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Sunny perspectives of PhotoVoltaics

Reduction of critical raw metals in heterojunction cells and modules

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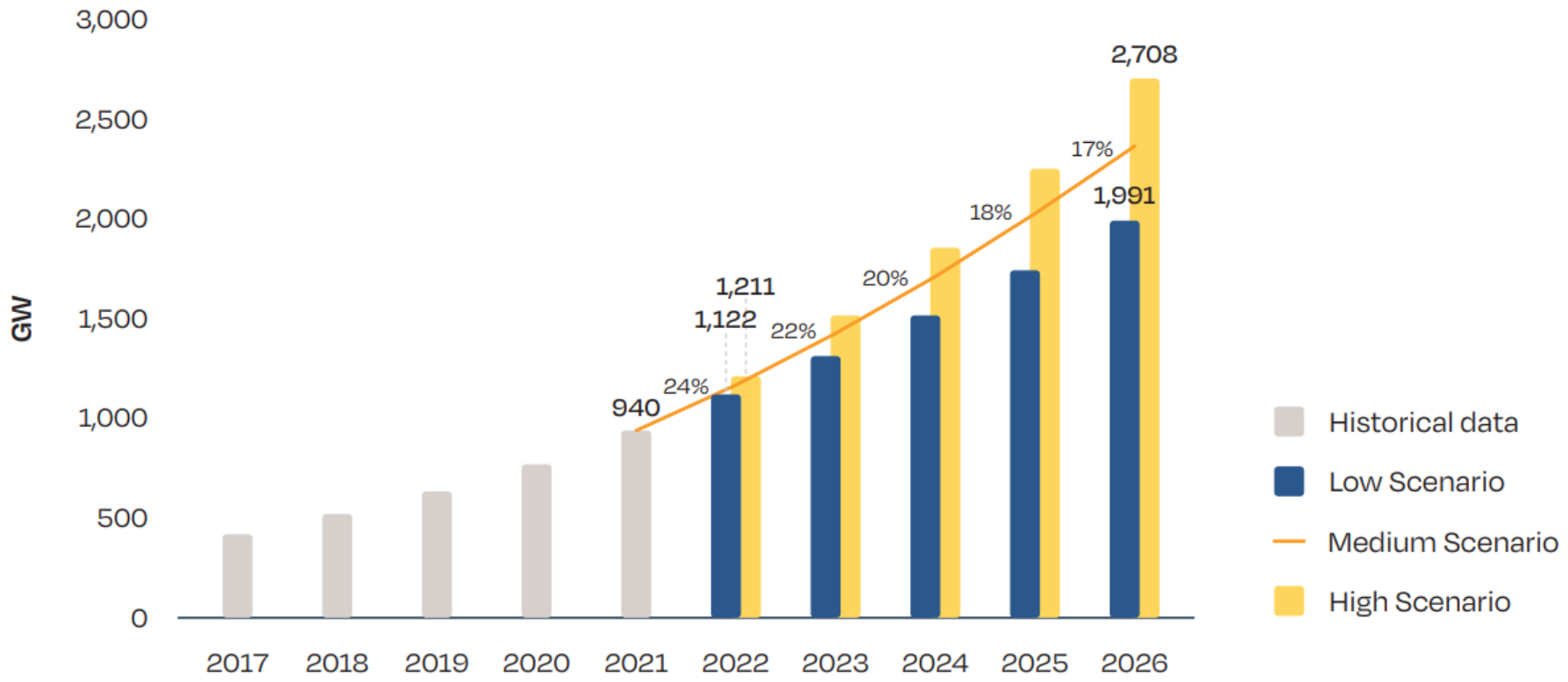
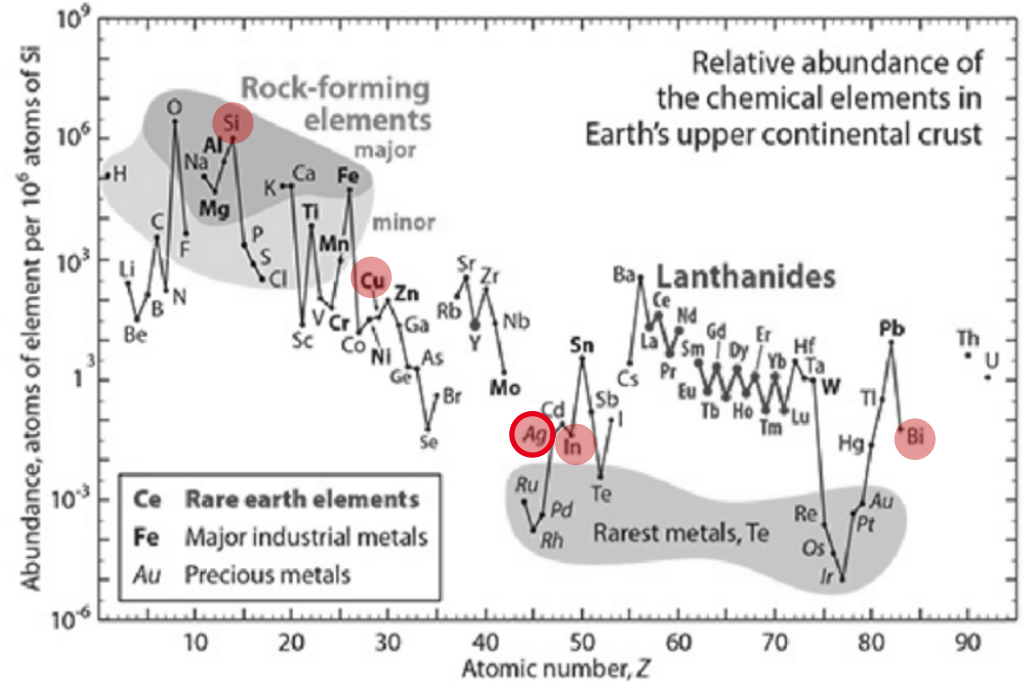
INSTITUT CARNOT Energies du futur

