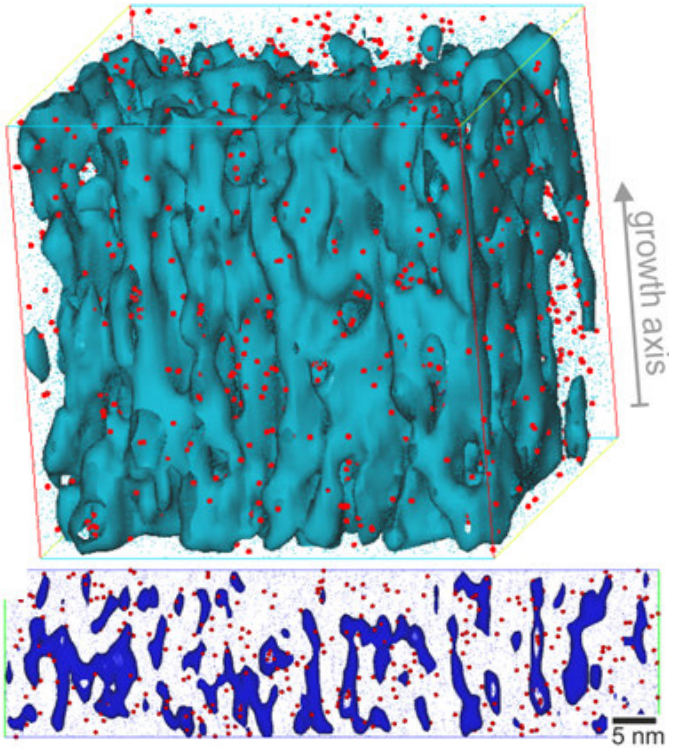


23.9% efficient IBC-SHJ with tunnel IBC concept achieved!

Tomasi, A., et al. (2017) Nat. Energy, 2 (5), 17062.

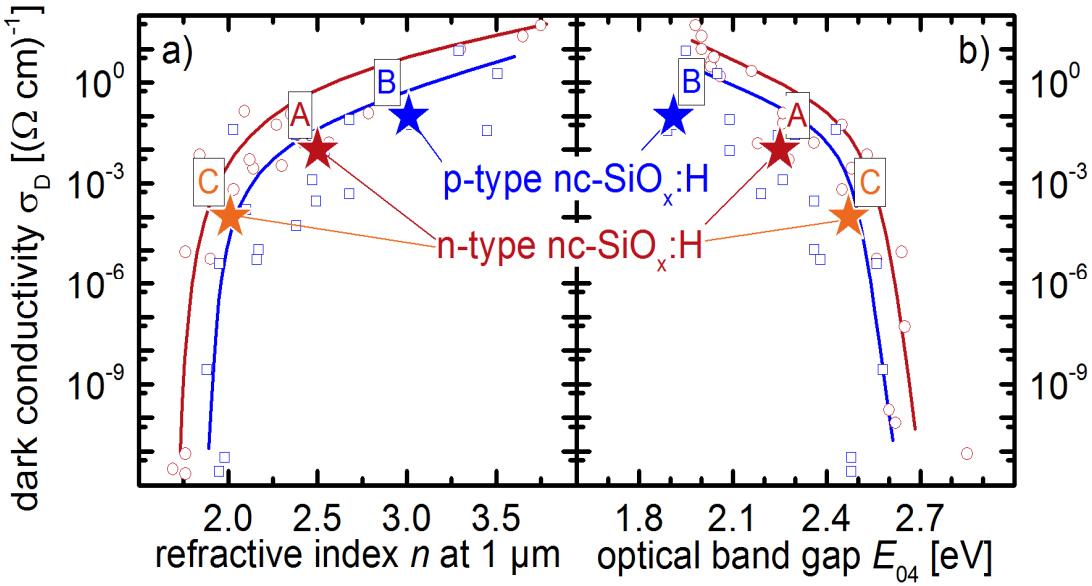
Nano-crystalline silicon oxide

Transparent and low refractive index contact layer



Advantages:

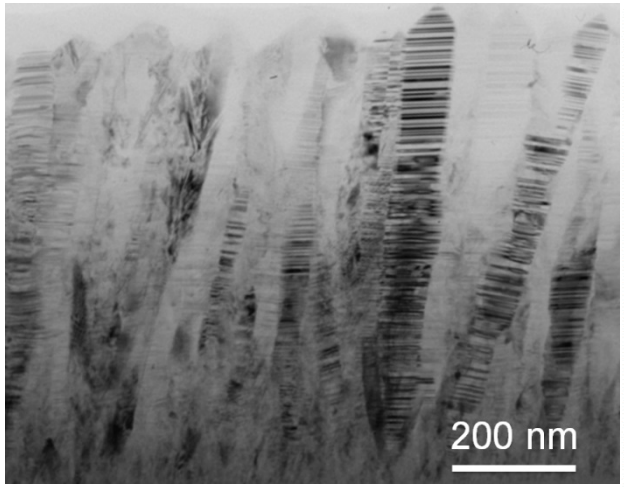
- Less parasitic absorption
- Better back reflection
- Less amorphous incubation
- More tuning options

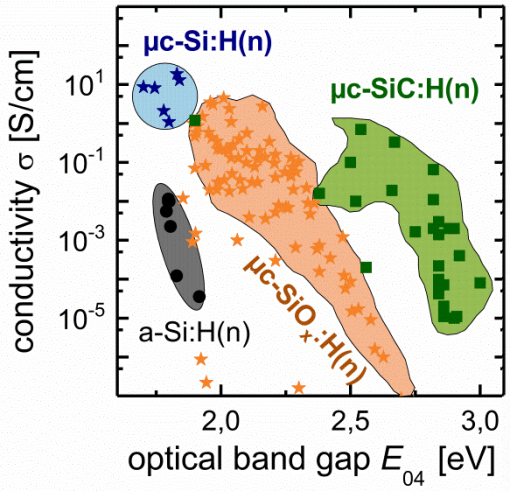


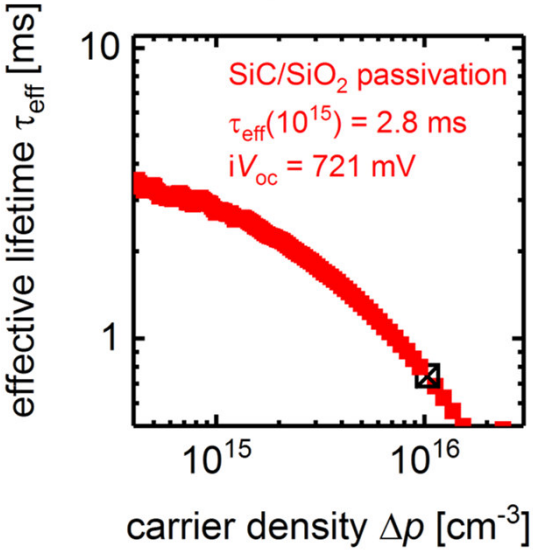
A. Richter, et.al.,Sol. Energy Mater. Sol. Cells, 174, 196–201.

