



INDustrial TECHNOLOGIES 2018
Innovative Industries for Smart Growth



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PILLAR 1

Session 1.4

STARCELL Advanced strategies for substitution of critical raw materials in photovoltaics

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Advanced strategies for substitution of critical raw materials in photovoltaics

Coordinator: IREC (Dr. Edgardo Saucedo) **Consortium:** 13 partners
Duration: 36 months until 31/12/2019 **Budget:** 6:218.203 €
www.starcell.eu

STARCELL aims to substitute two critical raw materials (In and Ga) used in conventional thin film photovoltaic (PV) technologies, via the introduction of sustainable kesterite ($\text{Cu}_2\text{ZnSn}(\text{S},\text{Se})_4$ - CZTS) semiconductors.

STARCELL MAIN OBJECTIVE:

Eliminate all materials classified as CRM from cost effective thin film PV technologies through development and use of earth abundant kesterite materials from Cu, Zn, Sn, S and Se.

STARCELL TARGET:


Optimise materials, processes & devices to achieve a kesterite solar cell with 18% efficiency (16% mini-module level) cost ≤ 0.30 €/Wp at TRL5.






Classification of available PV technologies

Wafer-based Si

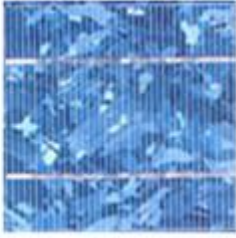


- Rigid (Si-wafer)
- Cut out of blocks (ingots)
- Technology mature, long lifetimes


Mono-crystalline



Poly-crystalline

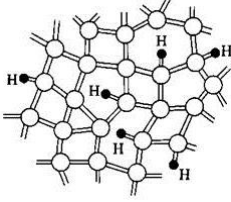


Thin Film PV

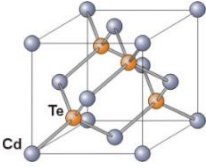


- Deposition of thin films, choice of substrate
- High cost reduction potential
- Low energy payback times

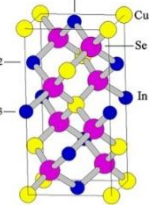
Amorphous Si




CdTe



Cu(In,Ga)(S,Se)₂




Emerging PV

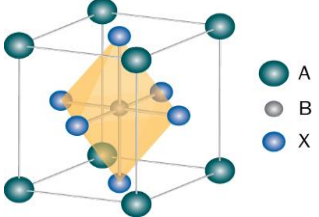
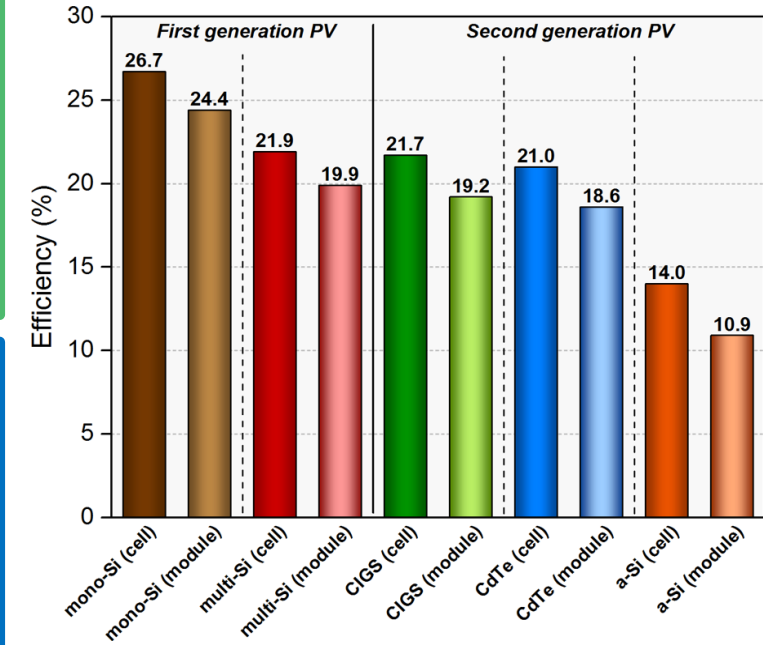


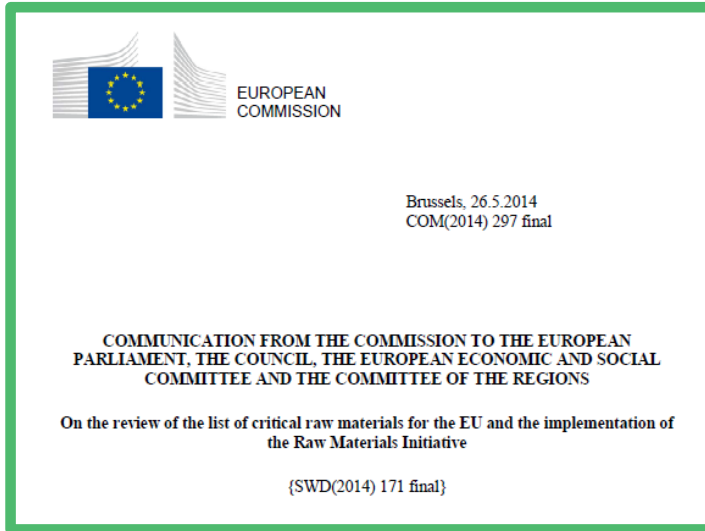
- Promising, but still less mature technologies
- New materials and concept
- Efficiency or stability main challenges