Challenges of TW scale PV manufacturing

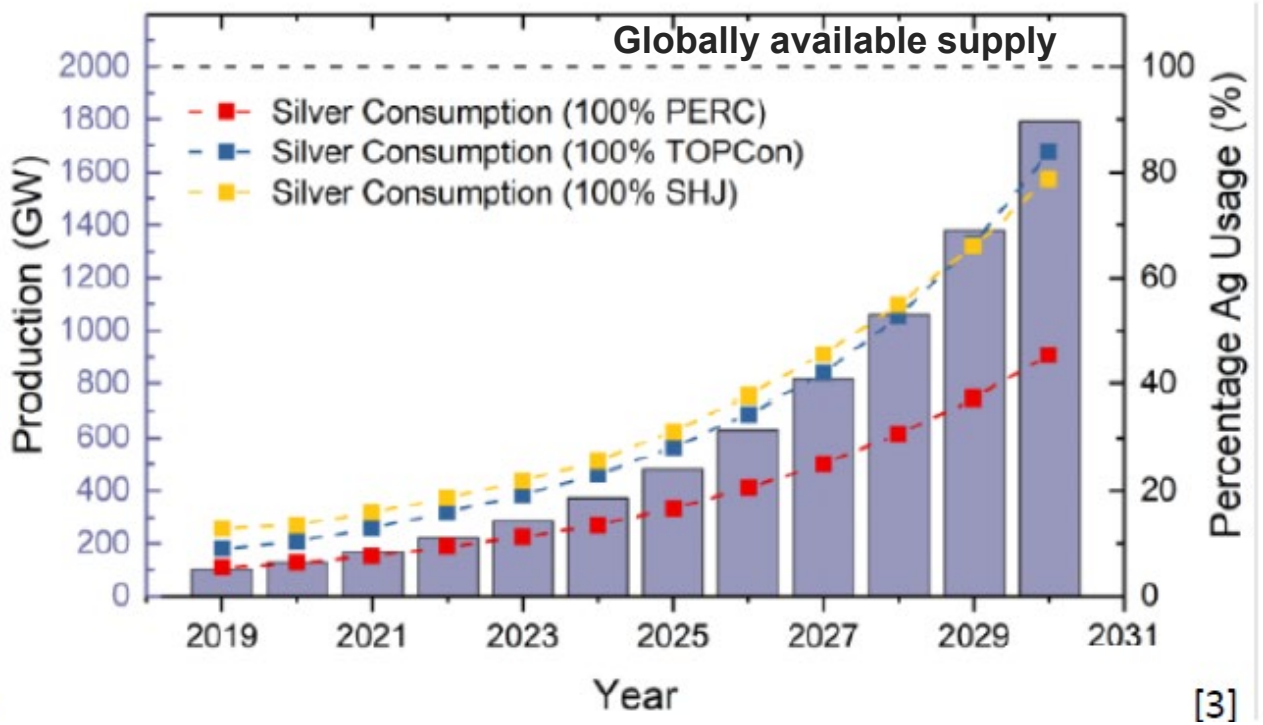
FIGURE 16 GLOBAL TOTAL SOLAR PV MARKET SCENARIOS 2022 - 2026



Challenges of TW scale PV manufacturing

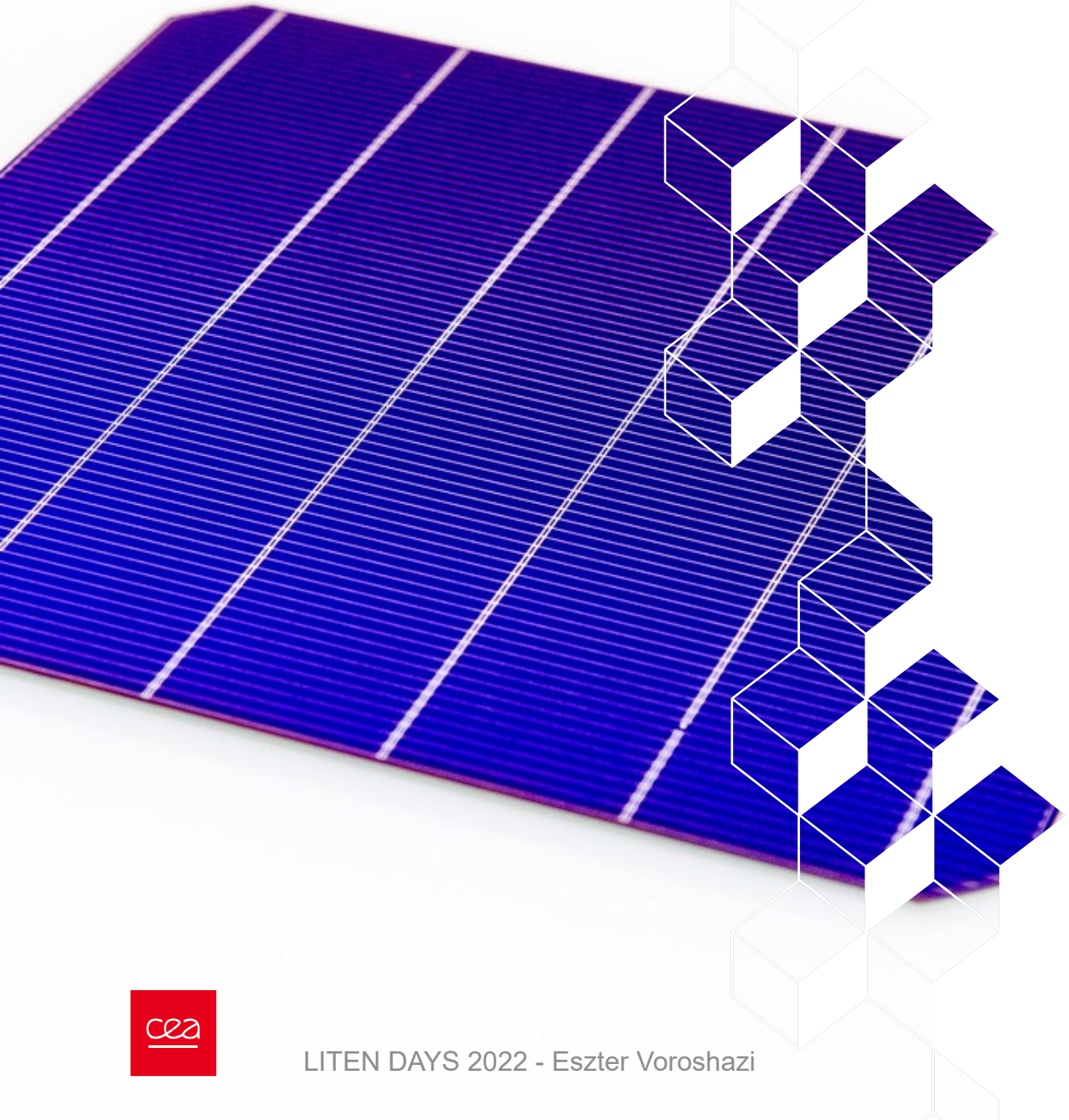


Abundance of elements in the Earth's upper crust (REEs are highlighted in red) (G. Haxel, 2018)



