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Compact and high efficiency micro-CPV module with high wafer utilization rate

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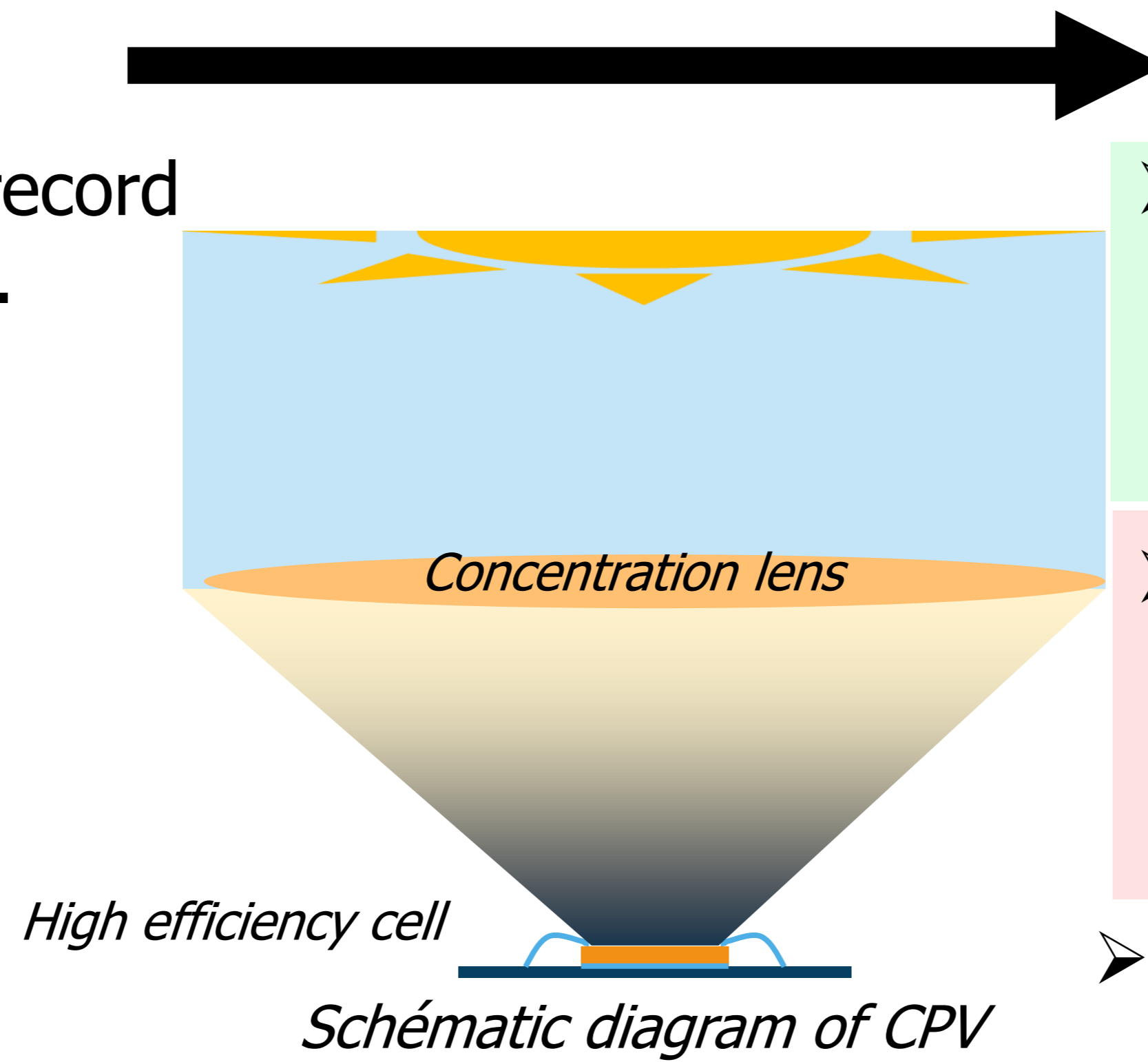
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Context

CPV

- Multi-junctions : Best performances (World record : 39,5% for a 3-junction cell at one sun [1]).
- Drawback : Price
- Add concentration lens to reduce amount of III-V materials used
- Drawbacks :
 - Compactness (~20cm thick)
 - Resistive and thermal losses
- **One of the most promising ways is the miniaturization**



