High-Efficiency GaAs Thin-Film Solar Cell Reliability

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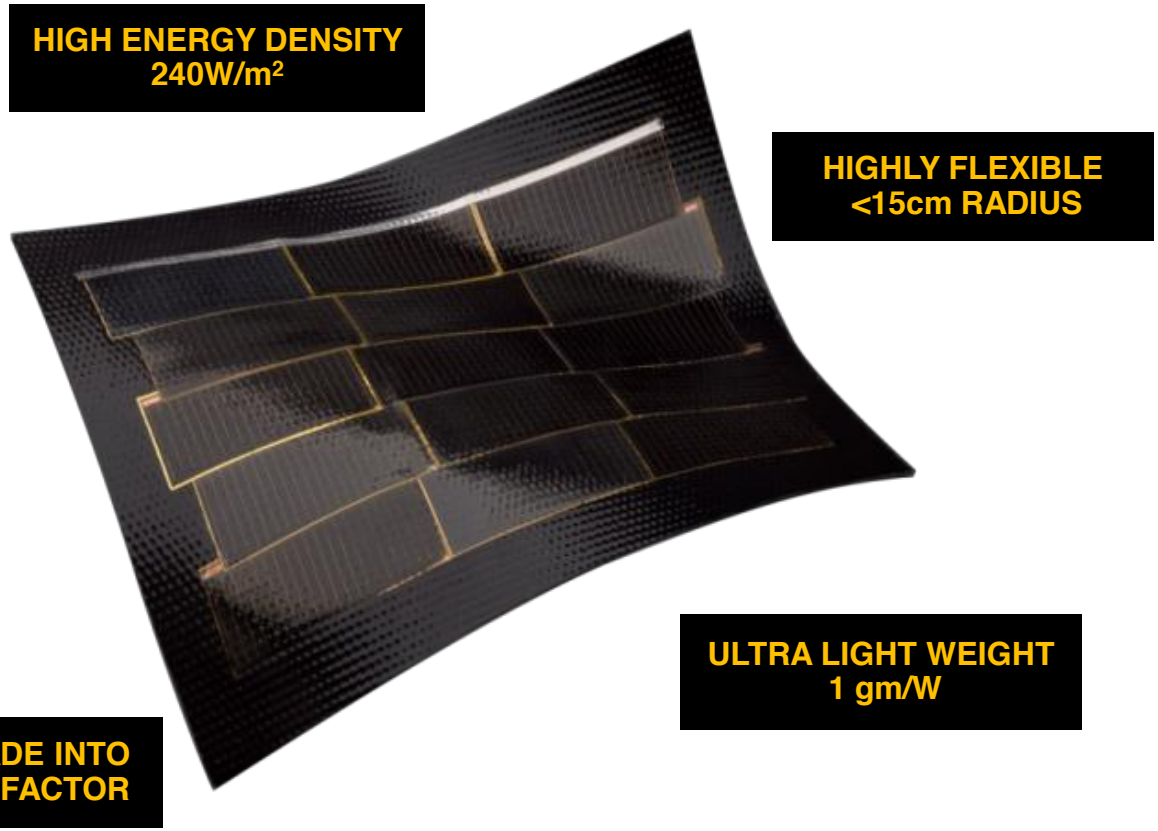
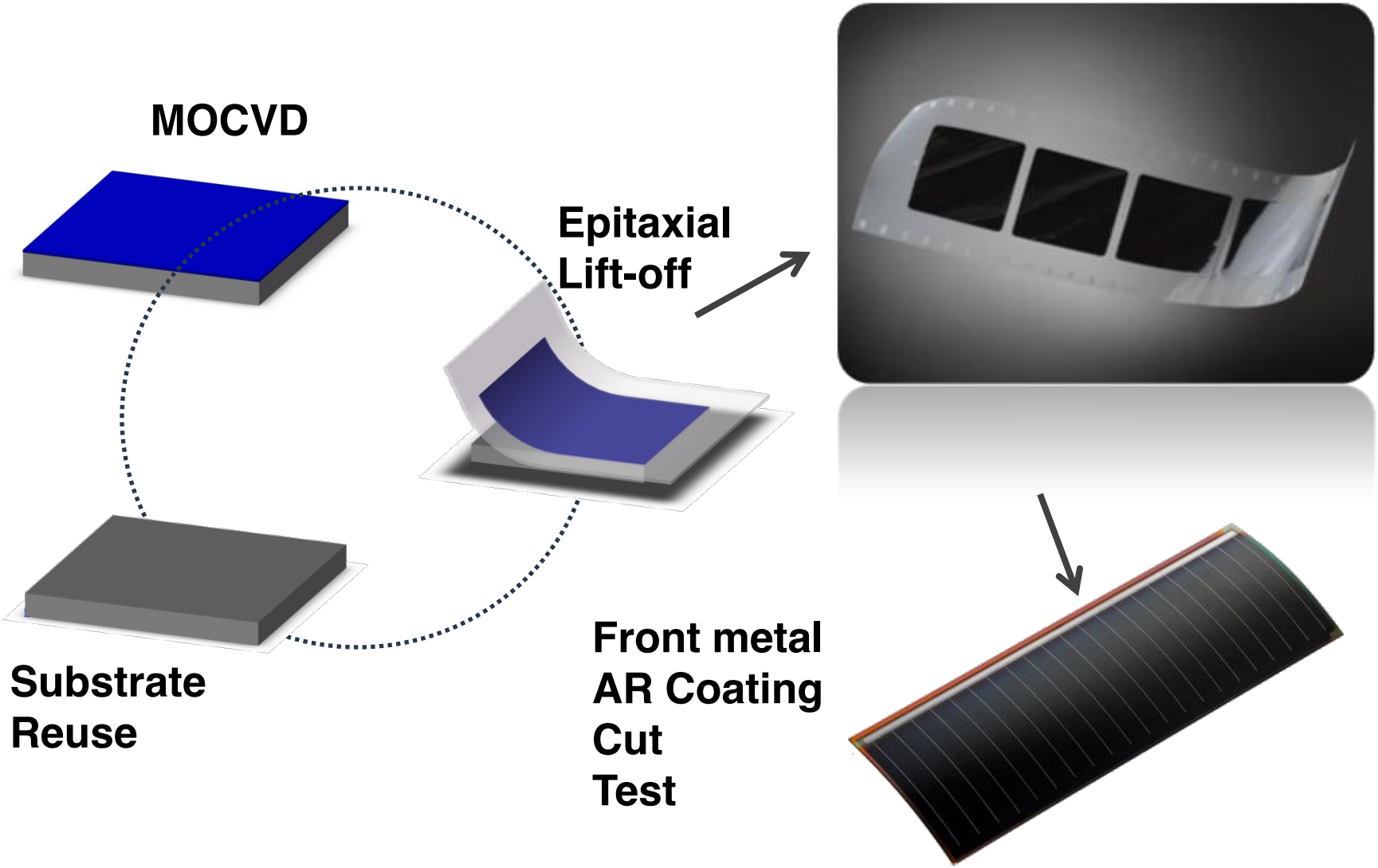
Alta Devices, Inc.

