

# Silicon Based Devices for Hydrogen Production

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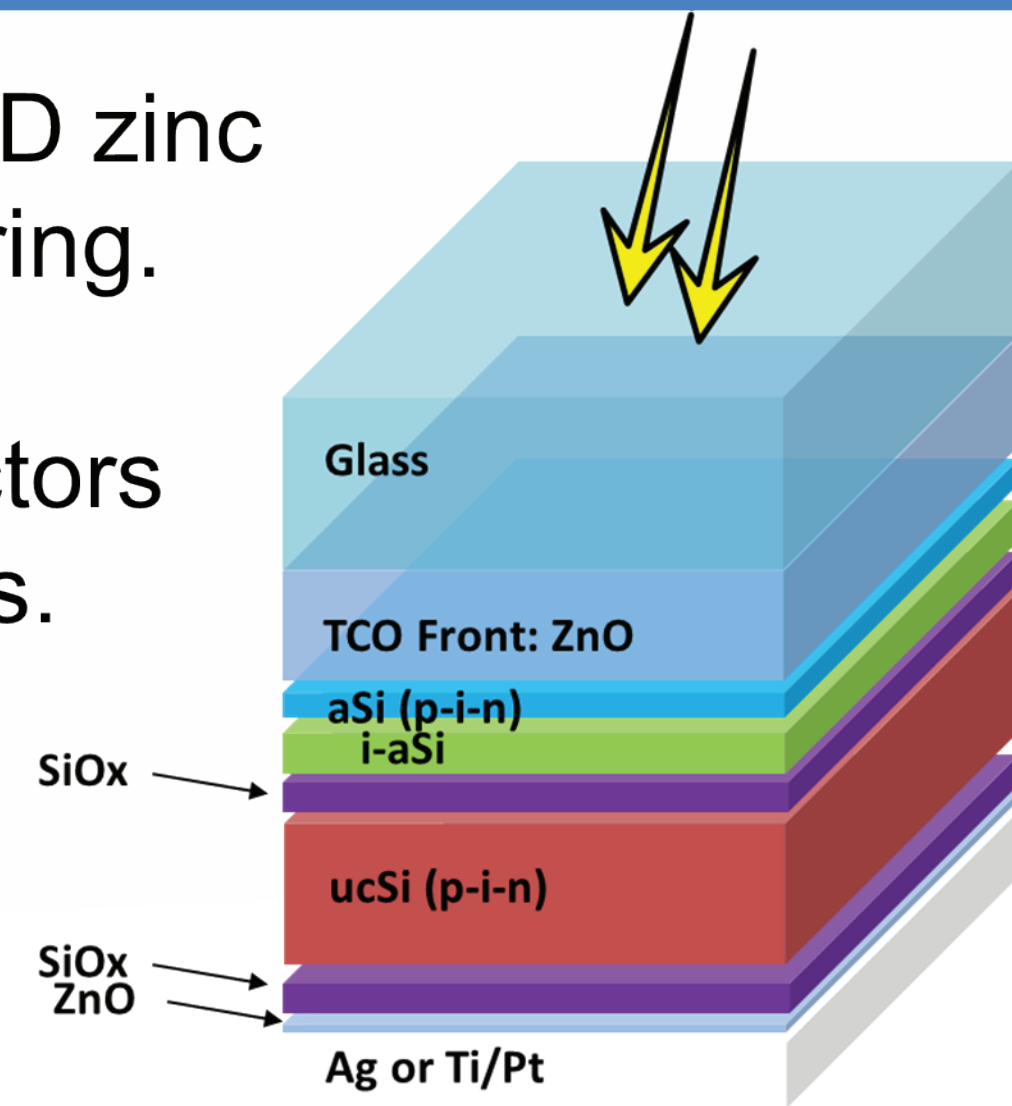


