Silicon heterojunction solar cells: solder, process and equipment qualification

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Introduction

- Soldering is widely used for the interconnection of homo-junction (PERC, TOPCON) solar cells
  - Advantages of soldering:
    - High mechanical and electrical performances
    - Reduced use of silver [1]
    - High throughput / Simpler equipment
  - Technical challenges of soldering on SHJ:
    - Process temperature small window adjustment to avoid degradation of the passivating contacts [2,3]
    - Adapted low temperature cured metallisation pastes to select/develop [4]

Mondragon Assembly MTS 3000 MBB soldering stringer

[1] CTMOD simulations, unpublished (2021) .
[2] A. De Rose, *et al. 36th EuPVSEC* (2019) 229–234.
[3] TaiyangNews | Heterojunction Solar Technology 2023
[4] S. Pingel *et al. 37th EuPVSEC* (2020) 508–511.

Experimental workflow

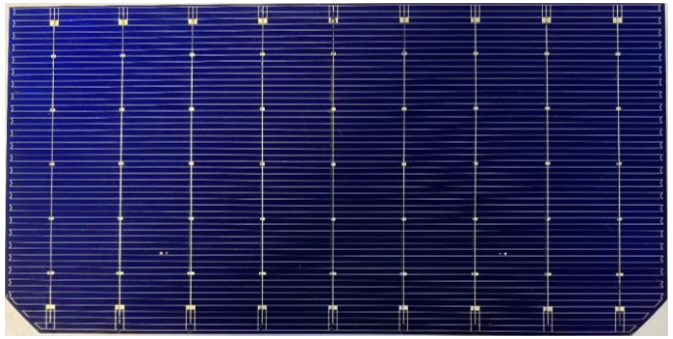
SHJ Cells → Metallisation → Stringing → Mini-module → Thermal Cycling