Alta Devices Flexible Solar Technology

- World-record efficiencies
  - Single junction cell/module: 28.8% / 24.1%
  - Dual junction cell: 30.8%

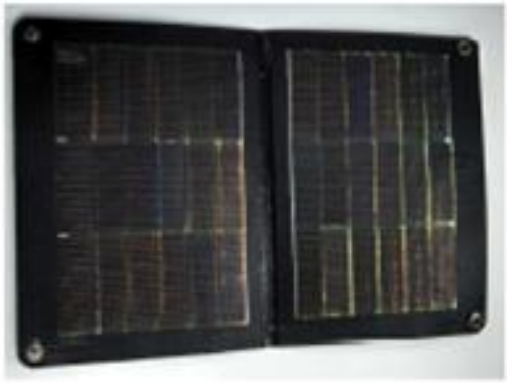


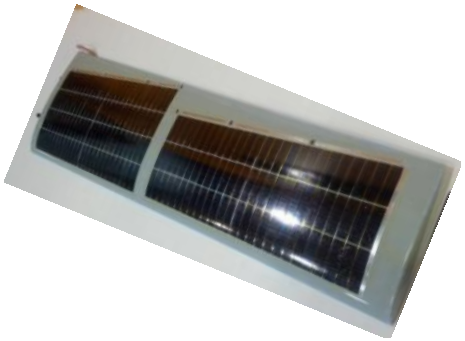
How Alta's Flexible Cells Are Formed



Mobile Power Applications

Remote Power



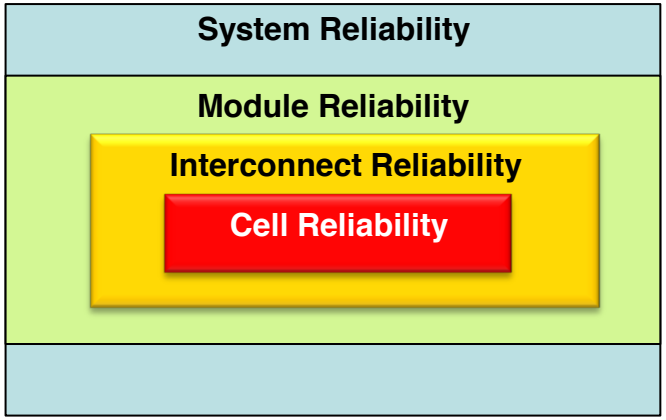


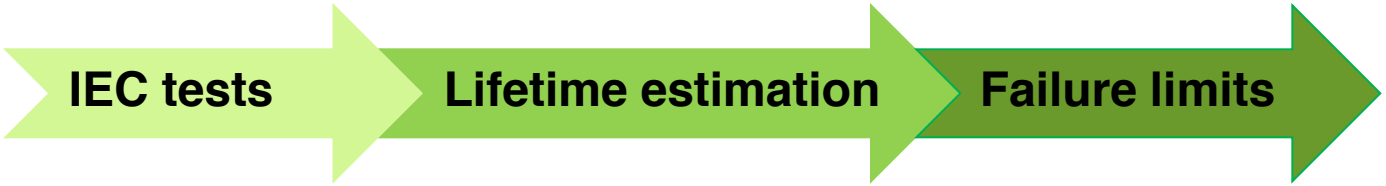
UAVs / Aerospace

Portable Electronics

Built-in Reliability Methodology

- In-depth reliability characterization, beyond certification & specs
  - Know when, where and why it fails
- Built-in reliability mindset
  - Reliability - integral part of development
  - Cell-level accelerated testing for fast feed-back





Reliability Tests

- Technology Reliability Characterization
  - Accelerated tests on bare solar cells (un-encapsulated)
  - IEC tests on glass mini-modules (150 cm^2)

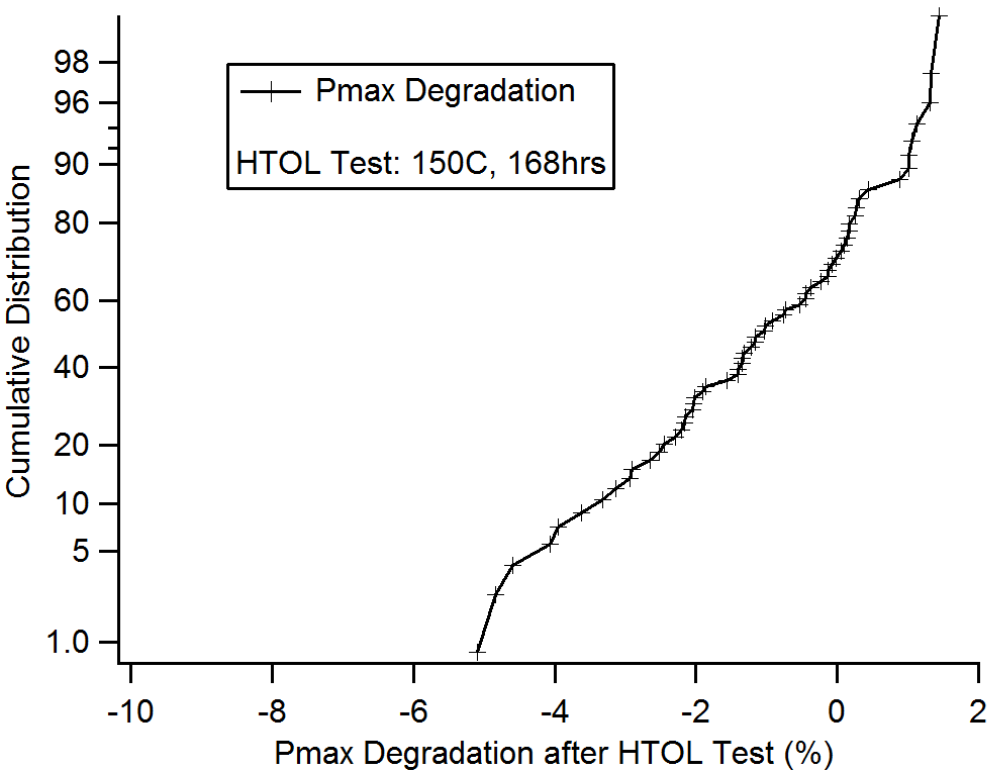
- Reliability Tests

Sample	HTOL	LTSL	Damp Heat	Thermal Cycling	Humidity Freeze
Cells	150C 168hrs	-60C 168hrs	85C/85%RH 168hrs	-40C/85C 200 cys	NA
Modules	110C 1000hrs	NA	IEC61646	IEC61646	IEC61646