**Constraint: Photovoltaic made from non-toxic and earth abundant materials (Si absorber)**

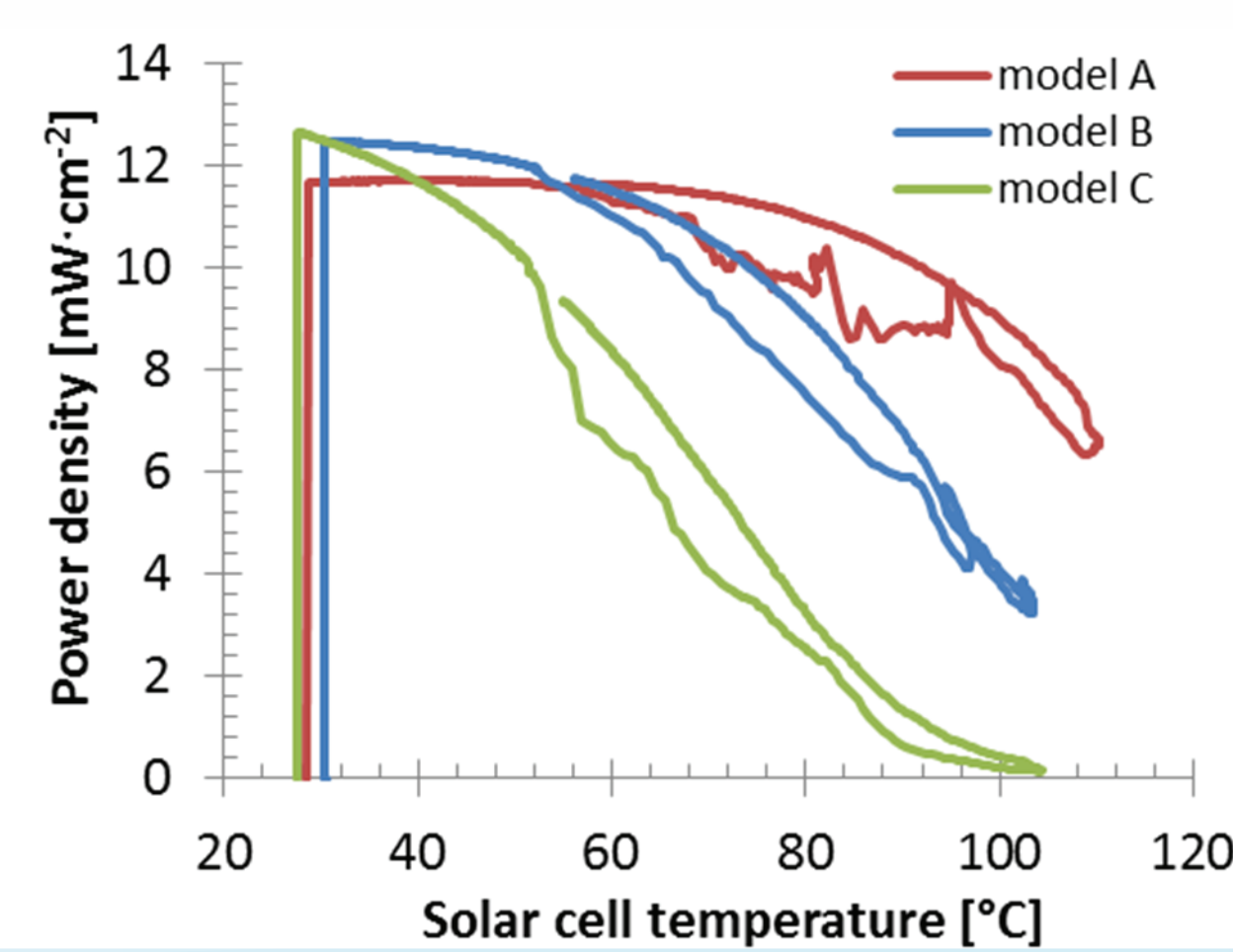
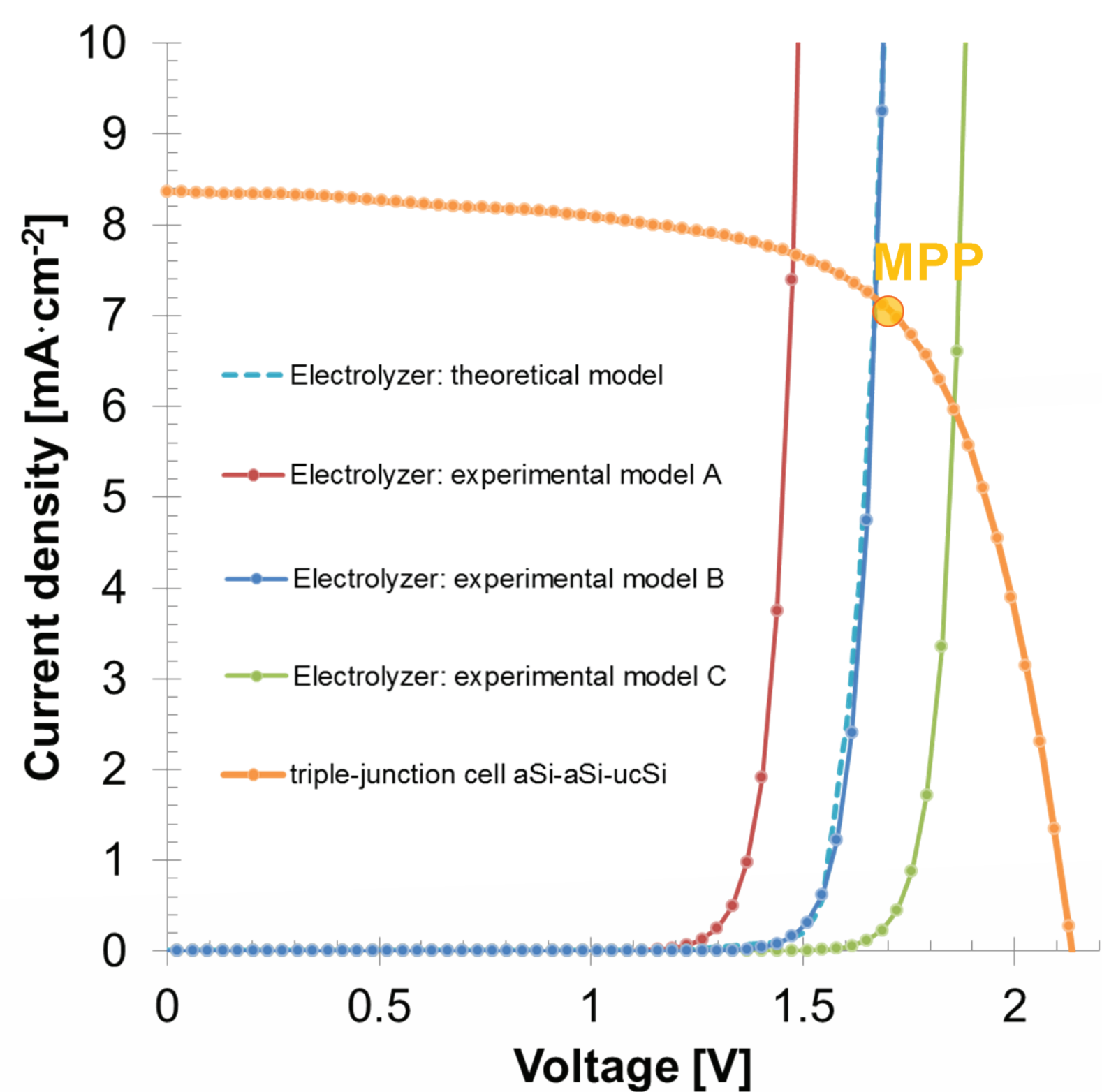
