R&D from material preparation up to next generation manufacturing: opportunities for local companies

Prof. Christophe Ballif

EPFL,IMT, PV-Lab and CSEM CSEM, PV-center

2000 Neuchâtel

PV-lab
IMT NEUCHATEL

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EPFL
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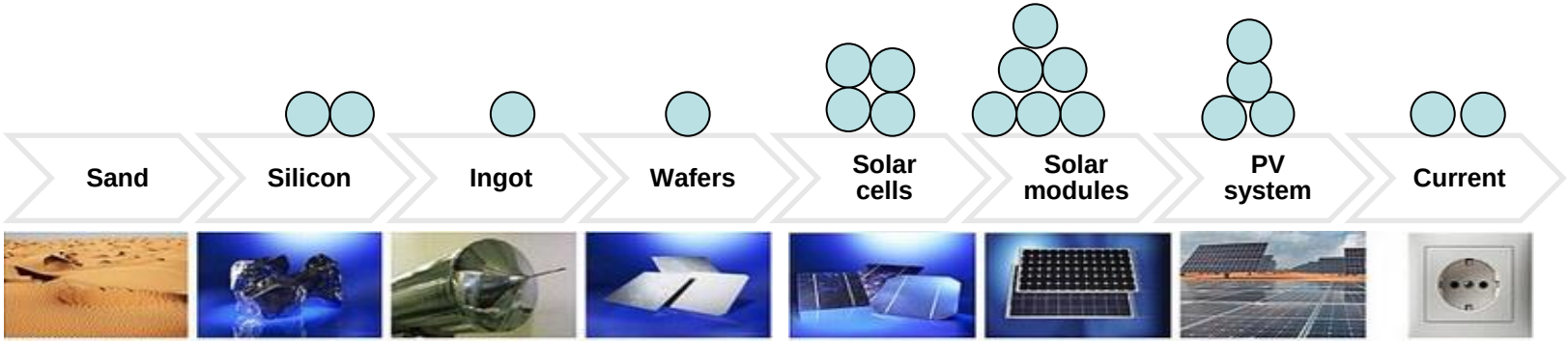
PV industry

- Ultra-low cost of PV products (below real production costs) → strong pressure on module/inverters makers
- Stop of activities of many key players in PV clean-tec recently in EU and CH (Tel Solar, Sputnik,…Flexcell, Pramac,)
- For components and equipments, increasing competition from far east.

→ **research, innovation, and selected markets**

CH with competences all along the value chain

- R&D strength in “semiconductor” and solar cell processes
- Leadership in PV equipment manufacturing
- Selected quality components
- Metrology, software



- Services
- Electricity management
- Storage solutions….

- Examples: Si feed-stock preparation

High Voltage Pulse Crushing Equipment

for poly silicon rods - or monocrystalline silicon wings/tails

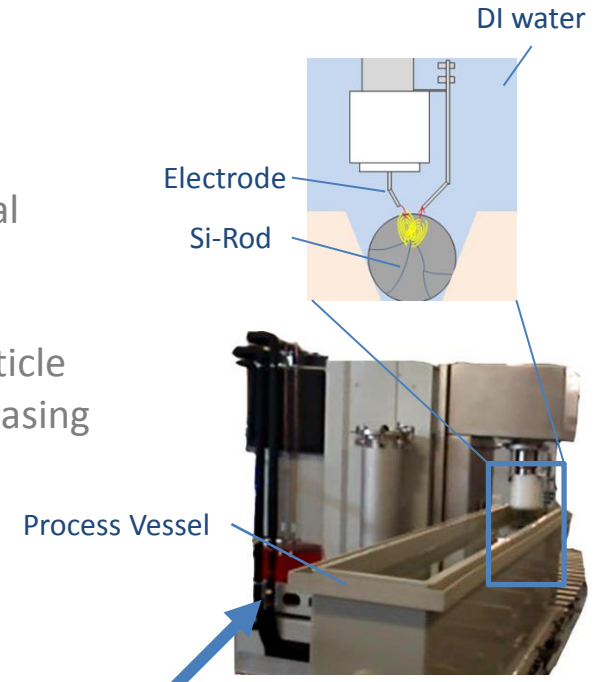
SELFRAG
HIGH VOLTAGE PULSE
POWER FRAGMENTATION

Challenges solved

- High purity process – minimal etching
- No mechanical contacts
- Low percentage of fines
- Controlled particle sizes, even in small particle range
- High productivity and quality of overall process
- Controlled, automated and traceable process
- Minimal manpower required
- Low energy consumption (< 3 kWh/t)