- **Today 1 TWp** installed PV capacity **>10 TWp by 2030**
- Material scarcity becomes a critical issue for the PV sector : **Ag reduction is a must!**
- Global context of increasing metal consumption by renewables

https://science.sciencemag.org/content/364/6443/836.full
Solar Power Europe , Global PV market Forecast, 2022
B. Hallam et al. 2022



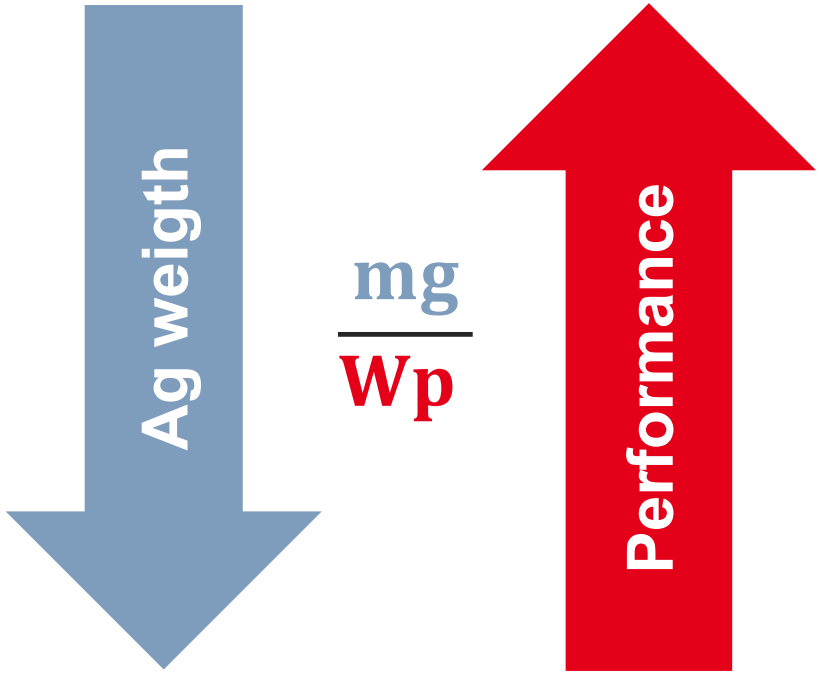
Duality of

increasing performance

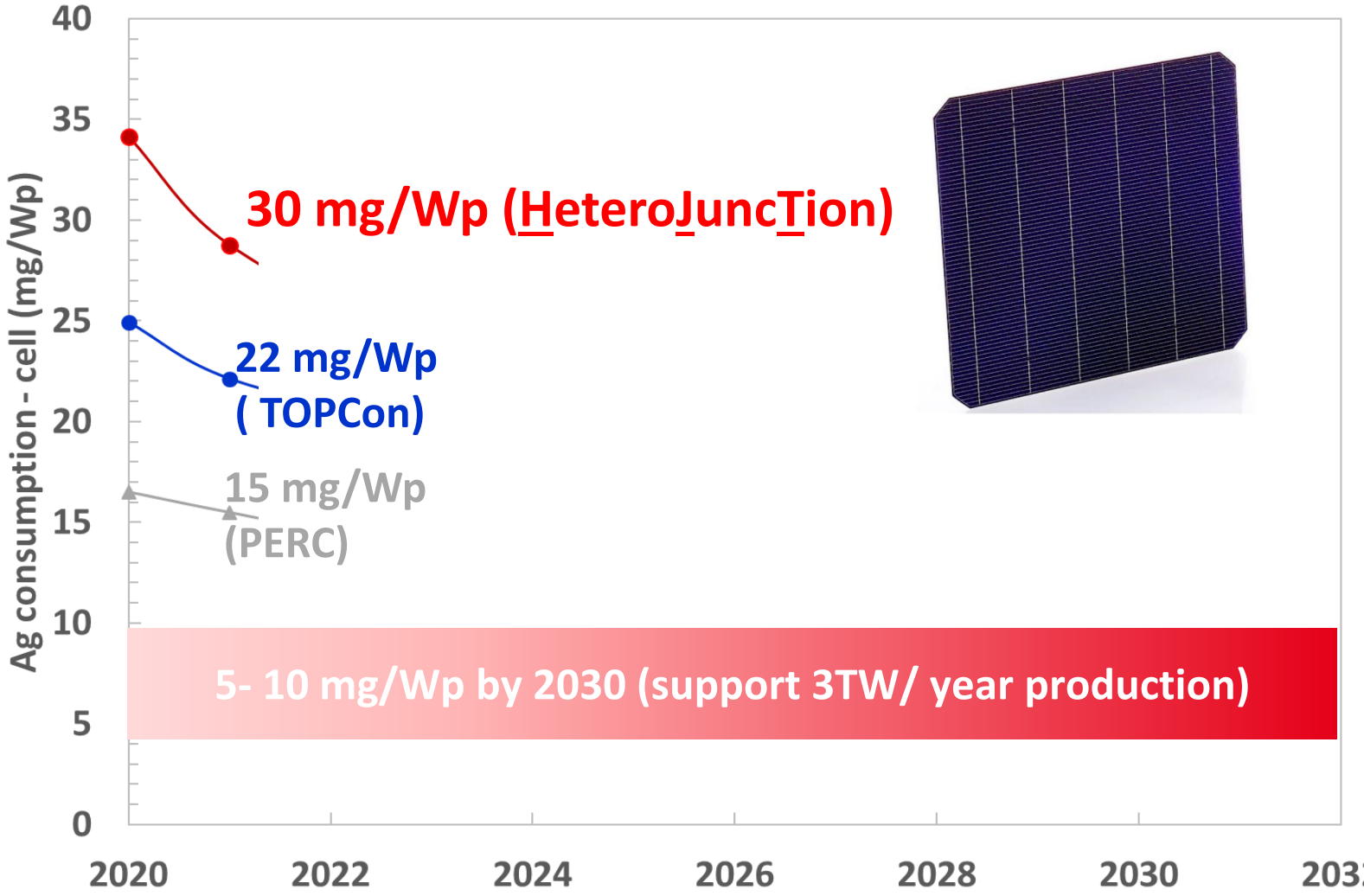
and

