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Changes in IV characteristics of a PV module with interconnects that are failing during cyclic mechanical loading

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Abstract

We performed cyclic mechanical loading on a JINKO JKM270PP-60 module using the LoadSpot mechanical tester from BrightSpot Automation. IV characterization and EL imaging were performed every 1000 cycles at 0Pa and 1000Pa. Early and throughout cyclic mechanical loading, few cracks were created as observed in the EL images. One interconnect failure started to be noticeable in the EL images. IV characteristics clearly started to degrade right after the introduction of the forward bias current leading to the interconnect failure.

Motivation

Understanding how key IV characteristics (Isc, Imp, Voc, Vmp, Pmp, FF, Eff, Rsh, Rs) change while the interconnects are failing will help us implement monitoring solutions capable of detecting or predicting interconnect failures of PV modules in the field.

Experimental Setup

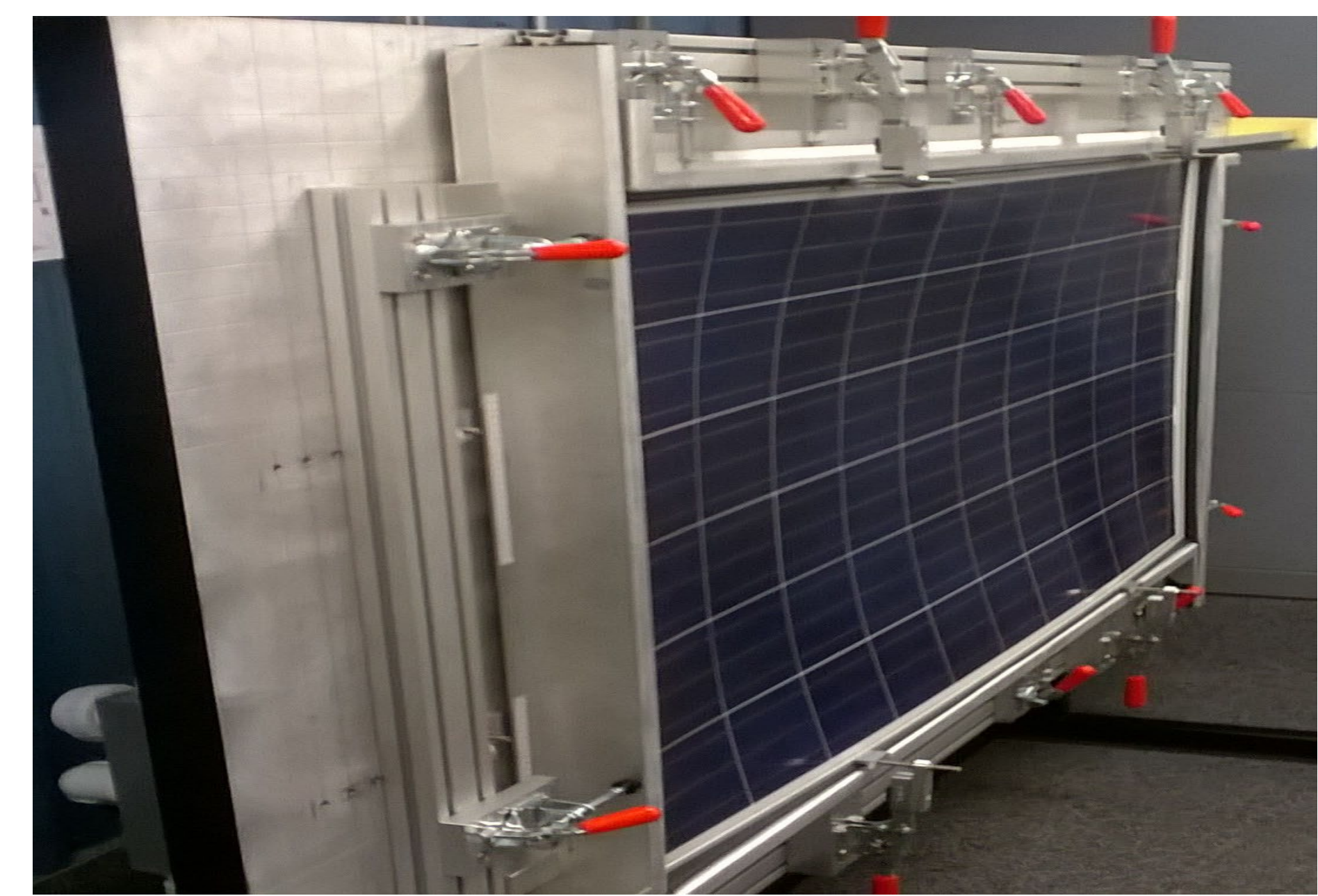


Figure 1. Image of the LoadSpot tool, a mechanical load tester from BrightSpot Automation

- Capable of performing standard IEC static and cyclic loading sequences
- Uniform load $\geq 5400\text{Pa}$ (Positive and Negative)
- Cyclic loading up to 1Hz
- Open front surface enables I-V characterization and EL imaging of modules under load.
- 3D surface mapping under load

Experiment

- $\pm 2000\text{Pa}$ @ 8.6s/cycle for a total of 50,000 cycles
- No current initially, After 32,000 cycles, 9A current