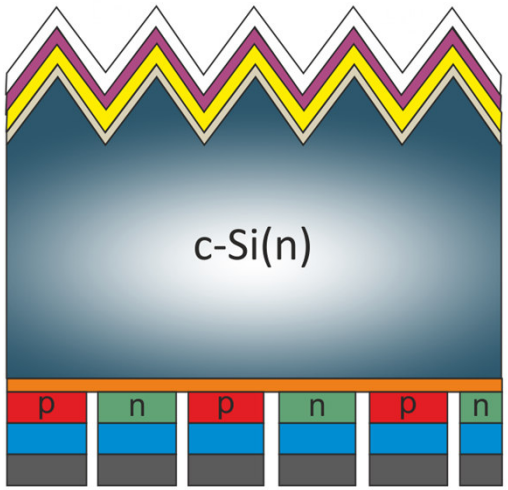
Nano-crystalline silicon carbide

Transparent front surface field









MgF_2
SiN_x
µc-SiC:H(n)
SiO_2

a-Si:H(i)
a-Si:H(n/p)
ITO
Ag

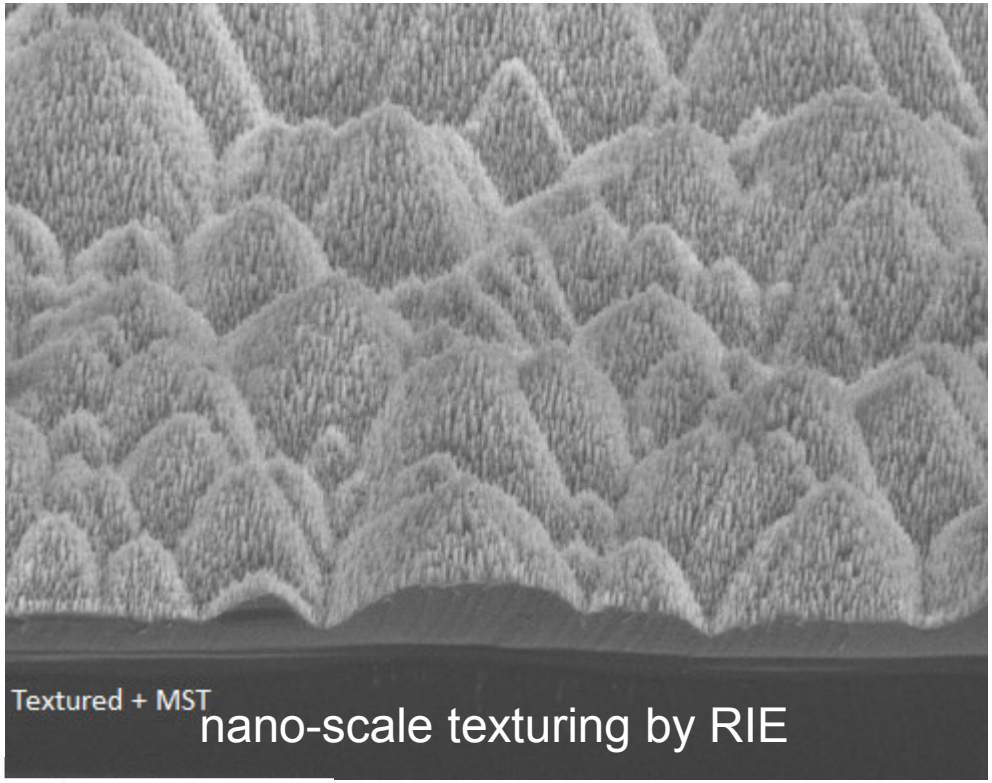
Advantages:

- Highly transparent SiO_2/SiC stack
- Refractive index matching
- High passivation quality
- Low-T process compatible with SHJ

