



SOLARONIX

All Screen Printed Dye Sensitized Solar Modules

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Stéphanie Narbey, Grégoire Laporte, Robin Cisneros, Giulia Tregnano, Andreas Meyer

www.solaronix.com

Overview

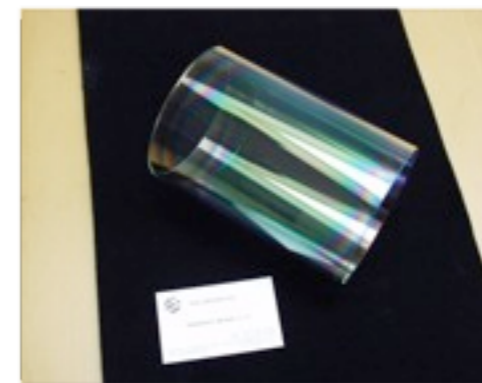
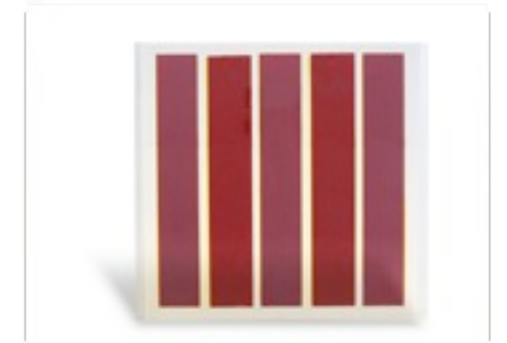
- Who is Solaronix ?
- What is a Dye Sensitized Solar Cell ?
- How to print solar cells ?
- State of the art
- Outlook

Founded by Andreas & Toby Meyer in 1993

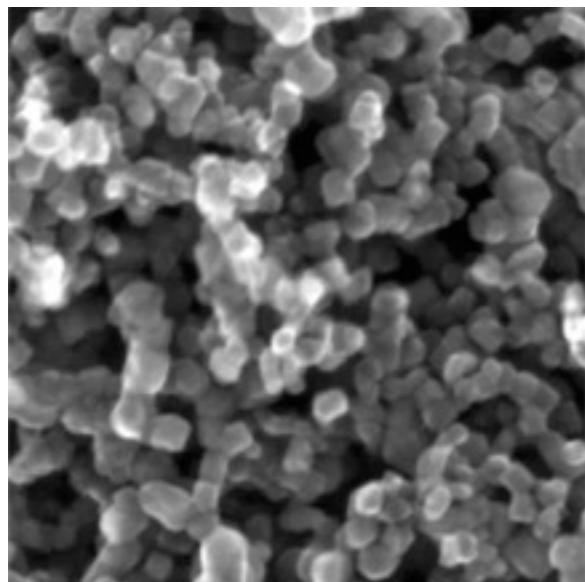
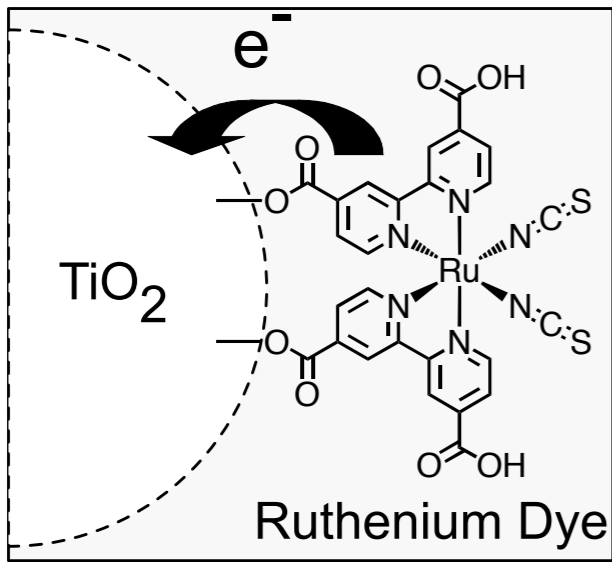
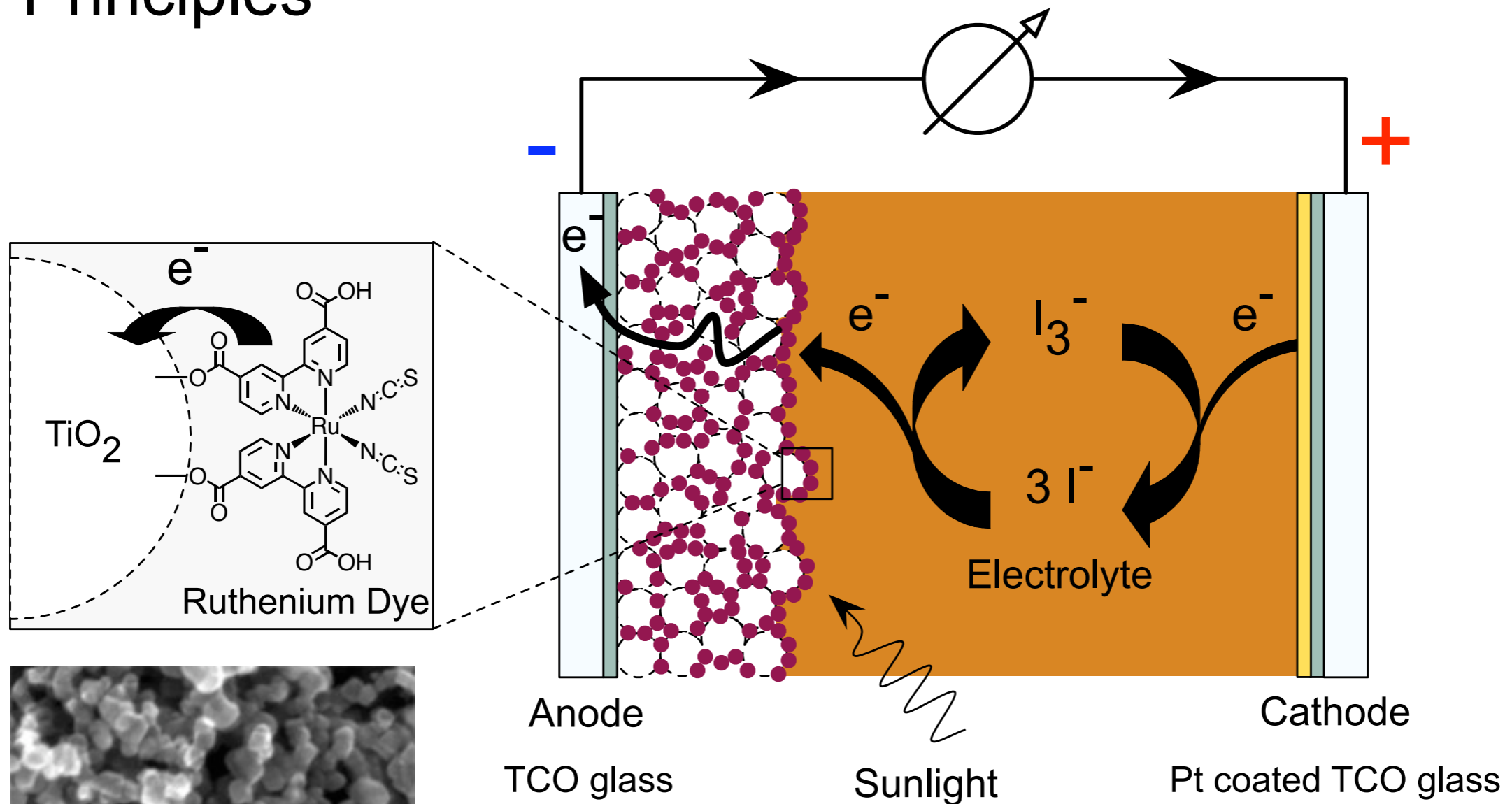
Located in Aubonne, Switzerland

- ☀ 13 motivated people + currently 3 interns
- ☀ Dye Solar Cell development
- ☀ World leader in DSC specialty chemicals:
nano-TiO₂, Ru-dyes, electrolytes, ionic liquids...
- ☀ Stability test lamps manufacturing based on
genuine "plasma light engine"
- ☀ Contracted R&D + 4 FP7 projects (started in '09)
- ☀ 2 KTI-Projects in preparation