- Failure Criterion
  - Pmax Degradation(%) = (Pmax@Tx-Pmax@T0)/Pmax@T0*100

Cell Level Reliability – High Temperature Test

- Cells tested @150C for 168hrs
- Pmax degradation < 6%



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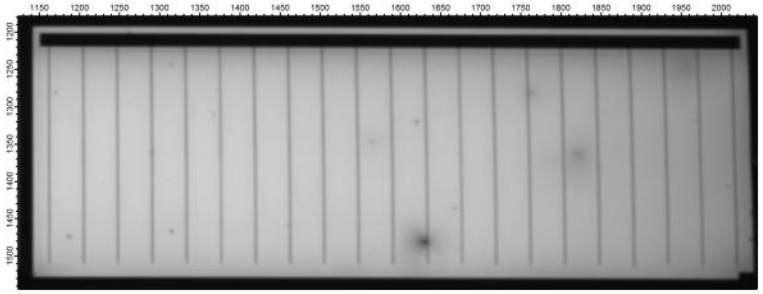
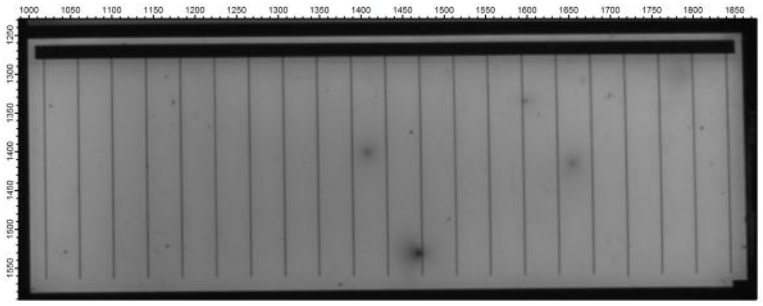
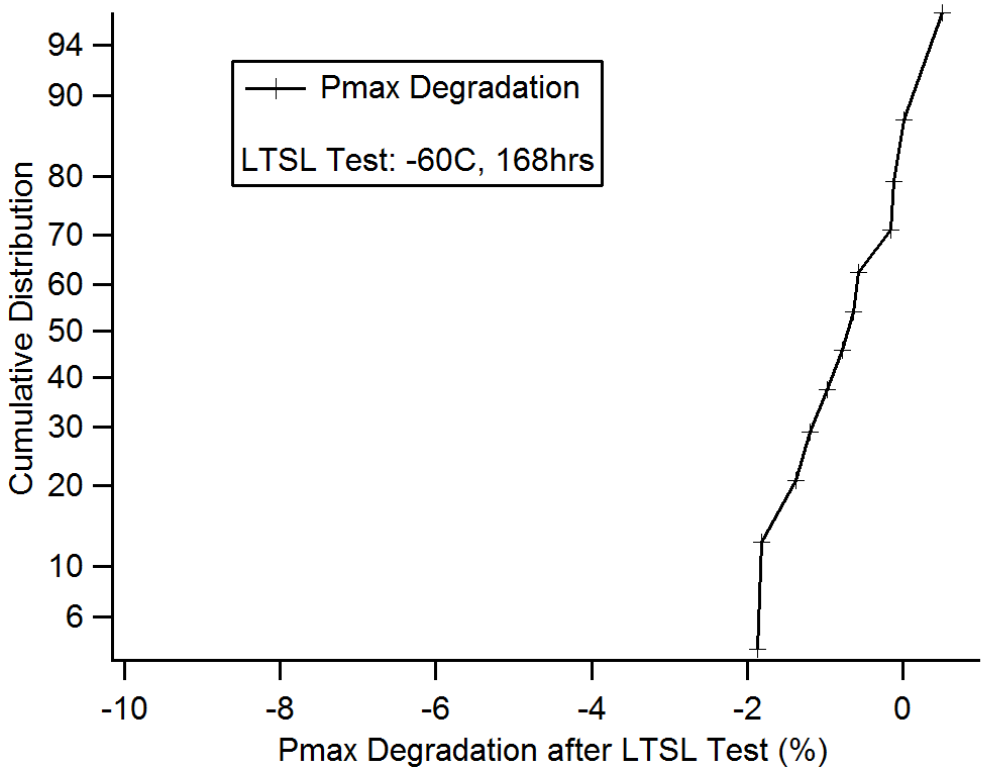