Further Research

- Increase Electrode lifetime
- Reduce further metal contamination to <5ppb/w
- Introduce InSitu particle size control for increasing further yield and throughput



Existing Technology

Jaw crusher product

New Technology

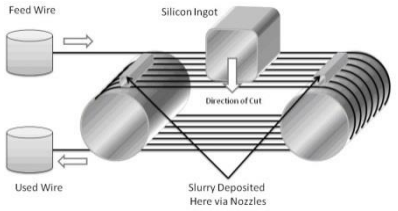
HVP crusher product

High Quality Silicon from Waste

Plus MAT
sustaining values

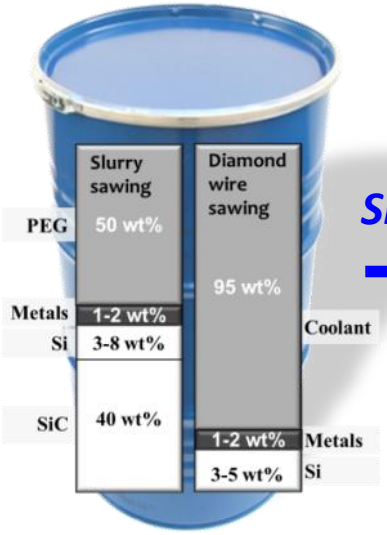
Silicon:
~20% of module cost

Huge value loss:
40% - 50% of Si is lost during wafer wire-sawing process



Sand → Silicon → Ingot → Wafers → Solar cells → Solar modules → PV system → Current

Technology@ +MAT: Highly pure Silicon extraction at cost << market price



Si recovery

µ-powder

Si sphere

applications

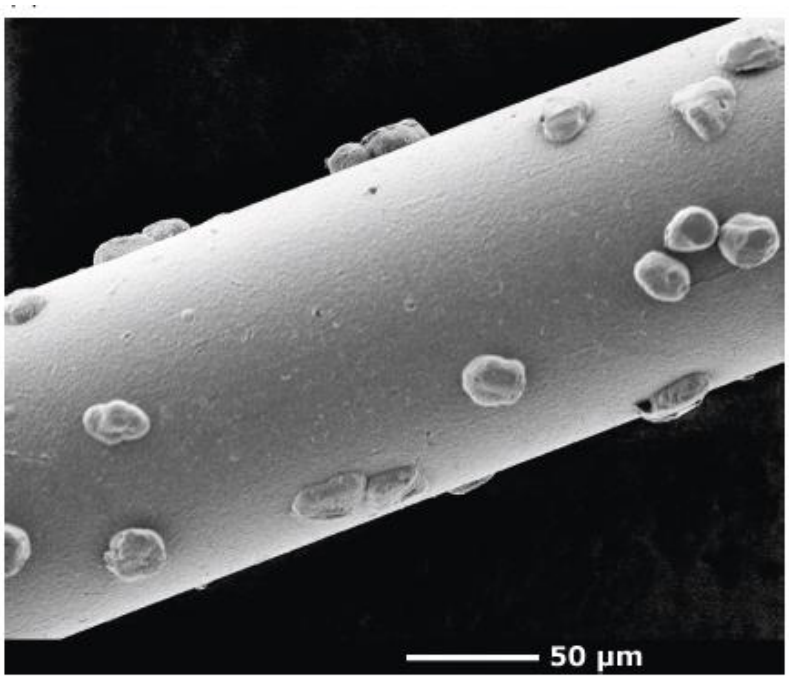
- Back to PV as feedstock
- Ceramics for turbines etc …
- Li-ion battery for energy storage
- Thermal spray
- …