M. Pomaska, et.al..(2015) Thin Solid Films, 595, 217–220.

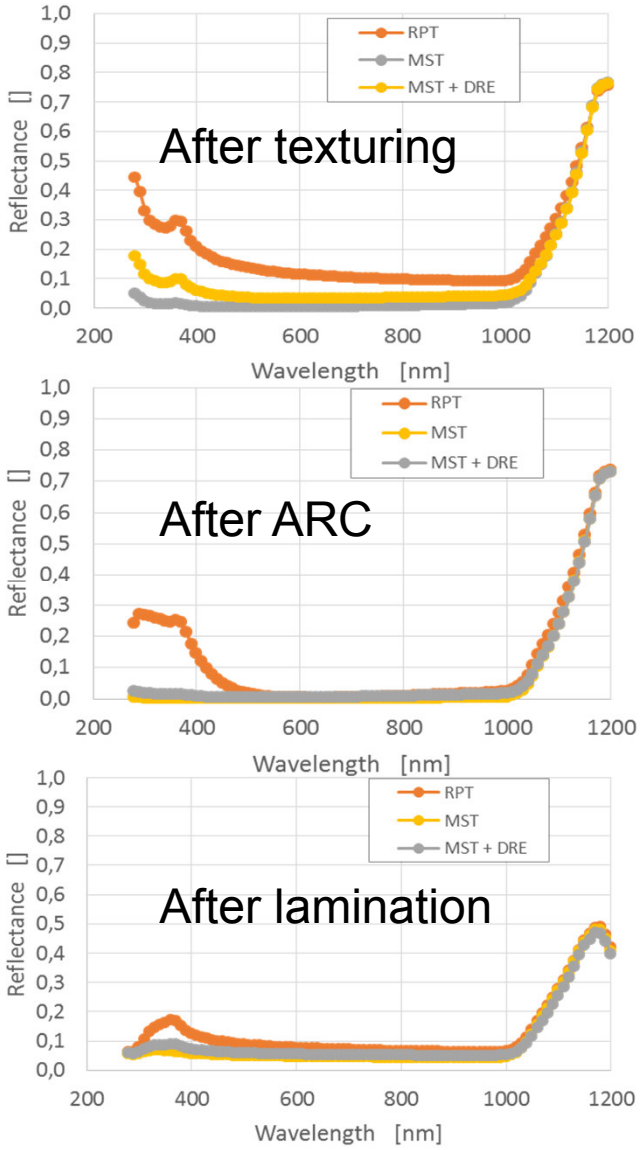
Nano-size modulated surface texture

Broad-band light in-coupling and light scattering on front



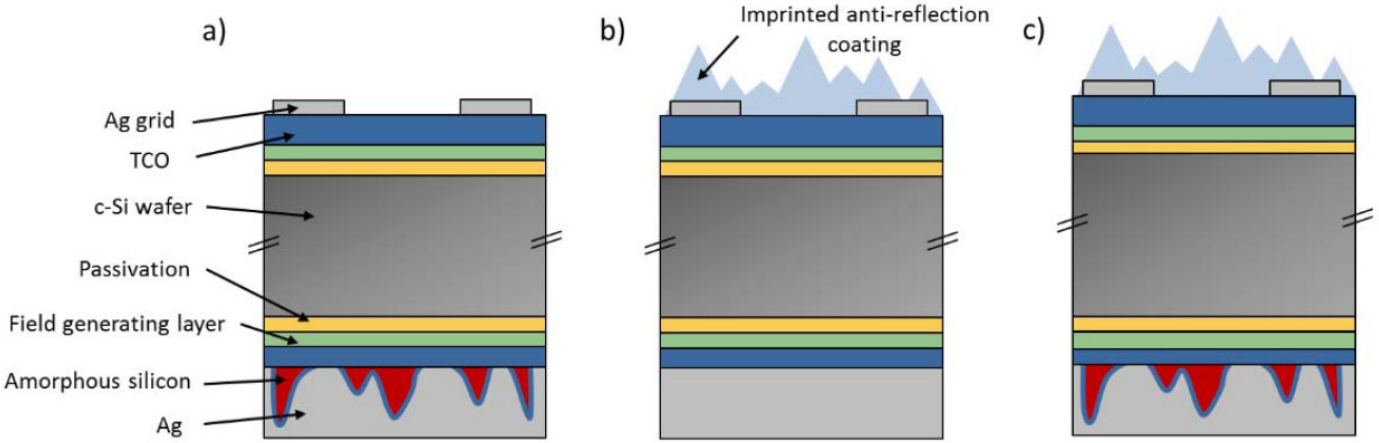
TU Delft imec

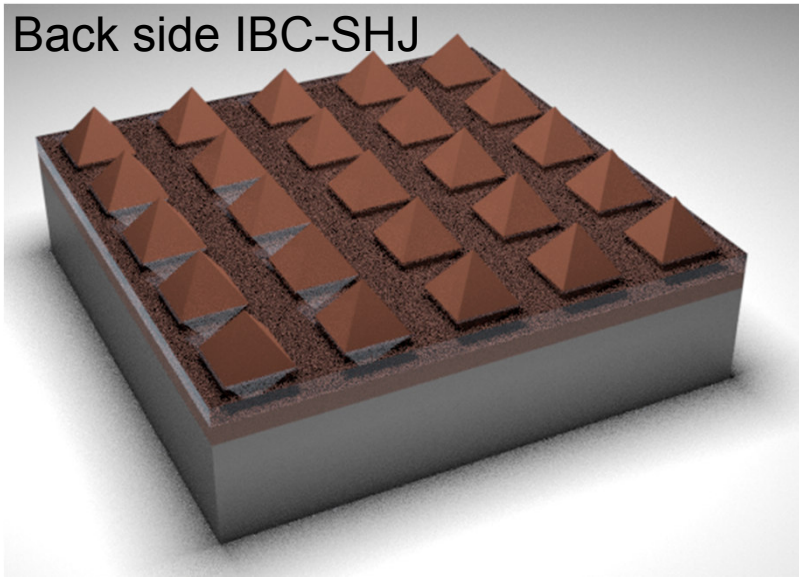
Lifetime above 1ms achieved after damage remove etch (DER)!



Nano-imprint structures

Post passivation light-management concepts





Advantages:

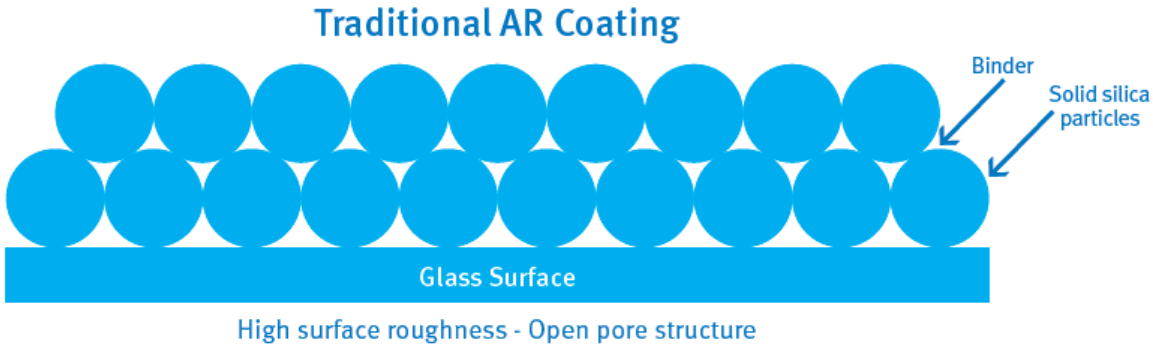
- Low cost process
- No harm to the passivation
- Flexible design of texture
- Ideal for thin wafers