PL @168hrs



Cell Level Reliability – Low Temperature Test

- Cells tested @-60C for 168hrs
- Pmax degradation < 2%



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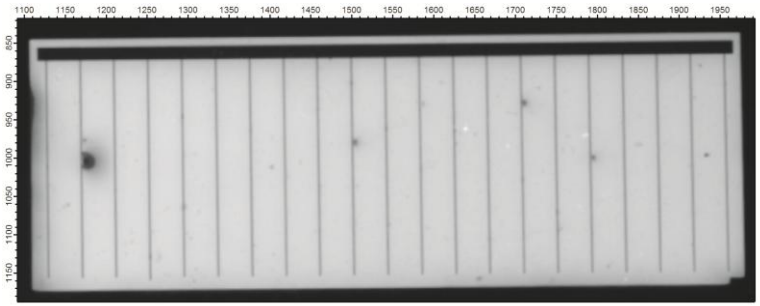
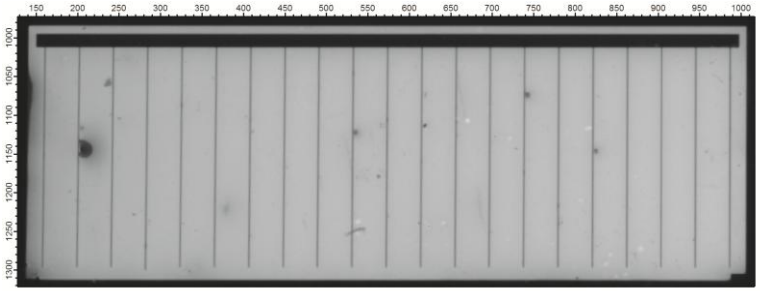
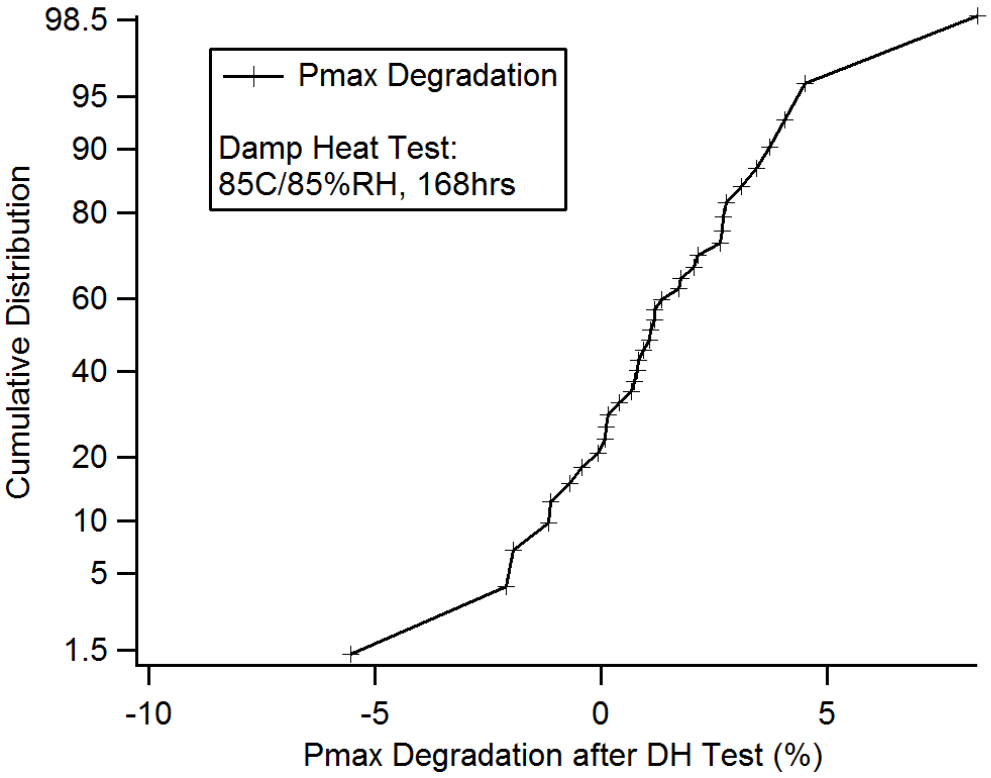


PL @168hrs



Cell Level Reliability - Damp Heat Test

- Cells tested @ 85C/85%RH for 168hrs
- Pmax degradation < 6%



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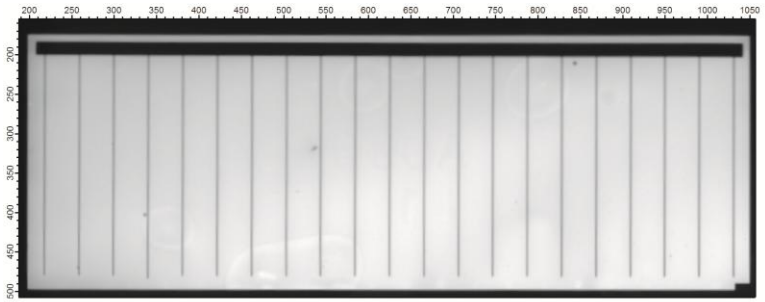
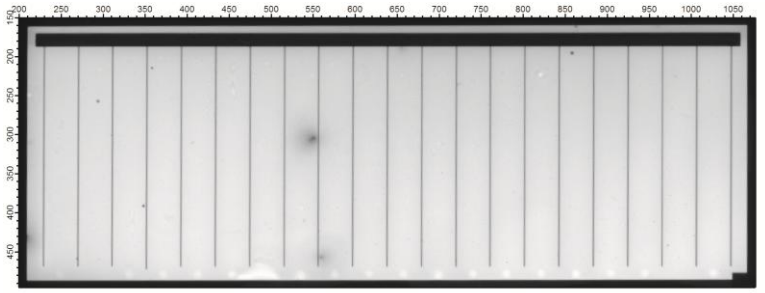
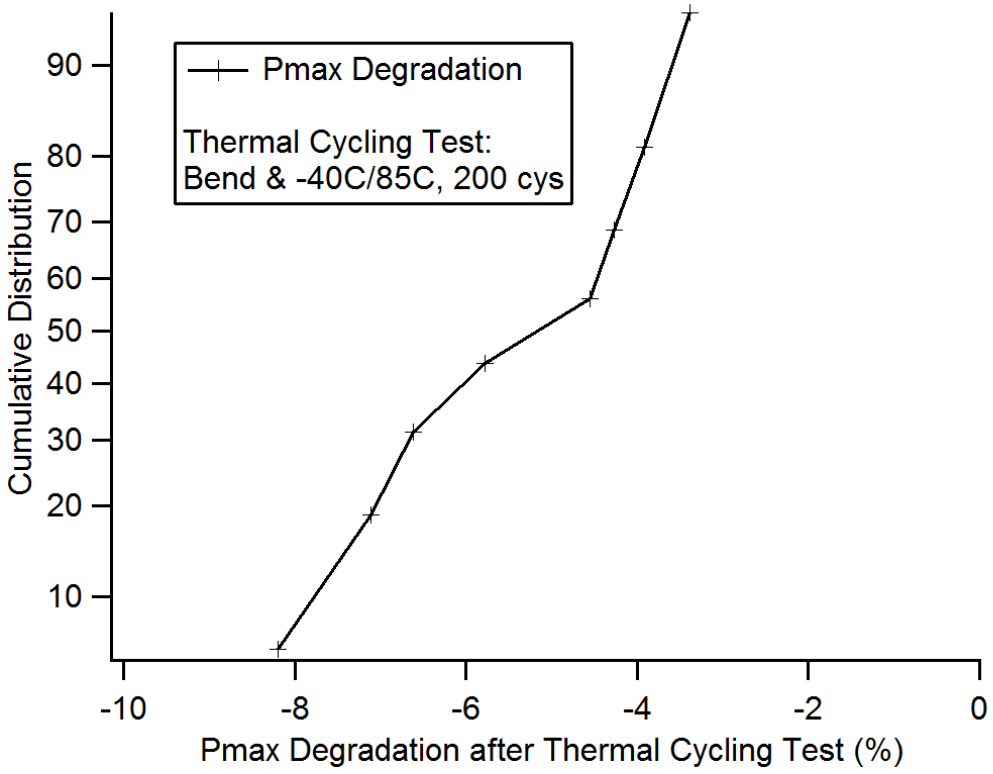