→ www.solaronix.com

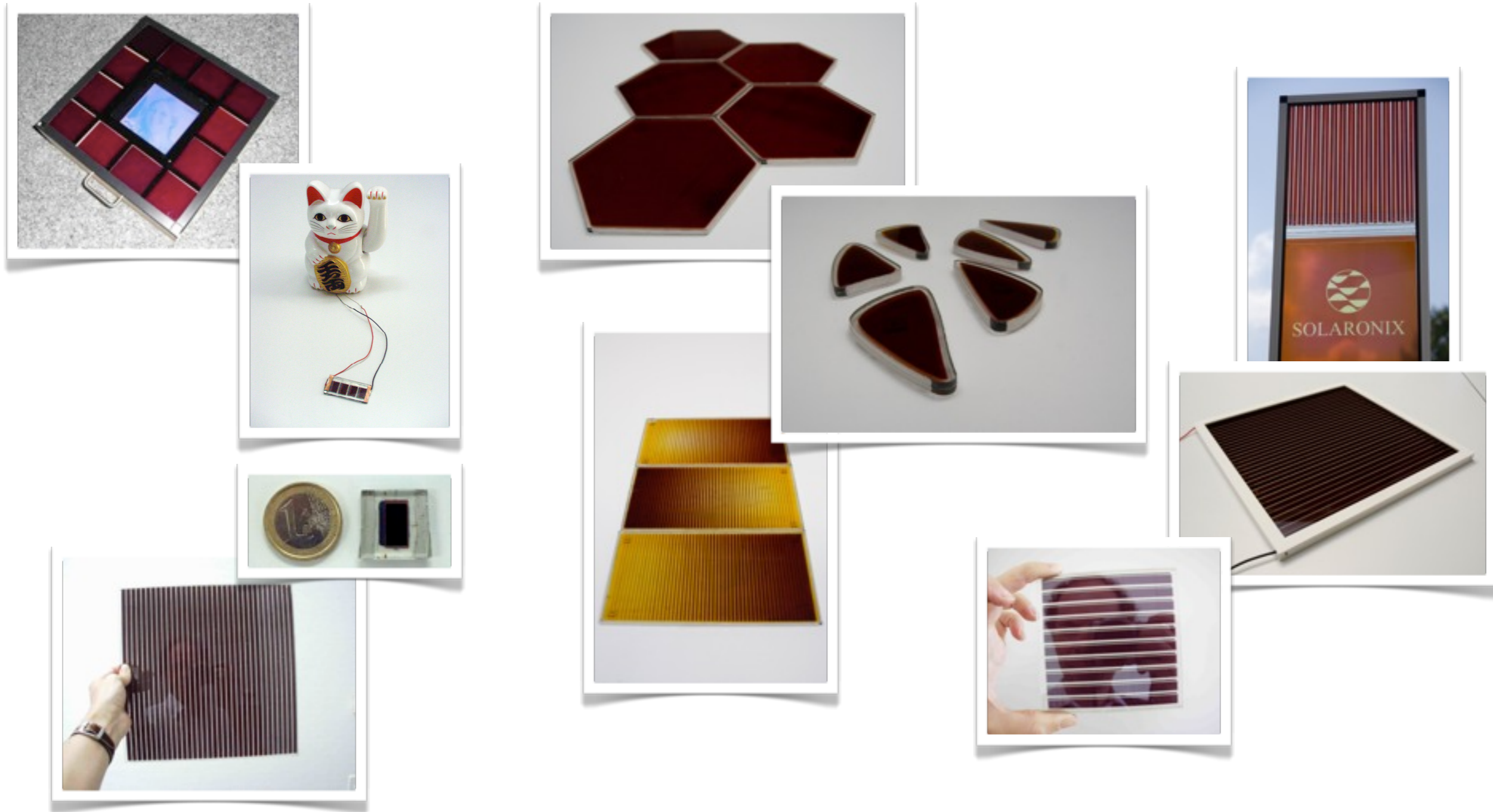


Principles

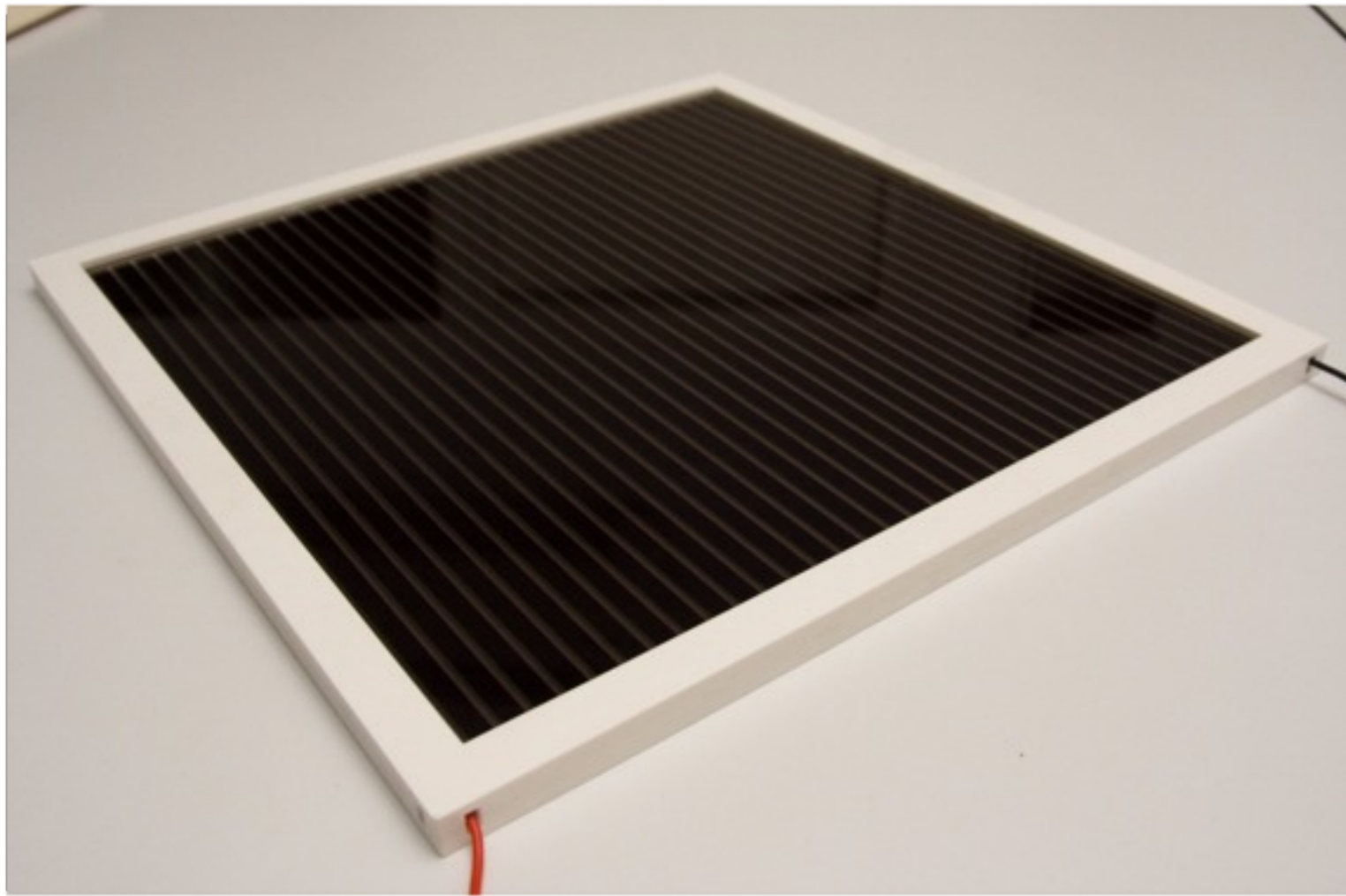


nano-TiO₂ ~ 20 nm ø particles

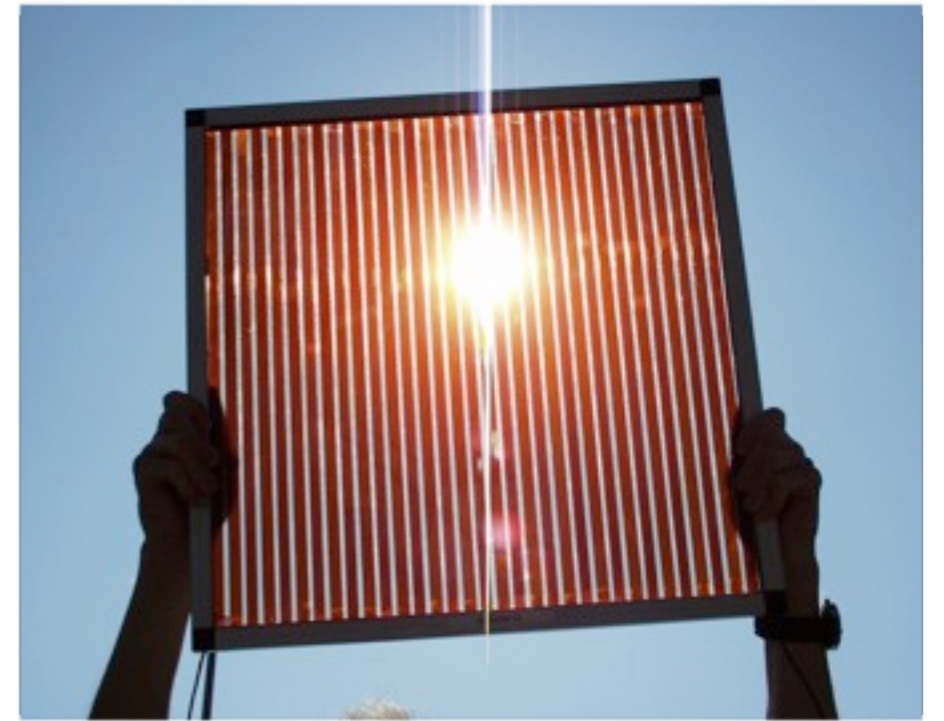
Dye Sensitized Solar Cells...in reality



Dye Sensitized Solar Cells...in reality












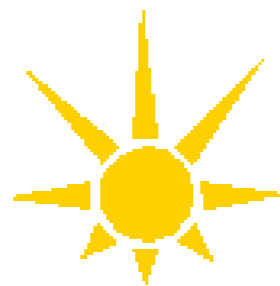
30 x 30 cm "Monolithically Integrated Module (MIM)
with 35 serially interconnected cells



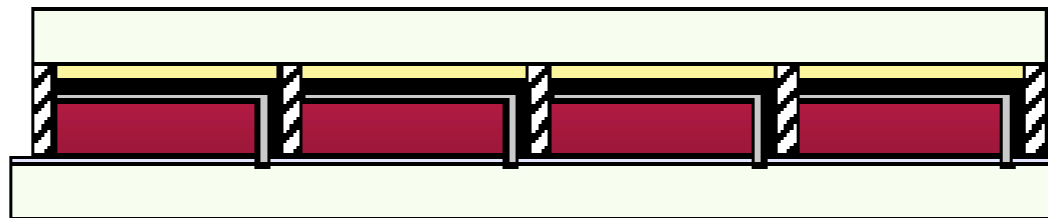
45 x 45 cm "W-Module" with 33 cells

Module types...

