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SHINE RTD 2013

FNSNF

Photovoltaics for H_2 Production

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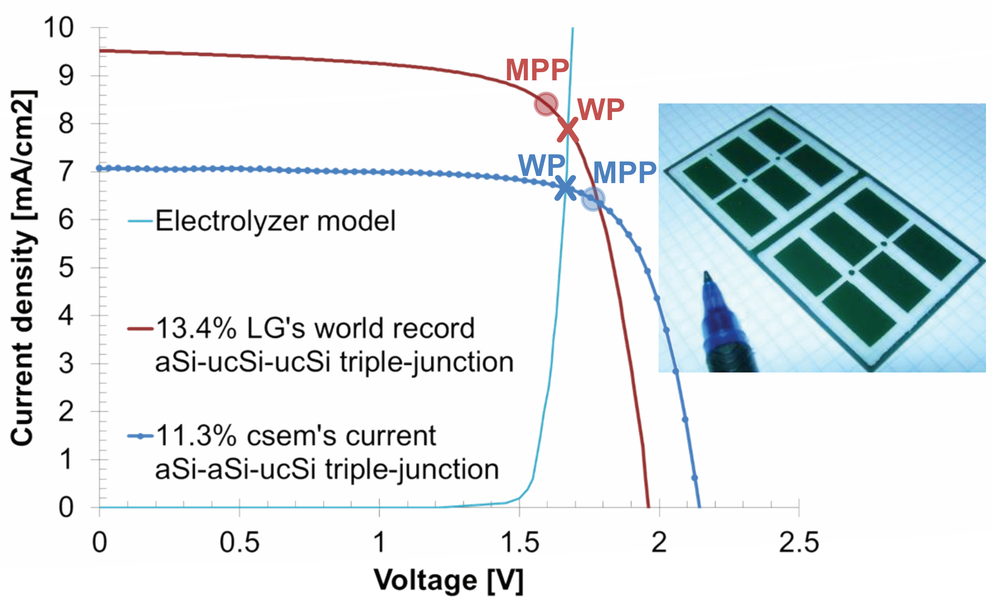
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

csem

EMPA Materials Science & Technology

MICHELIN

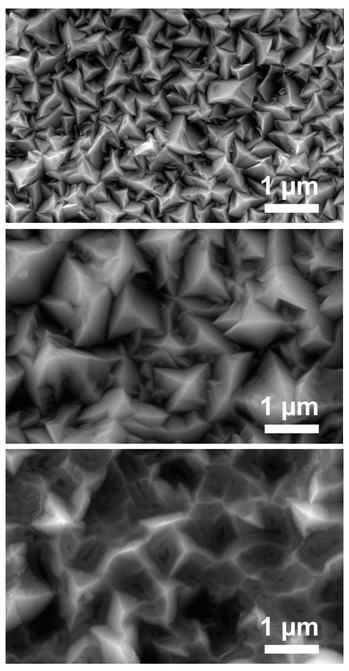
PV cell & electrolyzer: working point (WP)



- PV device must provide the voltage to break water molecules: open-circuit voltage V_{oc} > 2 V ;
- Stable working point at the left of the maximum power point (MPP) of the PV device. → OK for csem's device.

Thin-film PV technologies from EPFL PV-lab

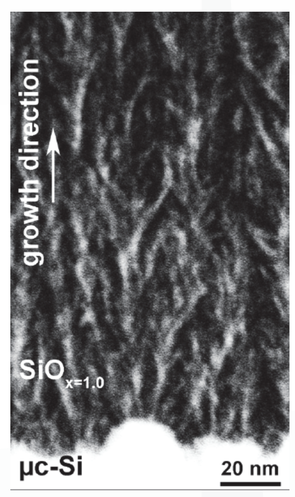
- Non-toxic and earth abundant materials ;
- Control of the surface morphology of zinc oxide transparent electrodes →light-trapping via diffuse scattering.



SEM pictures of the surface of (a) 2 µm and (b,c) 5 µm thick LPCVD ZnO layers without (a,b) and with (c) a surface treatment with Ar plasma.

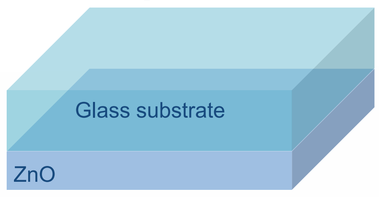
- Electronic transport through SiO_x reflectors via dendritic silicon filaments.

Cross-section EFTEM picture of a SiO_x film with refractive index of 1.8 and heavily doped Si dendrites [P. Cuony et al., *Adv. Mater.* **2012**].