SHJ Cells from INES Labfab

Paste formulation

&

Single/Dual Print



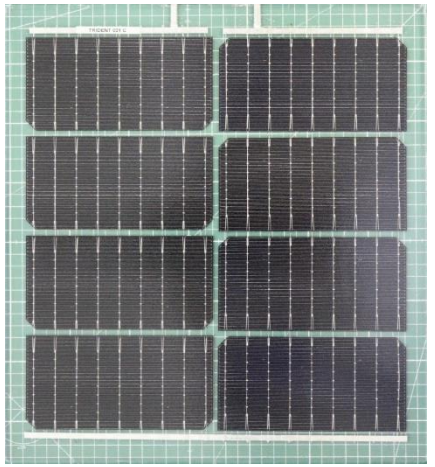
Solder

&

Process

8 x ½ cells

glass-glass



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&

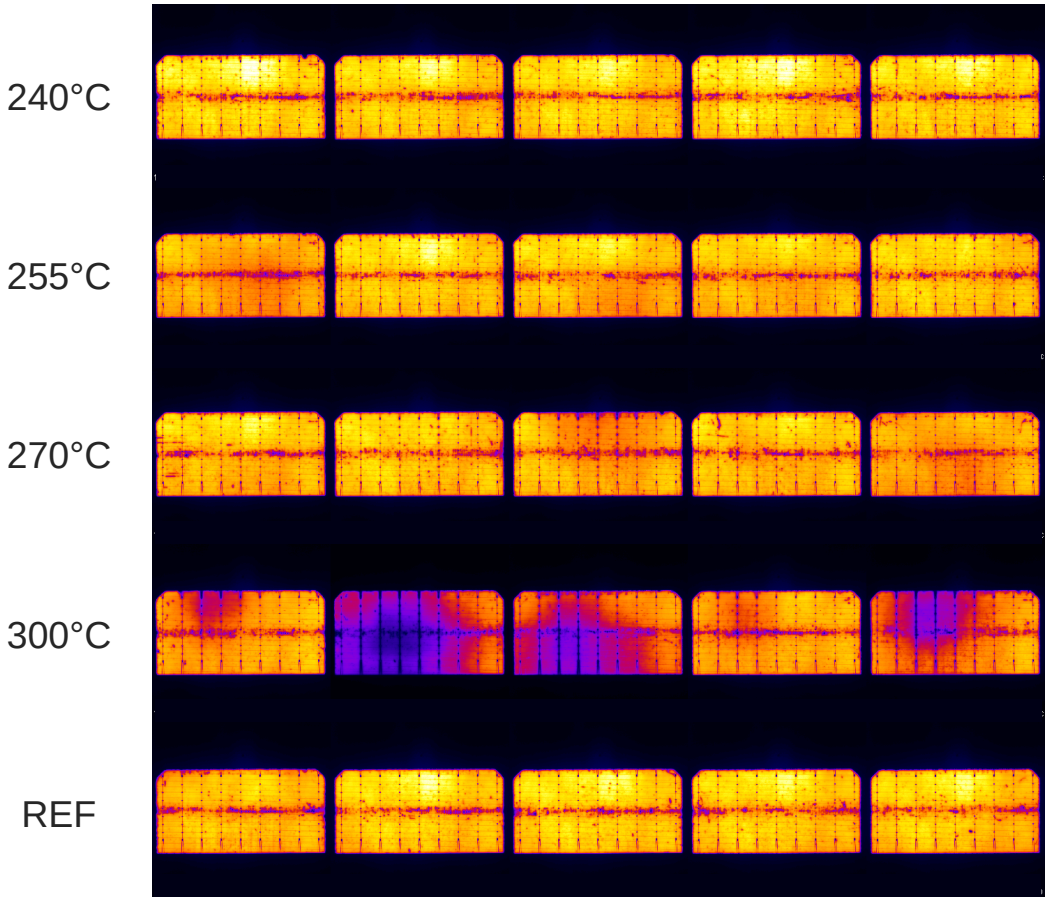
EL

Metallisation

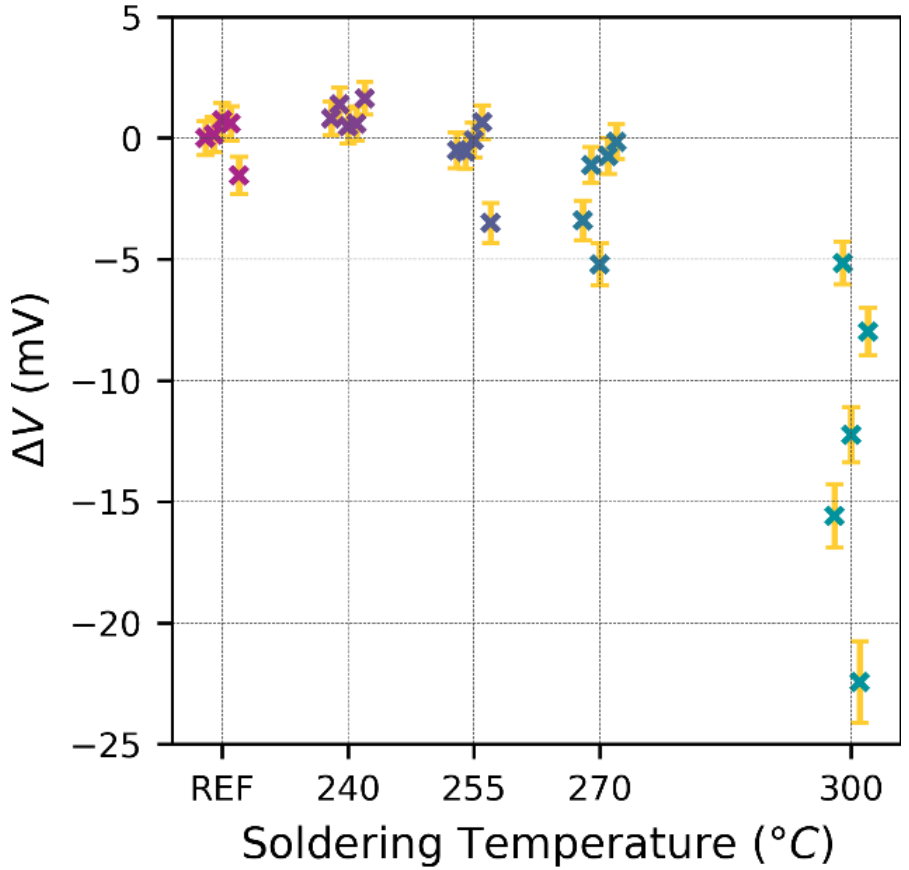
Metallisation	FRONT		REAR		FF	Eff
	Bus + pad	Finger	Bus + pad	Finger	(%)	(%)
A	Paste X	Paste Y	Paste Y		80.5	22.2
B	Paste X	Paste Y	Paste X	Paste Y	80.4	22.2

