**CEA is a key research institute with a strong expertise in photovoltaic**

- Full solar value chain
- 15 years of recognized expertise over on photovoltaic technologies
- Advanced prototyping platforms and industrial pilot lines
- Advanced testing platforms with irradiation facilities and thermal chambers

# Leveraging on Terrestrial Silicon Photovoltaïcs to Bring Space PVA Costs Down

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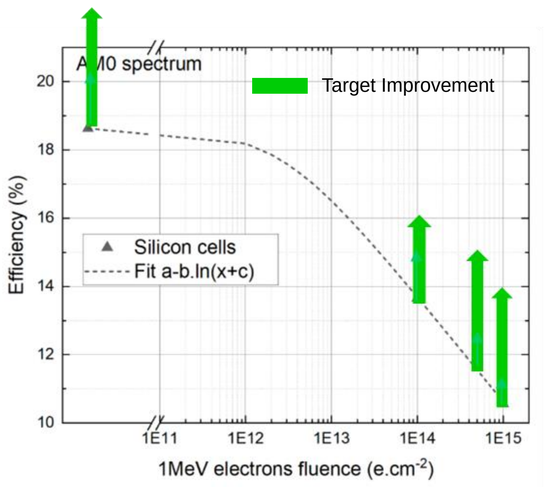
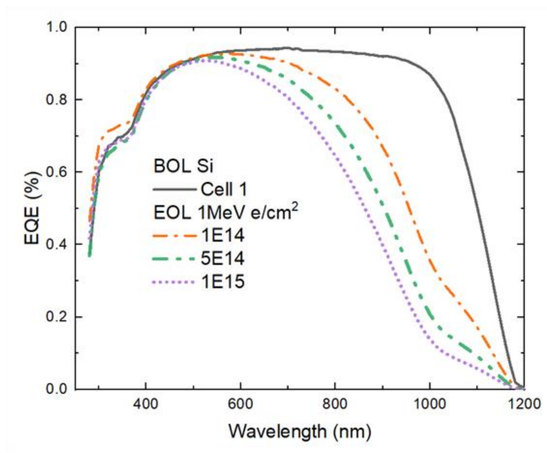
## New market segments, driven by low cost and high volume

- Low Earth Orbit (LEO) constellations
- Space based solar power
- Human explorations

> 10 MW / Year



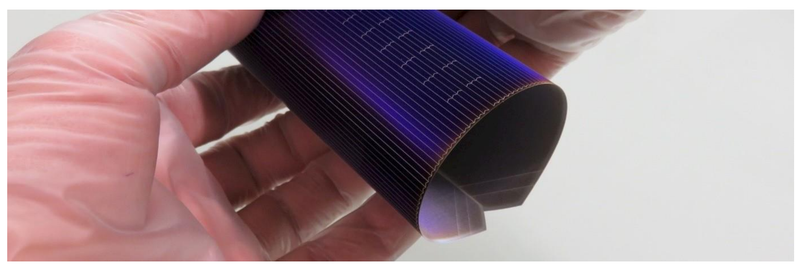




10 – 14% EOL with COTS silicon solar cells [1]

Improve the radiation hardness of Silicon cells
Adapt the degree of spatial qualification standards
Switch from 100€/W III-V technology to few €/W Si

## Cost effective silicon cells: radiation hardness / CEA Focus

- High throughput : > 2,400 wafers per hour on CEA pilot line
- Ability for dedicated space optimisations:
  - Low thickness (60 µm)
  - Doping and impurities for space



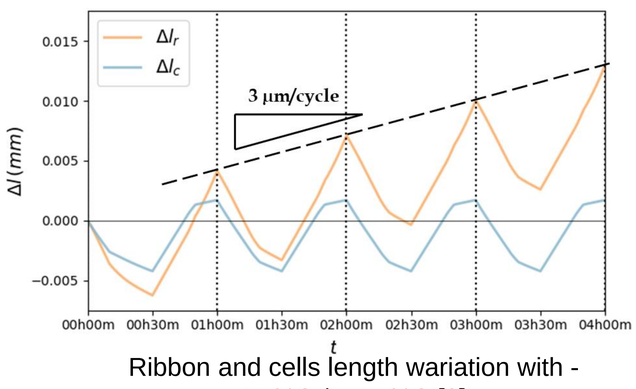
CEA thin heterojunction solar cells (60 µm)