-  Glass
-  TCO
-  Pt catalyst
-  Insulator
-  Catalyst & conductor
-  Conductor
-  TiO₂ with Ru-dye
-  Electrolyte
-  Sealing

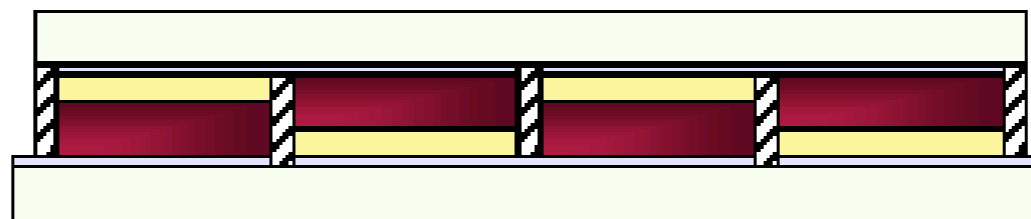


Series connection - monolithic



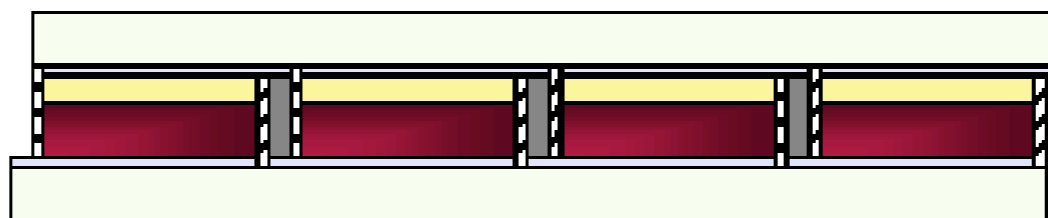
MIM

Series connection - W



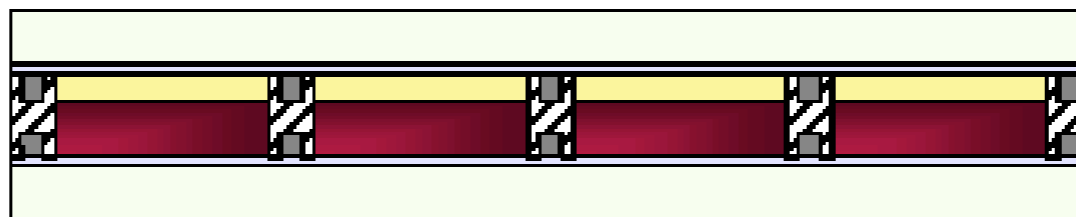
W-type

Series connection - Z



Z-type

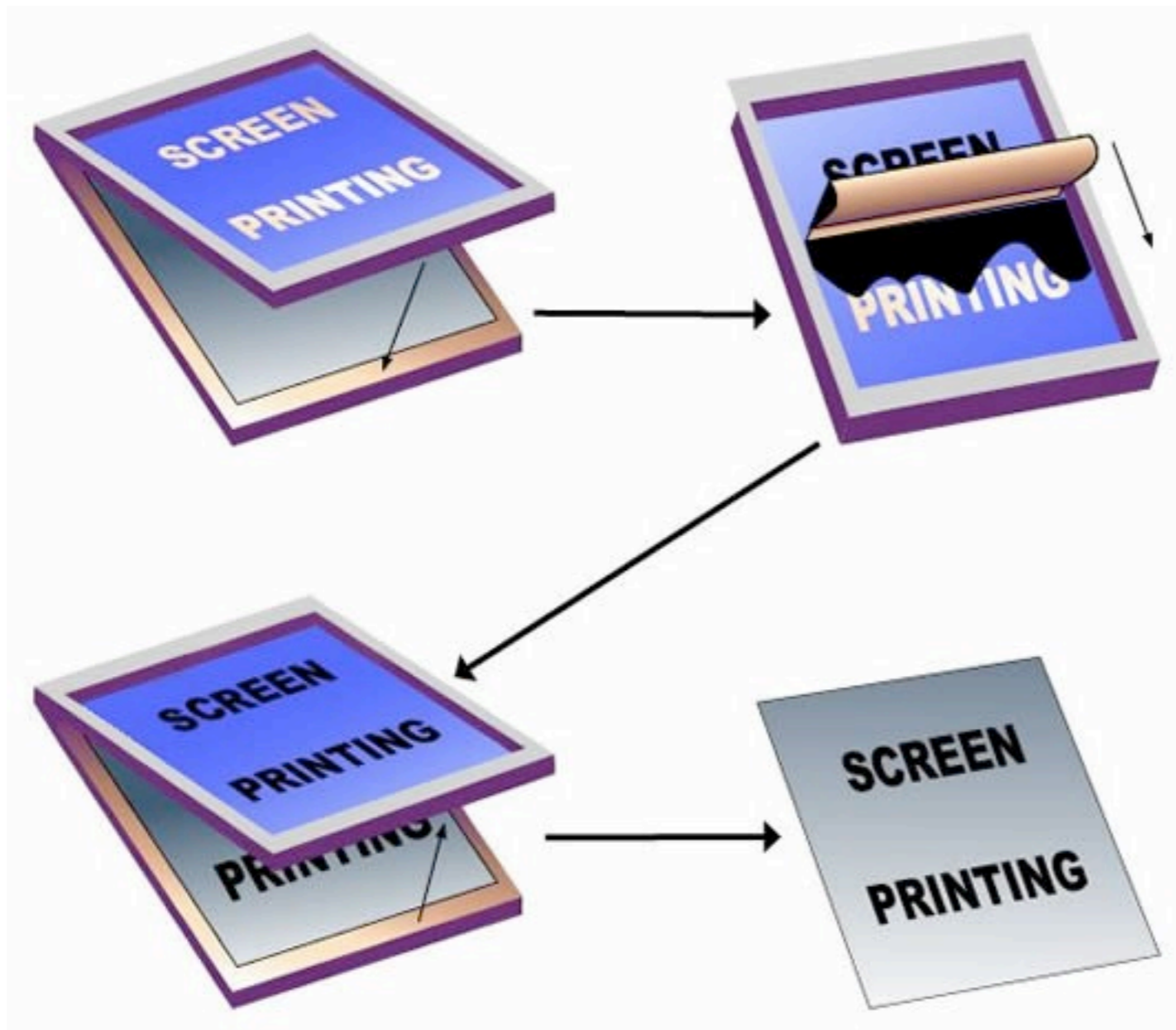
Current collection - metal grid



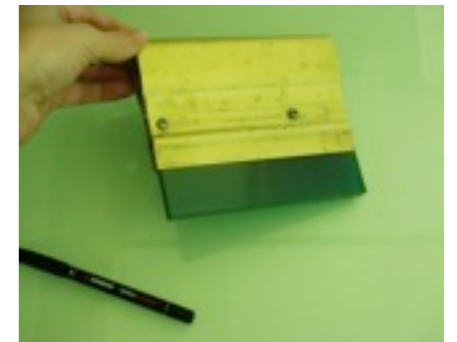
Parallel

Adapted from ECN

Screen printing...is very fast