- ½ M2 cells MBB9, 7 pads per bus.
- 2 different configurations tested.
- Similar efficiencies at cell level.

Soldering temperature of SHJ



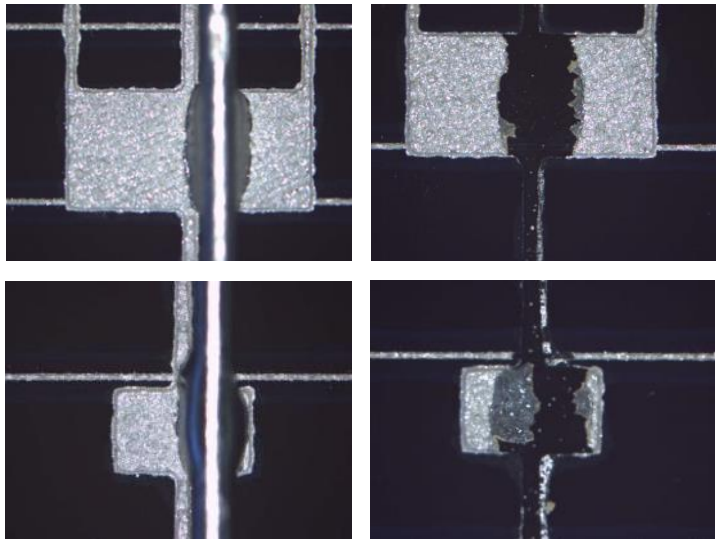
PL images of SHJ after passing through the stringer at different temperature (time 0.7 s)



- Process temperature < 255~270°C.