Results

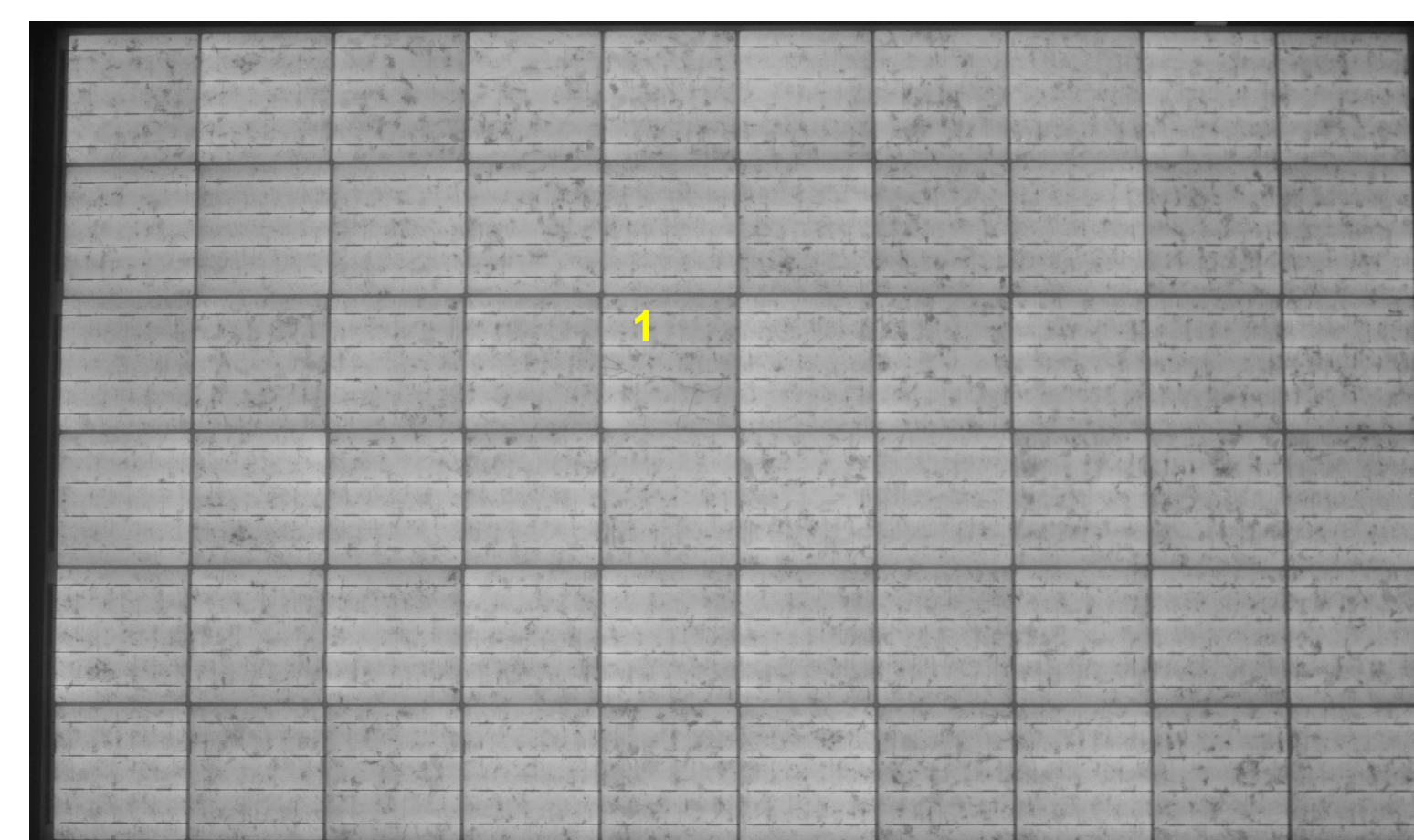


Figure 2. EL image at 0Pa after 5 cycles. Crack occurred after 5¹ cycles

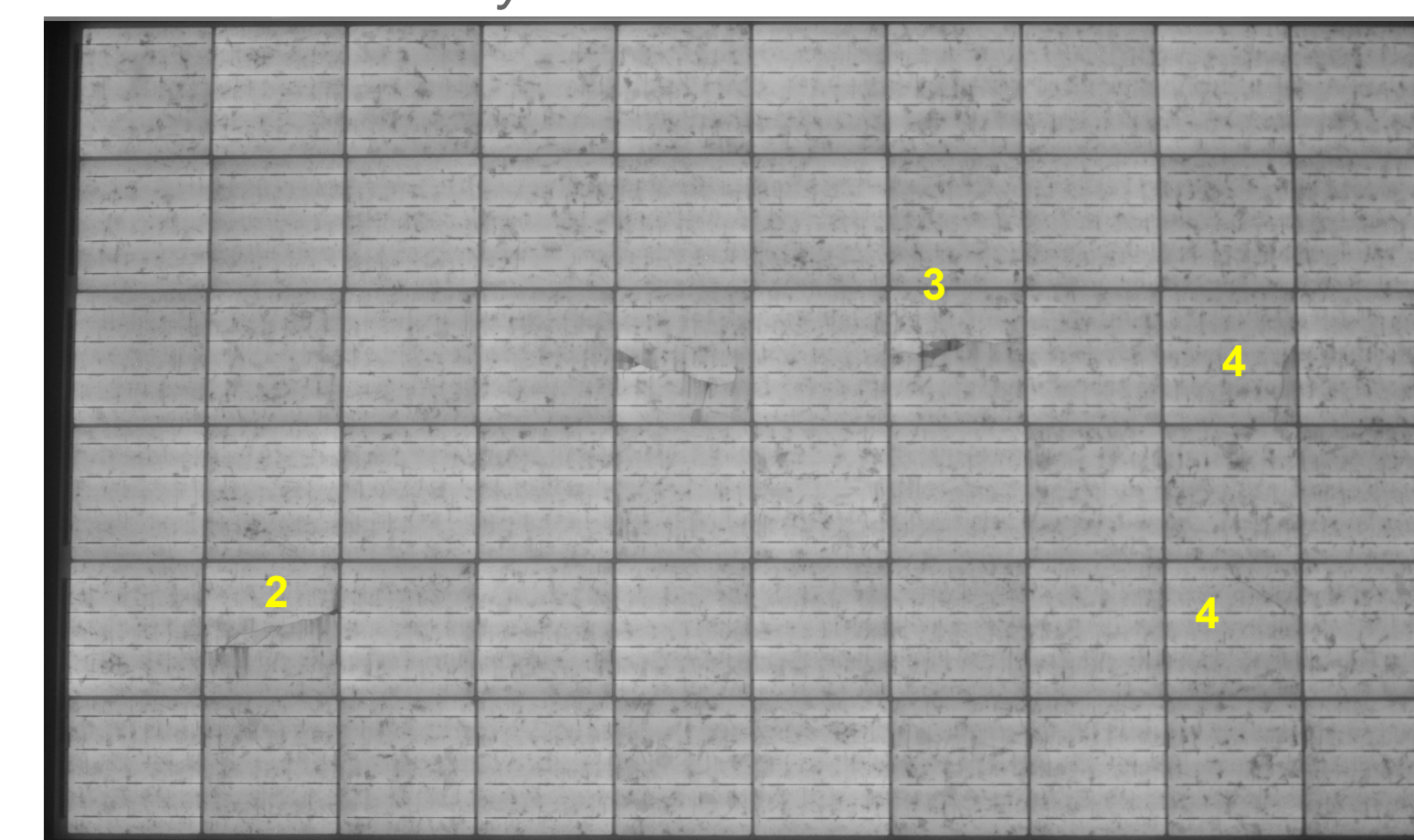


Figure 3. EL image at 0Pa after 10,000 cycles. Cracks occurred after 2000², 5000³, 9000⁴ cycles.