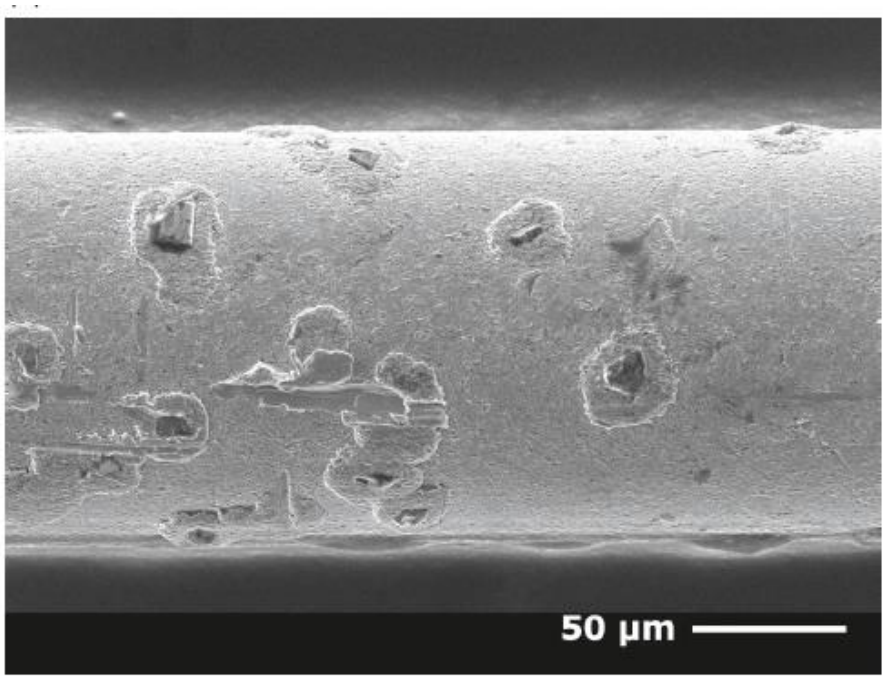
A key innovation at Meyer-Burger

- Sawing wafers with “diamond wires”

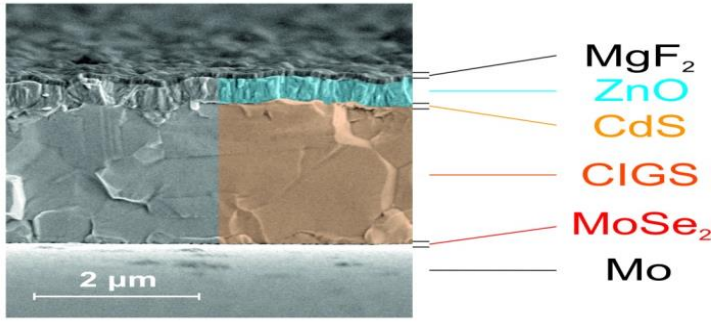
MEYER BURGER

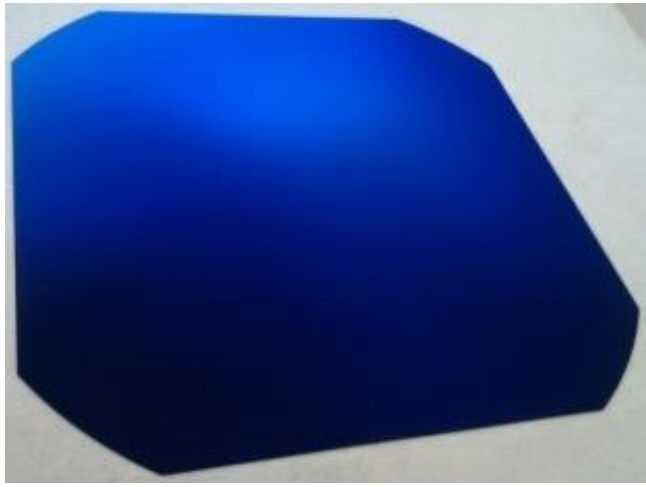
- New approach of **wire management** to reduce wire wear → huge increase in cost competitvness