Solder Alloys and joints morphology

Sn60**Pb**40

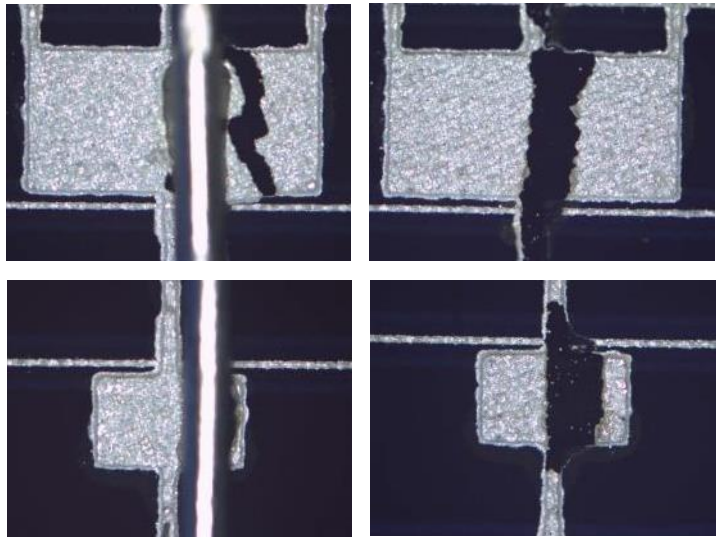


Wetting: good

Fracture: TCO/M & M/Solder

Peel Force: >1 N

Sn41**Bi**58**Ag**1

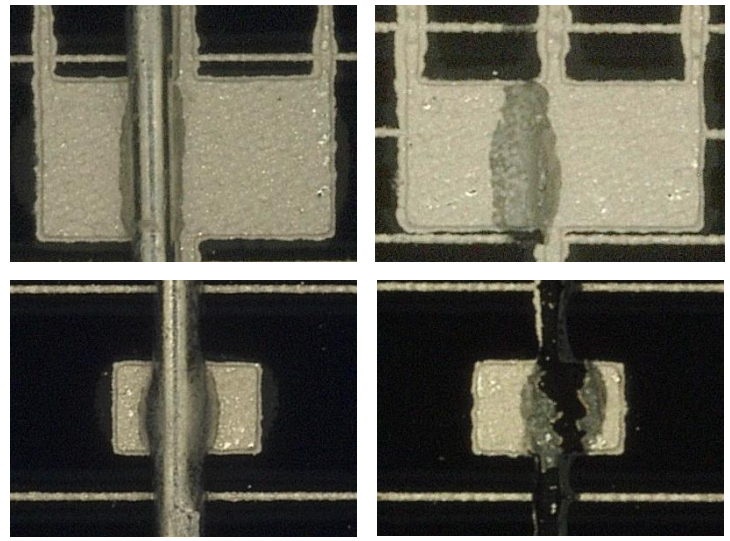


Wetting: poor

Fracture: TCO/M

Peel Force: <1 N