reducing Ag consumption

with novel cell and module interconnection technologies



Industry roadmap to reduce Ag consumption on cells

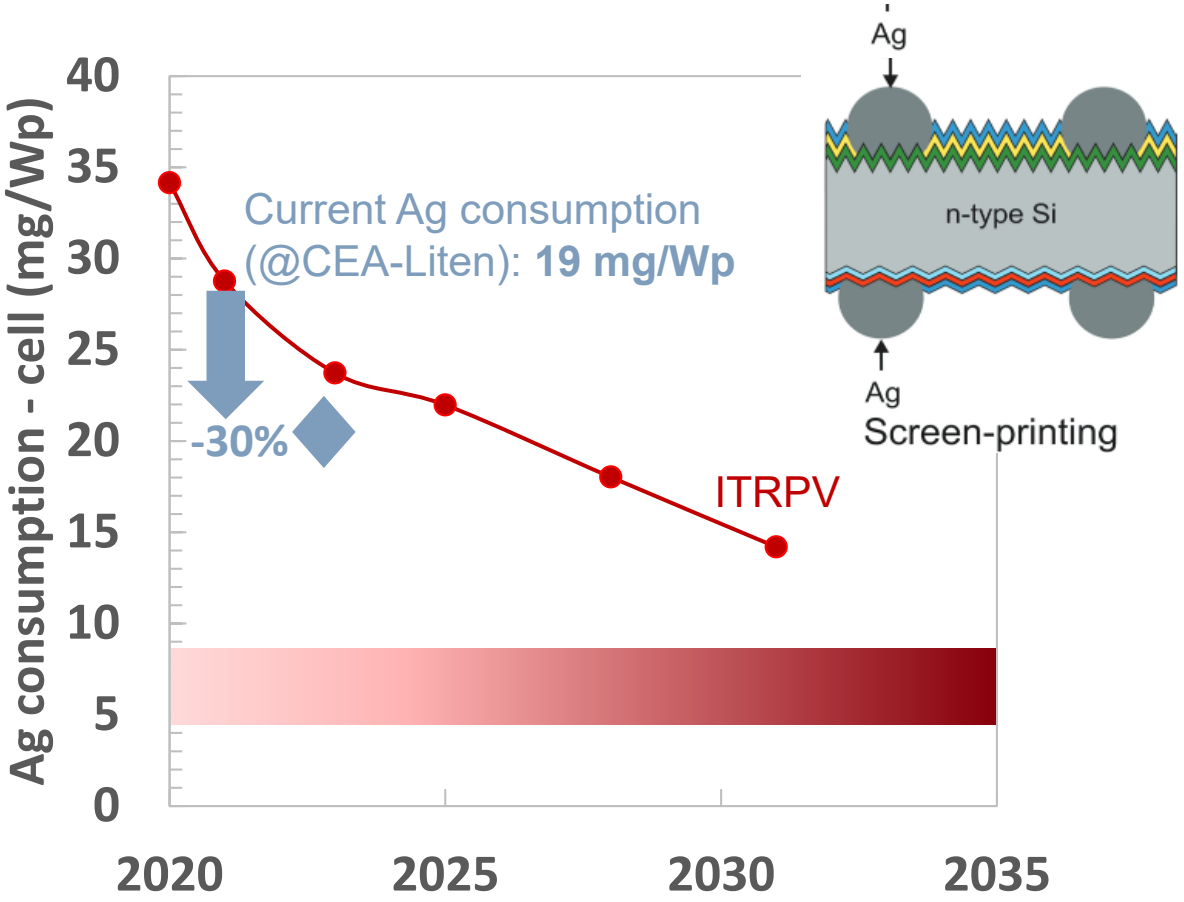


Adapted from: Y. Zhang et al., Energy et Environ Sci, 2021
Graph: based on data from ITRPV 2021

Innovations on heterojunction cell and module metallisation

- Cell metallisation with printing and plating using Cu,Al…
- Increasing efficiency with tandem cells
- Novel module interconnections