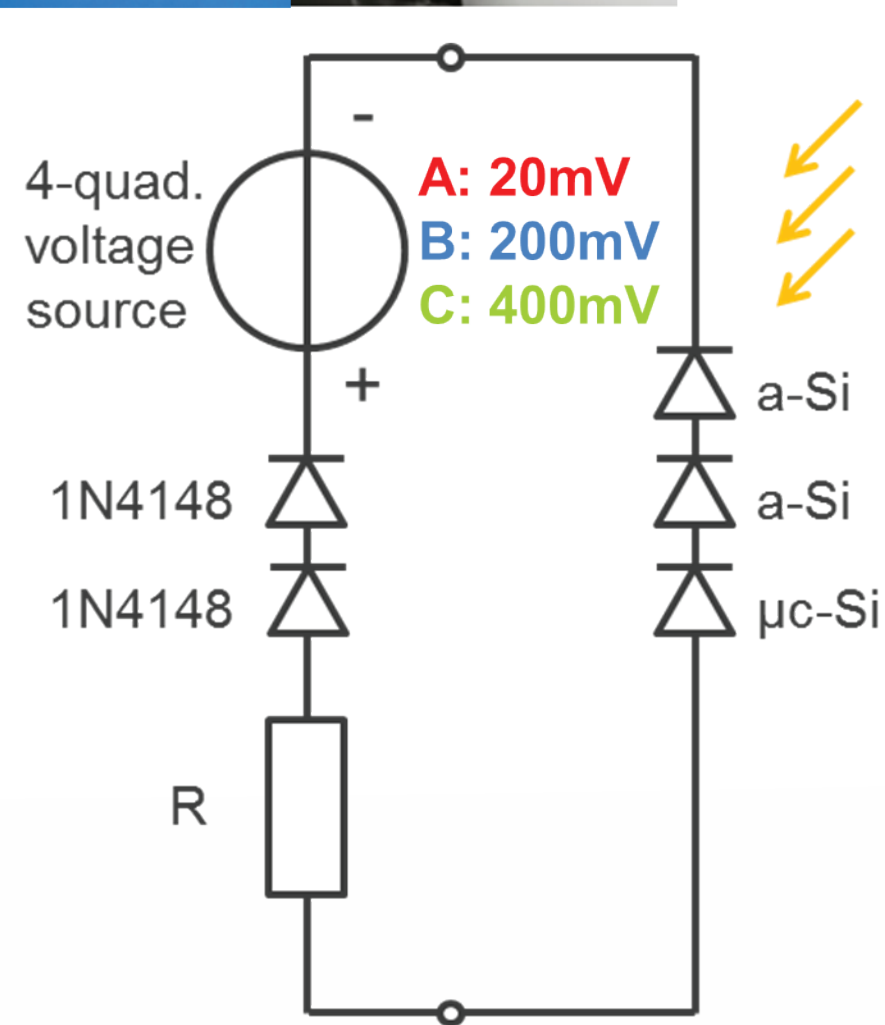
**Challenge: Provide the voltage to break water molecules i.e.  $V_{oc} > 2\text{ V}$ ;  $V_{mp} > 1.8\text{ V}$**