Screen



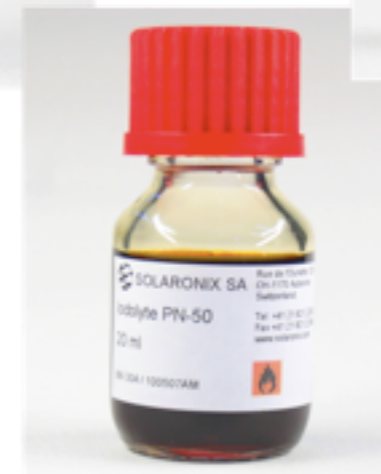
Squeegee



Thieme 510 E printer

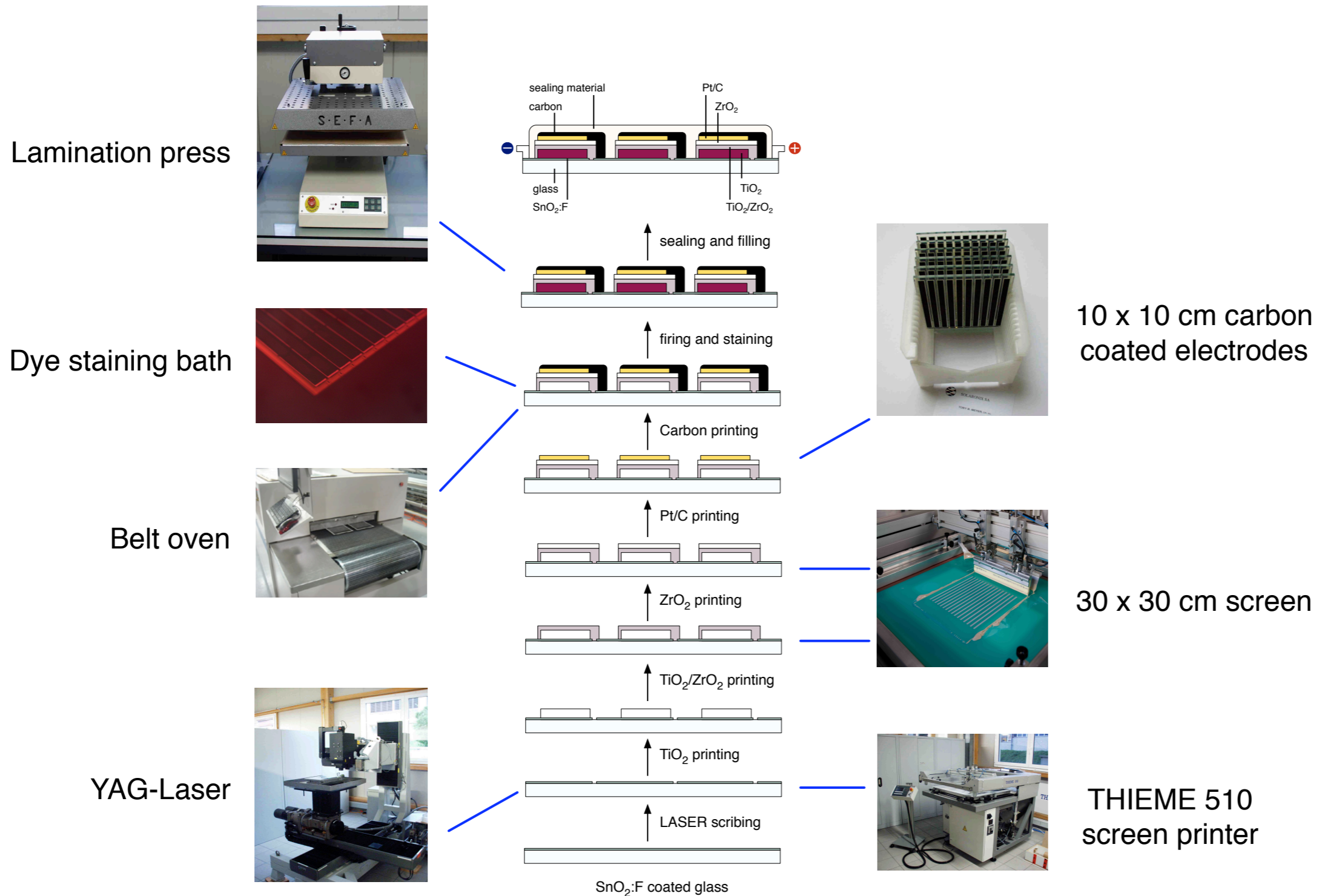
Required materials...

- TCO Glass (“low e” glass) 8-20 Ohm/sq
- nano-TiO₂ screen print paste
- ZrO₂ spacer screen print paste
- Pt catalyst screen print paste
- Carbon screen print paste
- Ruthenium dye
- Iodide electrolyte (ionic liquid)
- Back sealing foil



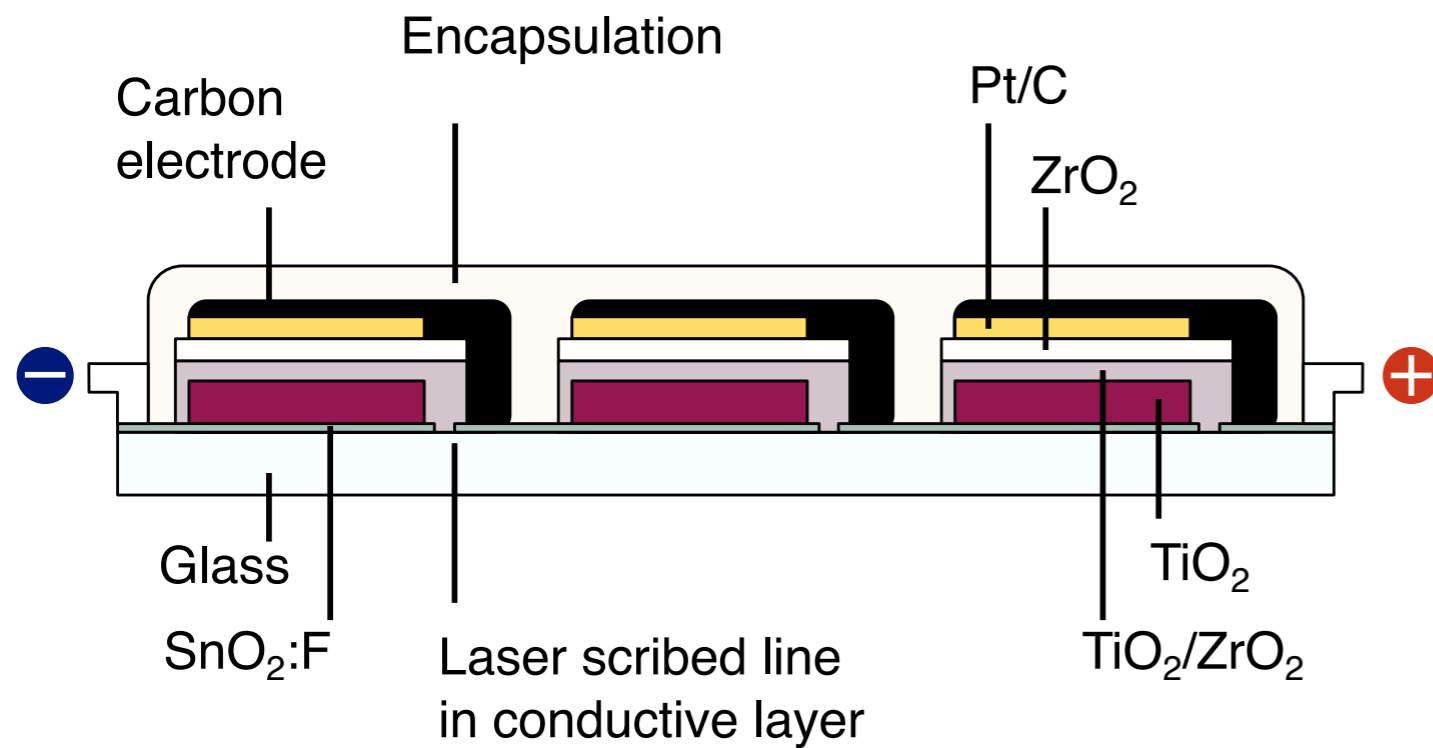
✓ All materials are available at www.solaronix.com

MIM manufacturing steps...