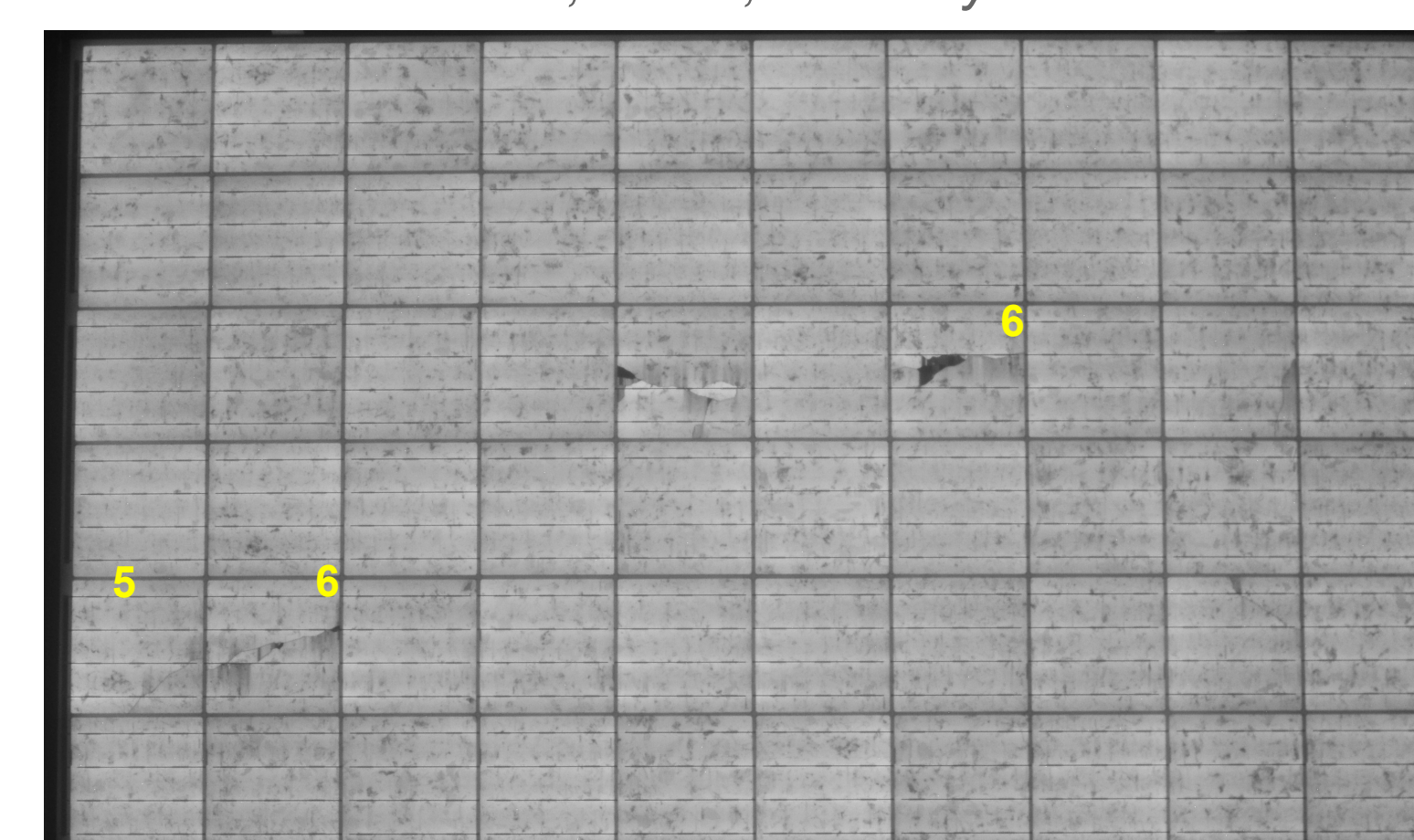


Figure 4. EL image at 0Pa after 31,000 cycles. Crack after 26000⁵, solder joint failure after 30000⁶ cycles.