Evolutionary reduction of Ag consumption by printing

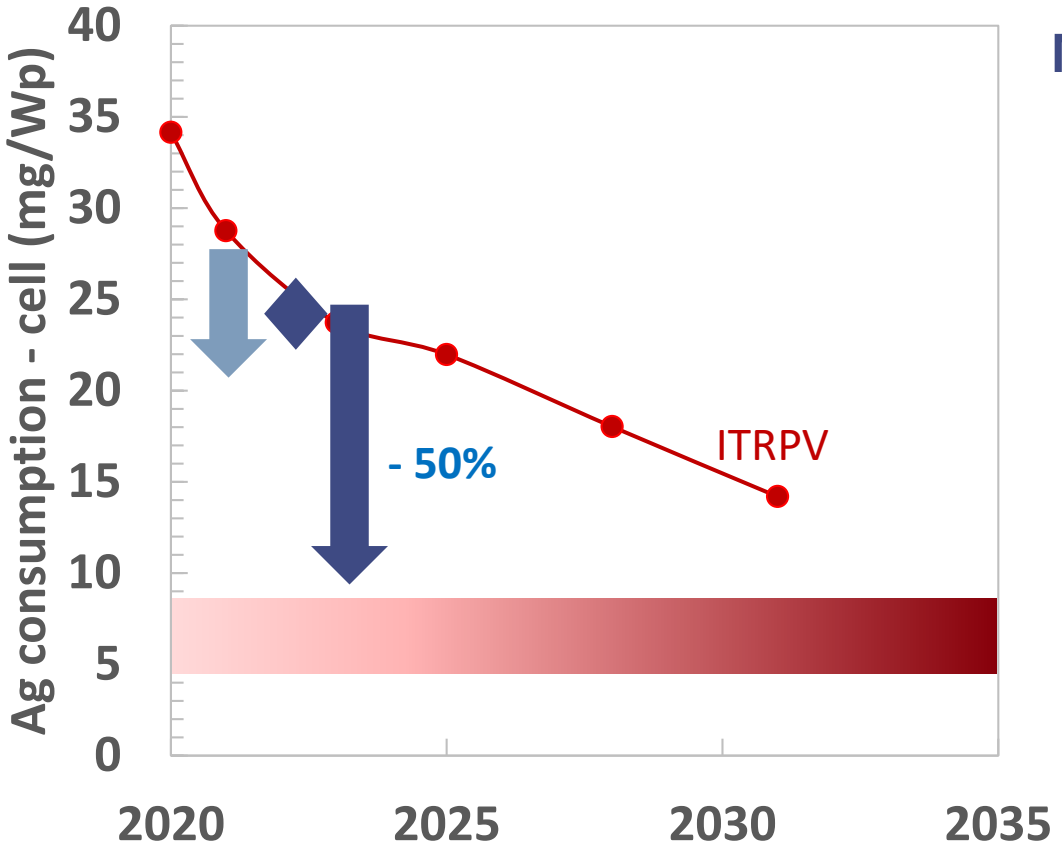


Ag screen-printing process optimisation

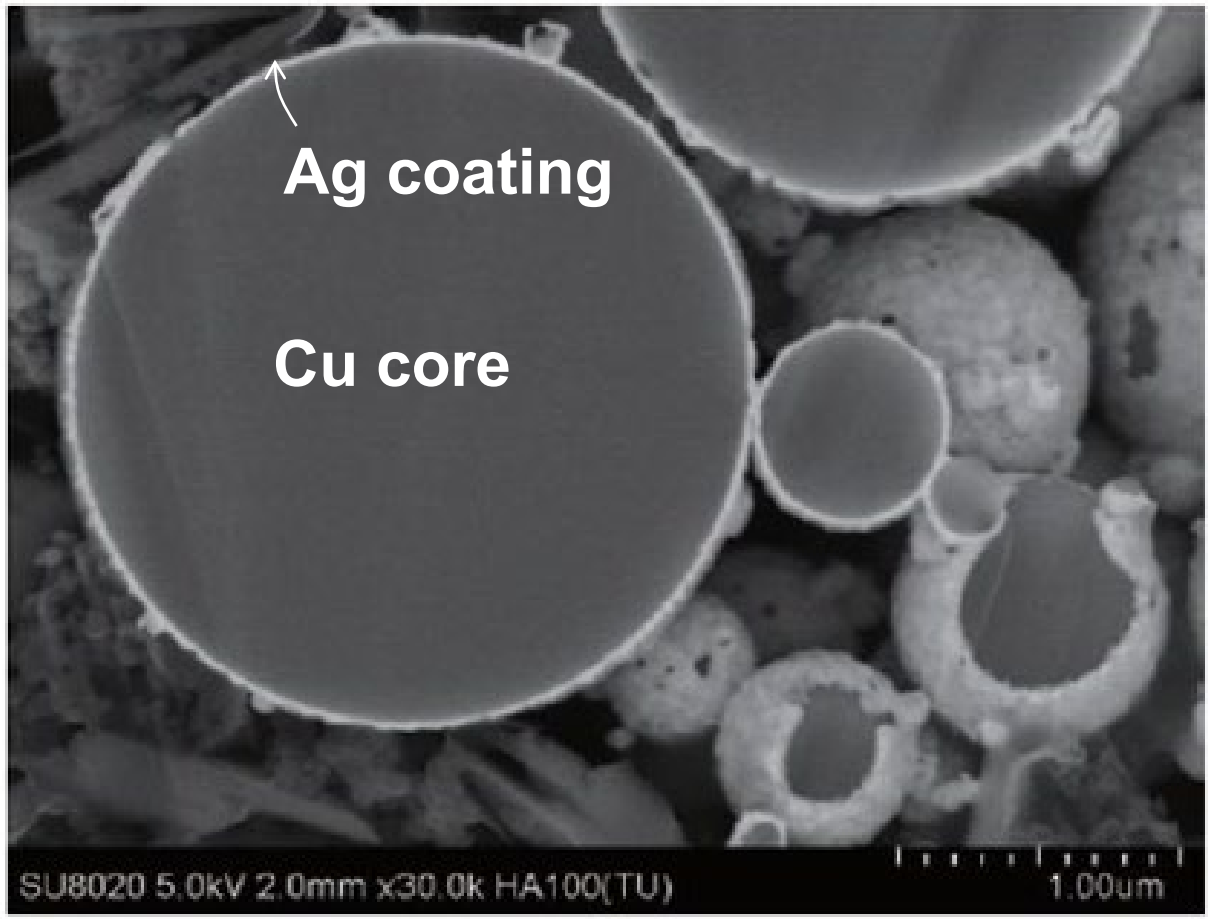
- Screen-printing process: screen angle and material design
- Cell metallisation design: thinner lines and increasing number of busbars

	Line width (µm)	Efficiency (%)	mg Ag / Wp
Ref	55	22,47	28,8
Improved	44	22,39	19,2

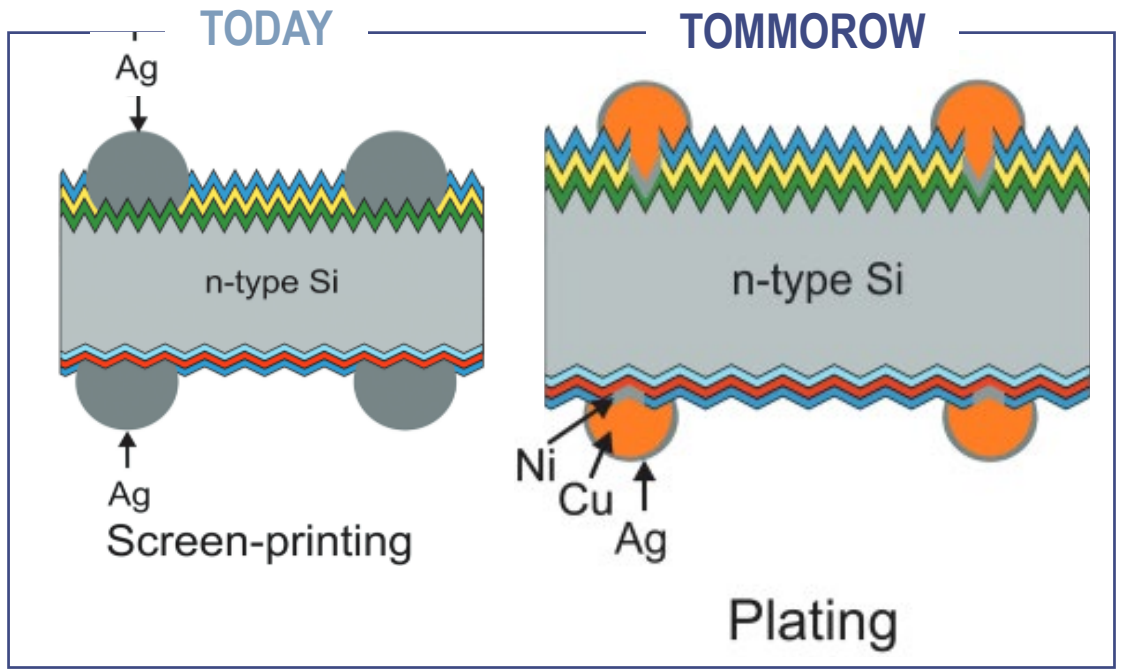
Evolutionary reduction of Ag consumption by Cu based pastes



Metallisation pastes with Cu core particles coated with Ag



Distruptive innovations of Cu by plating



Wet deposition techniques with 3 main approches:

- Electrolytic plating
- Light Induced plating (LIP)
- Dispense plating

Advantages

- Narrow finger width (<25µm)
- Low contact resistance

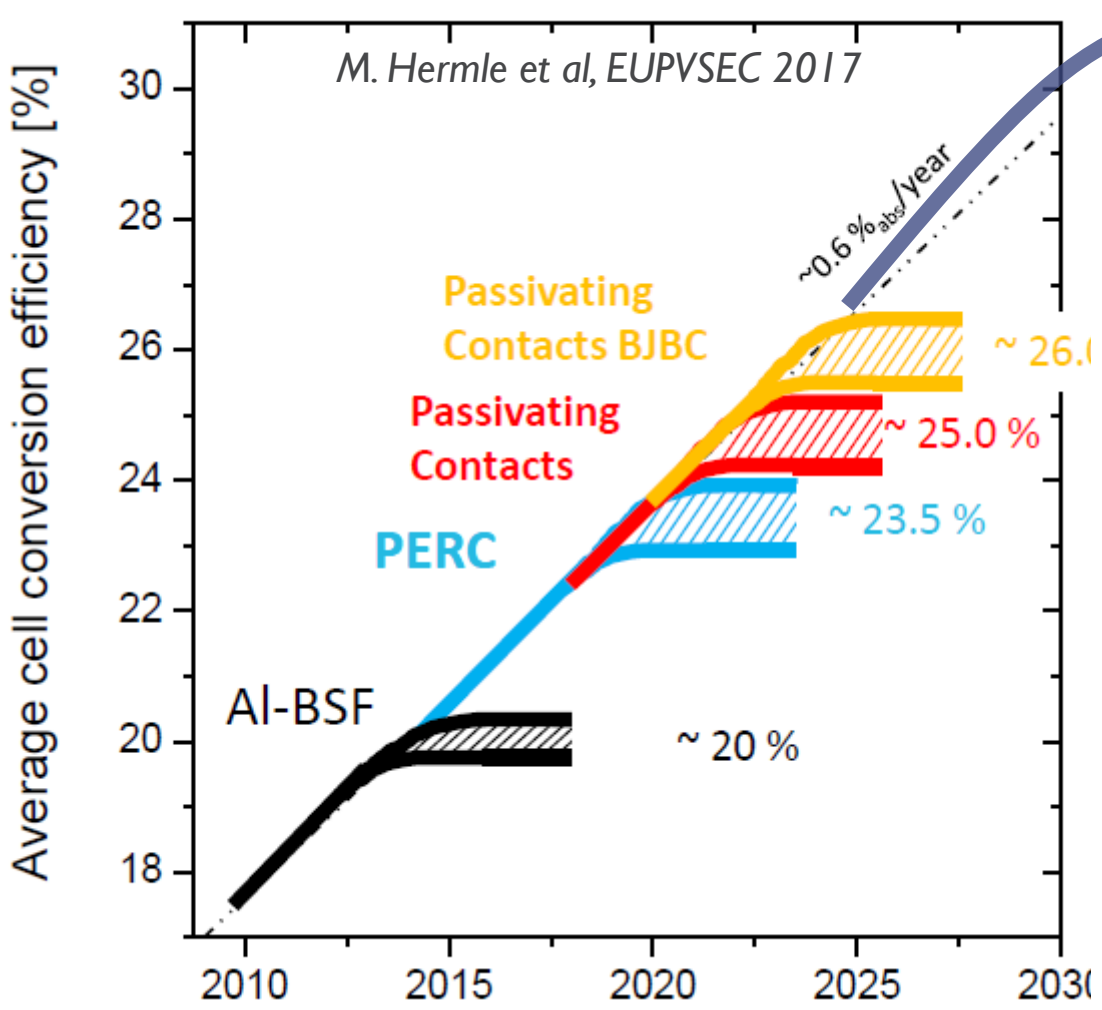
Challenges

- Complex process
- Reliability risk
- Waste treatment

In collaboration with RiSE Technology

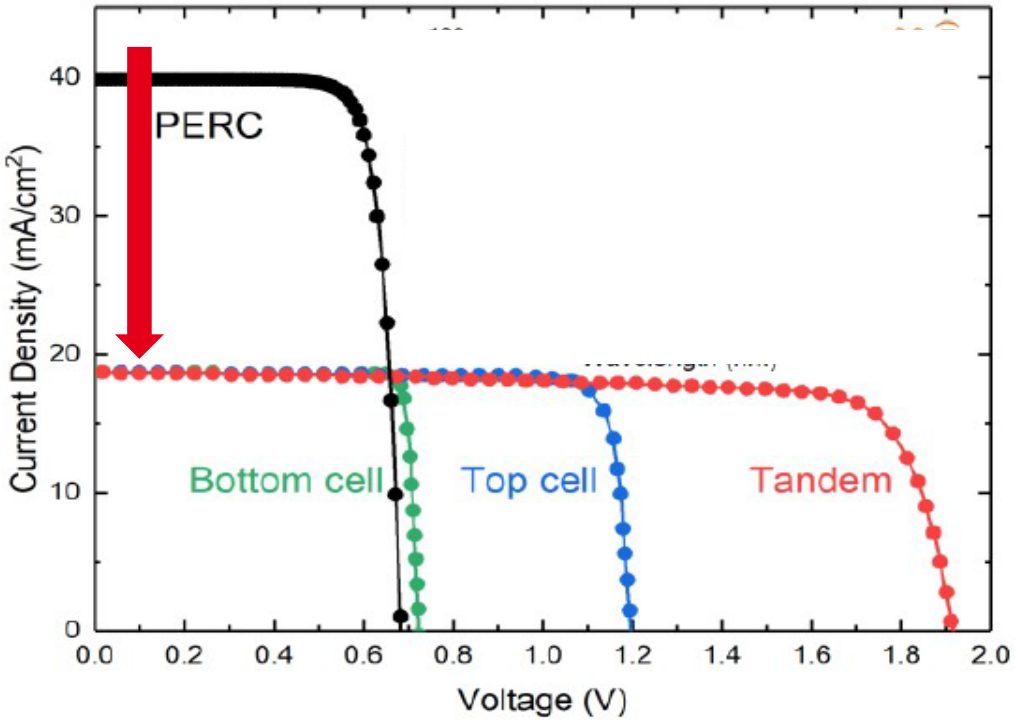
- ✓ Localized and free-form pattern
- ✓ Reduced waste and metal consumption