## Thin-film silicon triple-junction solar cell

- Control of surface morphology of LPCVD zinc oxide → light-trapping via diffuse scattering.
- aSi/aSi/ $\mu$ cSi p-i-n junctions by PECVD
- Electronic transport through SiO<sub>x</sub> reflectors by PECVD via dendritic silicon filaments.
- Back metallization by PVD
- All processes @ typ. <200°C



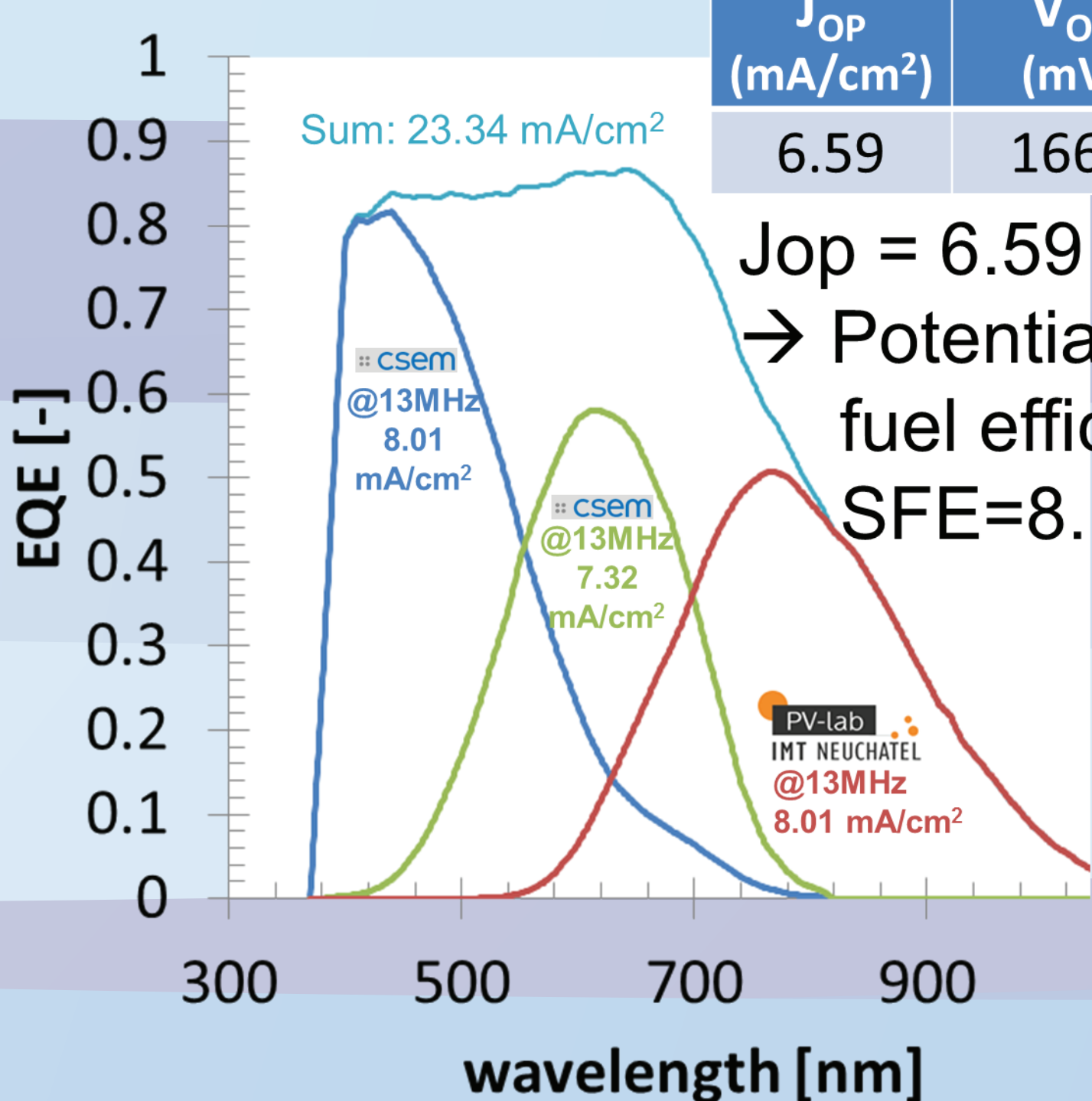
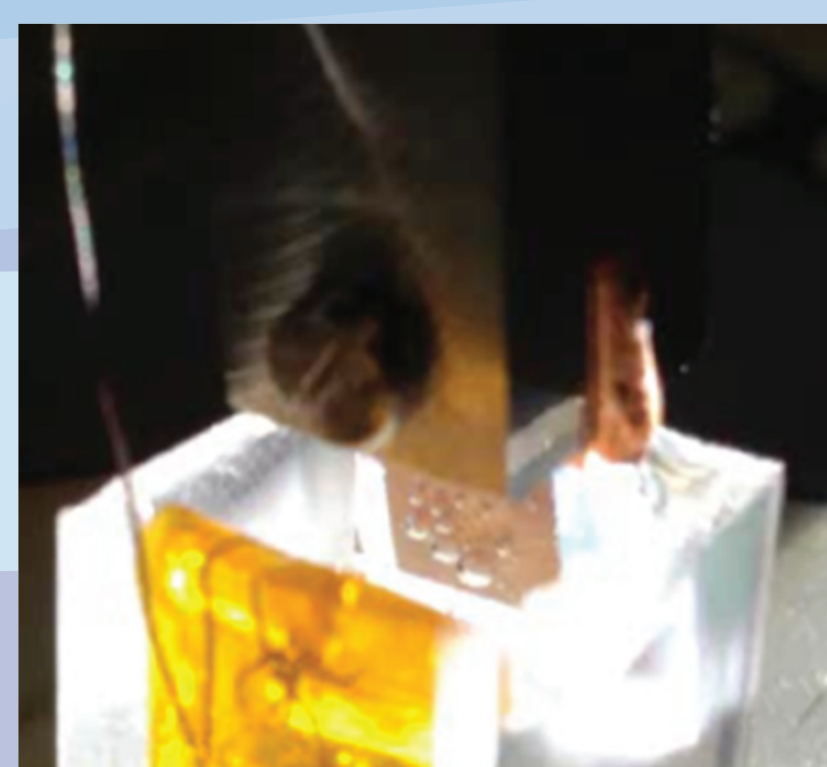
## Experimental study of thermal stability