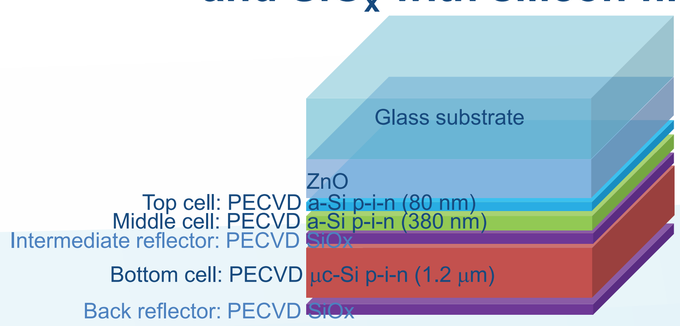
Fabrication flow for thin-film silicon triple-junction solar cells and photocathodes

Zinc oxide Front transparent contact



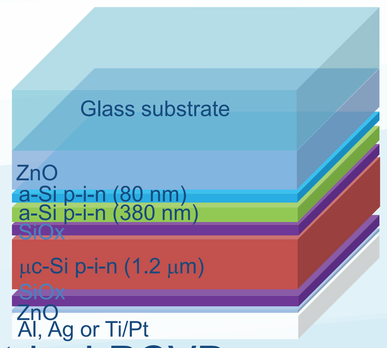
ZnO on glass substrate by *low pressure chemical vapor deposition* (LPCVD)

Thin film silicon p-i-n junctions and SiO_x with silicon filamentsn



Single run of *plasma enhanced chemical vapor deposition* (PECVD)

Back contact, reflector



Dielectric: LPCVD
Metallic: *sputtering, evaporation*

Application in PV+electrolyzer configuration

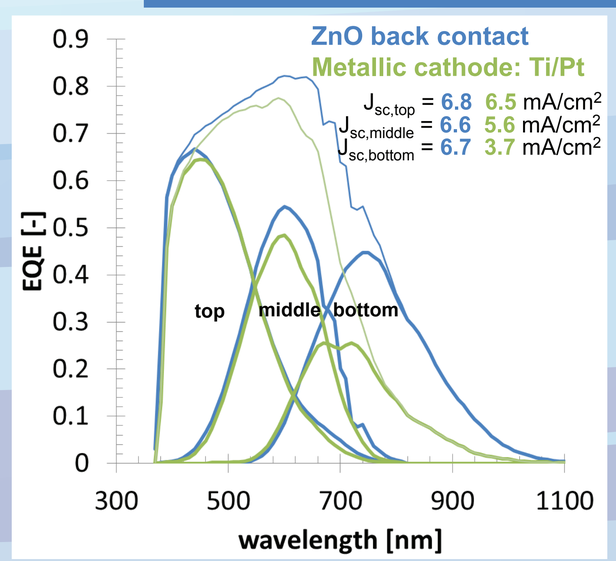
Jsc (mA/cm²)	Voc (mV)	FF (-)	Jmp (mA/cm²)	Vmp (mV)	Pmp (mW/cm²)
7.08	2144	0.749	6.41	1773	11.3

Model J_{WP} (mA/cm²)	Model V_{WP} (mV)	Model P_{WP} (mW/cm²)
6.68	1654	11.0

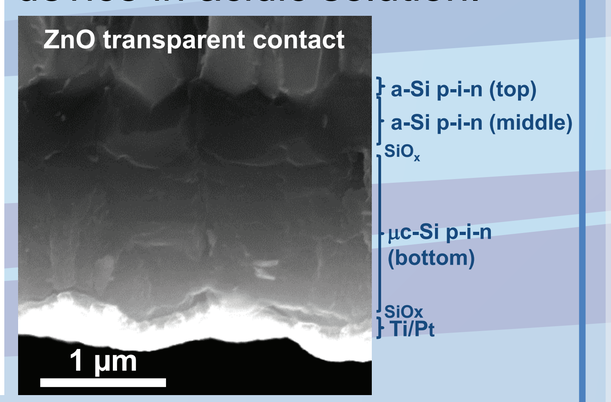
Conclusion:

- Csem's a-Si / a-Si / µc-Si solar cell with V_{oc} > 2 V allows for direct water splitting ;
- With 100 mW/cm² AM1.5 illumination, availability of 11.3 mW/cm² at MPP and 11.0 mW/cm² at the working point with the modeled electolyzer.

Application as photocathode



Photocathodic H_2 evolution from direct immersion of the device in acidic solution.



Jsc (mA/cm²)	Voc (mV)	FF (-)	Jmp (mA/cm²)	Vmp (mV)	Pmp (mW/cm²)
3.73	2173	0.667	3.07	1760	5.4

Conclusion for the photocathode application:

- Decrease of middle and bottom cell current densities ;
- This is due to the poor reflectivity of the Pt cathode.

Optofluidic Components