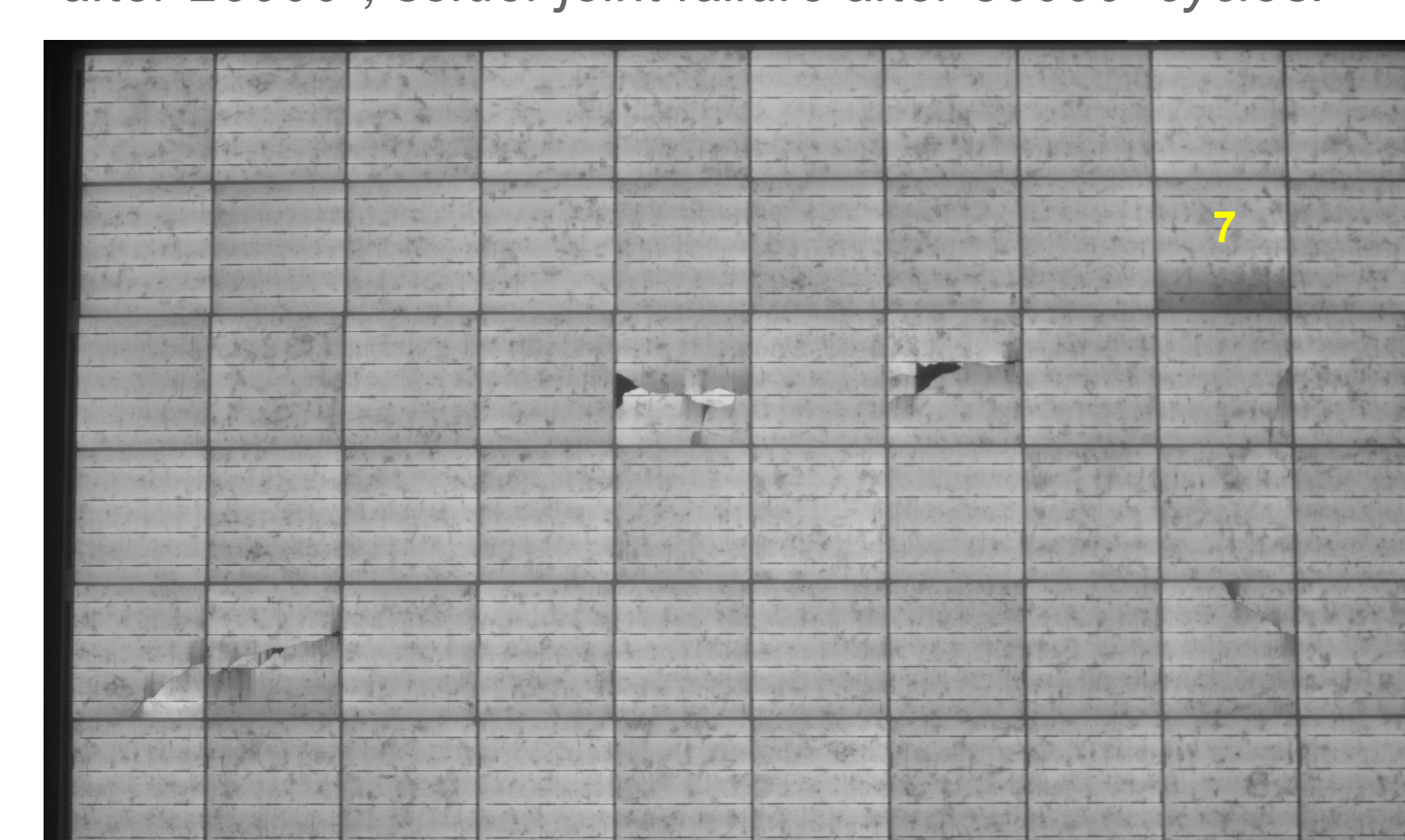
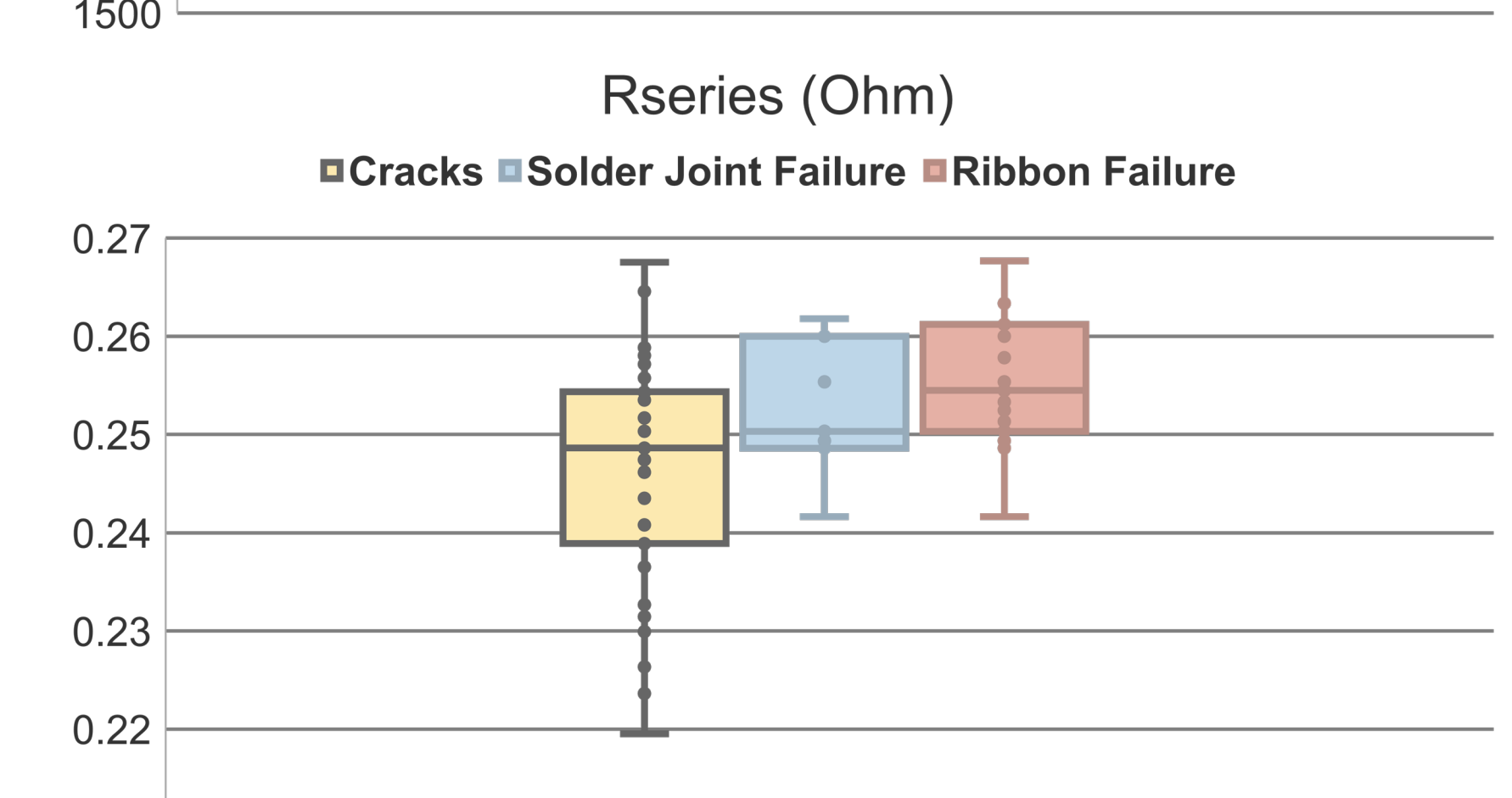
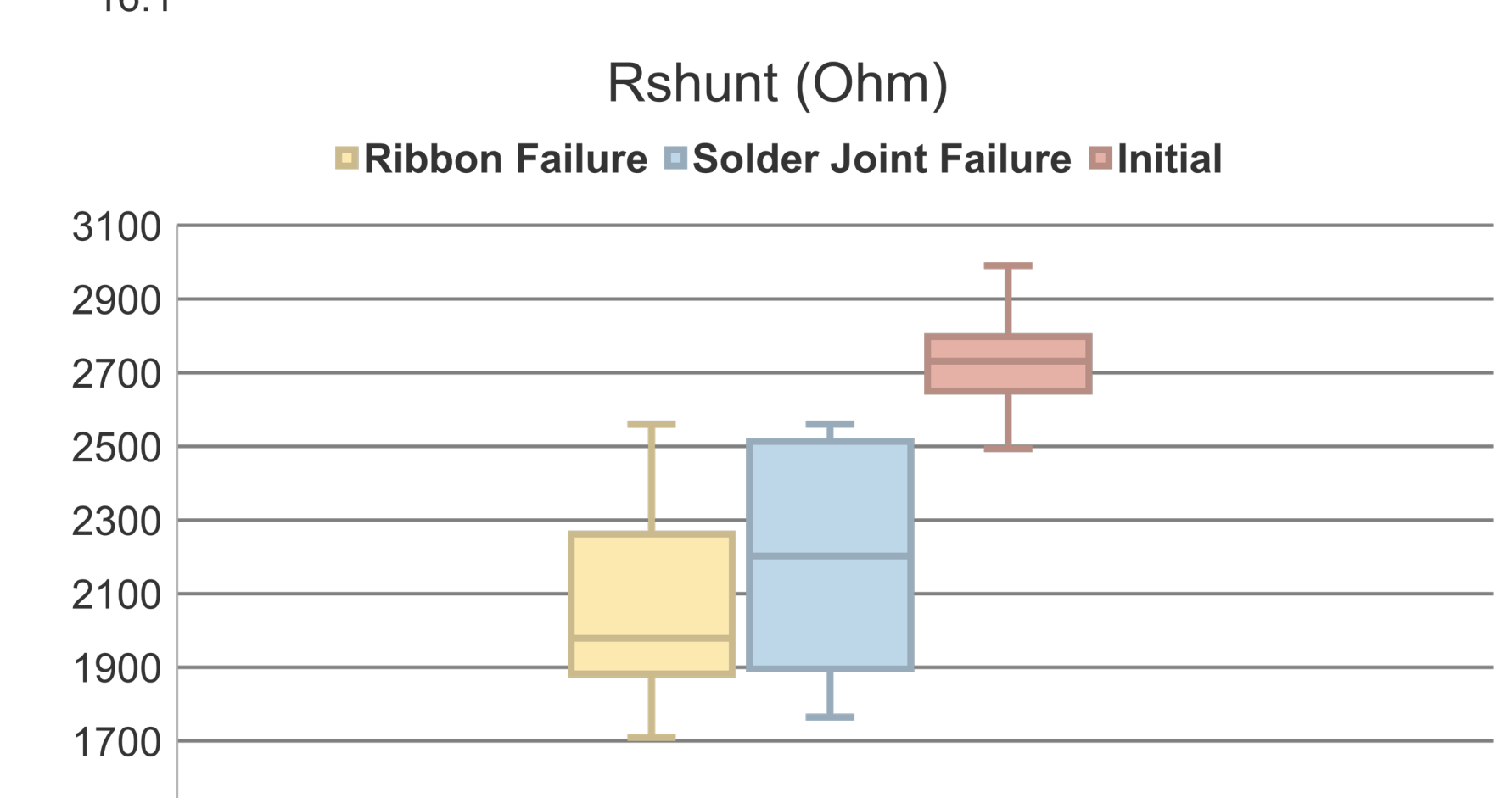