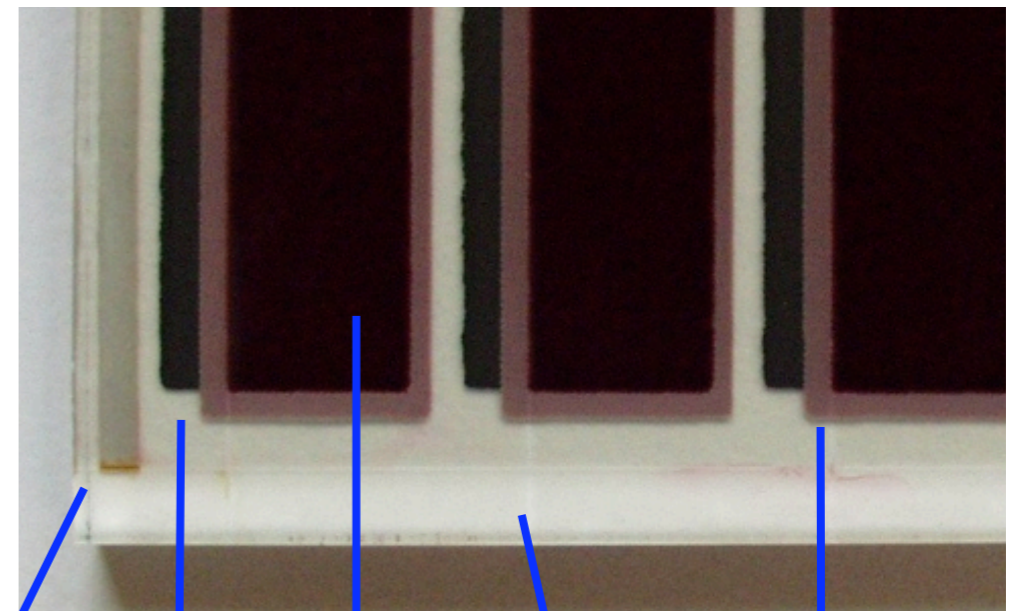


MIM - Monolithically Integrated Module

Schematic cross section



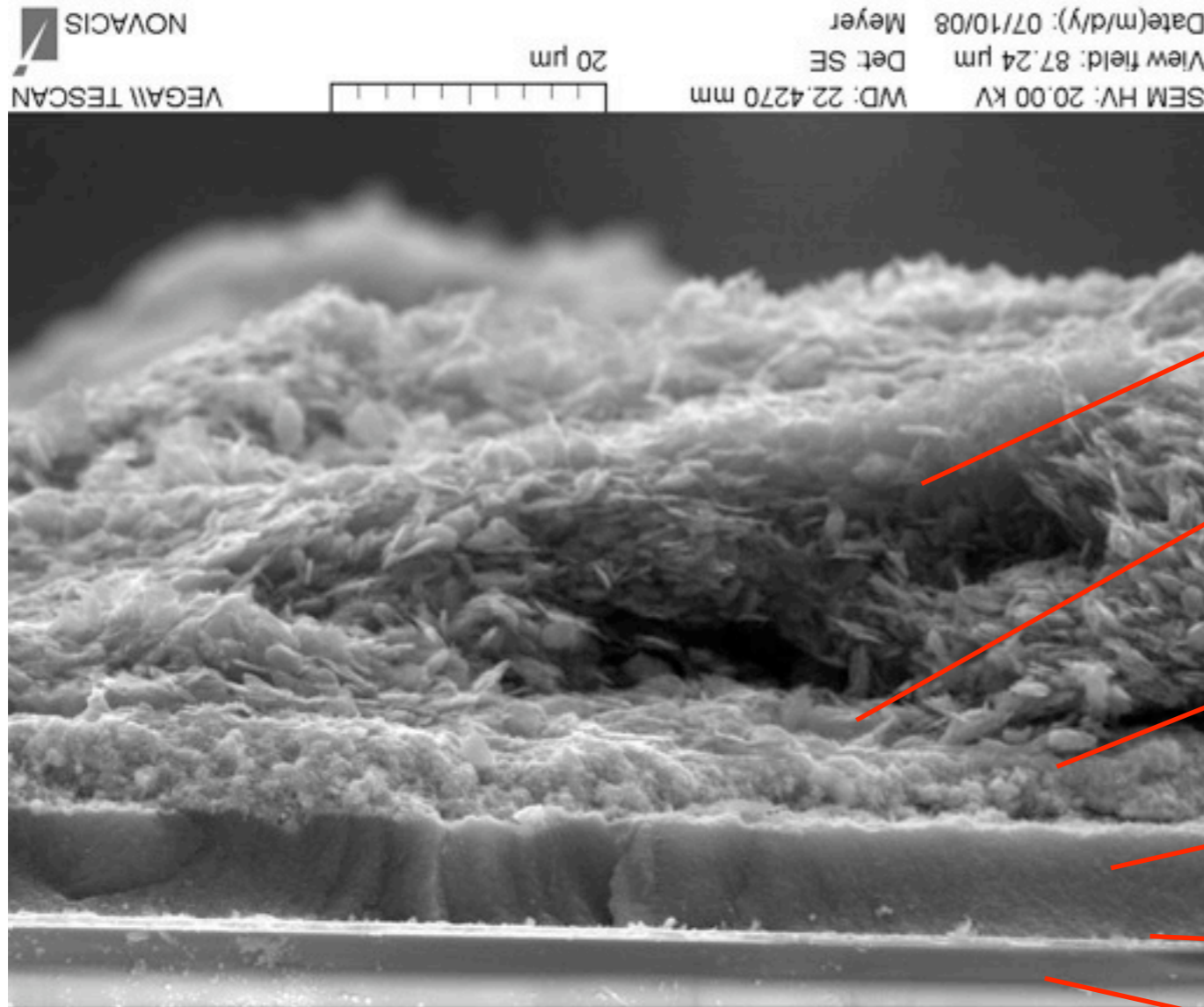
View through the glass side



Labels for the photograph view through the glass side:

- Carbon electrode
- Separation line
- TiO₂: Ru-dye electrode
- ZrO₂ layer
- Contact line

MIM...in the SEM



~ 30 µm conductive carbon layer

~ 1 µm platinum coated carbon layer

5.3 µm ZrO₂ layer
> 80 nm ø particles

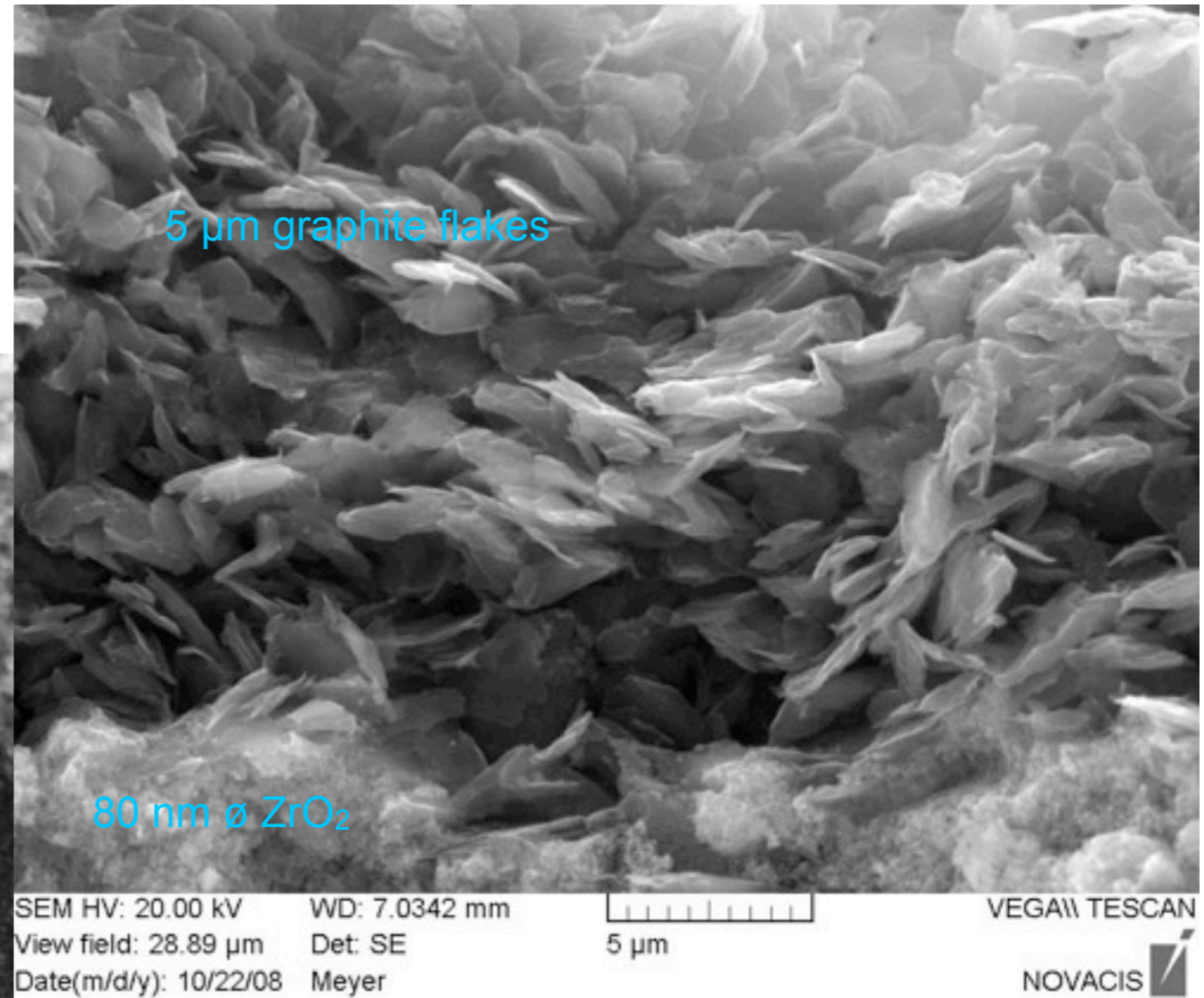
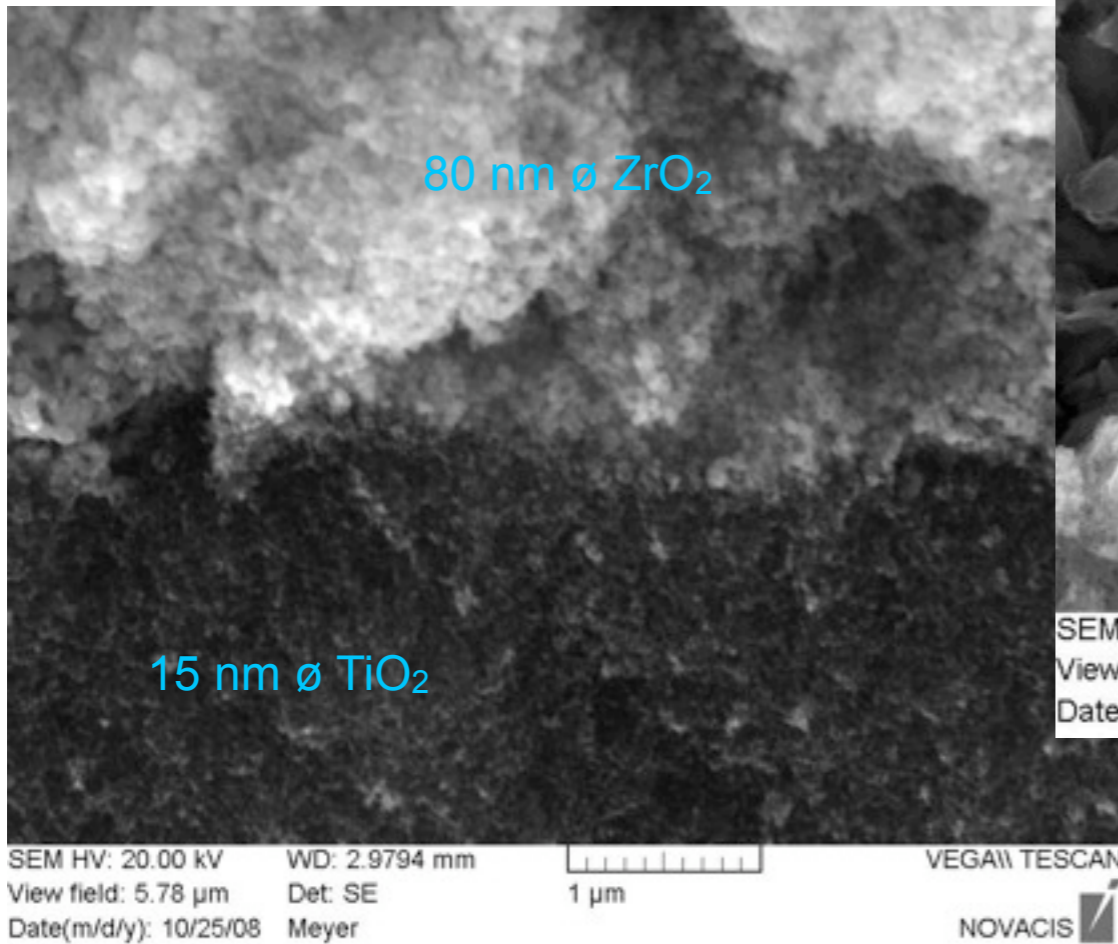
7.2 µm nano-TiO₂ layer
~ 15 nm ø anatase