μ-CPV

- Advantages of μ-CPV (cell size under 1mm²):
 - Compactness (few centimeters)
 - Price
 - Less resistive and thermal losses
- Challenges of μ-CPV :
 - Perimetrics recombinaison
 - More cells per wafer so more losses during cutting
 - Shading increase when cell size decrease
- **We aim at fabricating compact and high efficiency μ-CPV module with high wafer utilization rate**

Highlight

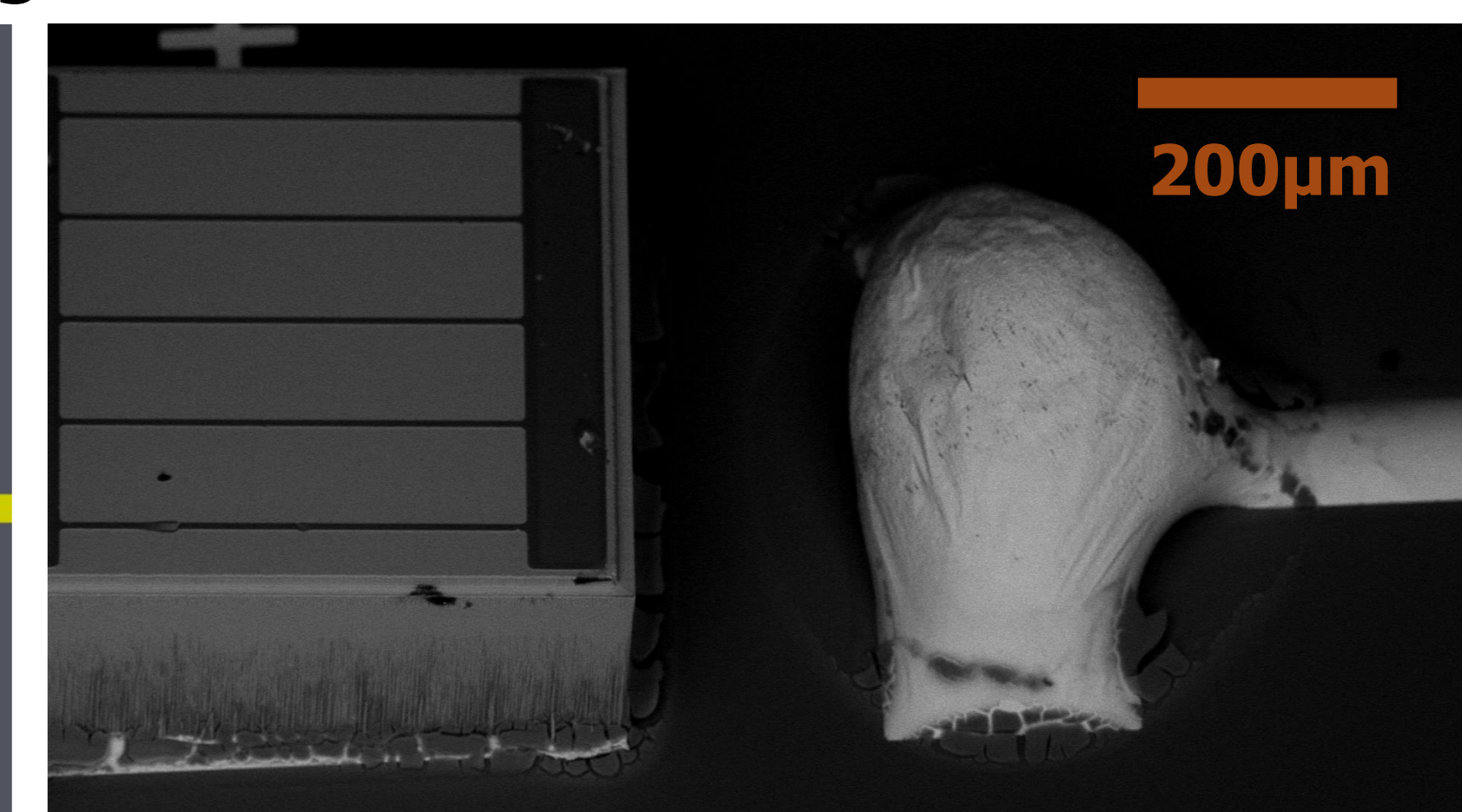
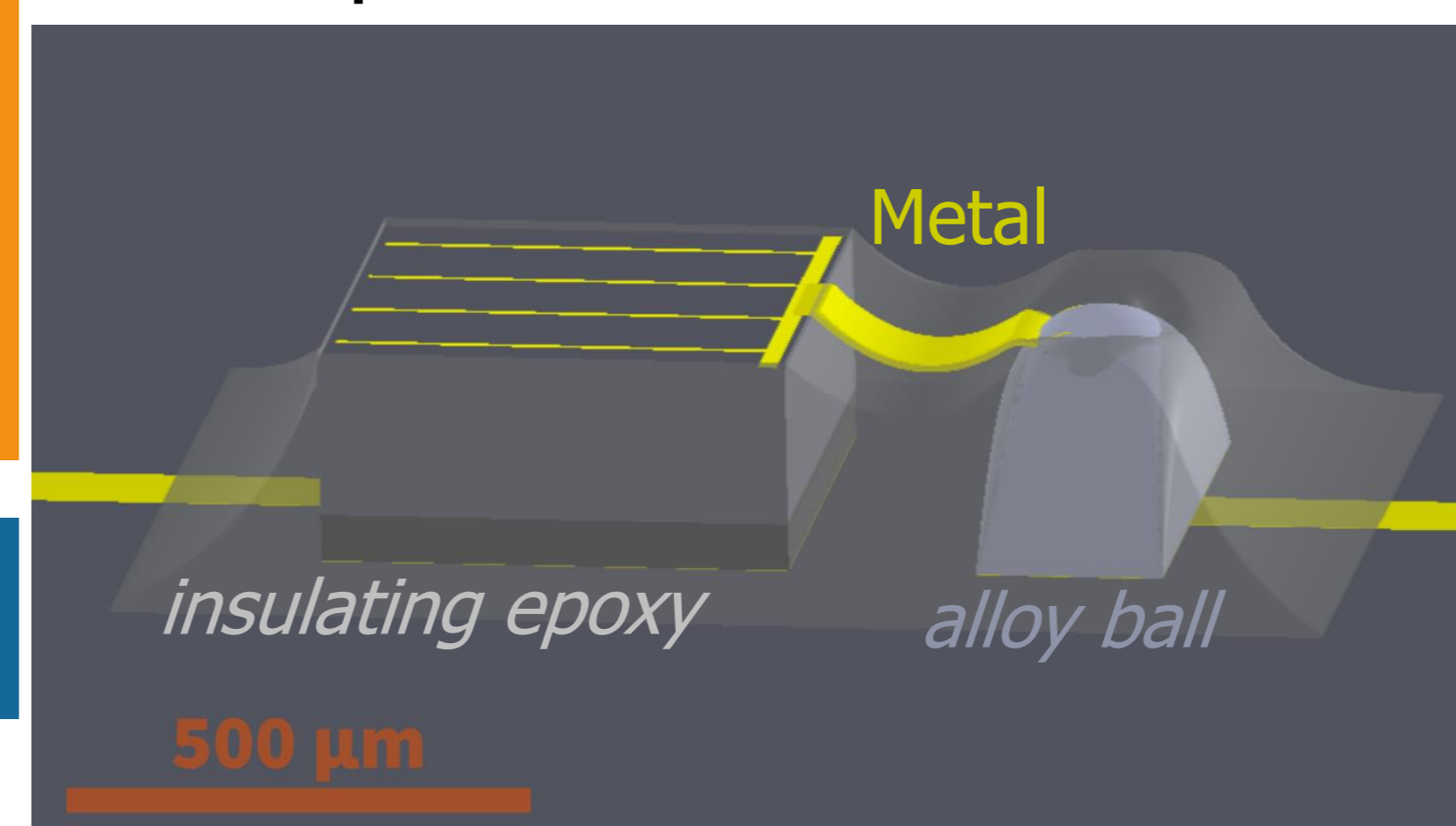
- **Plasma singulation : >90% utilization rate**
- **0,25mm² reach 31,26% efficiency at 1-sun**
- **Interconnection without busbars that increase the utilization rate**
- **High optics manufacturing tolerances**