Increasing cell efficiency to lower Ag usage



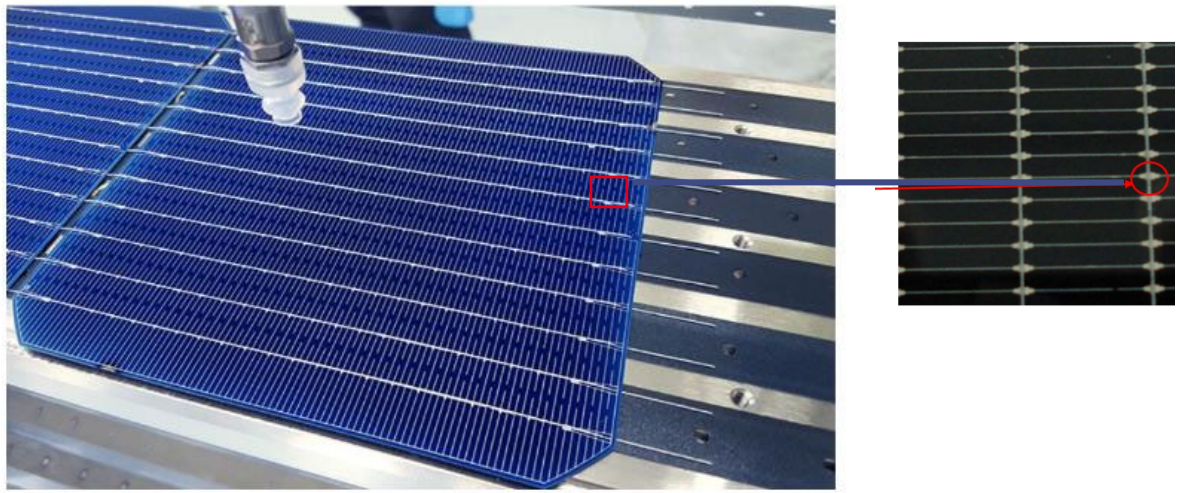
Tandem Si/Perovskite

- Cell performance of 2T : **25.8 % on 9 cm²** (CEA)
- Higher performance + considering the lower Isc of 2T tandem → **potential < 5 mg/Wp**



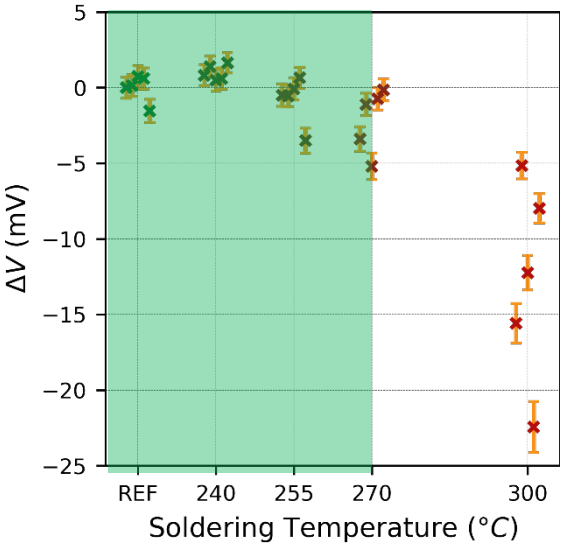
Multi BusBar soldering for PERT/TOPCon and also for HJT

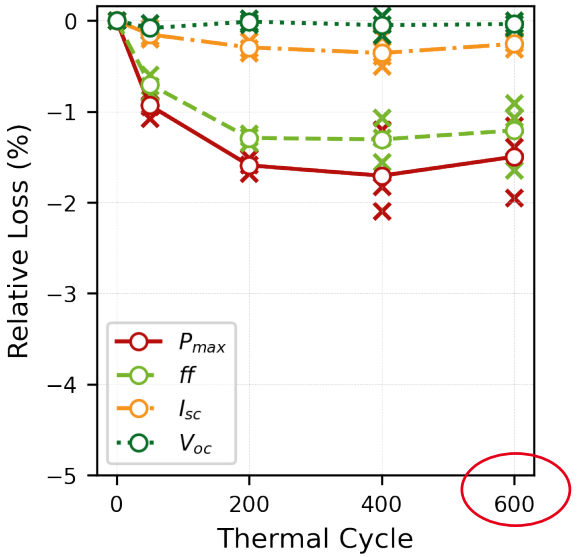
MBB soldering for PERC/TOPCon



- ✓ Becoming industry standard
- ✓ Improved performance: reduced shading and Rs loss
- ✓ Reduced Ag consumption if small solder pads
- ! Pb content
- ! High T process > 200°

MBB compatibility proven with SHJ

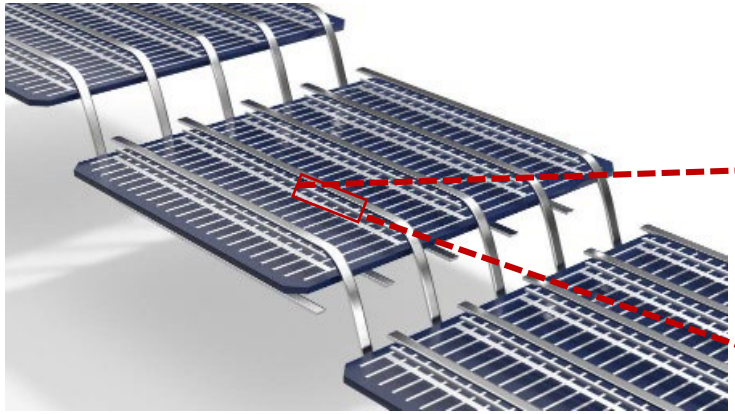




- ✓ Indentification of Pb-free alloys
- ✓ High/medium T process compatibility on SHJ (stability 3 x IEC)

BusBar gluing with ECA for HJT and Tandems

BusBar soldering

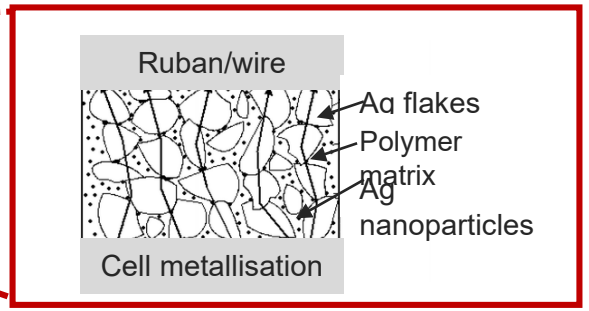


- ✓ Industry standard
- ✓ Reliability proven process
- ✓ Low Ag consumption
- ! Pb content
- ! High T process > 200°C STOP Tandems

