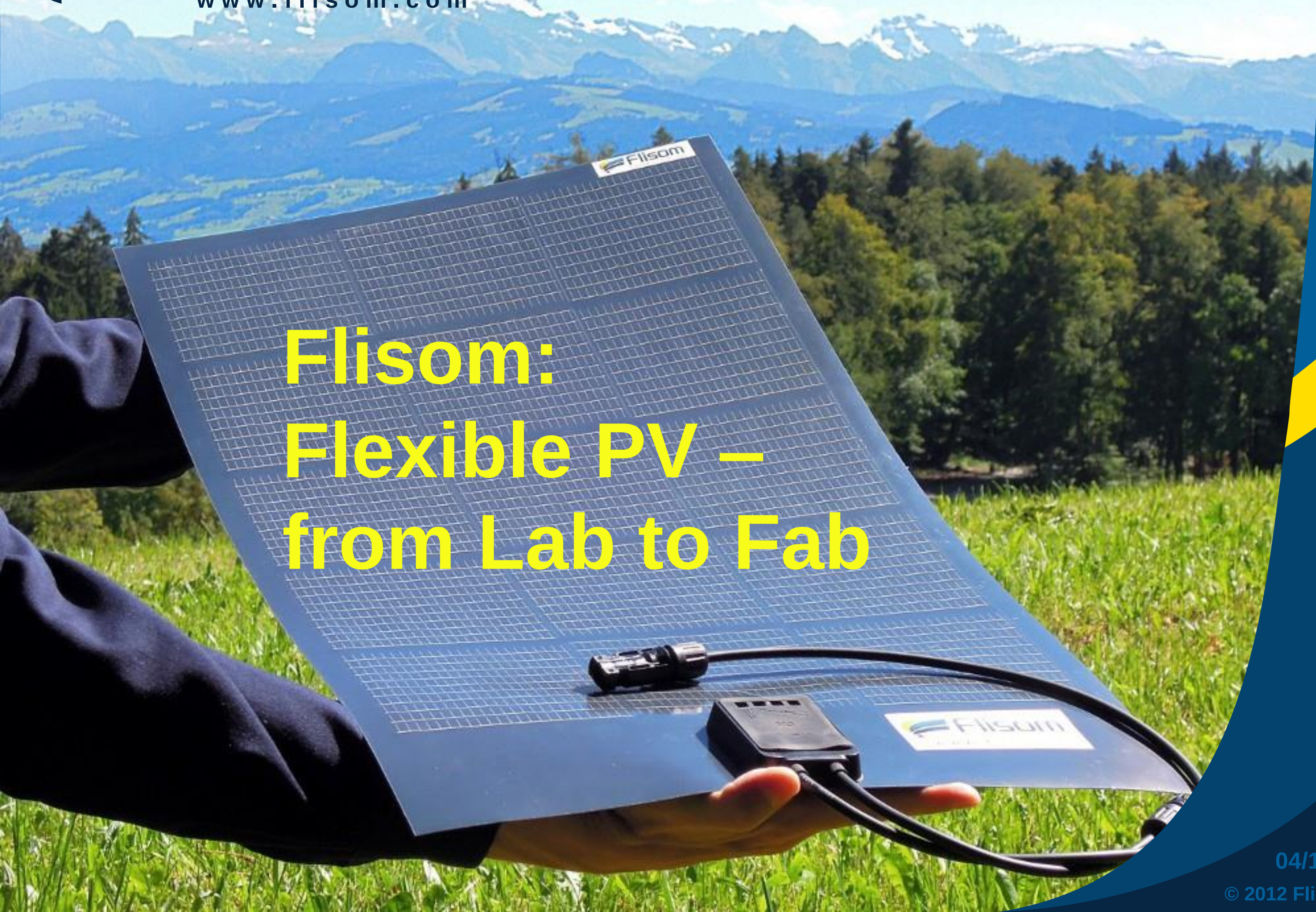
Flisom
Flexible Solar Modules
www.flisom.com