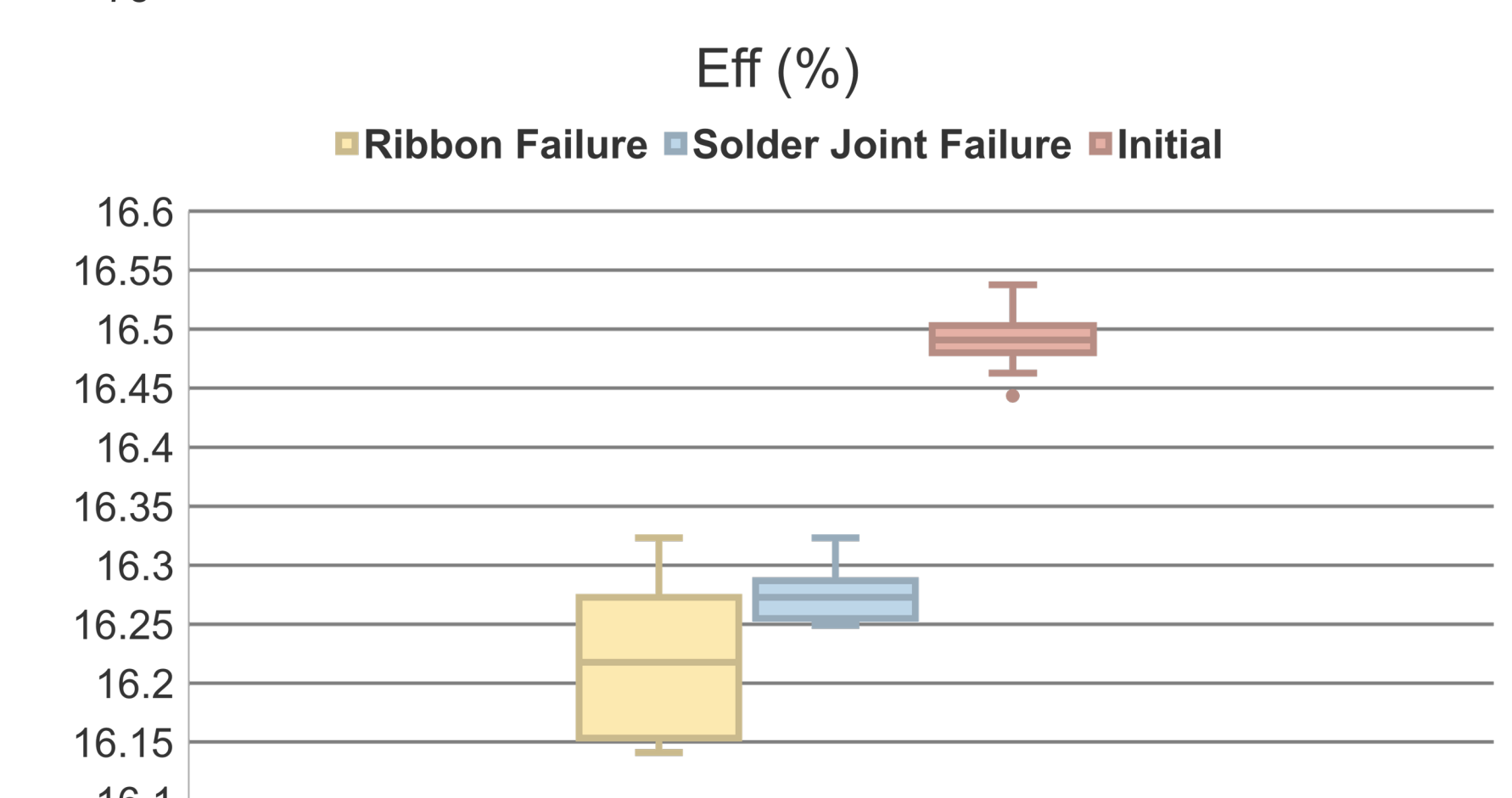
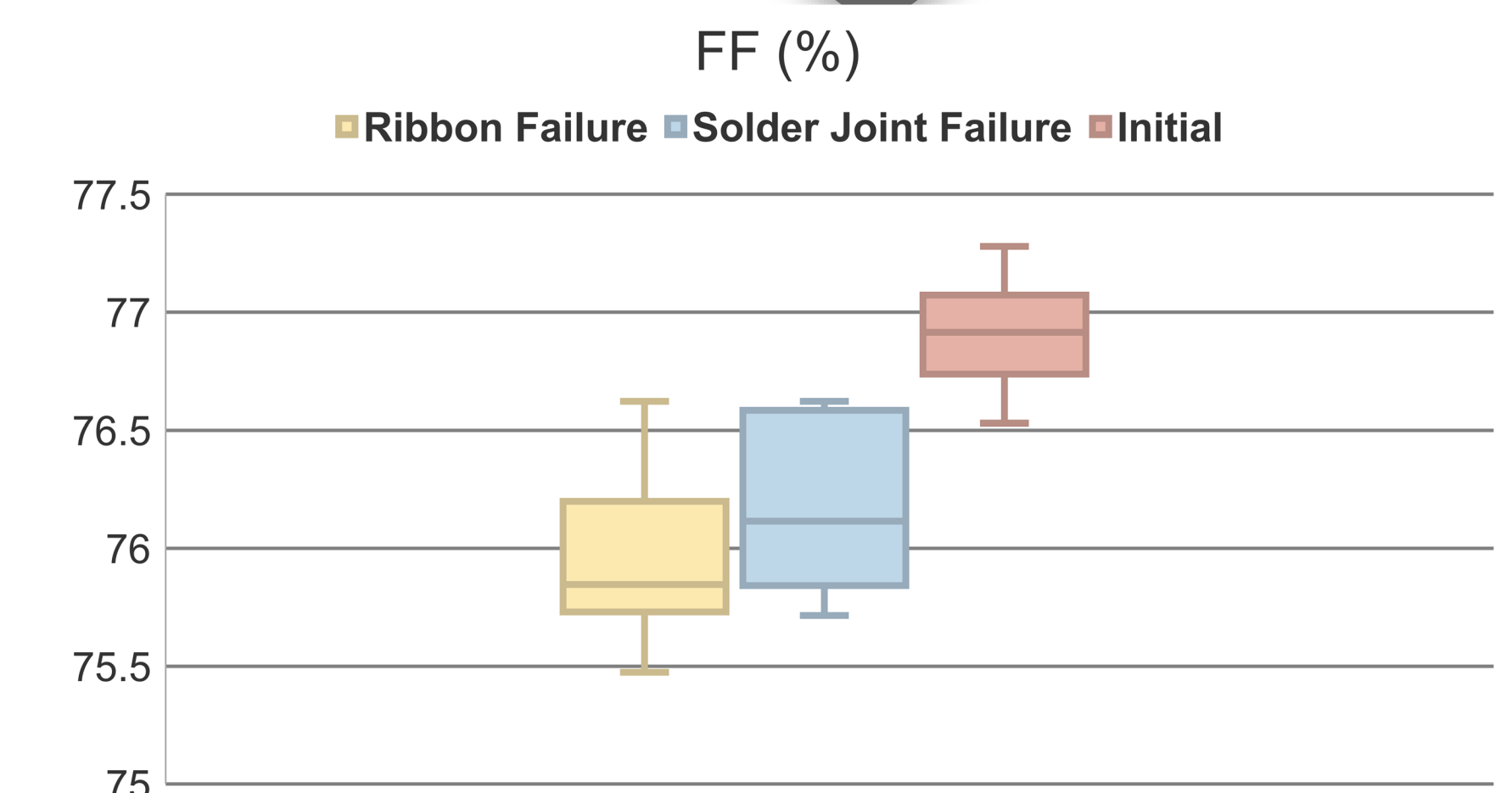
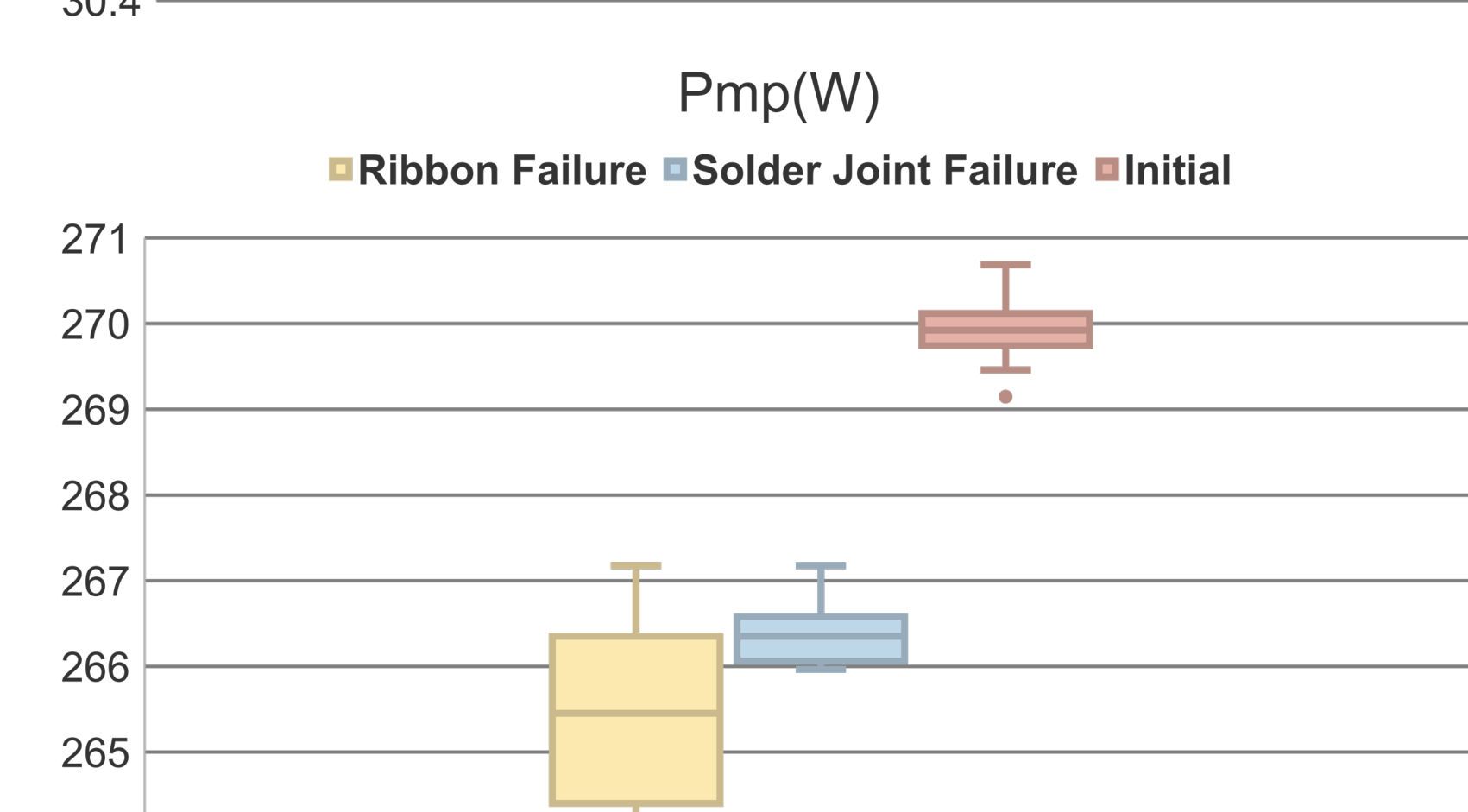