Sn43**Bi**14**Pb**43



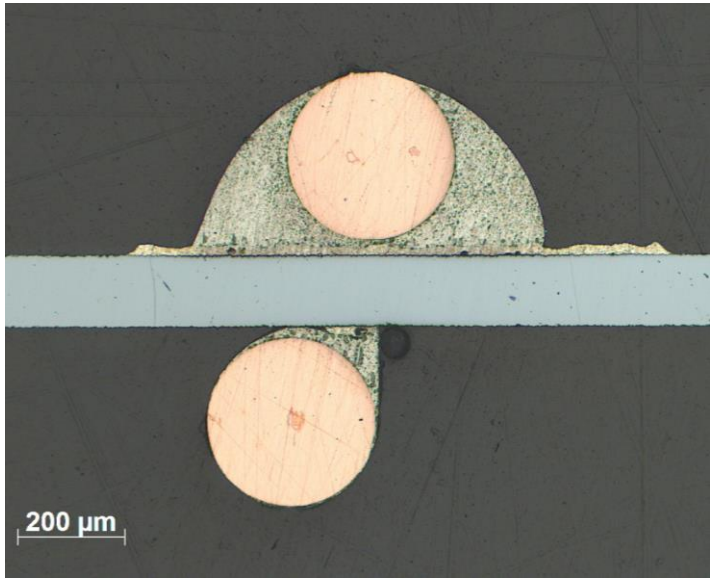
Wetting: good

Fracture: M/Solder & TCO/M

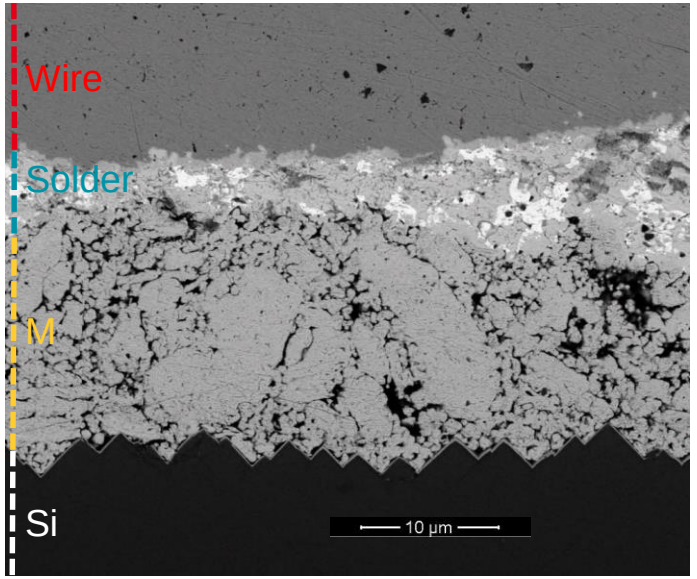
Peel Force: >1 N

Solder SnPb: crossectional metallography

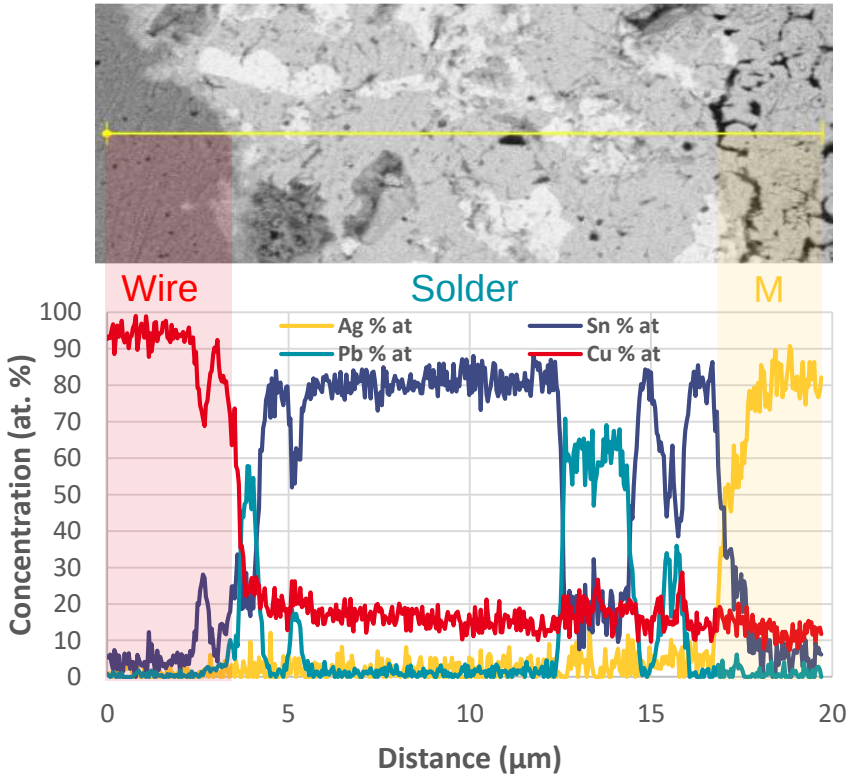