Flisom: Flexible PV – from Lab to Fab



04/11/2014

Agenda

I. Flisom's History
II. Why flexible CIGS Thin Film
III. Flisom's Technology
IV. From Lab to Fab

Flisom progress

Established in 2005
ETH spin-off company
1st round investment-seed

2nd round investment

3rd round investment

2005 2006 2007 2008 2009 2010 2011 2012 2013

Awards
Venture / McKinsey "special award"
ZKB Technopark Pioneer
CTI Start-up
World Economic Forum Tech Pioneer
CASH & SECA: 2nd most promising company of CH
Red Herring 100 (Europe)

R&D Line:

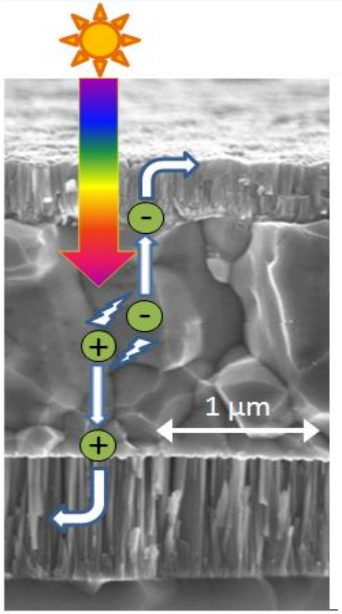
- Development of R2R equipment and technology
- Ensuring that innovative developments are transferable to mass production
- Prototype solar module demonstrators

Funding to ramp up 15MW capacity flexible CIGS production plant in Zurich area

Cooperation and research partner: EMPA

17.8% 18.7% 20.4%
Efficiency records for CIGS on plastic

CIGS – ideal absorber material for thin film solar cells



- Highest efficiency amongst thin film solar cells
- Efficiency comparable to poly-Si wafer cells
- Excellent performance stability
- Energy payback time lower than Si wafer cells
- Excellent stability under space radiation
- Large area coating on different substrates

Highest record efficiencies of solar cells (area: ~0.5 cm^2)				
Substrate	Glass	Steel	Aluminum	Polymer
Efficiency	20.8% *	17.7% *	16.2%	20.4*
Institute	ZSW	EMPA	EMPA	EMPA

Efficiencies of large area solar modules

Average module efficiency: 11% - 14%

Highest module efficiency: 15% - 16%

* Independently certified measurement at ISE-FhG

Cost advantage of flexible solar cells

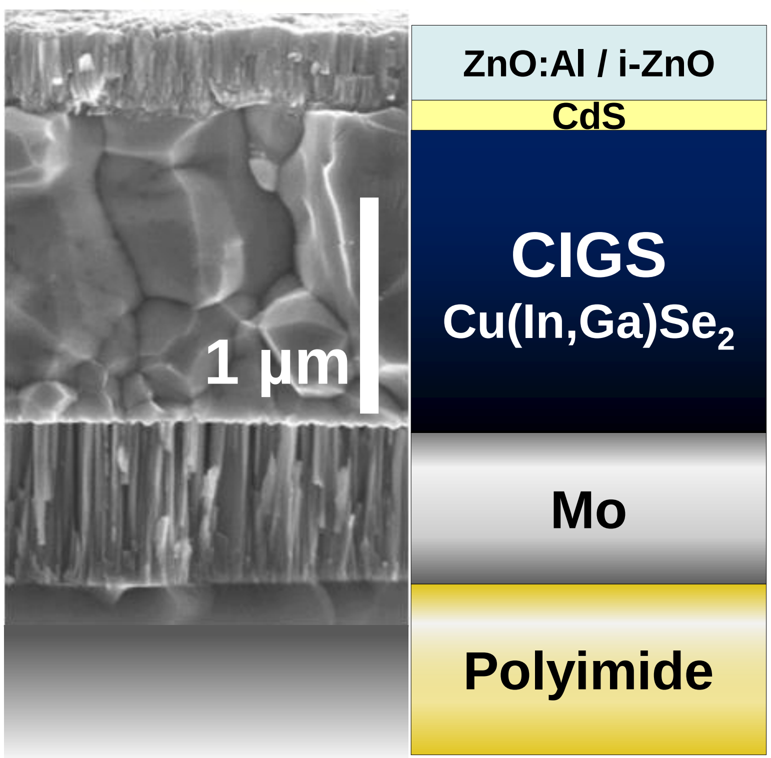
Lowest production cost potential:

- Roll-to-roll manufacturing
  - Compact machine size
  - No spacious automation
  - No robotics for handling
  - High speed processing
- Low energy and material consumption

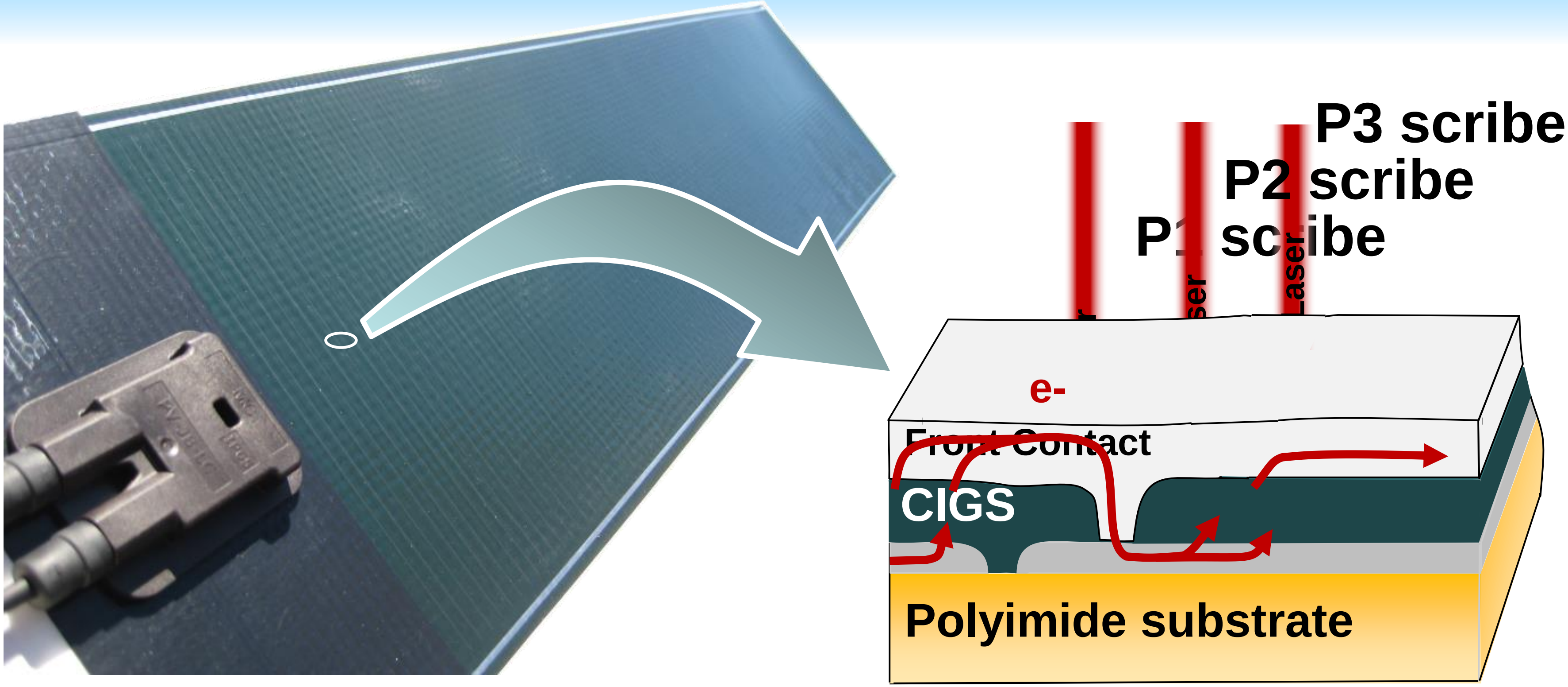
Lowest installed cost potential:

- Lightweight:
  - Low transportation cost
  - Simpler installation systems are possible
  - Easier and faster installation
- Flexible:
  - Unique solutions are possible
  - Less risk of damage during installation

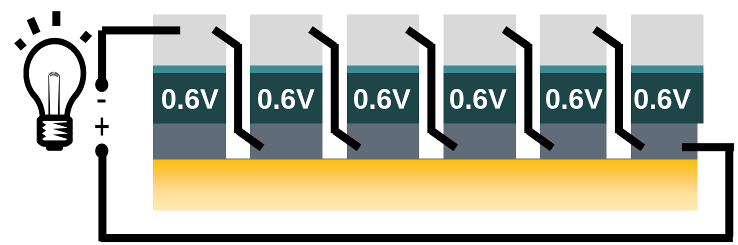
Structure of Flisom's CIGS Solar Cells



Function	Deposition Process
Front Contact	Sputtering
Buffer	Chemical Bath
Absorber	Vacuum Evaporation
Back Contact	Sputtering
Substrate	50m – 2.5km Roll



- Number of interconnections determines voltage of module
- Voltage and current can be designed
- Automated and highly precise processing required



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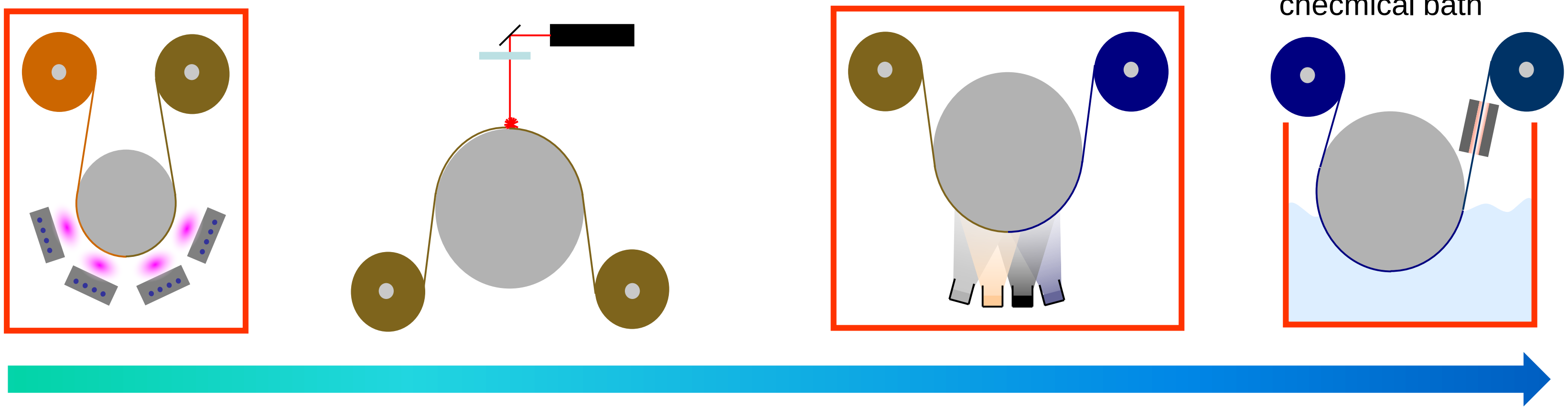
Non-integrated roll-to-roll manufacturing concept