BusBar gluing with ECAs for HJT and TANDEMS

Electrically **C**onductive **A**dhesive

- Conductive particles (approx 50-70 w% Ag)
- Polymer matrix



- ✓ First industry products >21% by ENEL and CEA-Liten
- ✓ Reliability proven process
- ! Medium Ag consumption (15 mg/Wp for ECA)
- ✓ Pb-free
- ✓ Low T process **<** 200°C

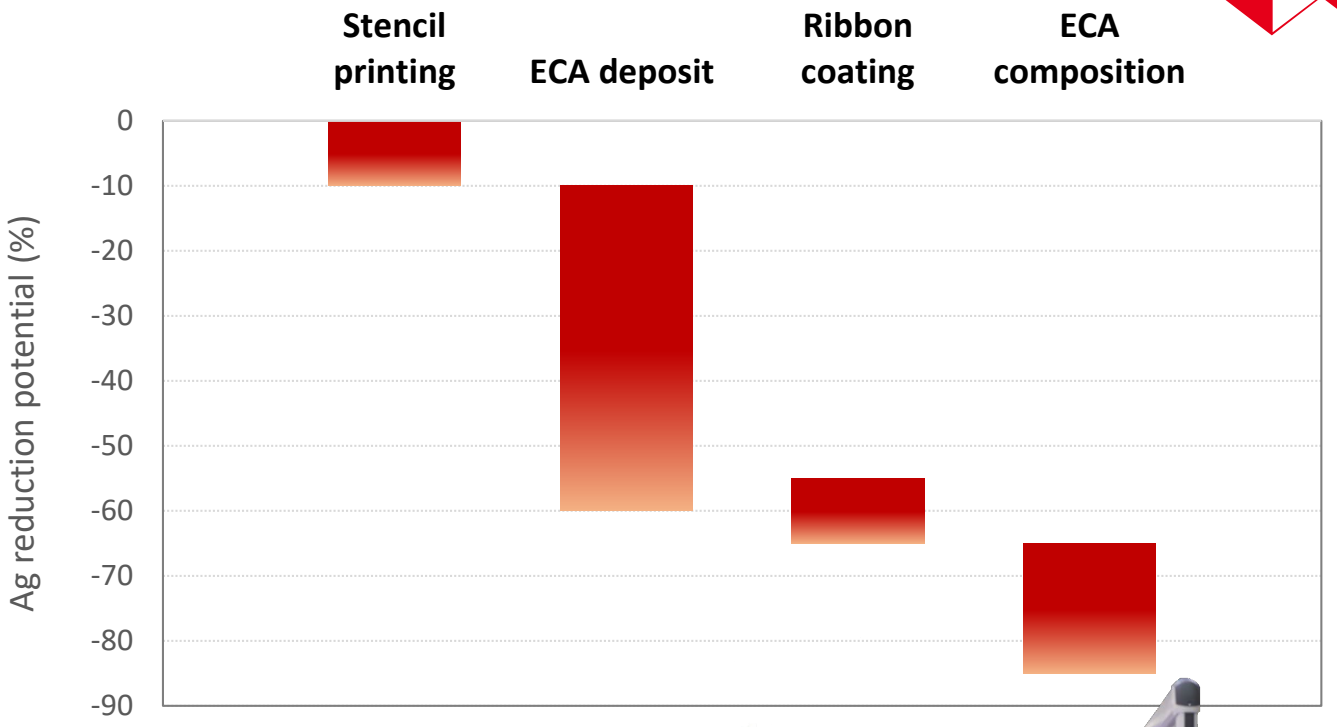
L. Corentin et al., WCPEC 2022
D. Tune et al., The sun is rising on conductive adhesives, PVI, 2022
Image: Longi

BusBar gluing with ECAs : strategies for further Ag reduction

- Introducing stencil printing and improved deposition accuracy (< 100 um)
- Optimized ECA deposit pattern and elimination of busbars/pads
- Ribbons with Ag-free coating
- Novel Cu-particle based ECAs

Roadmap to Ag consumption (cell+module) reduction to **<25 mg/Wp**

Combined cell and module innovations with Cu enable **< 5-10 mg/Wp**



Industrial stringer @CEA- Liten PV Module platform

MONDRAGON ASSEMBLY

R. Monna et al. Prog.PV Tech, 2022

Sunny perspectives to tackle CRITICAL METAL usage in PV modules

Radical reduction of Ag metallisation is a must for TW scale manufacturing in PV

We must target 5 – 10 mg/Wp by 2030!

PV cell and module metallisation **pilot lines** @ CEA for **new materials and technology qualifications**

Industrial eco-system (and expanding)

RISE Technology

MONDRAGON ASSEMBLY

PROTAVIC INTERNATIONAL

Henkel

Toyal

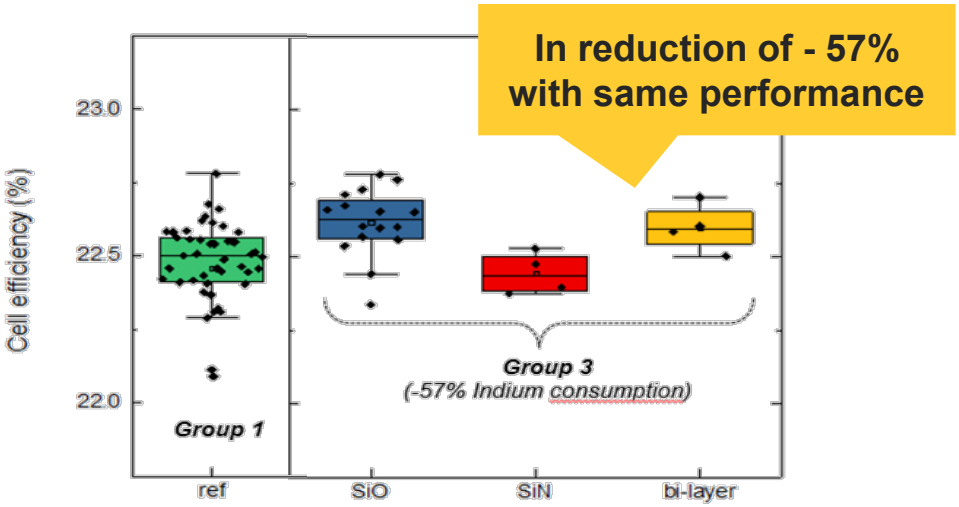
Connecting and Communicating through Conductive Materials

Kyoto Elex Co., Ltd.

Recycling of Ag and metals for a **circular PV industry**

PHOTORAMA

Reduction of other critical materials: Indium



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Thank's for your attention