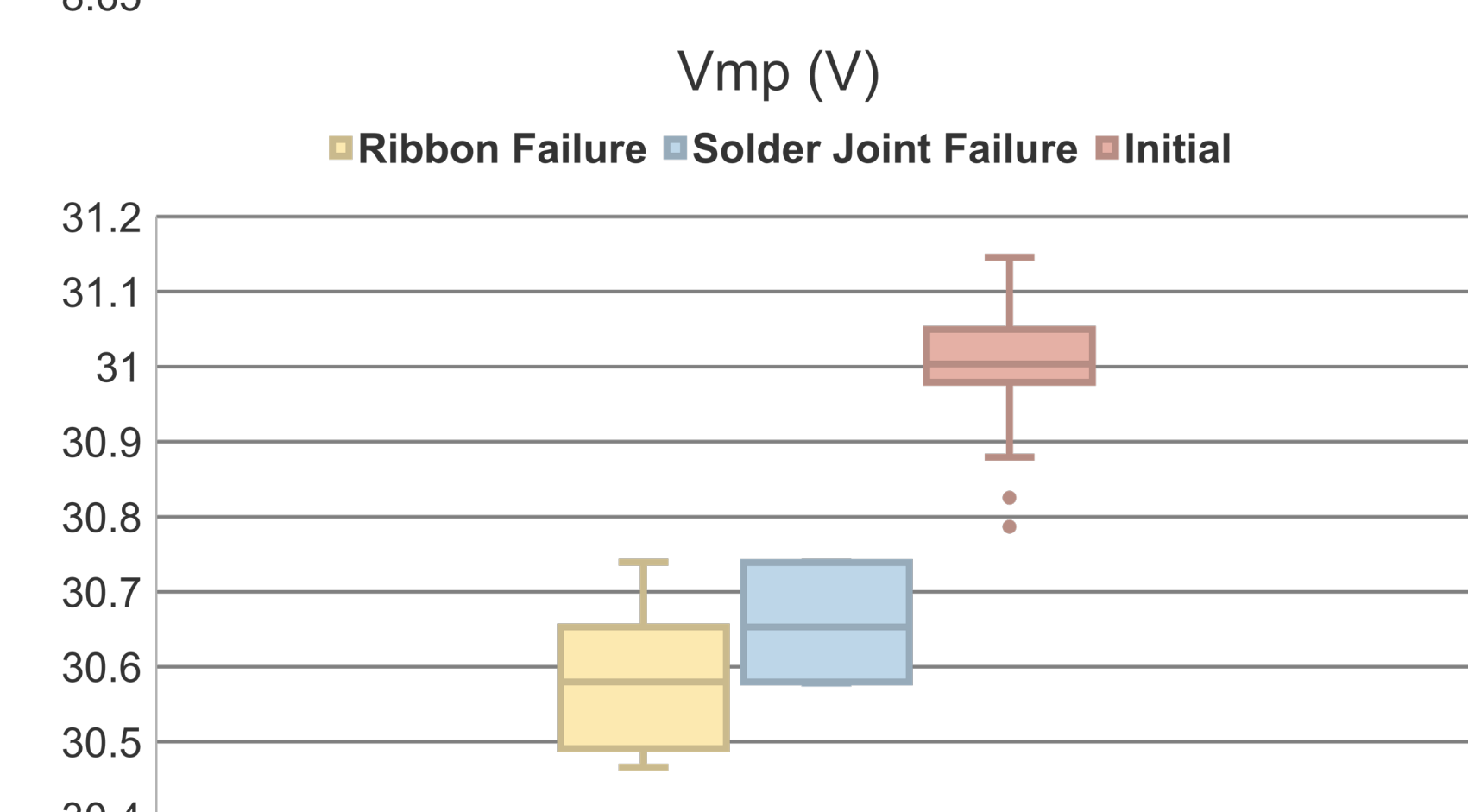
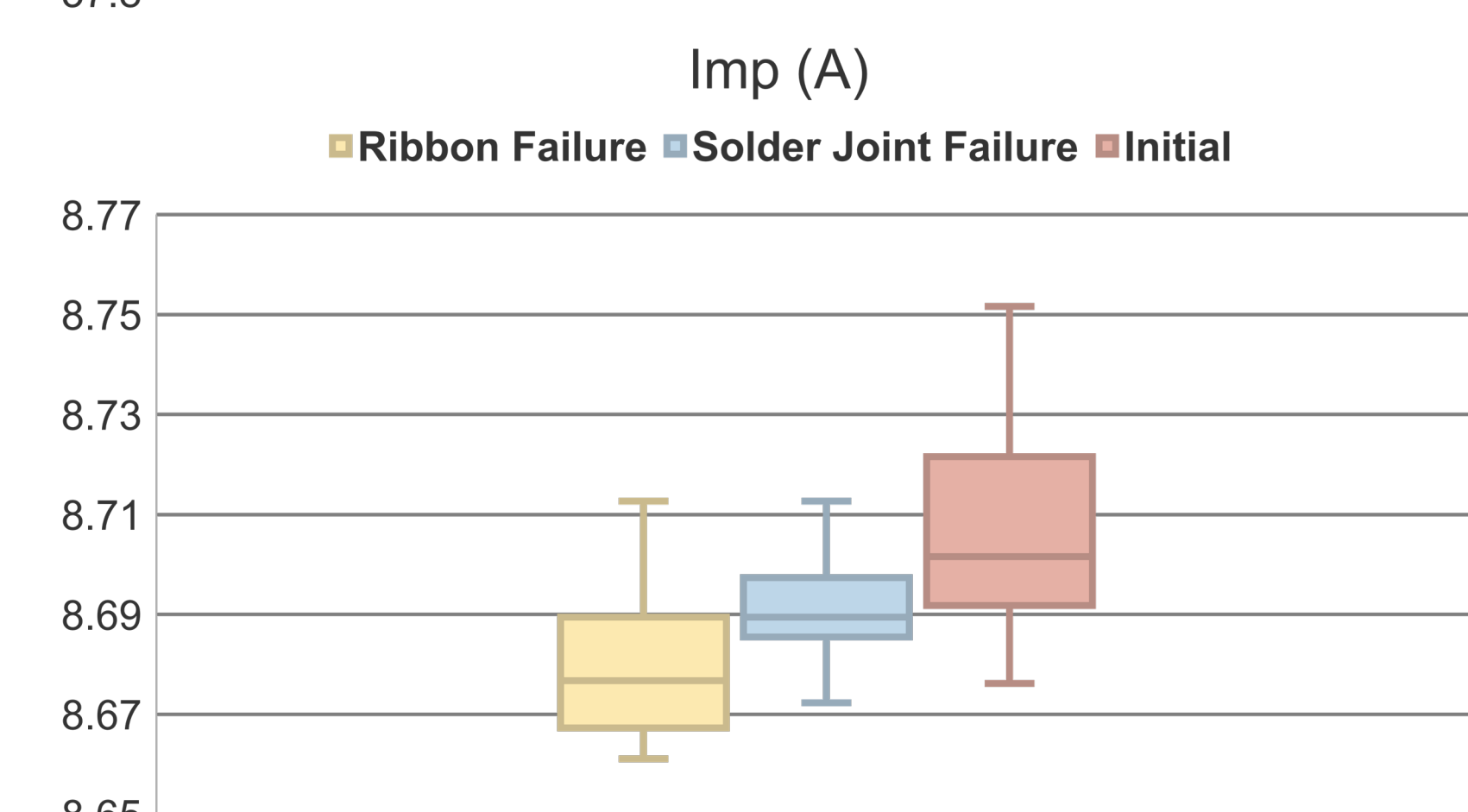
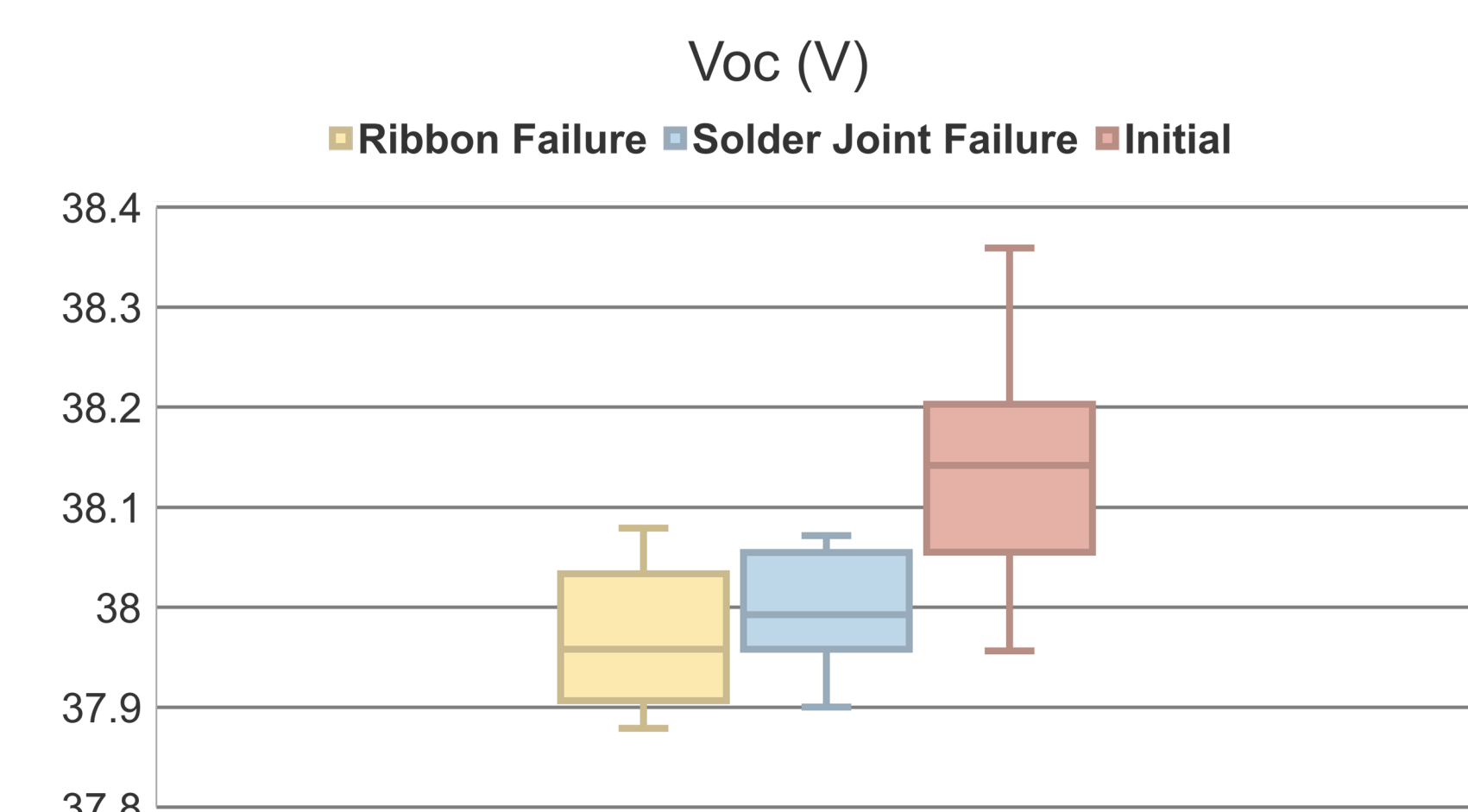