550 nm SnO₂:F layer

Glass

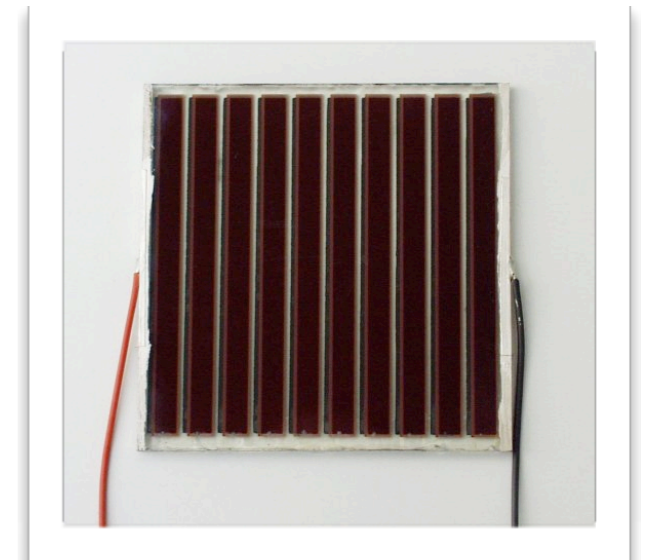
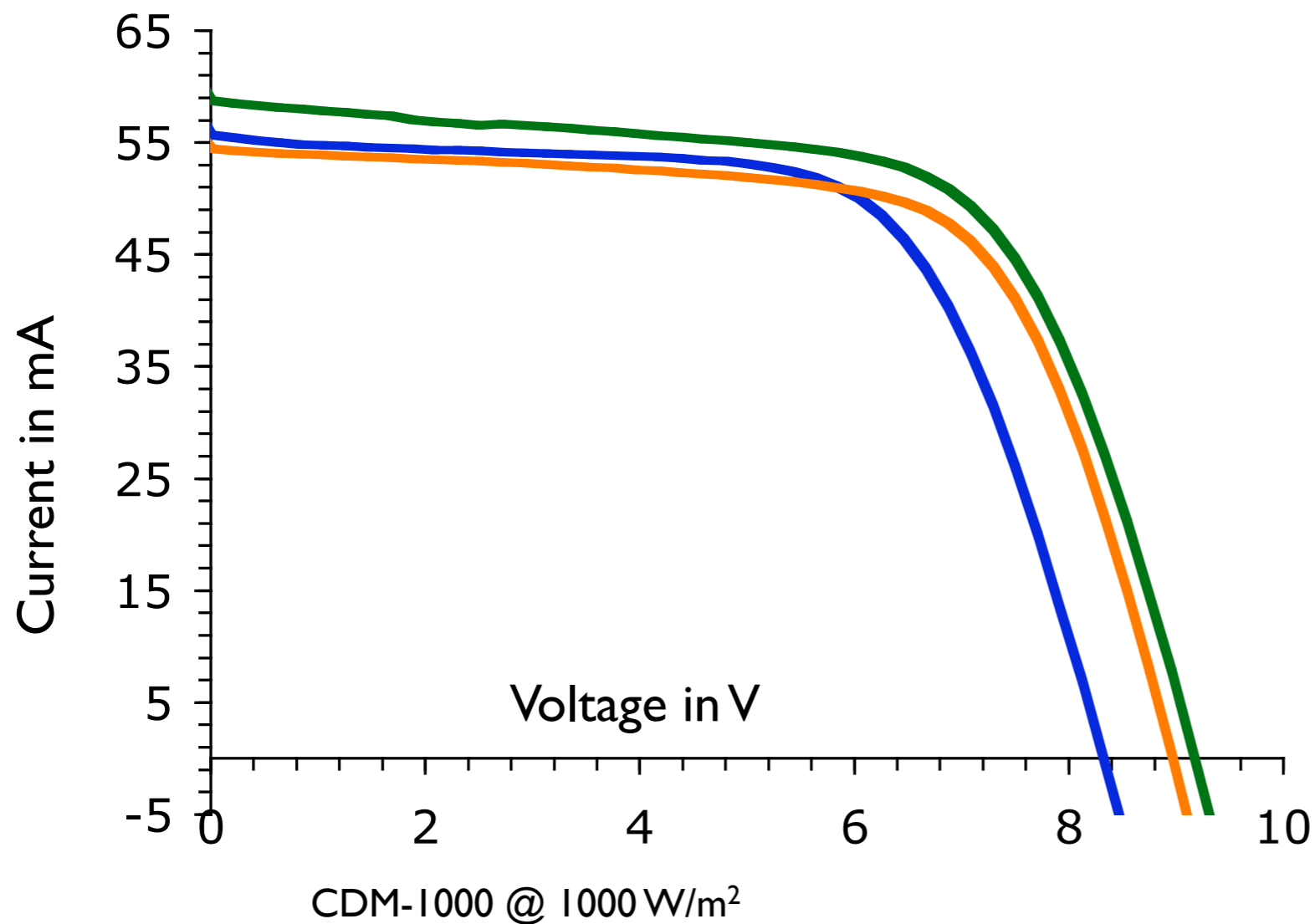


MIM...in the SEM



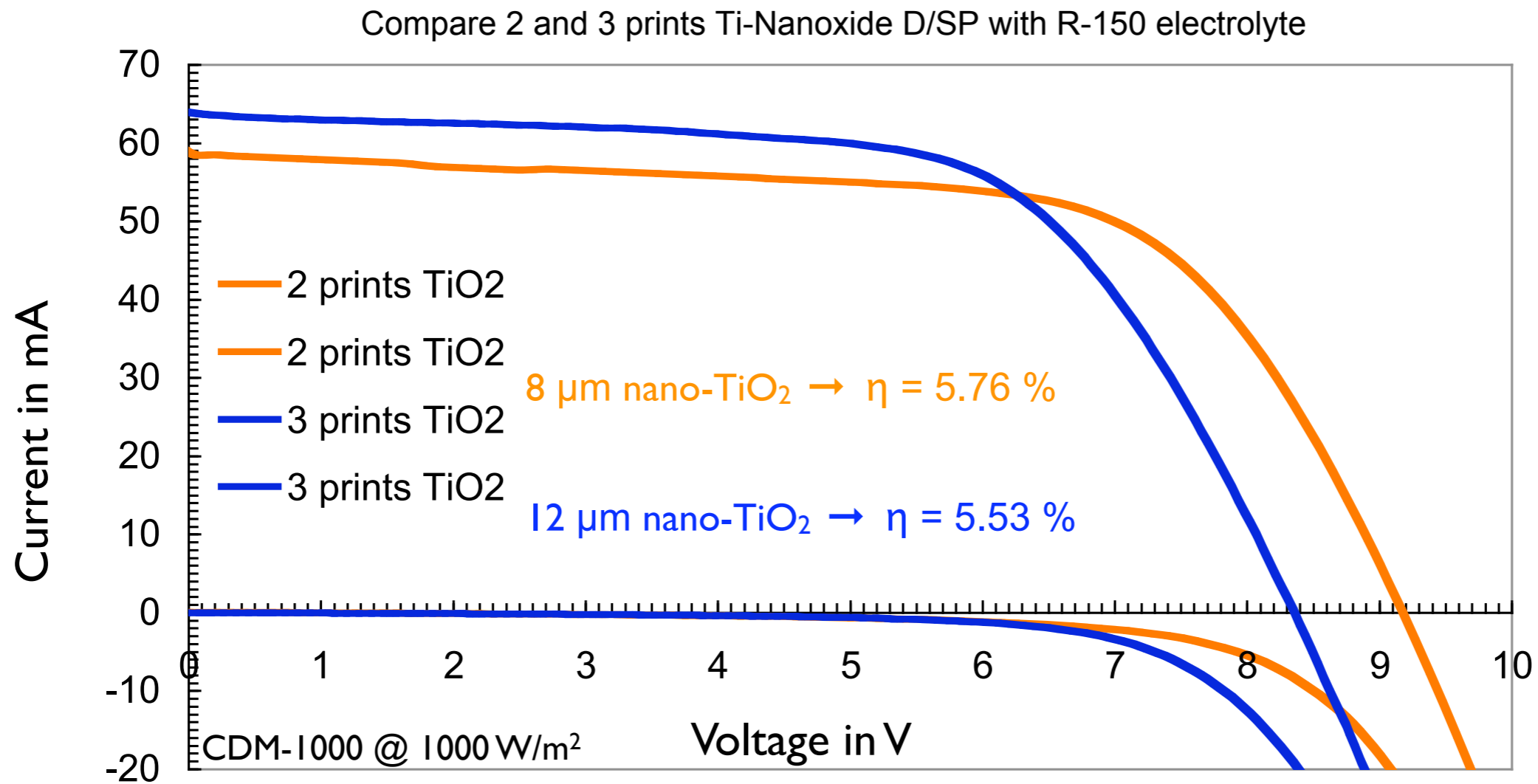
Results...

MIM with 11 cells, total active area 60.7 cm², with ~8 μm thick nano-TiO²



Electrolyte system		
R-150 100 mM I ₂	AN-50 50 mM I ₂	MPN-50 50 mM I ₂
η = 5.7 % FF = 0.65	η = 5.4 % FF = 0.68	η = 5.0 % FF = 0.67

Results...