→ Development supported by CNES [2]

| Irrad. | Spectrum | Cells | Jsc [mA/cm²] | Voc [mV] | FF [%] | Efficiency [%] |
|---|---|---|---|---|---|---|
| 1MeV 1E14 e/cm² | AM1.5G (calibrated) | 60µm | 36.8 | 0.568 | 74.0 | 15.5 |
| | AM0 (calc. from calibrated meas.) | | 44.2 | 0.573 | 74.0 | 13.8 |

## Interconnection for silicon solar cells

- Development of thermo-mechanical models
- Study of ribbon lengthening
  - Influence of Coefficient Thermal Expansion mismatch
  - SnAg solder mechanical behavior



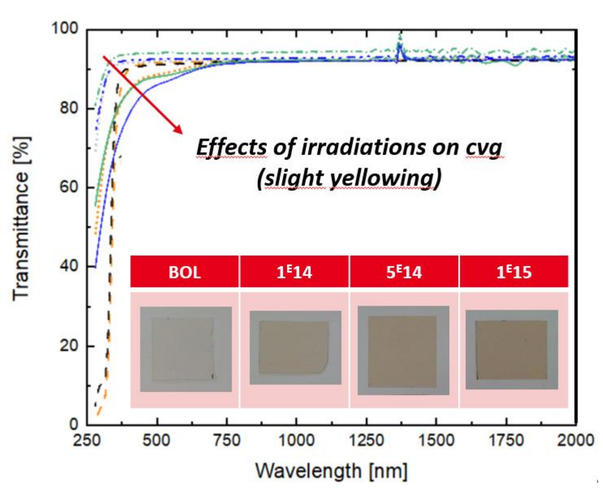

Ribbon and cells length wariation with -140°C / + 140°C [3]

Picture of backside buckled ribbon (after thermal cycling) [3]

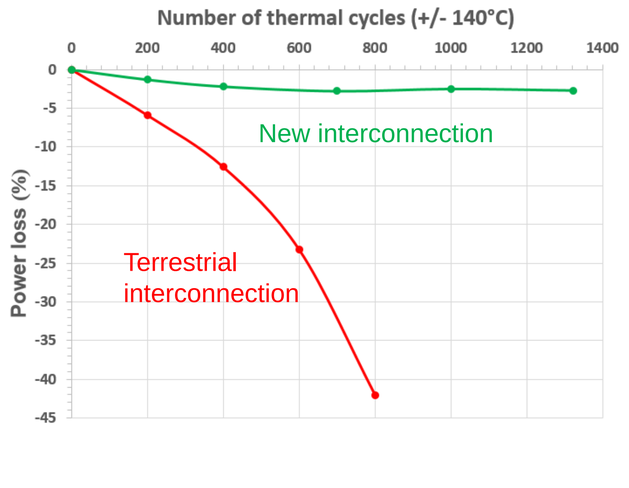
- Global approach with numerical modeling
- Assess the plastic strains locally
- Predict the behaviours of the ribbon/adhesive/substrate under multiple thermal cycles

## PVA modules improvements

- COTS coverglass radiation study
- Thermal management




T% loss <5% (depending on glasses) [4]




Thermal cycling (+/-140°C) on Silicon solar arrays [4]

- Radiations hardness of COTS materials
- Innovative array design based on terrestrial solution

## Conclusion and challenges tackled at CEA

- Improvement of the EOL efficiency for LEO: mid term target at 16 %
- Interconnection robustness versus thermal cycles (> 30 000)
- Global system analysis trade-off

References:
[1] R. Cariou et al, SPRAT 2022
[2] R&T GALAXSI, CNES : R&T n°R-S22/PF-005-149
[3] J.B Charpentier et al, SPECIAL PV Workshop, Le bourget du lac, 2021
[4] J.Gaume et al, SPECIAL Workshop, Le bourget du lac, 2021

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