- Examples: solar cell technologies





Key Research strengths

- Solar cell processing

CIGS — EMPA

CdTe — EMPA

Thin film silicon — EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE :: csem

Crystalline silicon — EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE :: csem

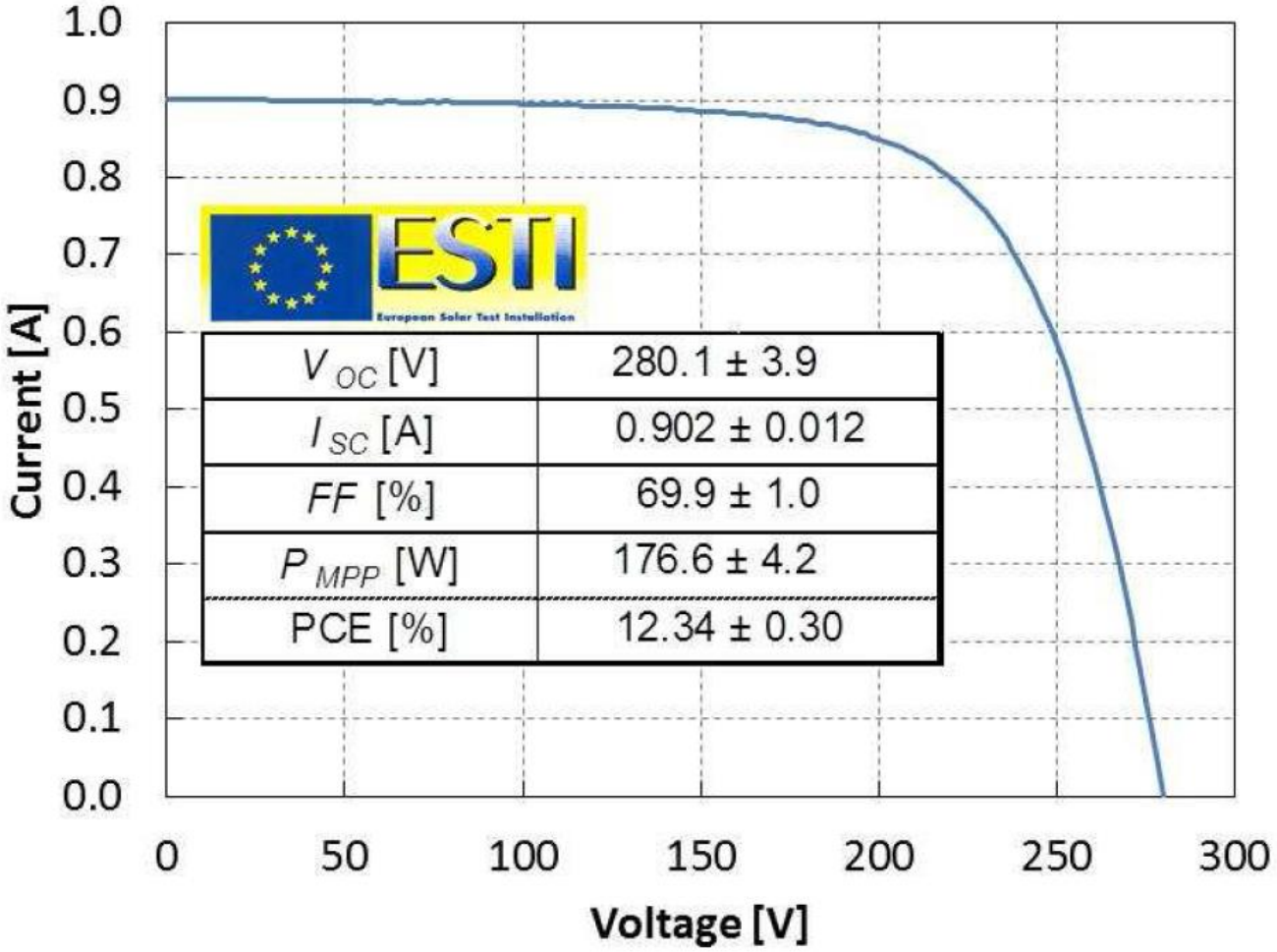
DSSC — EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Perovskite — EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE, EMPA, :: csem