MIM with 11 cells, total active area 60.7 cm²

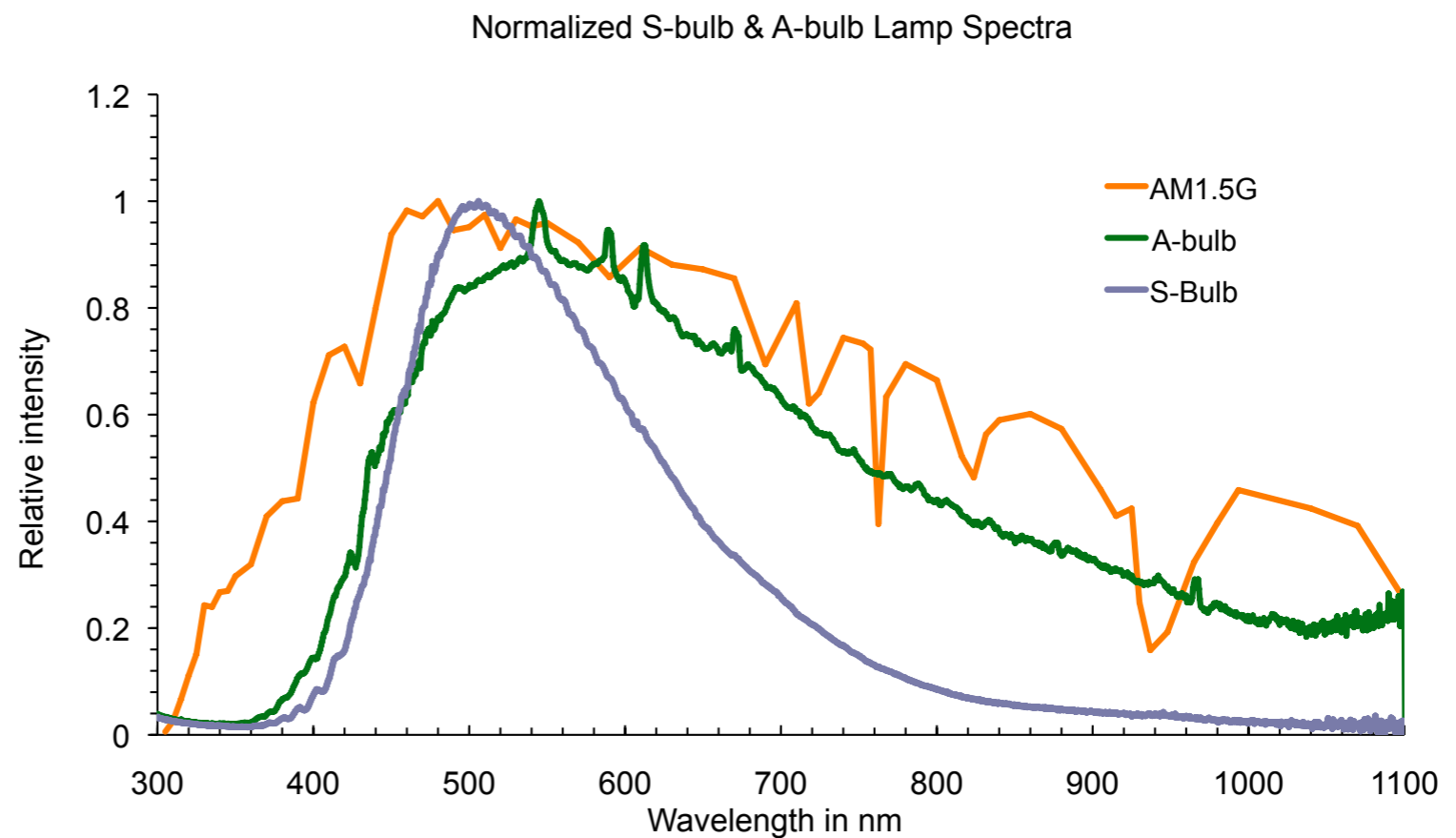
Stability testing equipments...



SolarTest-65 light soaking system

A-bulb: Class A

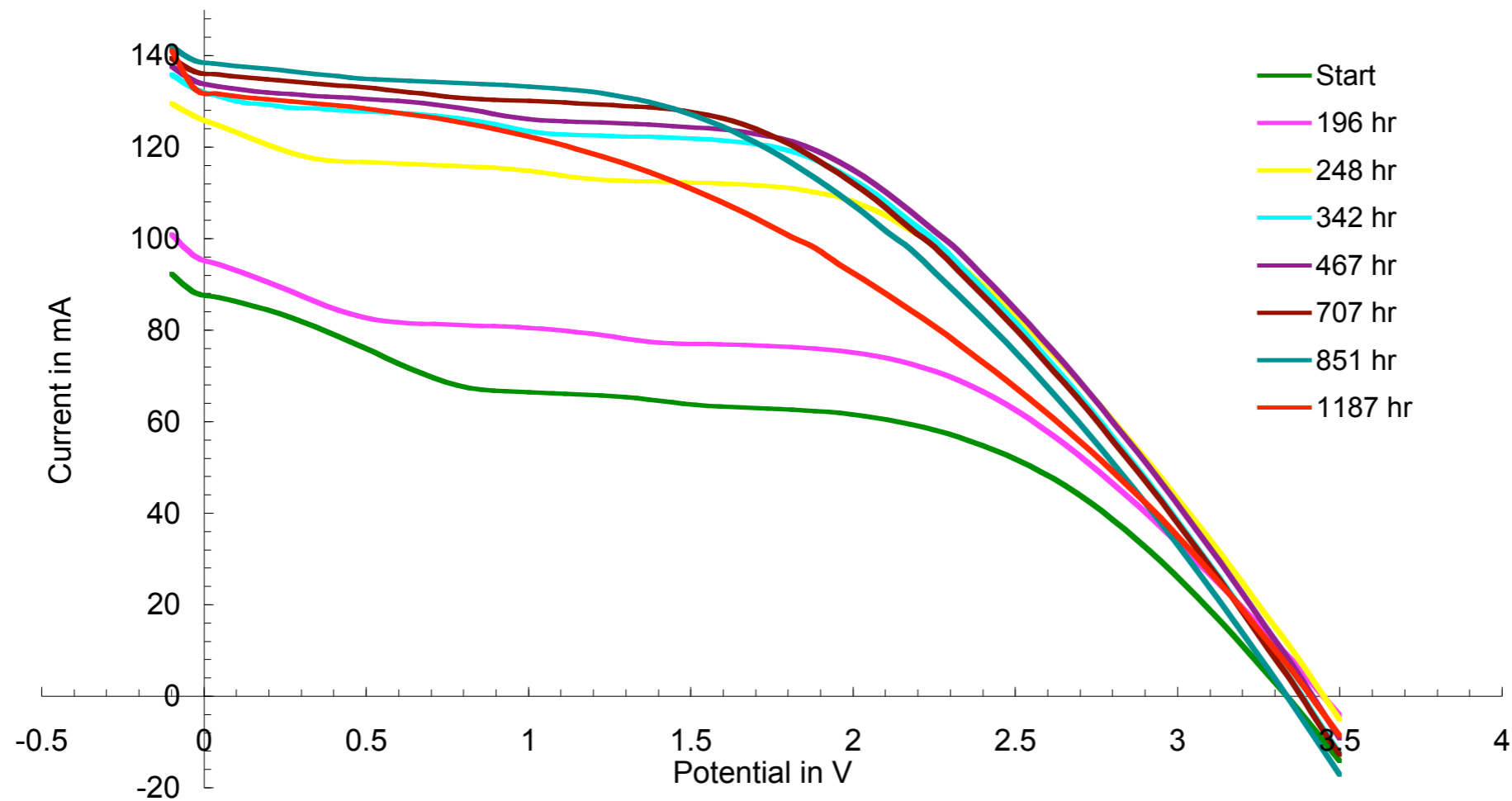
S-bulb: Class C



Stability testing equipments...

Plasma light engine set to $\sim 1000 \text{ W/m}^2$

DSC 1010W5 110908MS3 A-bulb at ca. 40°C



Economic estimation parameters

- Module size: 60 x 90 cm
- Module efficiency: 7 % active area
- Area usage factor: 80 % of total area
- Loss factors: 0.9
- Resulting total area efficiency: 5 % i.e. making 27 Wp per module.
- Yearly produced modules: 740'000
- 3 shift production: 96 modules/h
- Equipment CAPEX: 5.3 M €, depreciation 20 %.
- Interest on CAPEX: 6 %
- 45 people employed
- FOREX: 1 € = 1.6 CHF = 1.1 US \$

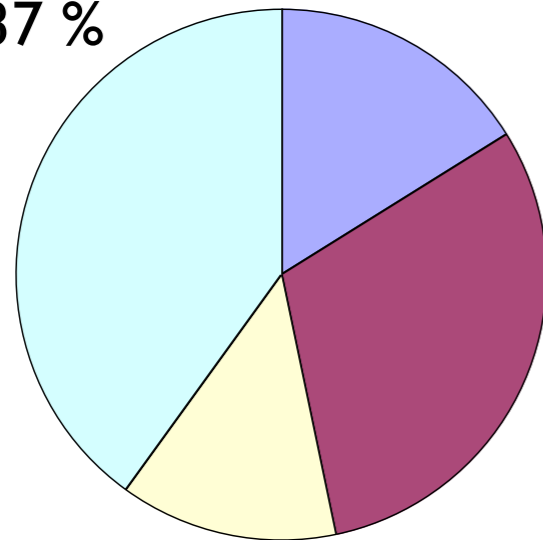
Economic estimations...