Optical



SEM

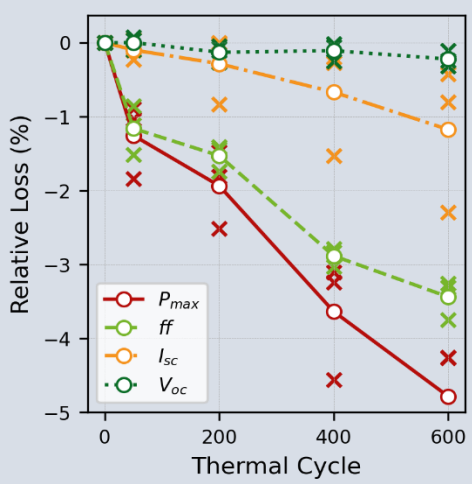
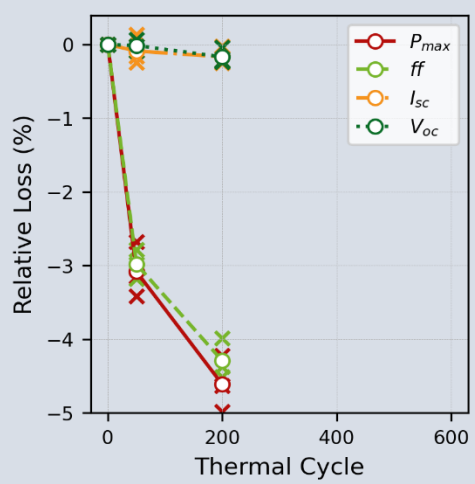
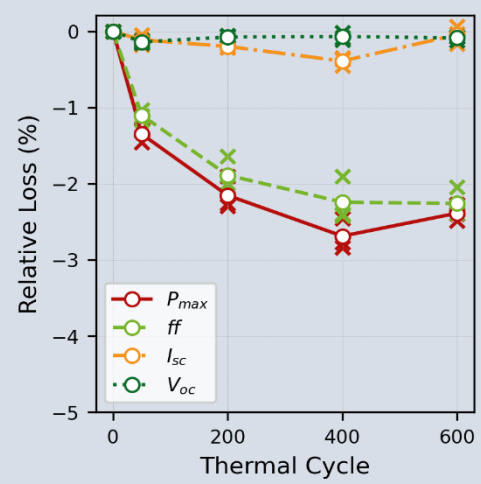
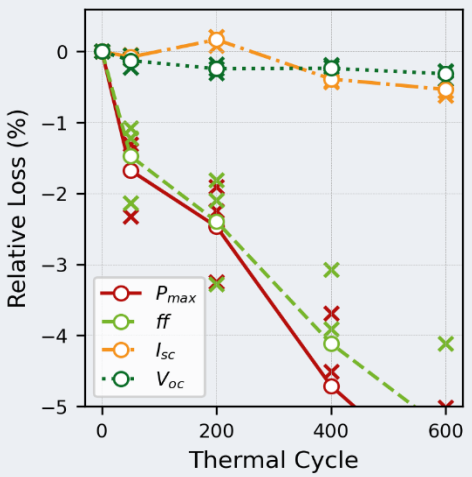
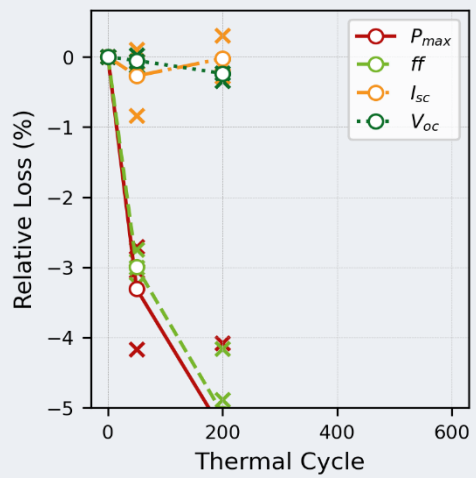
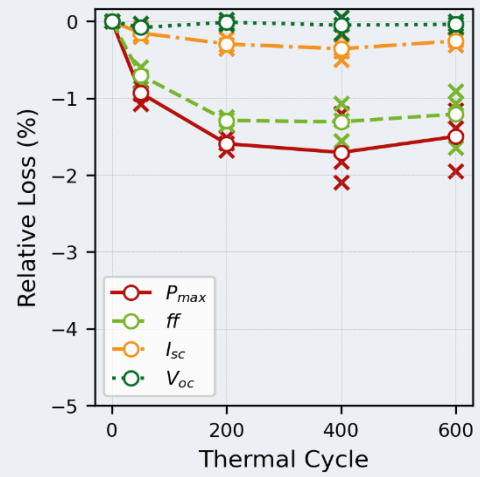