Back contact sputter deposition

Laser scribing P1

CIGS co-evaporation

Buffer layer deposition by checmical bath



FE

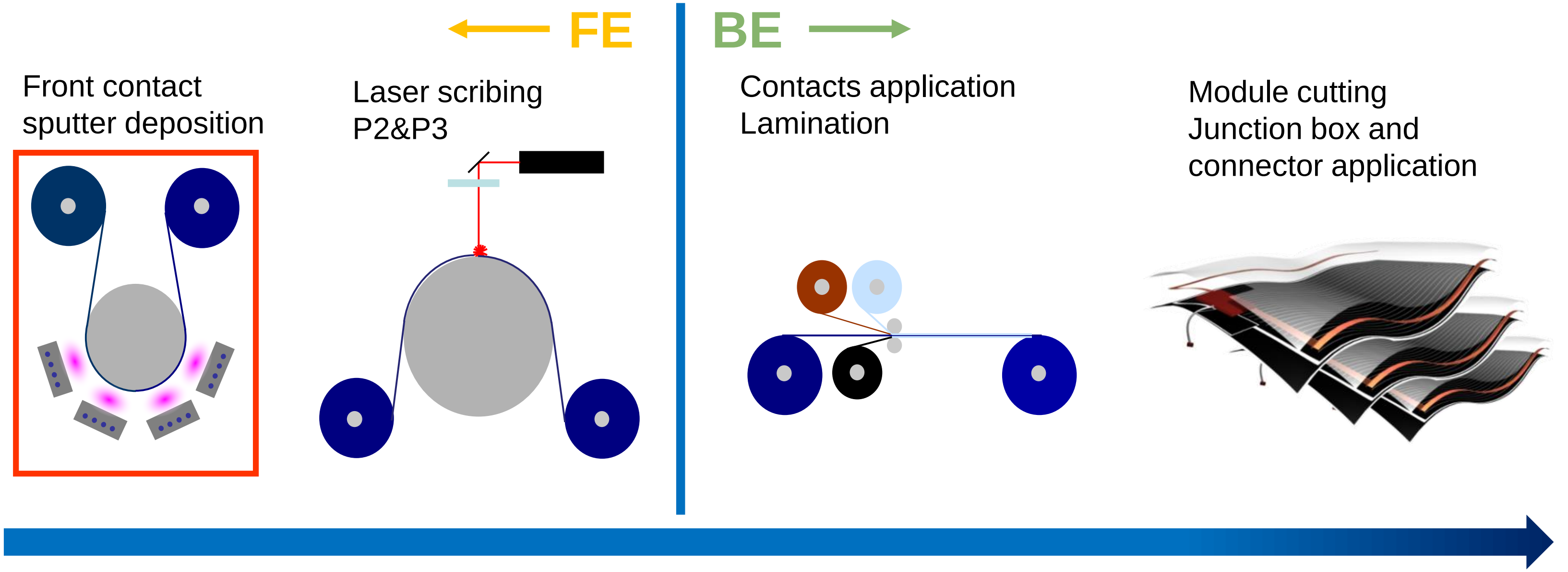
BE

Front contact sputter deposition

Laser scribing P2&P3

Contacts application Lamination