- Thermal perturbation: dramatic loss with model C.
- Models A, B with OP at the left of MPP: <20% loss up to  $T_{cell} = 65^\circ\text{C}$ .

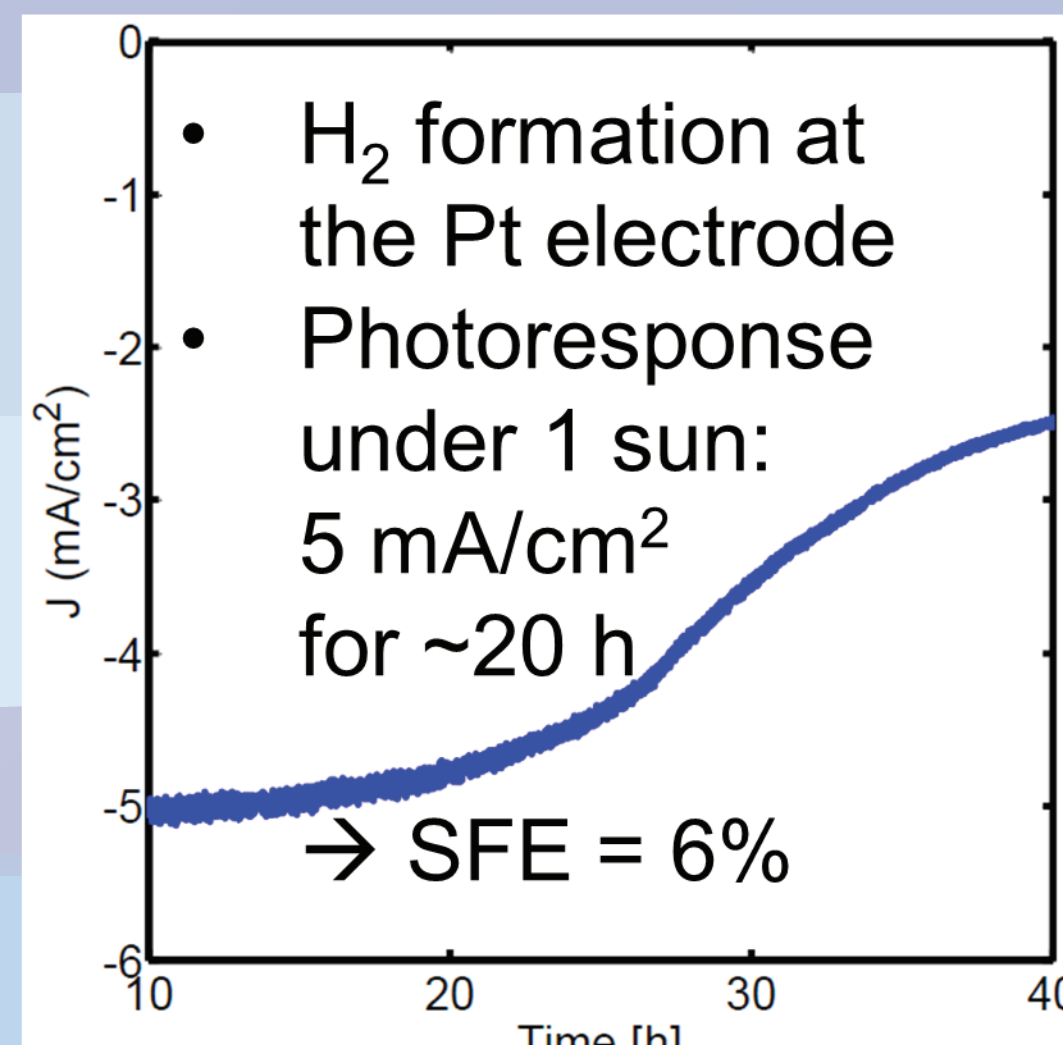
## Wired and photocathode applications

Jsc (mA/cm <sup>2</sup> )	Voc (mV)	FF (-)	Jmp (mA/cm <sup>2</sup> )	Vmp (mV)	Pmp (mW/cm <sup>2</sup> )
7.14	2234	0.710	6.24	1815	11.3