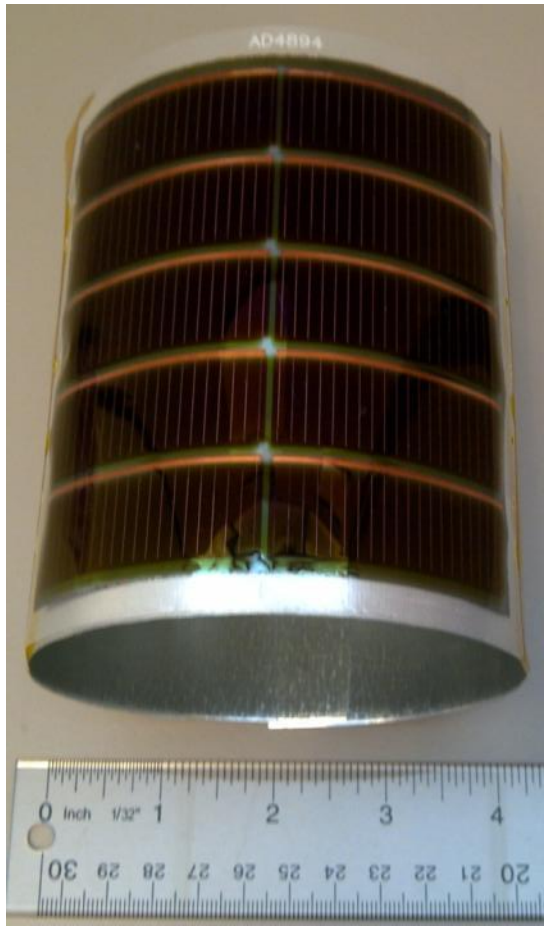
PL @168hrs



Cell Level Reliability - Thermal Cycling Test

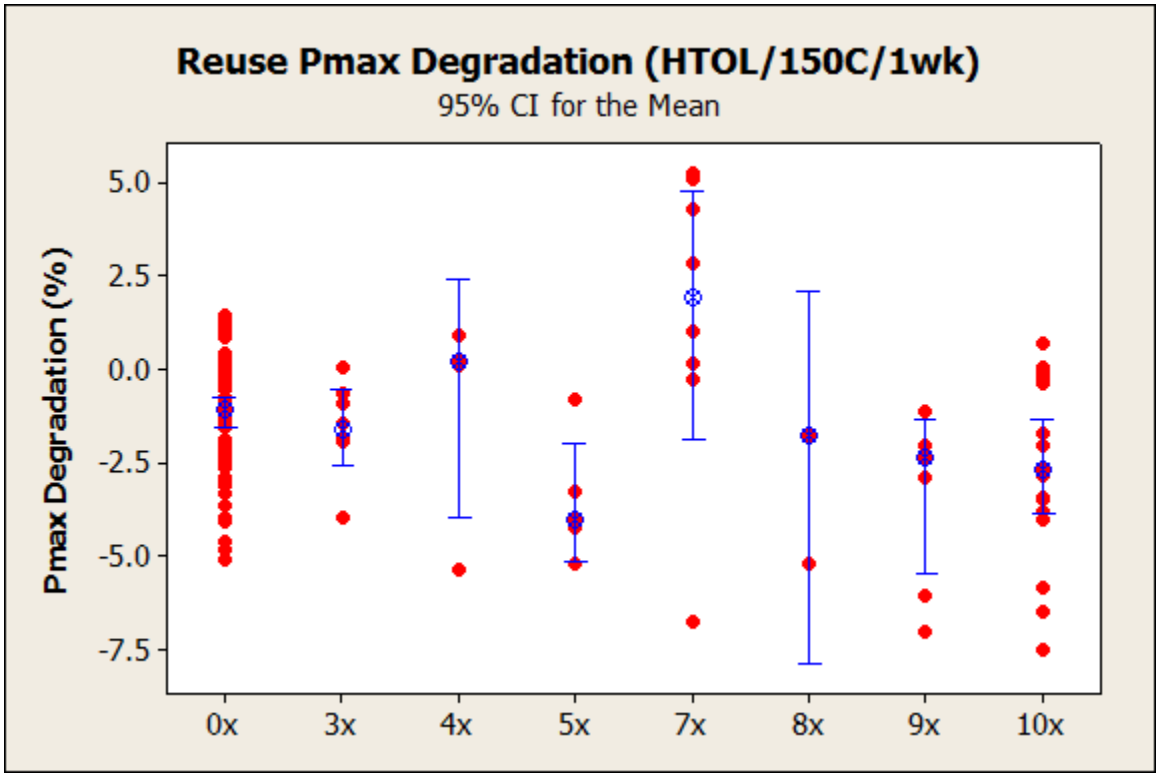
- Thermal cycling under 2” bend radius (-40C/85C, IEC profile, 200 cycles)
- Pmax degradation < 10%





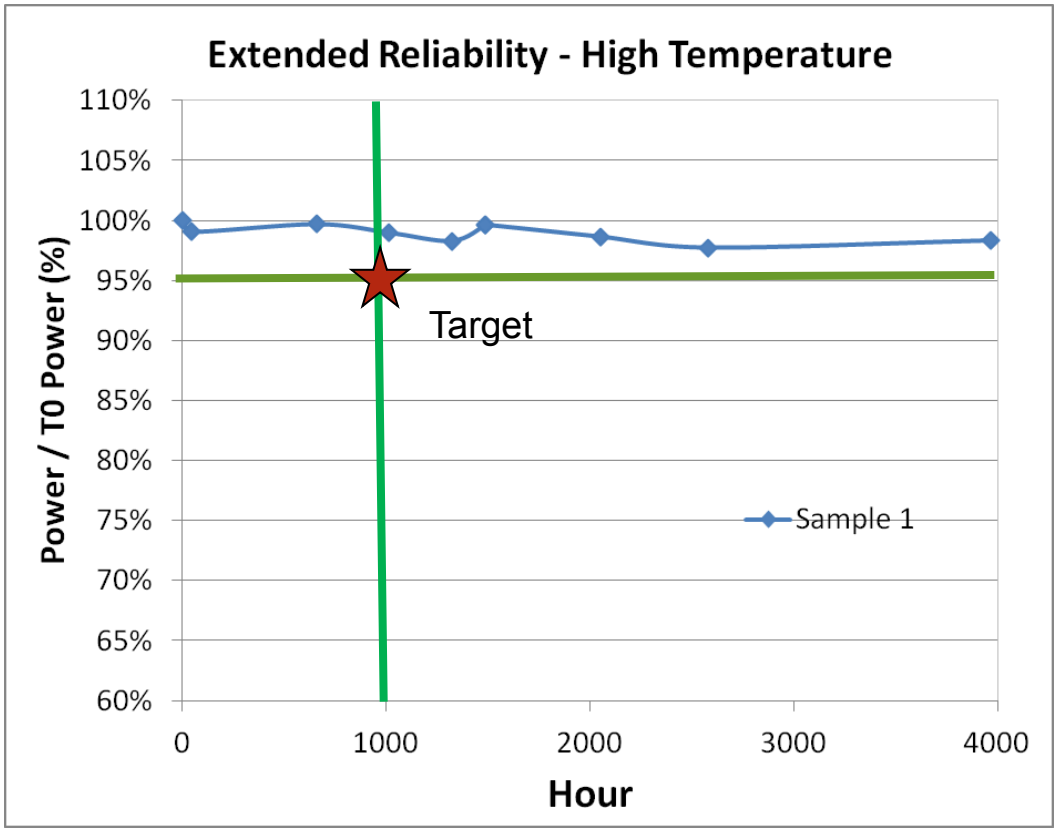
Reliability of Cells from Multiple Substrate Reuses