OPV — :: csem, EMPA

State of-the art results of Swiss research group

Last results by TEL solar Trübbach



V_{OC} [V]	280.1 ± 3.9
I_{SC} [A]	0.902 ± 0.012
FF [%]	69.9 ± 1.0
P_{MPP} [W]	176.6 ± 4.2
PCE [%]	12.34 ± 0.30

Certified stabilised efficiency of 12.34 in pilot line, total area 1.4m^2 modules !

Roll-to-Roll manufacturing for low cost flexible solar cells

World record efficiency (20.4%) flexible CIGS solar cells on polymer film by EMPA

Empa provides R&D support to Flisom

Lowest production cost potential:

- **Compact machine size**
- **High speed processing**
- **Lower energy consumption**
- **High material utilization**
- **No robotics for handling**

- **Lower module cost (€/Wp)**
- **Lower balance of system cost (€/Wp)**
- **Lower transportation and installation cost**
- **Flexibility & lightweight enabling unique solutions**

Flisom
Flexible Solar Modules

Landmark Projects Delivered & on Order

2013
Geneva Airport

2015
City of Lausanne, Switzerland

2015
Smart City Graz

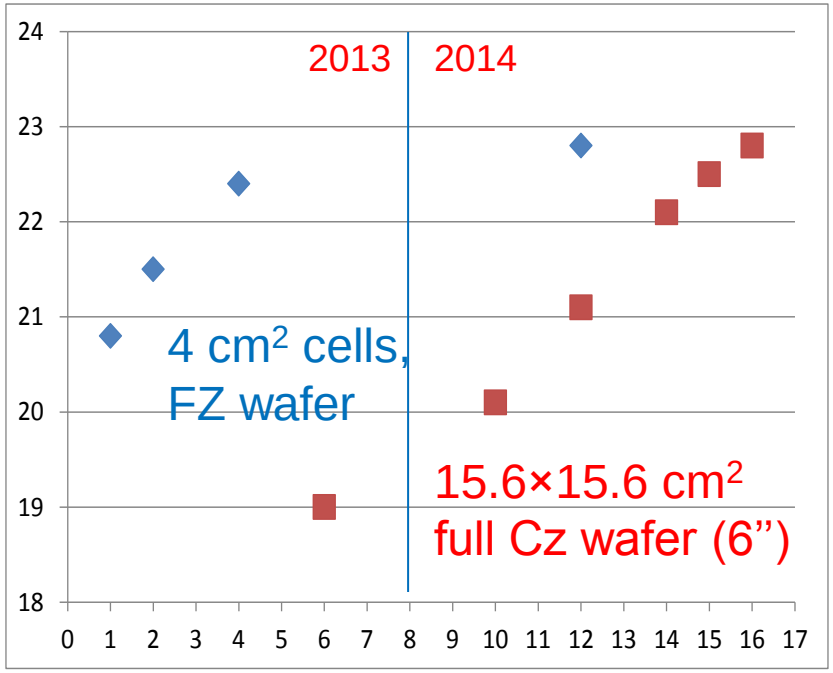
glass 2 energy

collaboration with LPI, EPFL

LPI

Working on low cost crystalline Si heterojunction

MEYER BURGER



Meyerburger pilot-line with production size tools at Hauterive site.
See talk by B. Strahm et al.