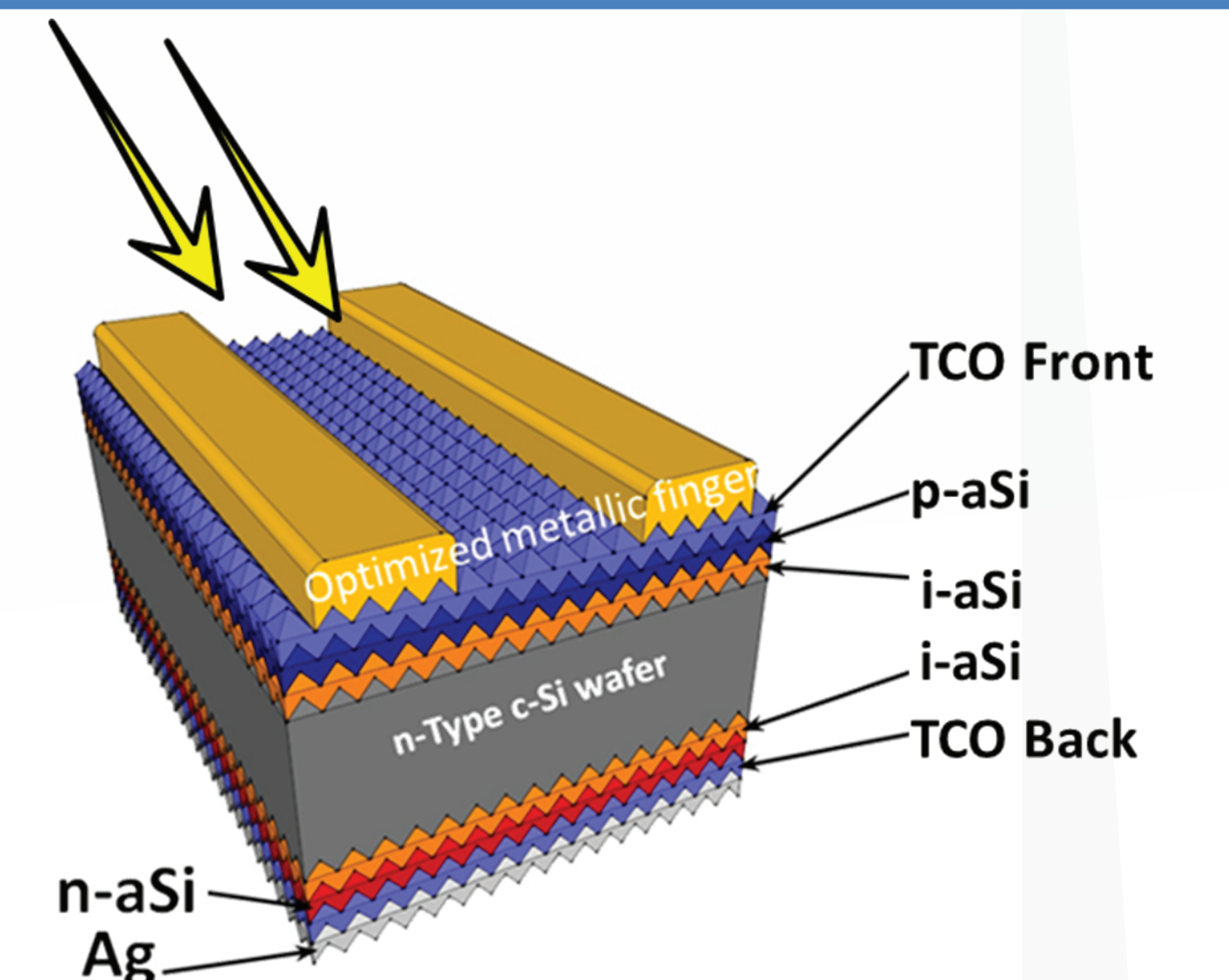
Model	Model	Model
$J_{OP}$ (mA/cm <sup>2</sup> )	$V_{OP}$ (mV)	SFE (%)
6.59	1664	8.1