- Substrate reuse is one of the key process steps to lower cost for GaAs thin-film solar technology
- Cells tested @150C for 168hrs
- No intrinsic degradation mechanism was found on material up to 10-time substrate reuse



Module Level Reliability – High Temperature Test

- Module tested @110C, 1000hrs
- Pmax degradation < 5%



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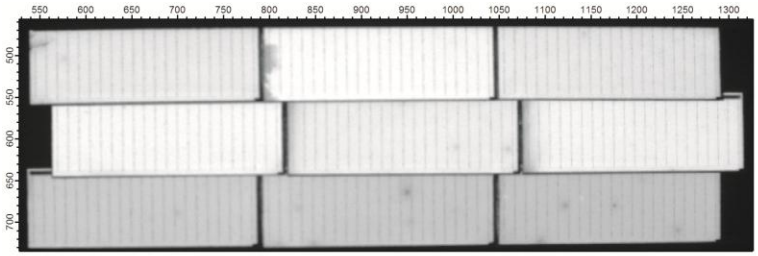
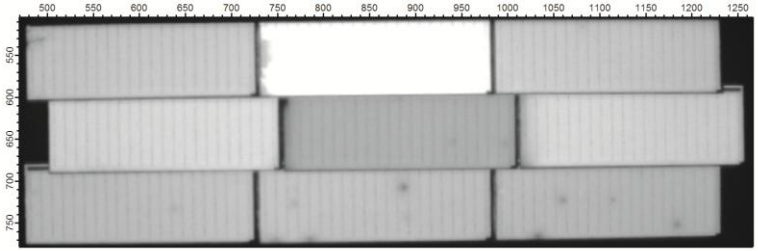
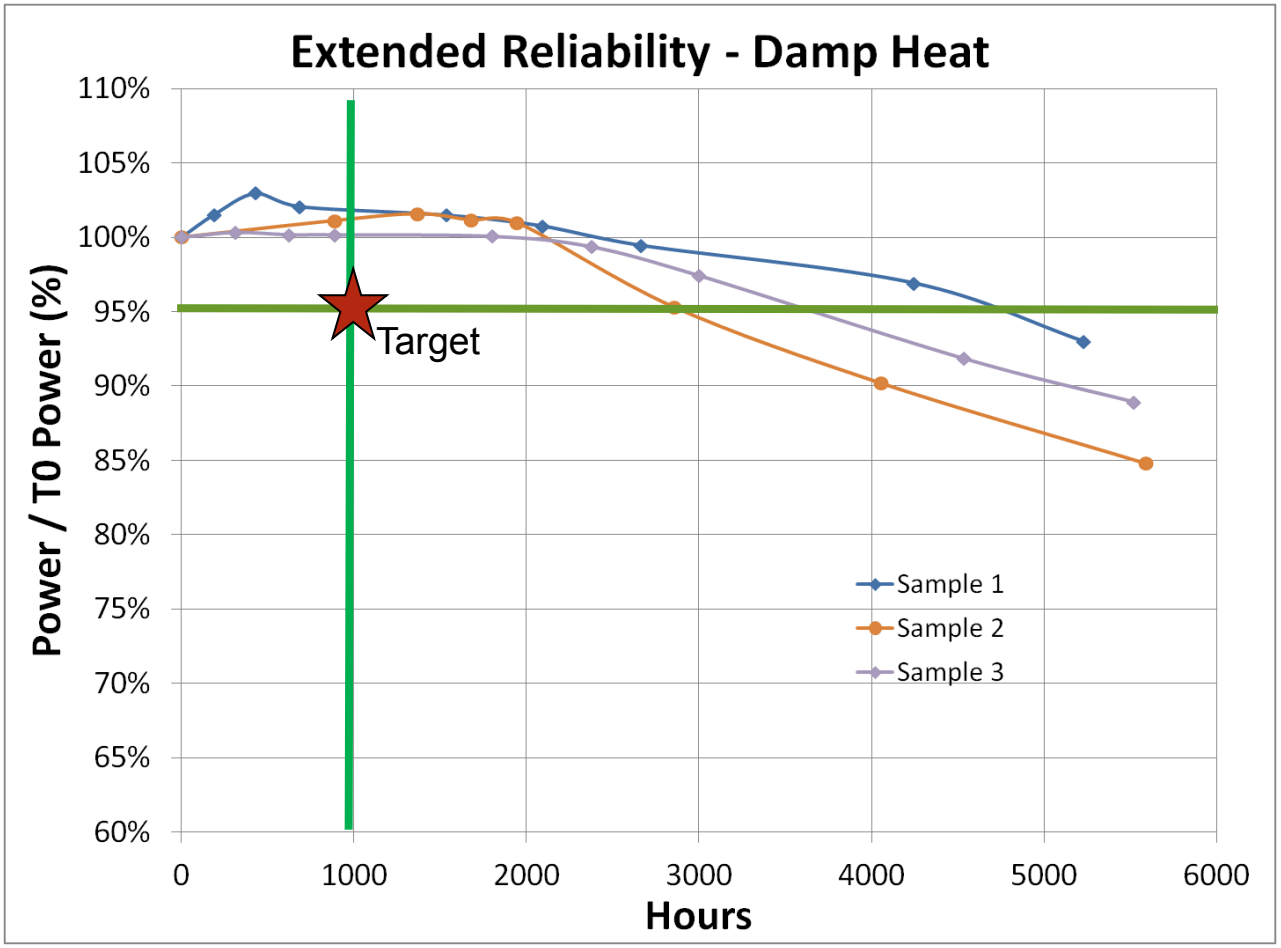