OPV/DSSC/QD



Perovskites



Raw materials	Main producers (2010, 2011, 2012)	Main sources of imports into the EU (mainly 2012)	Substitutability index ^a	End-of-life recycling input rate ^{**}
Gallium ⁵	China 69 % (refined)	USA 49 %	0.60	0 %
	Germany 10 % (refined)	China 39 %		
	Kazakhstan 6 % (refined)	Hong Kong 8 %		
Indium	China 58 %	China 24 % ↓	0.82	0 %
	Japan 10 %	Hong Kong 19 % ↑		
	Korea 10 %	Canada 13 %		
	Canada 10 %	Japan 11 %		
Silicon metal (Silicium)	China 56 %	Norway 38 %	0.81	0%
	Brazil 11 %	Brazil 24 %		
	USA 8%; Norway 8 %	China 8 %		
	France 6 %	Russia 7 %		

• In, Ga and Silicon Metal are identified by the EC as critical raw materials with high difficulty in substituting these materials:

- ❖ In and Ga are used in commercial Cu(In,Ga)Se₂ thin film PV modules:
 - In is mainly used in the flat screen industry
 - Ga is mainly used in lighting applications
- ❖ Silicon metal is used in commercial crystalline and microcrystalline Si PV modules
 - Si is mainly used in the aluminium casting, ferrosilicon and microelectronic



The prediction STARCELL

Table 7. Estimated use of CRM and tellurium for the three main PV technologies in the market based on meeting the entire past (2014) and forecast (2019 and 2030) PV market demands.

PV technology	CRM usage [tonnes per GW]	CRM usage to cover [entire PV market demand] (and percentage of existing/forecast global supply of CRM)			
		2014	2019		2030
		[40GW]	Low Scenario [121 GW]	High Scenario [158 GW]	[300GW]
Crystalline Silicon [2]	6,000t <i>Silicon metal</i>	240,000t (12.7%)	726t (27.9%)	948t (36.4%)	1,800,00t (NA)
CdTe	93t <i>Tellurium*</i>	3,720t (501%)	11,300t (900%)	14,700t (1170%)	27,900t (1300%)
CIGS [46]	7.2t <i>Gallium</i>	288t (100%)	871t (193%)	1,137t (252%)	2,160t (324%)
	14.4t <i>Indium</i>	1008t (74%)	3,049t (160%)	3,980t (209%)	7,557t (288%)

(*): Tellurium is not currently included in the list of CRMs, although availability will likely limit the growth of CdTe technology

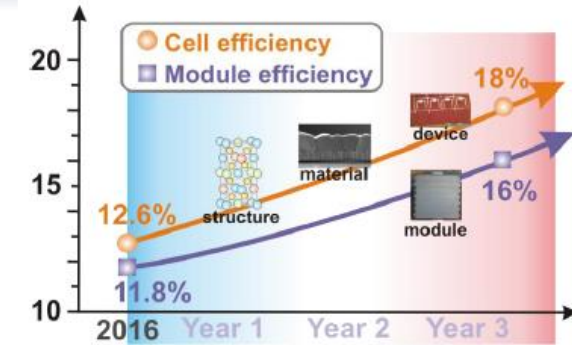
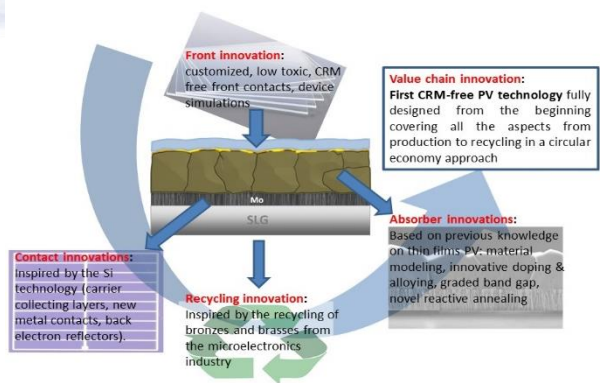
In a low scenario for 2019:

- 28% of produced silicon metal will be required for PV, or
- 193% of produced In and 160% of produced Ga, or
- 501% of produced Te



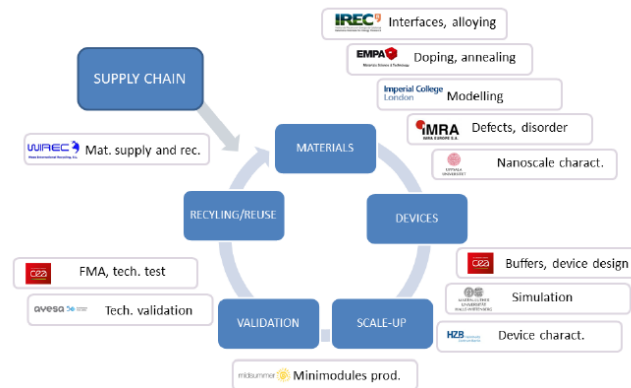
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In a short term STARCELL introduces innovative approaches to better understand kesterite absorbers and to improve the PV devices properties

In a mid term STARCELL aims to increase the solar cell devices conversion efficiency at both, laboratory scale (1 cm²) and minimodule (10x10 cm²)



In a long term to establish a fully sustainable, cost-efficient, and free of critical raw materials PV technology available for the European Society.