$J_{op} = 6.59\text{ mA/cm}^2$   
→ Potential sun to fuel efficiency: SFE=8.1%



## c-Si HJT (hetero-junction technology)

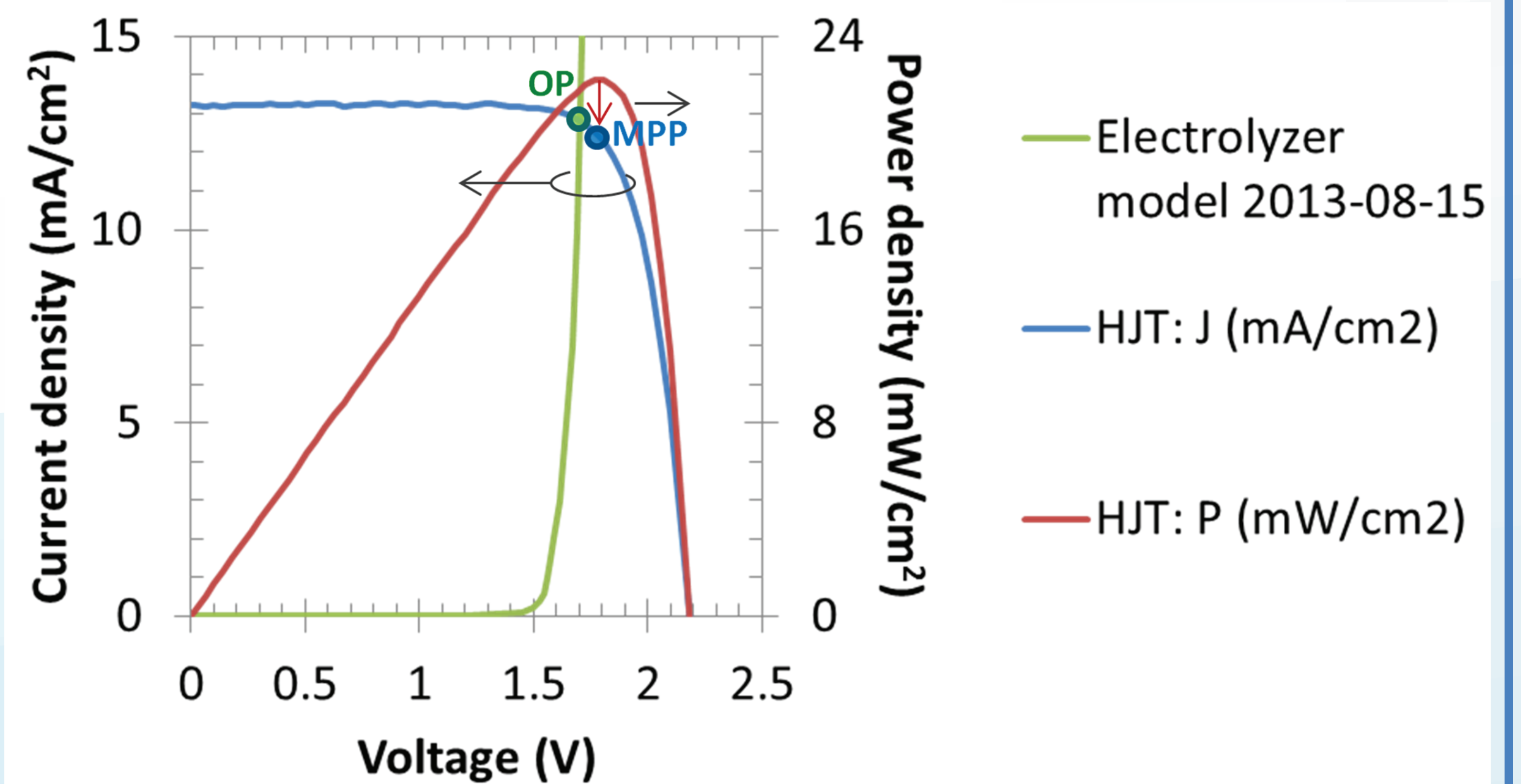
- High quality n-type crystalline silicon (float zone)
- Wafer texturing
- HF cleaning
- Surface passivation with a-Si deposited by PECVD
- TCO deposition by PVD
- Front and back metallization
- All processes @ typ. <200°C



## Motivation for 3 HJT cells in series

Eff. (%)	Voc (mV)	Jsc (mA/cm <sup>2</sup> )	FF (%)	Vmp (mV)	Jmp (mA/cm <sup>2</sup> )
22.2	728	39.7	76.8	596	37.2

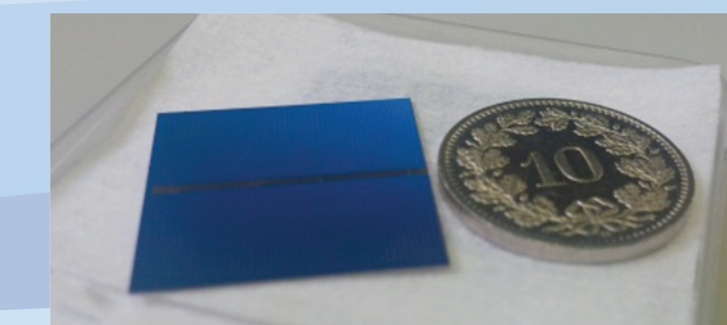
Baseline at CSEM for HJT. If 3 cells connected in series and no area lost, @1sun:  
 $V_{oc} = 2.18\text{ V}$   $J_{sc} = 13.2\text{ mA/cm}^2$   
 $V_{mp} = 1.79\text{ V}$   $J_{mp} = 12.4\text{ mA/cm}^2$