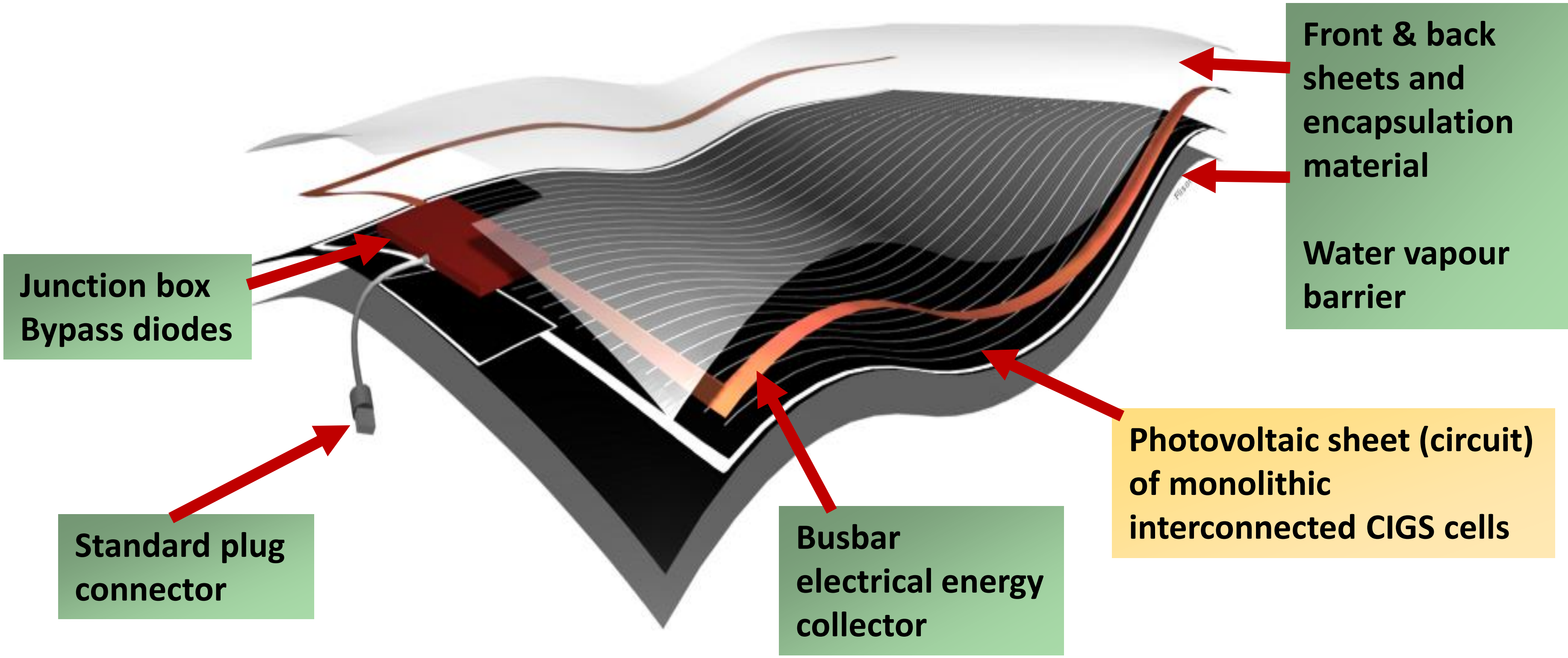
Module cutting Junction box and connector application



Solar Module: Back-end Processing

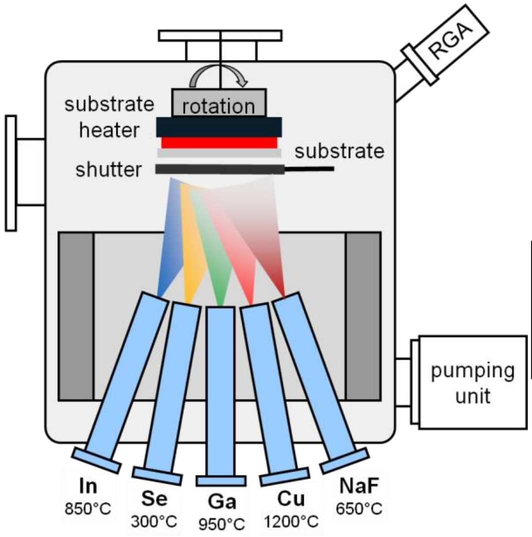
Front-end processing: Active layers & metal grid coatings on Substrate material