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Multi-chamber /PECVD/Sputtering

SWISS MADE
INDEOtec
PLASMA PROCESS EQUIPMENT

Working out next generation cell technologies

- Extending efficiencies in all technologies
- Hetero-interfaces for higher voltage in thin film cells
- Novel passivating contacts allowing high fill factor and/or higher current in crystalline Si…, IBC cells

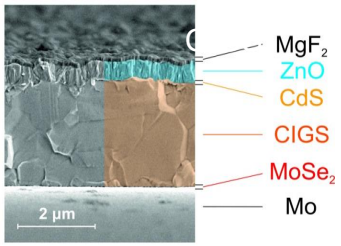
Disruptive approaches:

- Example of PV 2050 (PNR70) and Nanotera-OFEN synergy

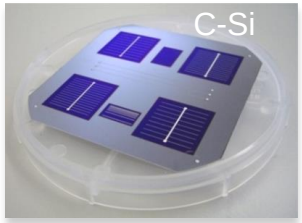
PNR PV 2050, Nanotera-OFEN Synergy projects

- High-bandgap chalogenides cells and perovskites cells that can be incorporated as top cells in multiple-junction devices
- Redesigned bottom c-Si and low band-gap chalcogenides cells
- Combine top and bottom cells to validate potential of 30% and over
- Assess potential of monolithic versus 4-terminal configuration.

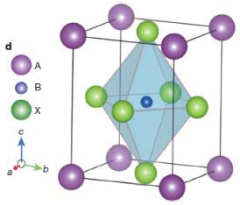
WP1



WP3

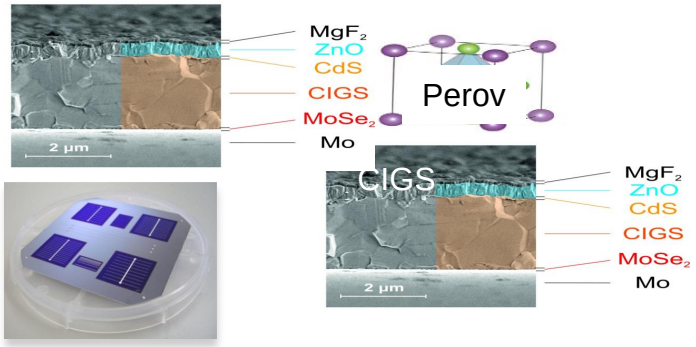


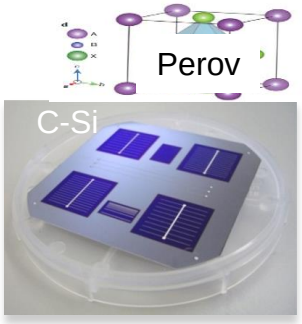
WP2



Perov

↓ Tandem structures (examples) ↓ WP4





Potential of > 30% for all device structures

Achieved > 18% in 4 terminals

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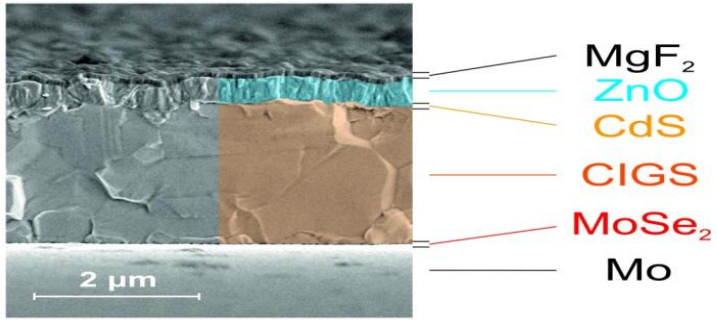
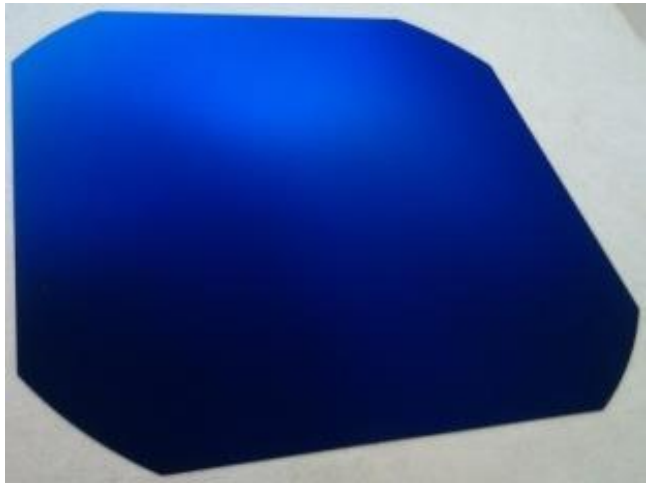
- Examples: solar cell technology