Interconnexion of submillimetric cells

Interconnexion without wirebonding

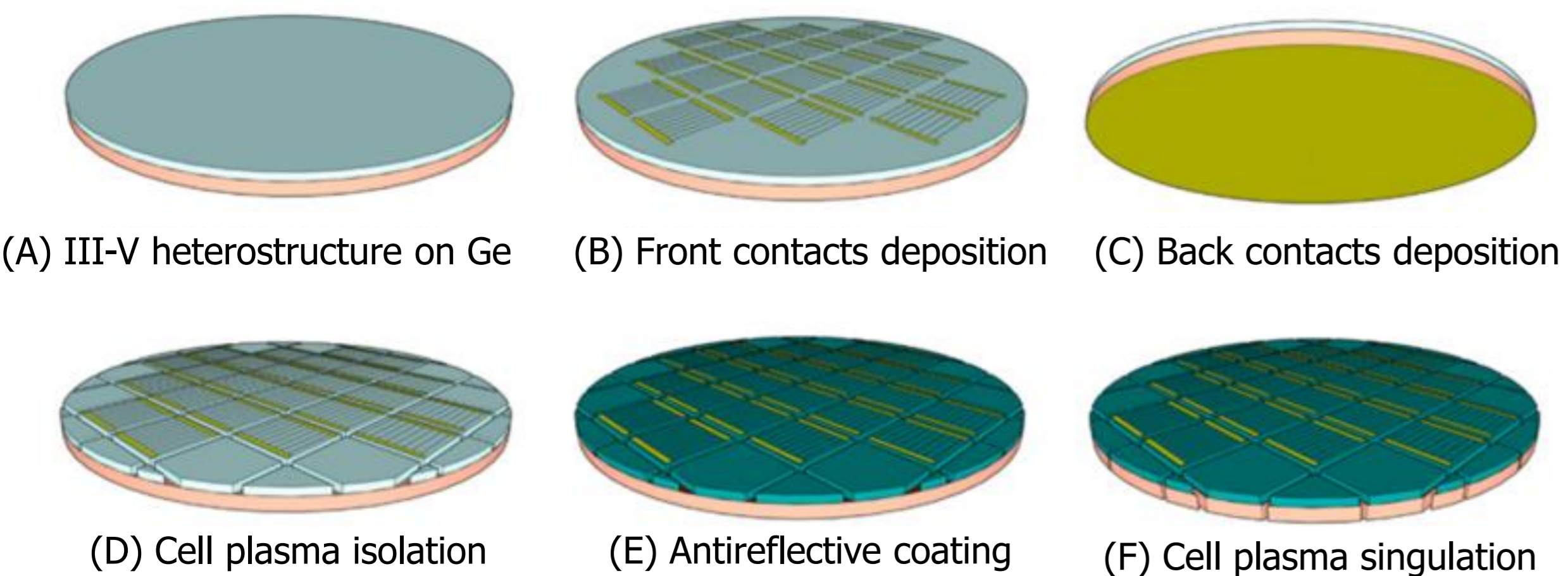
- No busbars needed
- Important reduction in shading