PL @4000hrs



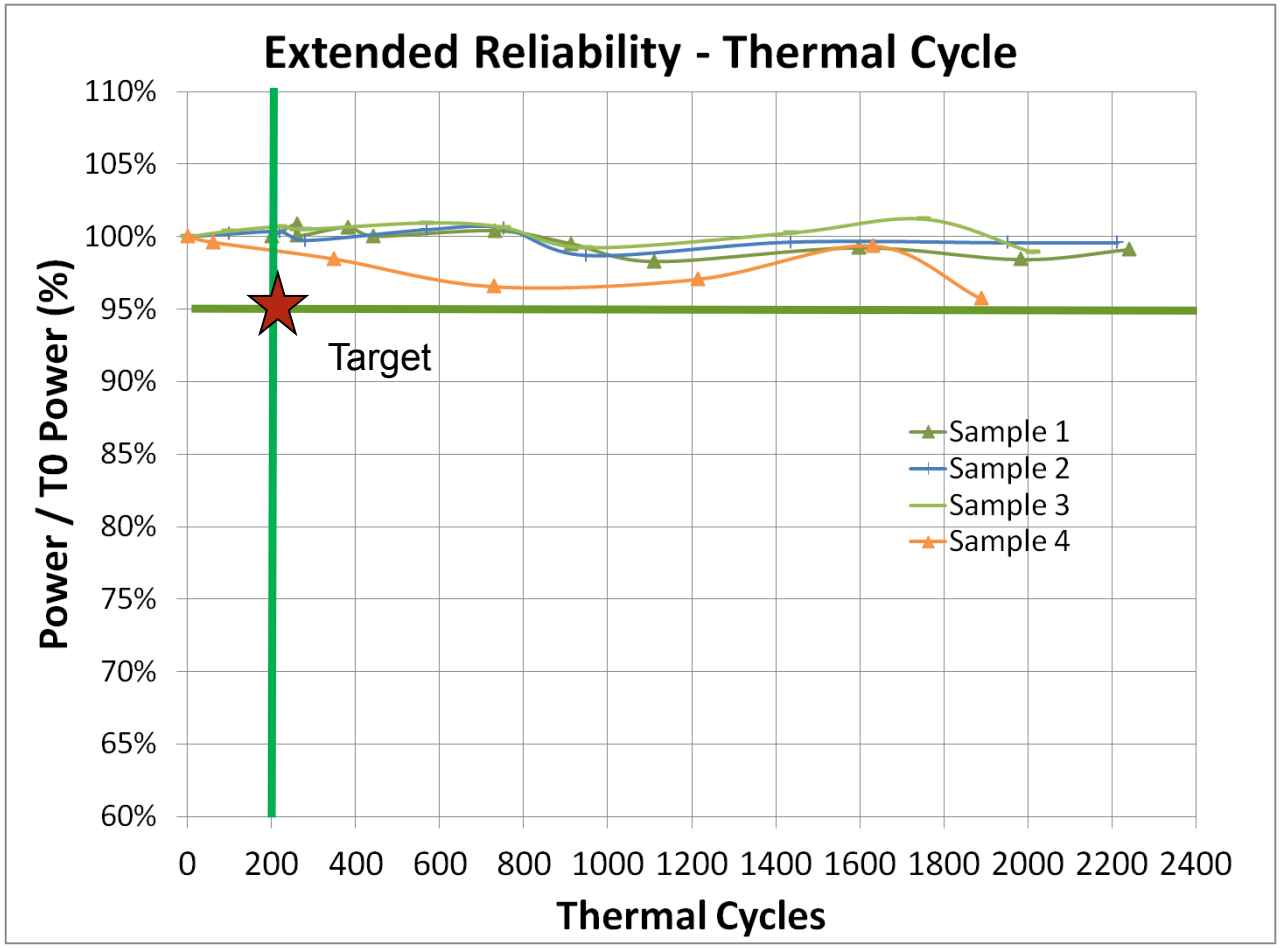
Module Level Reliability – Damp Heat Test

- Pmax degradation < 5% at 1000hrs
- Results exceed IEC test requirements



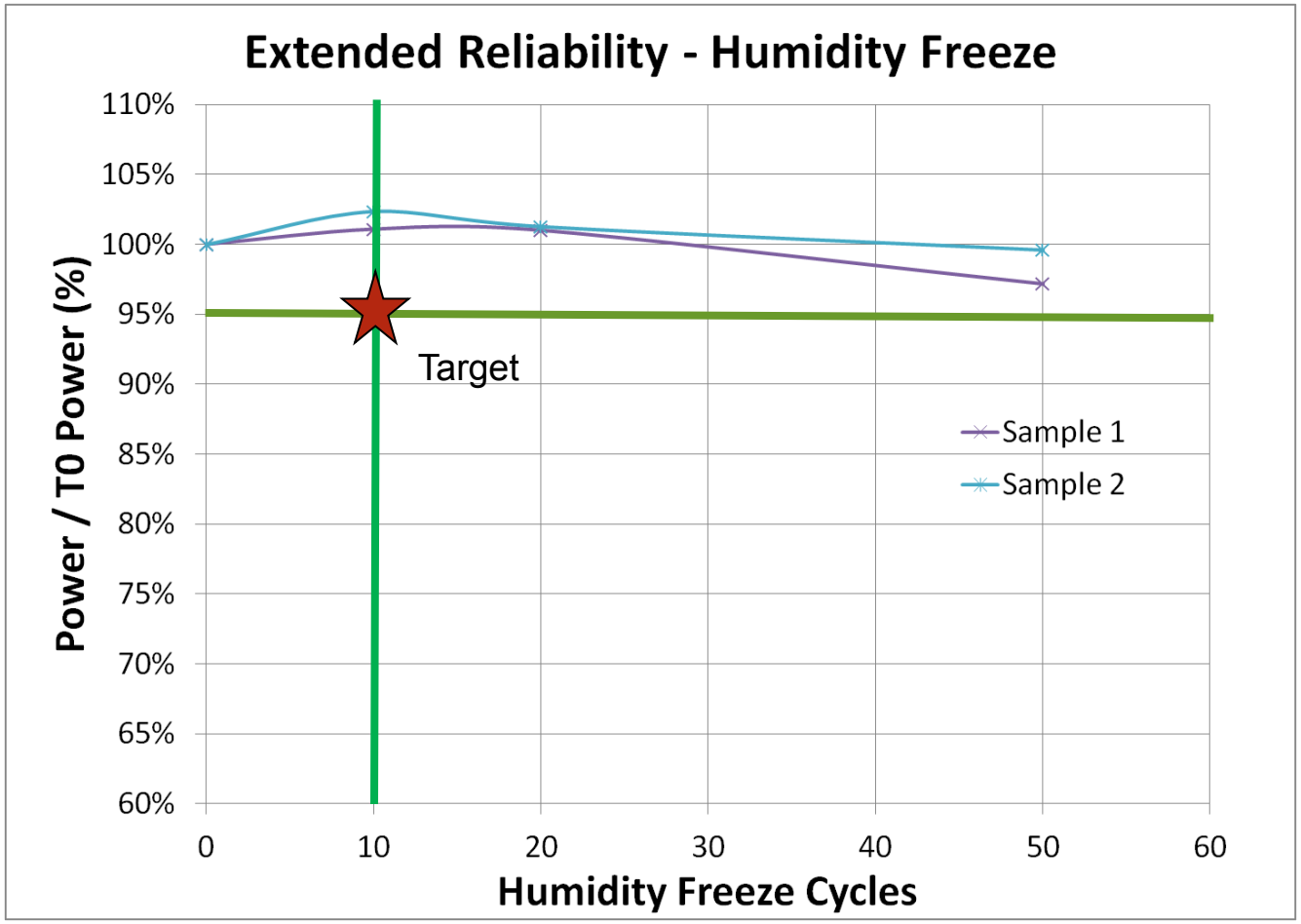
Module Level Reliability – Thermal Cycling Test