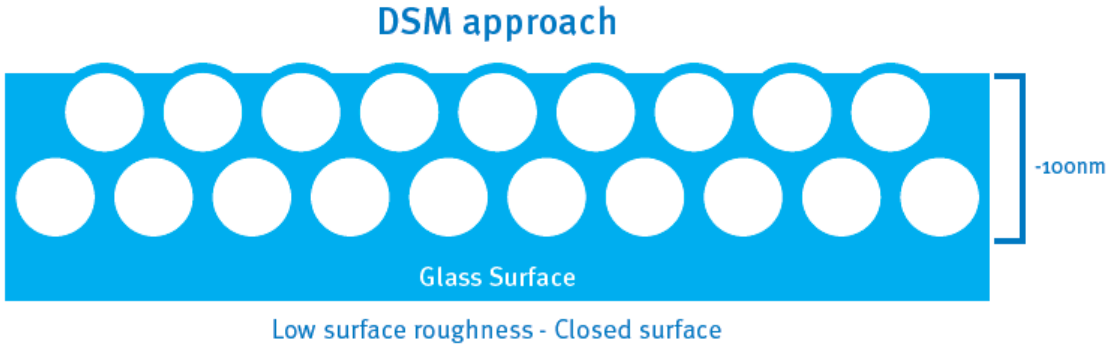
Nano-porous AR coating

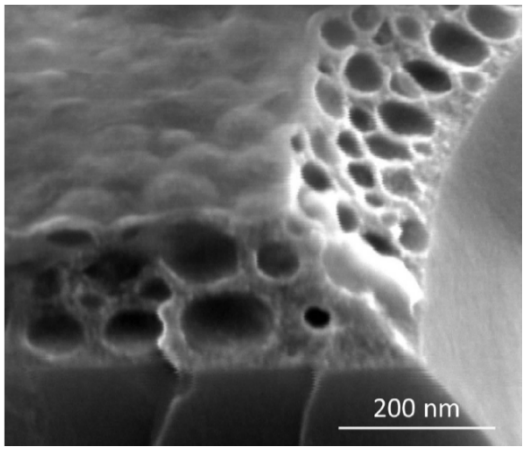
Refractive index matching for light incoupling

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

Single layer AR Coatings:
Traditional versus Core-shell AR Coatings







Up to 4% less reflectance on module level at comparable fabrication cost at traditional AR coating

Acknowledgements

Thank you for your attention!

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727523

KPIs

Project KPI 3.1	Ingots of n-type Cz silicon with radial resistivity distribution in the range of +/-20% from target and oxygen content below 15 ppma.]
Project KPI 3.2	Implied photo-generated current density in targeted double- or single-side textured > 41.0 mA/cm2.
Project KPI 4.1	Hole and electron contacts based on a-Si:H/nc-Si:H layers and TMOs with optimal specific contacting resistivity (ρcontact<50 mOhm*cm2) and contact passivation quality (J0<10 fA/cm2).
Project KPI 4.2	IBC-SHJ front-side stack with optimal surface recombination velocity (Seff < 5 cm/s under maximum power point conditions) and low absorption loss (Jabs < 0.5 mA/cm2).
Project KPI 5.1	IBC-SHJ devices processed with Voc > 740 mV, FF > 82 % and Jsc > 42 mA/cm2. IBC-SHJ device with efficiency ≥ 26.0% on 6-in wafer.
Project KPI 6.1	Silicon doped layer thickness between 5 to 20 nm. Activation energy (Ea) < 0.4 eV for n and p doped layers.
Project KPI 6.2	6-in passivated wafer with patterned doped layer with lifetime level above 2 ms. Minimum throughput of 10 wa-fers per hour.
Project KPI 7.1	Module performance of higher than 22% and CTM power ratio of higher than 95%
Project KPI 7.2	Relative power decrease of less than 5% after 400 cycles of thermal cycle test (TCT) and 2000 h of damp heat