- Example modules and novel products

PV cells and modules are becoming low cost raw materials…

Infinite possibilities to “integrate” PV

Switzerland “sensitive” to aesthetic aspects…

DESIGNERGY®

structurally integrated solar building solutions

Aesthetics in PV

Thermal Insulation

H2O-tightness

Structurally tough

- Designergy is penetrating the roof market with the first real solar building material and system
- New developments will include new applications for both buildings and civil engineering

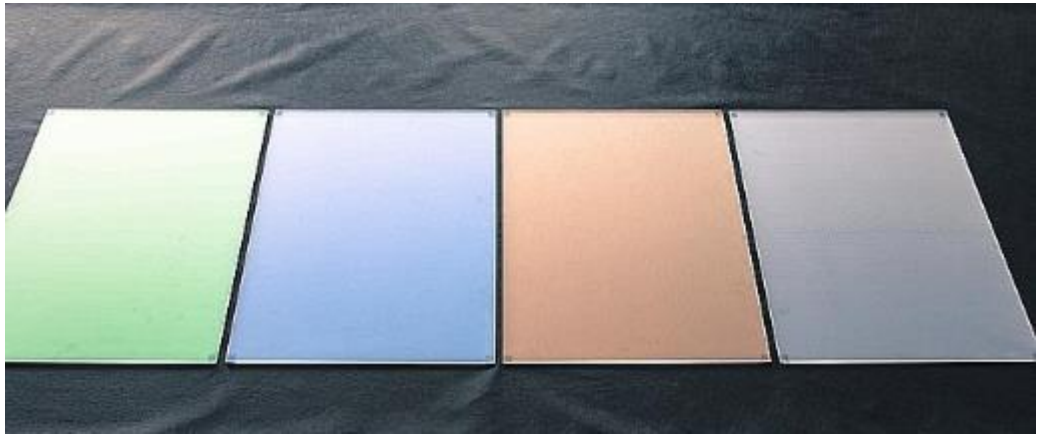
«BIPV 2.0», Designergy is launching the next level: Structurally Integrated PV (SIPV)