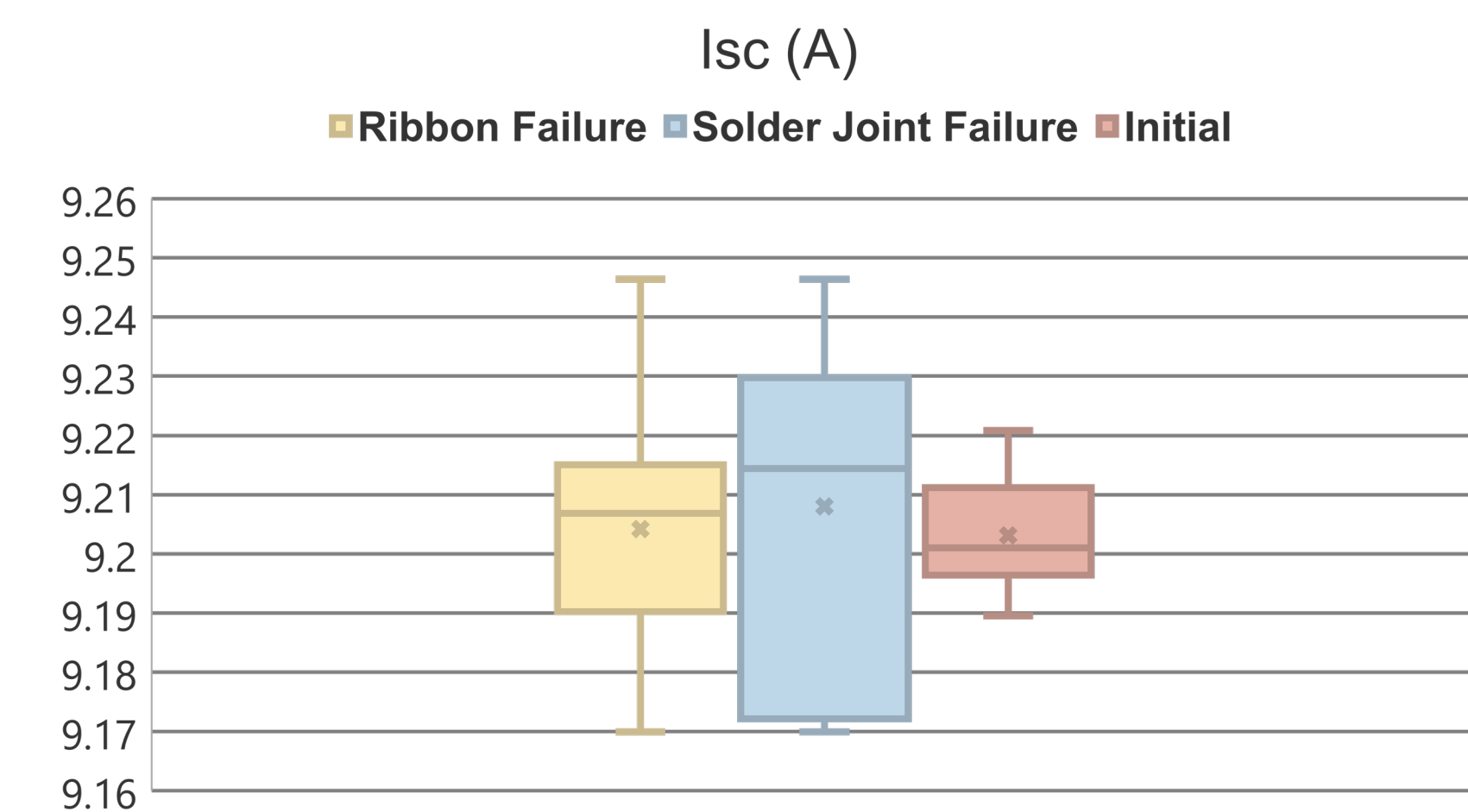


Figure 5. EL image at 0Pa after 50,000 cycles. Interconnect failure occurred after 45,000⁷ cycles.

Analysis



Conclusion

I-V parameters showing the highest sensitivity to the interconnect failure are:

- Vmp
- Pmp
- Efficiency