EDX



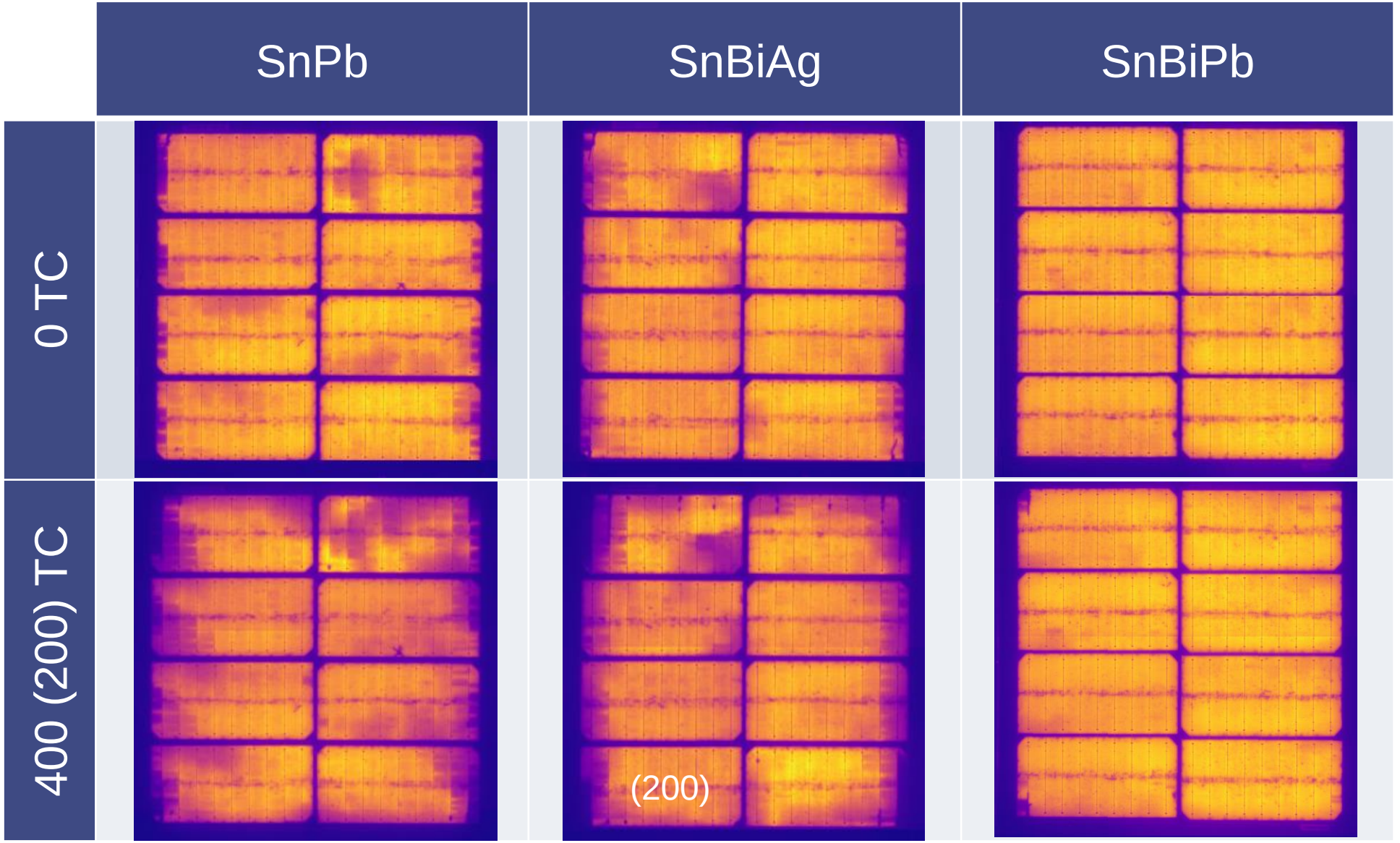
- Bimodal Ag grain size.
- No deep penetration of the solder in the metallisation.
- Intermetallic compounds at the Cu and Ag sides.

Module performance against thermal cycling

	SnPb	SnBiAg	SnBiPb
Metallisation A			
Metallisation B			

- Performance are correlated with joints properties
- SnPb: 2~3x IEC.
- SnBiAg: 0~1x IEC.
- SnBiPb: 3x IEC (<3%).

Module performance against thermal cycling



- Finger breaks detected for SnPb & SnBiAg but not for SnBiPb

Conclusion

1. **Equipment development for SHJ : MTS 3000 IR soldering stringer**
2. **Process and solder (SnPb, SnBiAg, SnBiPb) qualification for SHJ**
3. **SnPb: wetting: good, fracture: TCO/M & M/Solder, TC: 2~3x IEC.**
4. **SnBiAg: wetting: poor, fracture: TCO/M, TC: 0~1x IEC.**
5. **SnBiPb: wetting: good, fracture: M/Solder & TCO/M, TC: 3x IEC (<3%).**
6. **Perspectives: reduce Ag consumption & develop Pb, Bi-free solder**

Merci/Thank you

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