- **Improvement of wafer utilization rate**



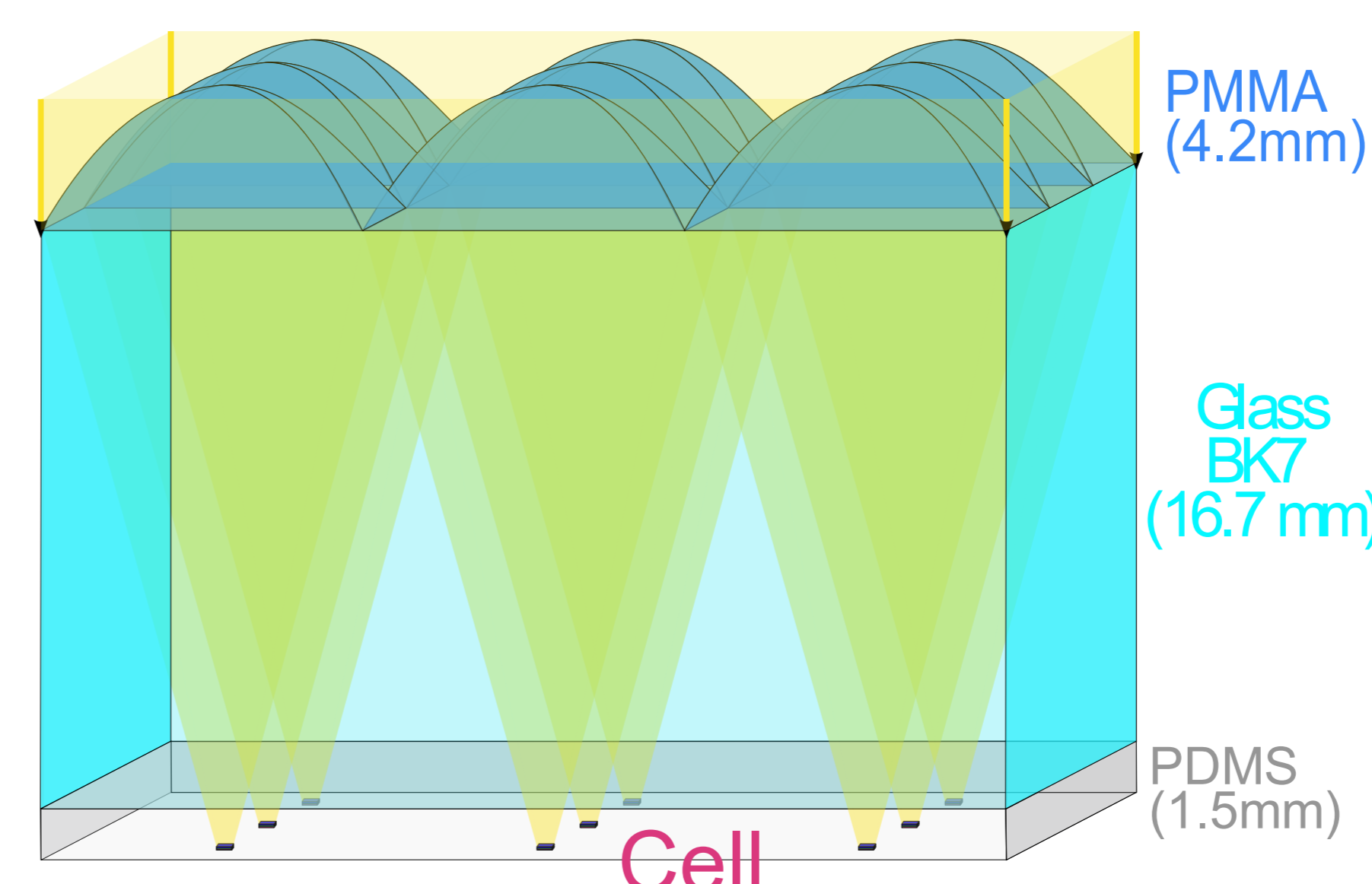
Fabrication of singulated submillimetric cells

- 6 standards steps except for isolation and singulation.



Process flow for cell manufacturing [2]

Concentration optics for μ-CPV



3D drawing to scale of a micro-CPV module with 3 by 3 array of cells, bonded to glass BK7 substrate using PDMS. The light is focused on the cells by the POE optics disposed on the top glass surface.

POE curvature radius	± 70 μm
POE conicity constant	± 0.04
Cell misalignment	± 50 μm
POE thickness	± 210 μm

Table of manufacturing tolerances calculated with ZEMAX simulations

- **Simple stage concentration optic (350X) with high manufacturing tolerances**

Perspectives

- Increase performance by improve the passivation of our sidewalls.
- Interconnection on several cells to make a receiver
- The receiver must be aligned with the optics to build a module