Monolithic Module Production 20 MWp / Year

90 x 60 cm Module with 50 Wp/m² output power

Raw-Materials

Sealing & Contacts
37 %



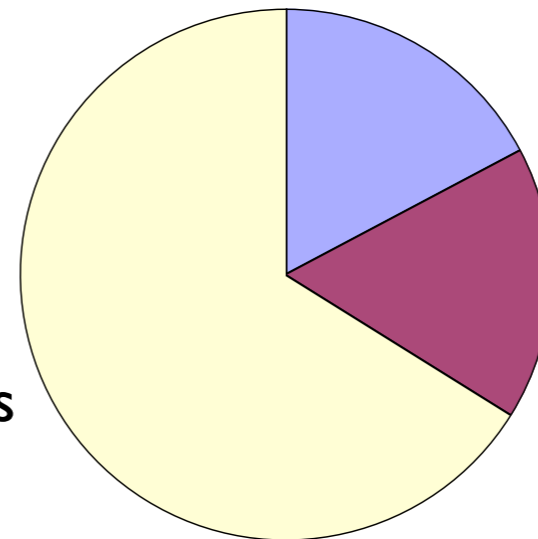
TCO-Glass
17 %

Ru-dye
32 %

nano-TiO₂
14 %

Module cost: 0.97 € /Wp

Materials
69 %

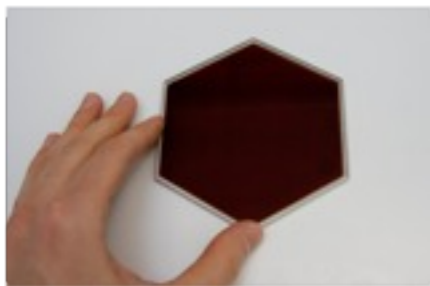


Personnel
19 %

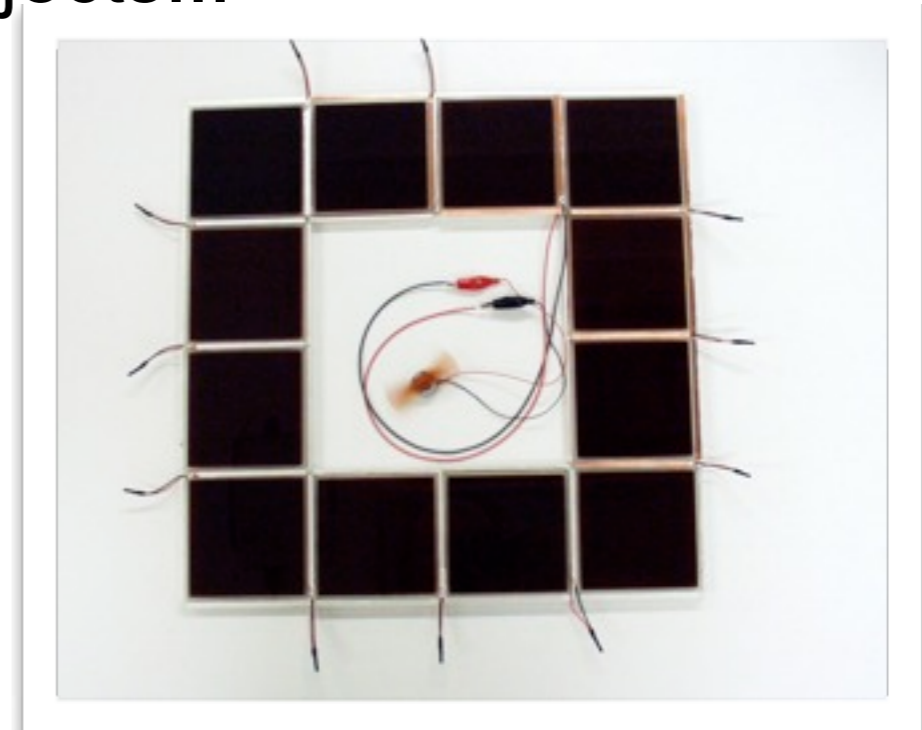
Fix costs
12 %

Product developments...

- (Monolith) Module for indoor & outdoors testing
- Design objects... "Sunny Memories" project completed
- Module sizes from a few cm² to 30 x 30 cm²
- "Zero-standby" powering
- Niche markets: Artistic interactive objects...
- Future: solar home systems ?



Prototype I Project "Lachen"
40 x 40 cm



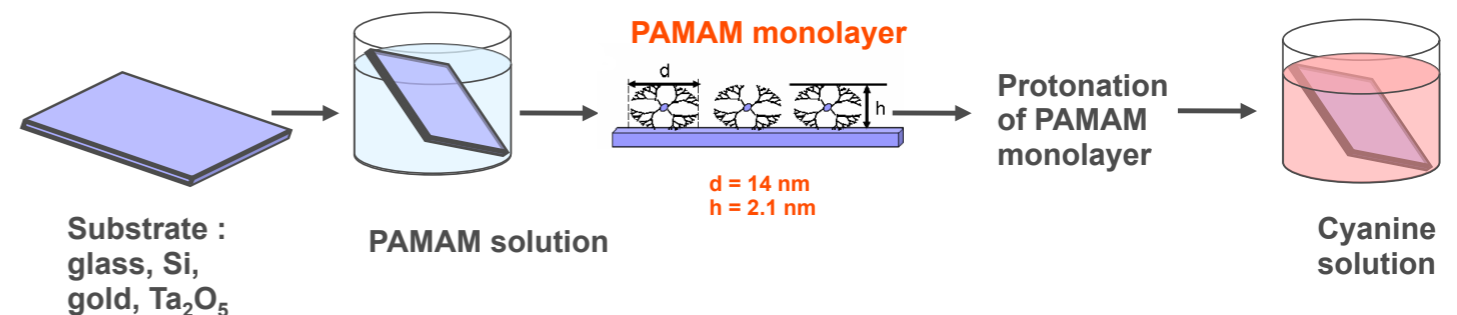
Dye Solar Cell Modules are...

- 😊 Easy to manufacture - all layers are screen printed
- 😊 “Low-Cost” materials - glass, TiO_2 , carbon paste, dye, polymers
- 😊 10 x 10 cm module realized and characterized
- 😊 30 x 30 cm module test line operational
- 😊 Best efficiency so far: 6.5 % \rightarrow 48 Wp / m² on total area
- 😊 Industrially ready for consumer electronics & appliances
- 😞 Not yet qualified with standard tests (IEC 61646)
- 😞 No products yet for the built environment (roofs & façades)

KTI Projects in the pipeline...

Project with CSEM: Raphaël Pugin + Emmanuel Scolan)

Dendrimer assisted J-aggregation of cyanines dyes within metal oxides layers for application in solar energy conversion



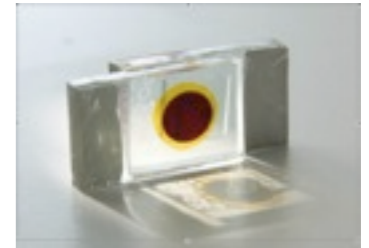
Exploit J-aggregated dyes:

- enhanced absorption
- higher stability thanks to stacking
- CSEM process is compatible with DSSC-technology

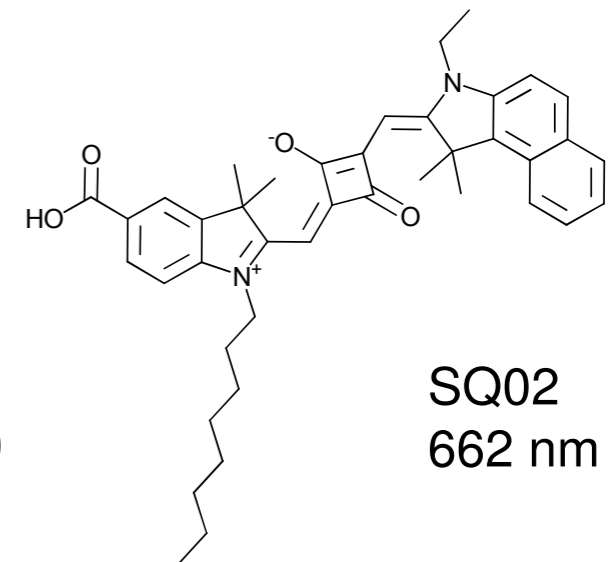
KTI Projects in the pipeline...

Project with EMPA: Thomas Geiger + Frank Nüesch)

Neuartige Sensibilisatoren für Farbstoffsolarzellen:
Squarain- und Heptamethinfarbstoffe mit einer grossen
spektralen Vielfalt oberhalb 700 nm.



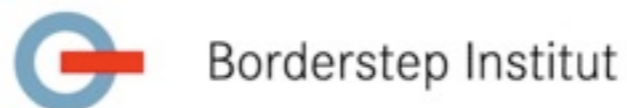
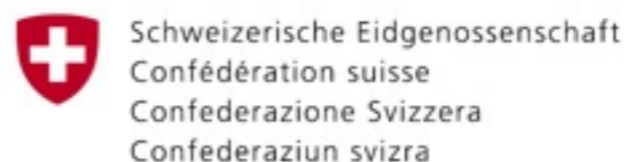
- Explore new dyes in NIR
- Upscale synthesis
- Improve efficiency to $> 5\%$ (now $\sim 2.5\%$ SQ2)
- Demonstrate in large DSSC's (now 10x10 cm)



Outlook

- Production of 30 x 30 cm MIM's for samples & testing
- Production of specialized DSSC's & MIM's
- Go to 7-8 % efficiency in MIM's
- Take advantage of KTI & FP7 projects to maximize performances
- Long term stability tests similar to IEC 61646
12 months + field testing
- Pilot production, maybe with partner(s)
Scale-up to 60 x 90 cm MIM's ?

Partners & Sponsors



Thank You for the Attention