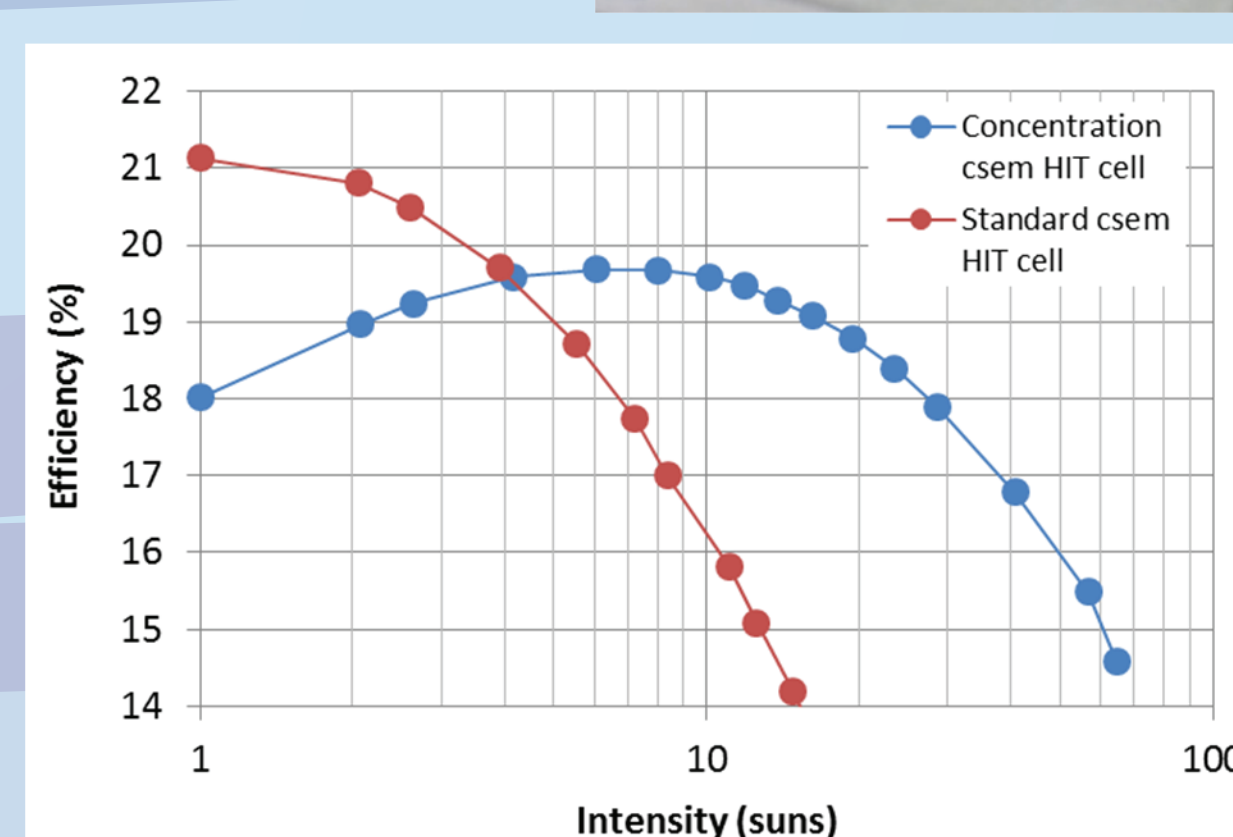
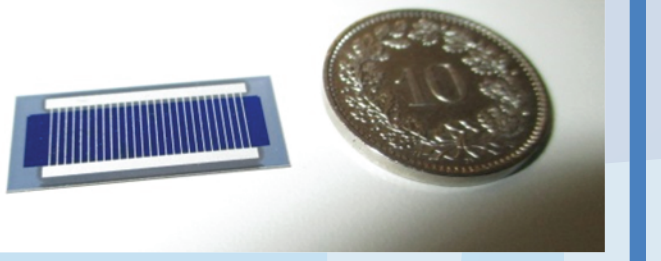
Loading by model electrolyzer:  $V_{op} = 1.72\text{ V}$ ;  $J_{op} = 12.8\text{ mA/cm}^2$   
→ Potential SFE = 15.7% , and OP at the left hand side of MPP

## Small c-Si HJT cells under concentration

4 cm<sup>2</sup> HJT cell



0.9 cm<sup>2</sup> HJT cell silver fingers



- 4 cm<sup>2</sup> device: Optimum concentration @8 suns
- 0.9 cm<sup>2</sup> device: Hint of a potential barrier at the front TCO / p a-Si interface