Swissinso/Kromatix

SWISS INSO
innovative solar solutions

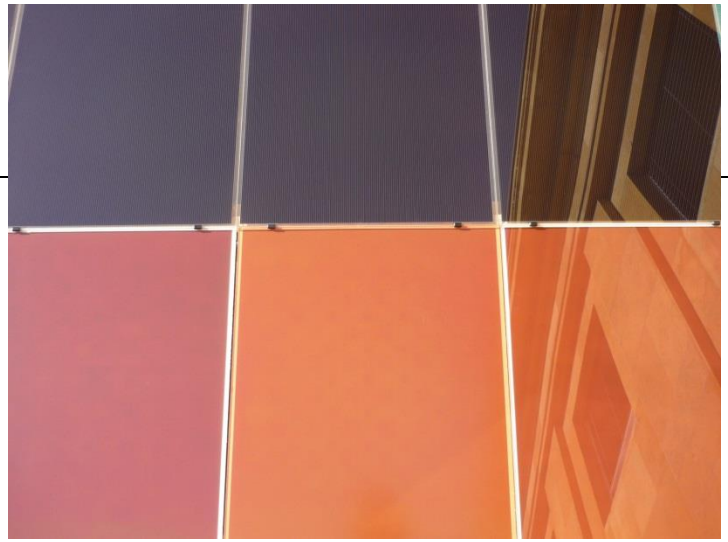
Collaboration
with LESO
EPFL

LESO-PB



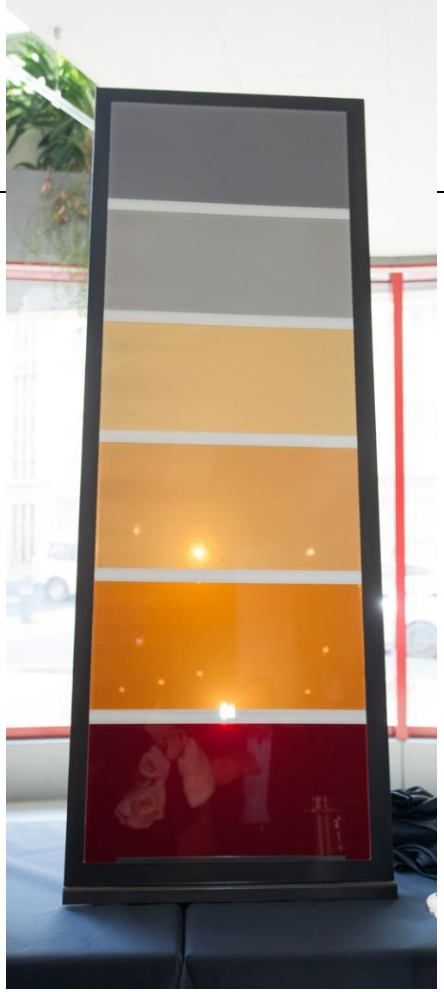
ses

Terra-cota like thin film



Userhuus
Development within Archinsolar by PV-lab industrialisation by CSEM

White and colored modules



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See talk by L.E. Perret-Aebi

SOLAXESS
white solar technology

- Examples: contacting and power electronics

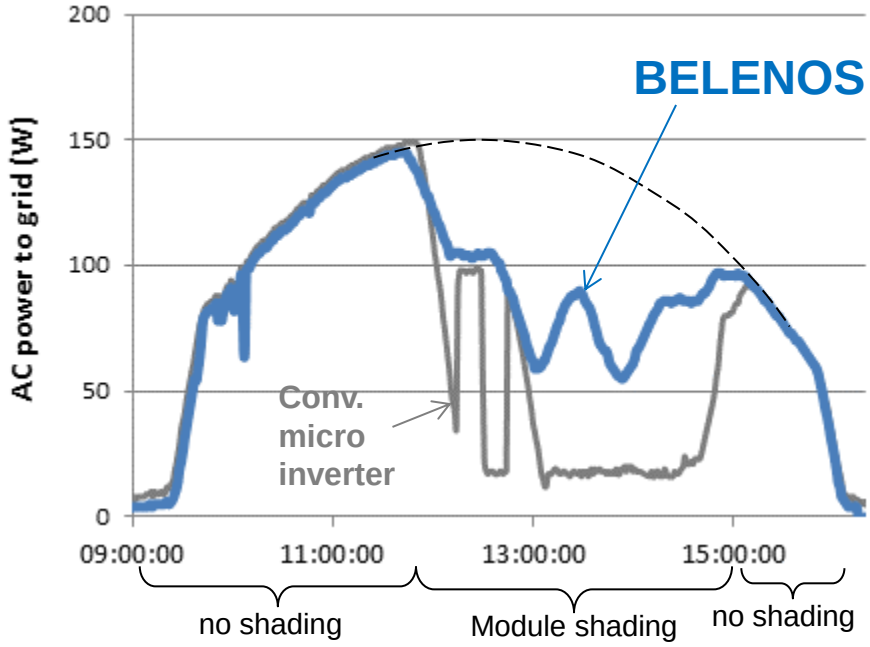
Belenos 3 MPP tracker, module integrated micro-inverter

- 300 - 330 Watt DC, for 60 and 72 cell modules
- «Solarbox» module interface (4 wire)
- 3 independent sub-string MPP trackers
- No J-Box, no bypass diodes, no DC cables
- Snap-in mounting on modules
- Back side cooling (air gap)
- Integrated daisy-chain AC cable
- PLC data communication

Higher energy production

Lower installation costs

Improved system safety



Conclusions

- Excellent pipelines of R&D research results
- From PV clean-tec point of view, difficult times
- Strong technologies in place, selling
- Several start-ups and innovative product approaching or reaching the market
- All research efforts support the pressure on improving PV products …
- Global importance to support R&D and technology transfert/Piloting