- Pmax degradation < 5% at 200cys
- Results exceed IEC test requirements



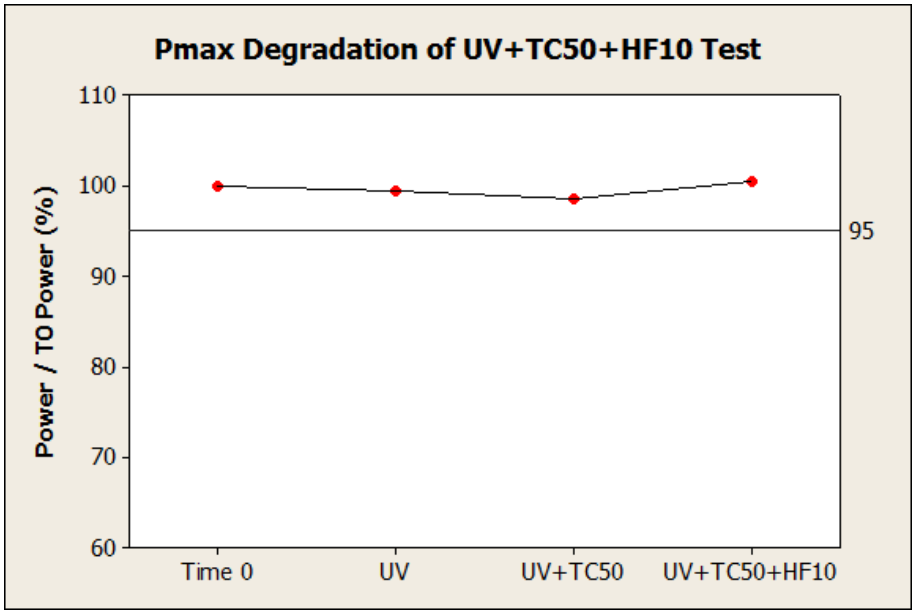
Module Level Reliability – Humidity Freeze Test

- Pmax degradation < 5% at 10cys
- Results exceed IEC test requirements



Module Level Reliability – UV + TC + HF

- Pmax degradation < 5%
- Modules passed UV sequence test
  - UV (15kWh/m^2)
  - TC50
  - HF10



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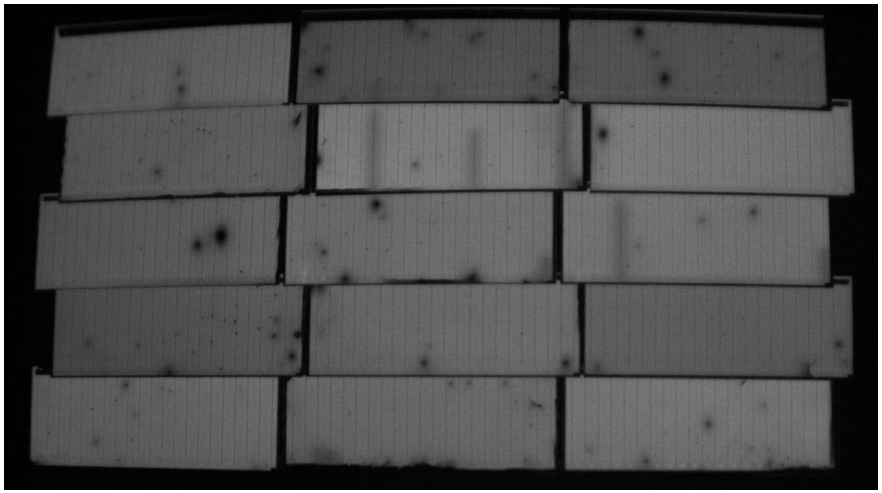
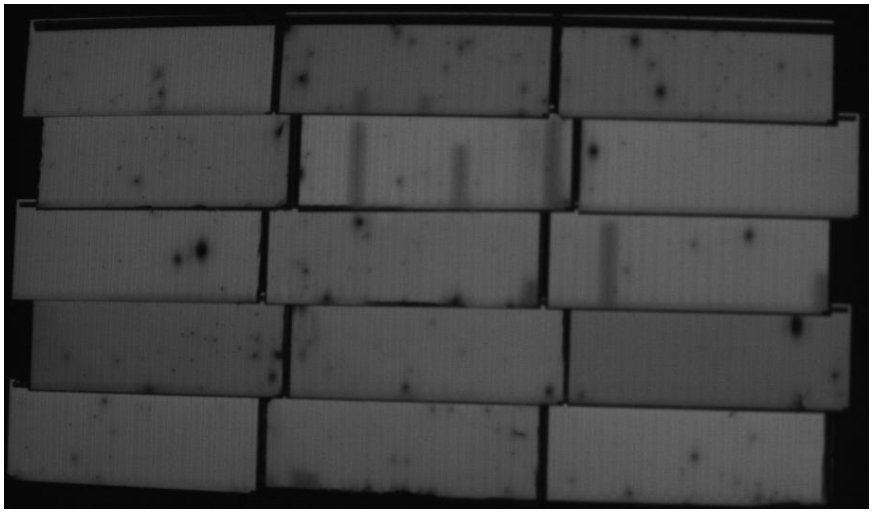


EL @UV+TC50+HF10



Conclusion

- Thin-film solar cells from GaAs reuse substrate show no intrinsic degradation after reliability tests

- Broad range of cell-level and module-level reliability tests demonstrate that Alta Devices GaAs thin-film solar technology from Epitaxial Lift-off (ELO) process exceeds lifetime requirements for PV applications

Acknowledgement

- Thanks to Chris Ling, Sharon Myers and Chris France for support

- Thanks to the Device/EPI/Process/Integration/Matrix team to provide materials for this reliability study