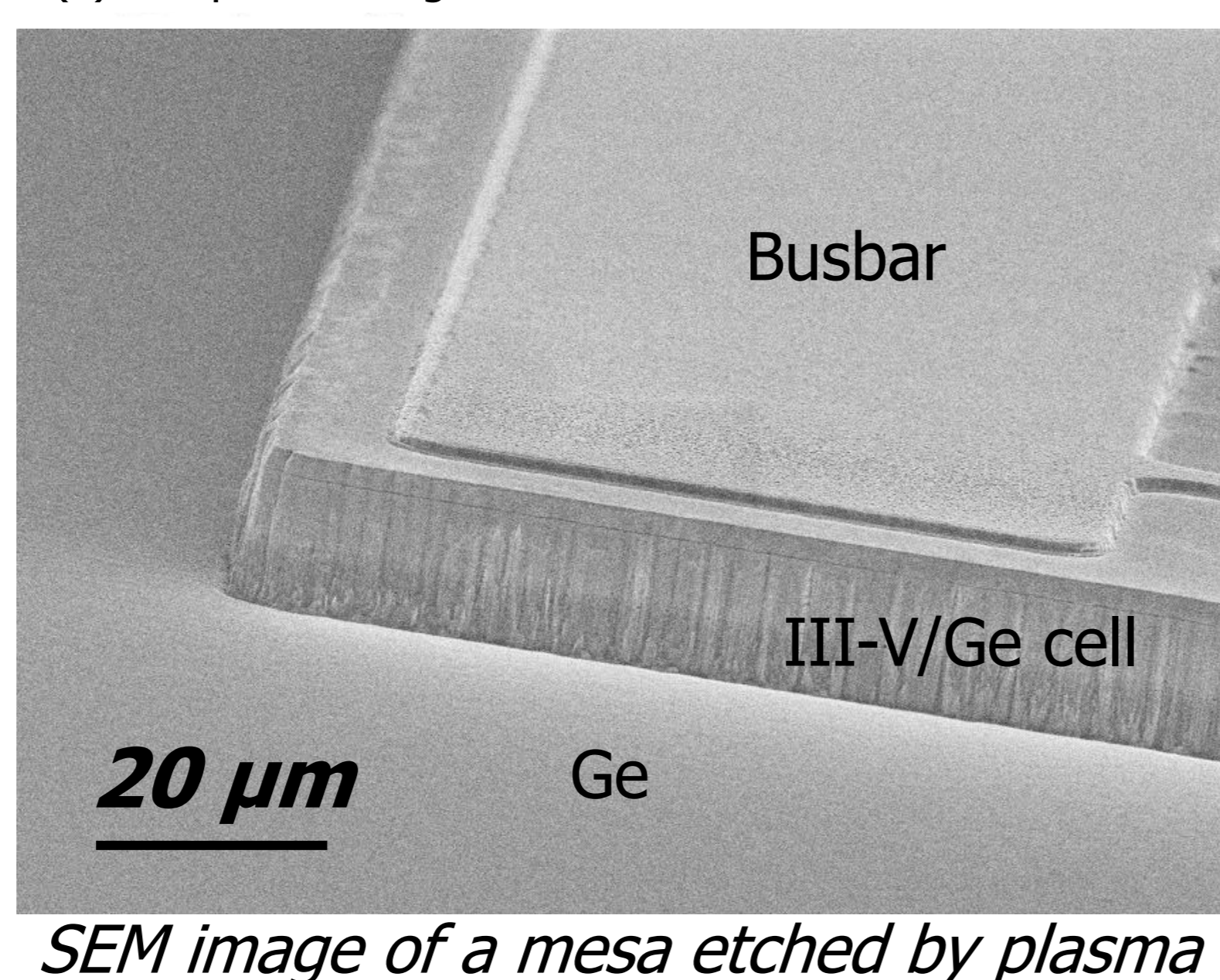
References

- [1] Site NREL, chart 2023, consulté le 01/05/2023
- [2] Albert et al., « Miniaturization of InGaP/InGaAs/Ge solar cells for micro-concentrator photovoltaics », Prog. Photovolt. Res. Appl., 2021.
- [3] M. de Lafontaine et al. « Influence of plasma process on III-V/Ge multijunction solar cell via etching », Sol. Energy Mater. Cells juin 2019

Originality:

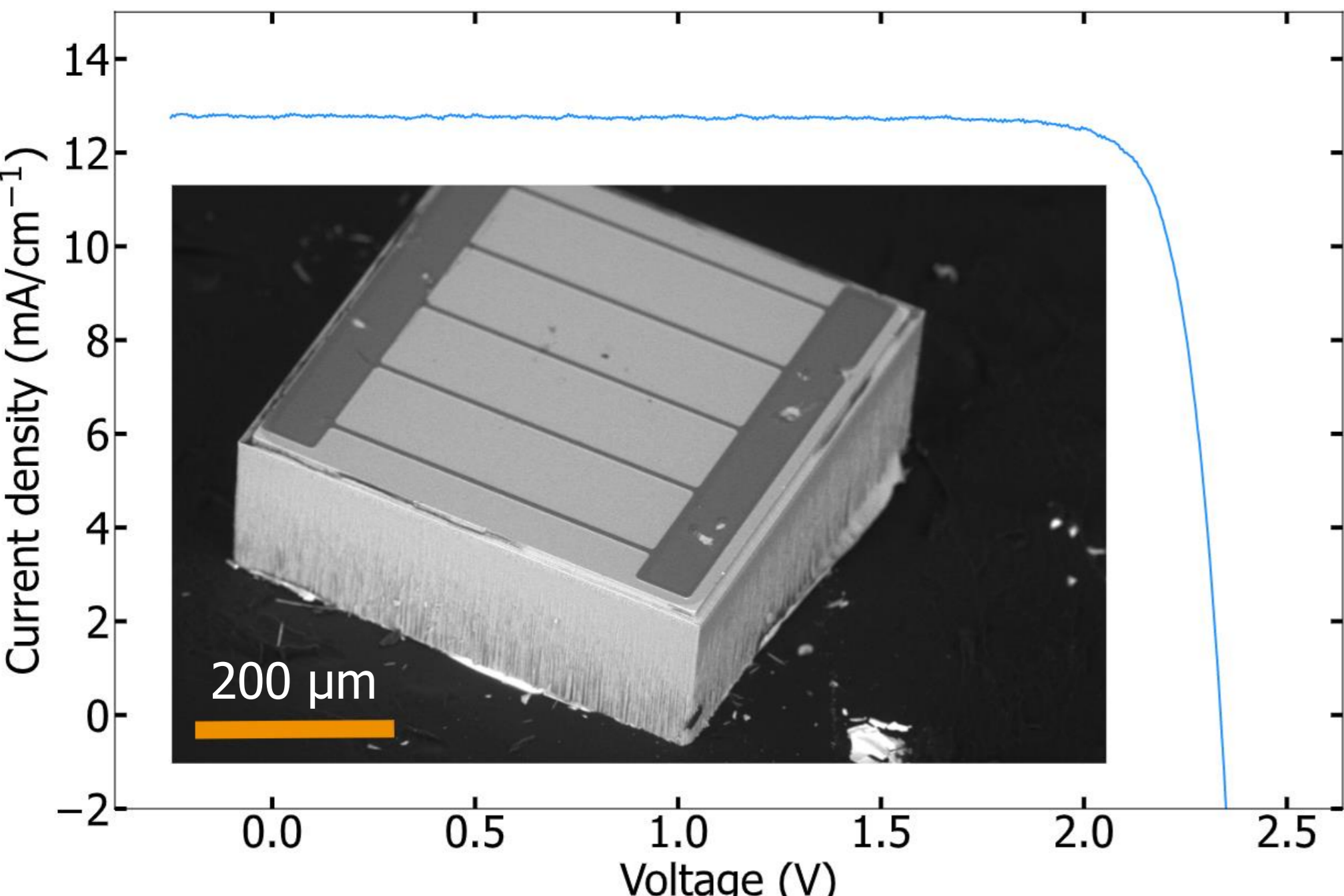
1) Isolation by plasma etching:

- Less damage than with a blade
- Sidewall passivation by Hydrogen [3].
- **Reduced perimetric recombination.**



2) Singulation by plasma etching:

- **Best wafer yield (more than 90%) [2]**
- **0,25mm² cell reach 31,26% efficiency at 1 sun**



I-V measurement of a 0,25mm² cell after singulation and SEM image of a 0,25mm² cell singulated by plasma

Acknowledgments