Back-end processing: Contacts, Encapsulation foils, Lamination, Junction Box

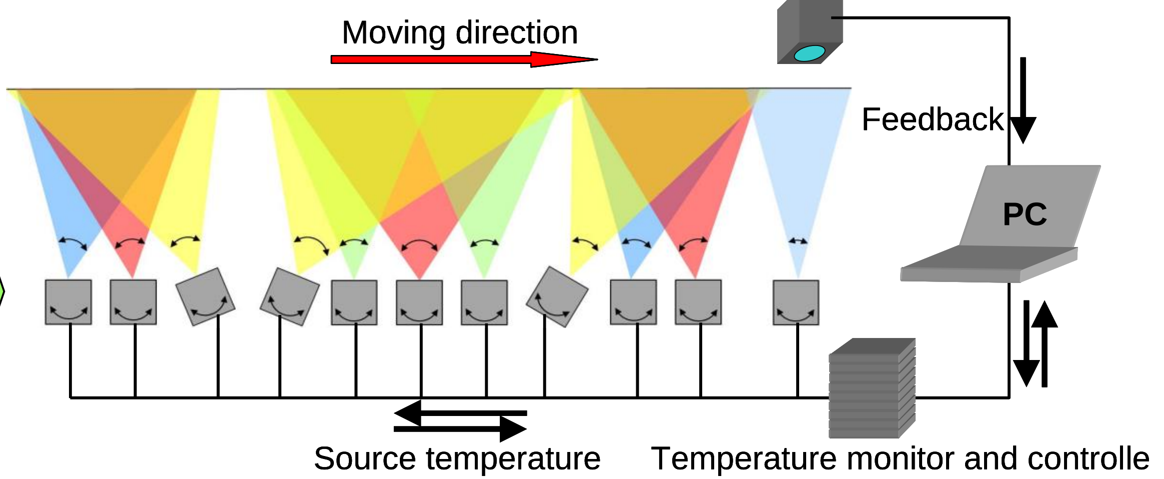


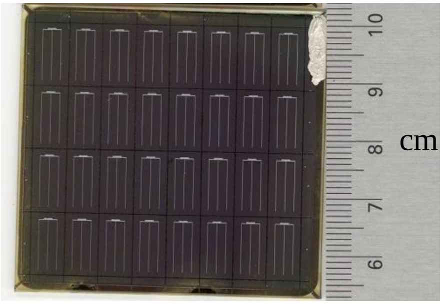
- **Currently high material costs in back-end processing – more than 50% of total material cost**
- **Low cost moisture barrier front sheet is needed**

Laboratory stationary co-evaporation



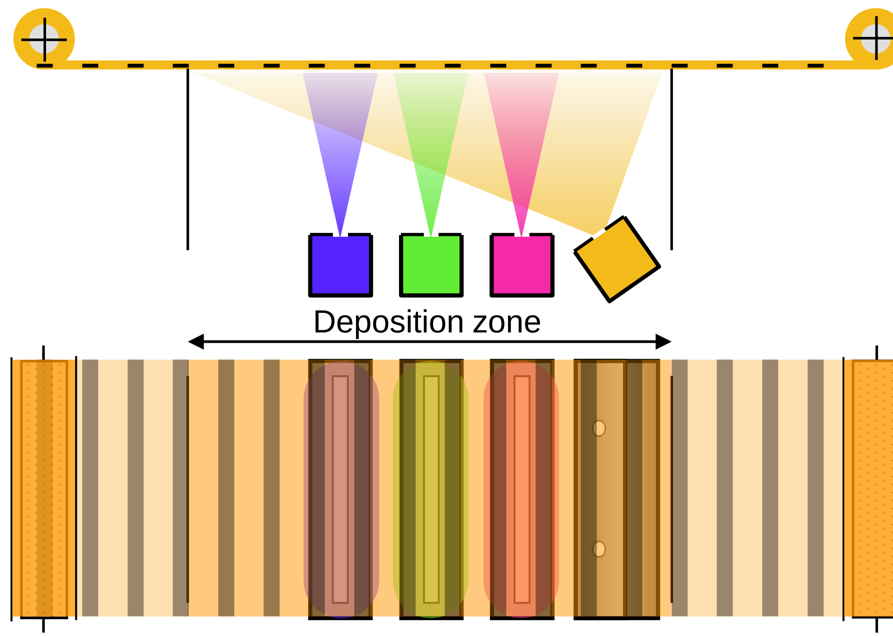
Pilot in-line co-evaporation





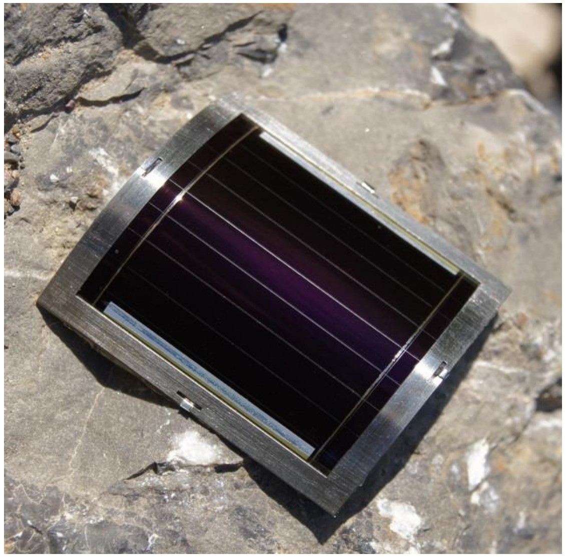
Manufacturing and scale-up challenges

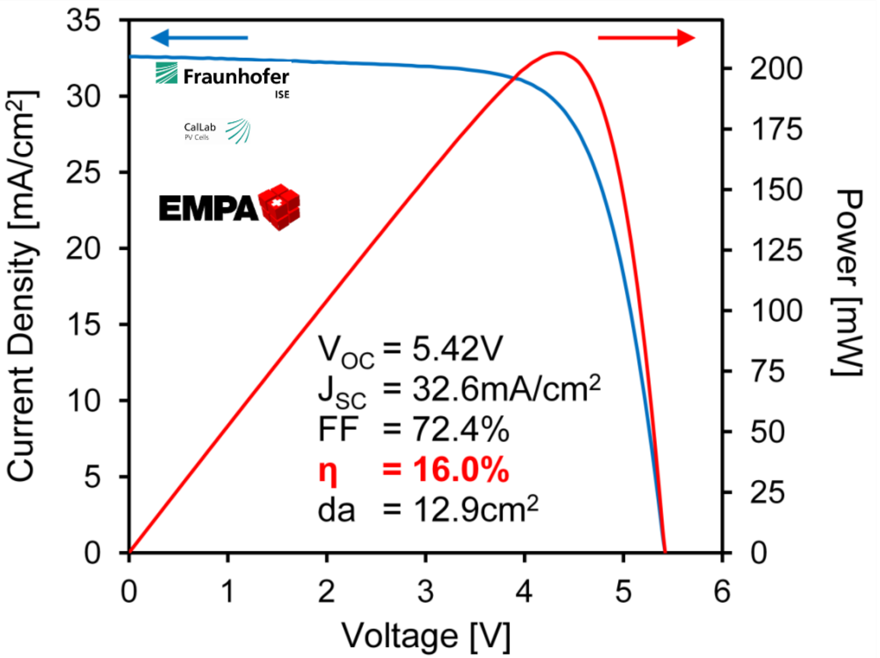
- Roll-to-roll equipment for CIGS on metal or polymer not readily available
- Deposition with evaporation on large width (beyond 1m)
  - Uniformity of coating is very critical
  - Substrate temperatures: 450°C – 600°C
  - Temperature uniformity of heaters
- Composition control of Cu, In, Ga, Se/S, Na, K
  - Stability of deposition rates especially of evap. sources
  - Stable process for more than 6 days of operation (2500m)
- Line yield



High efficiency flexible modules are possible

Certified 16.0% efficiency: Record!





- 8 Monolithically interconnected cells, V_{OC} = 678 mV per cell
- Coating by EMPA, Laser scribing by Flisom
- Challenges for transfer technology to large areas have been described
- Good scale-up will work without additional losses on efficiency

>17% module efficiency expected with further optimisation !

Thank you for your attention