Thin Film PID Field Failures and Root Cause Determination

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Outline

- Field Data
- Laboratory measurements on return modules
- Degradation model
- Verification
- Acceleration factors
- Manufacturing excursions
- Fixing the problem

Field

- Location: Germany
- Size: 3 MW
- Inverter: Transformer less
- Voltage: 1000 V
- Grounding: Ungrounded
- Modules: Thin Film (CdTe)

- Issue: Substantial under performance after 1 year of operation

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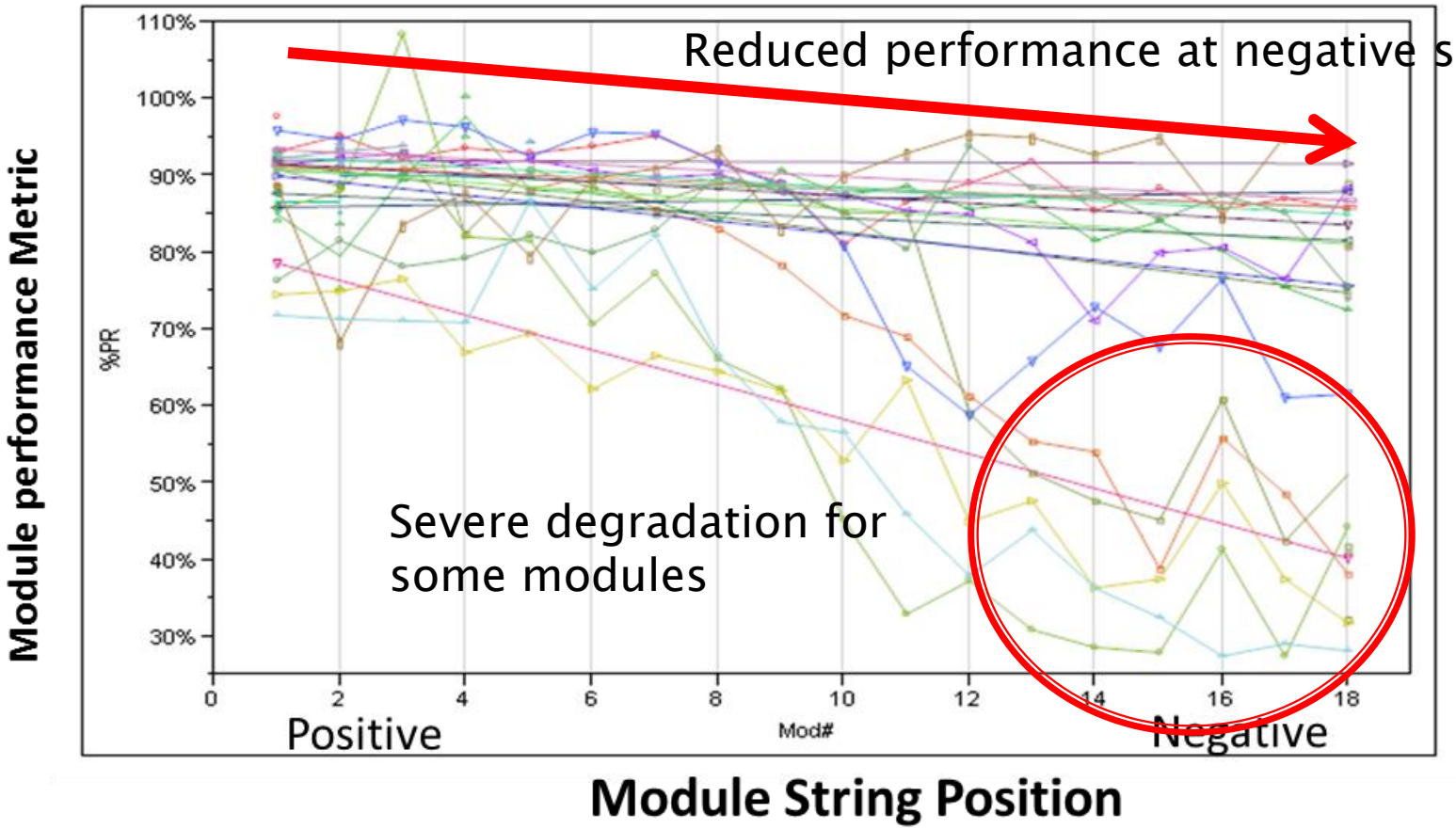
Field Measurements



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Return Module I-V

Severe degradation in Rsh is the issue

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Additional tests on return modules

- HiPot: pass
- H_20 ingress: none
- Delam inspection: none

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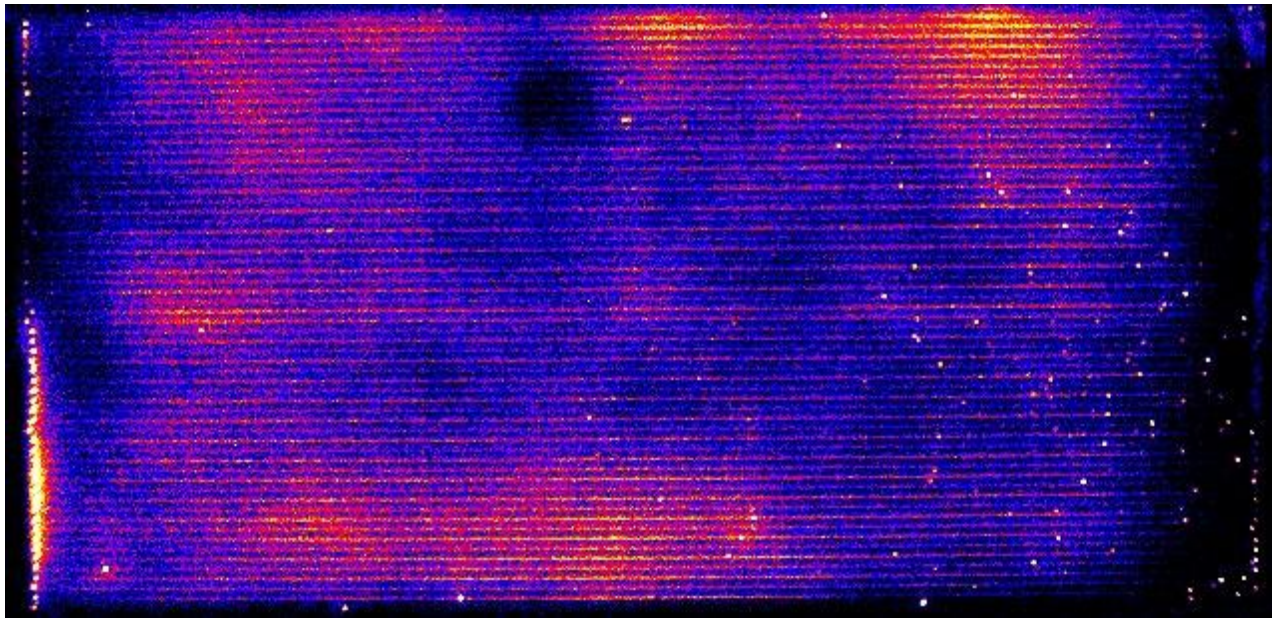
Lock-In thermography

Pinpointing the location of shunts



Severe scribe shunts in degraded module

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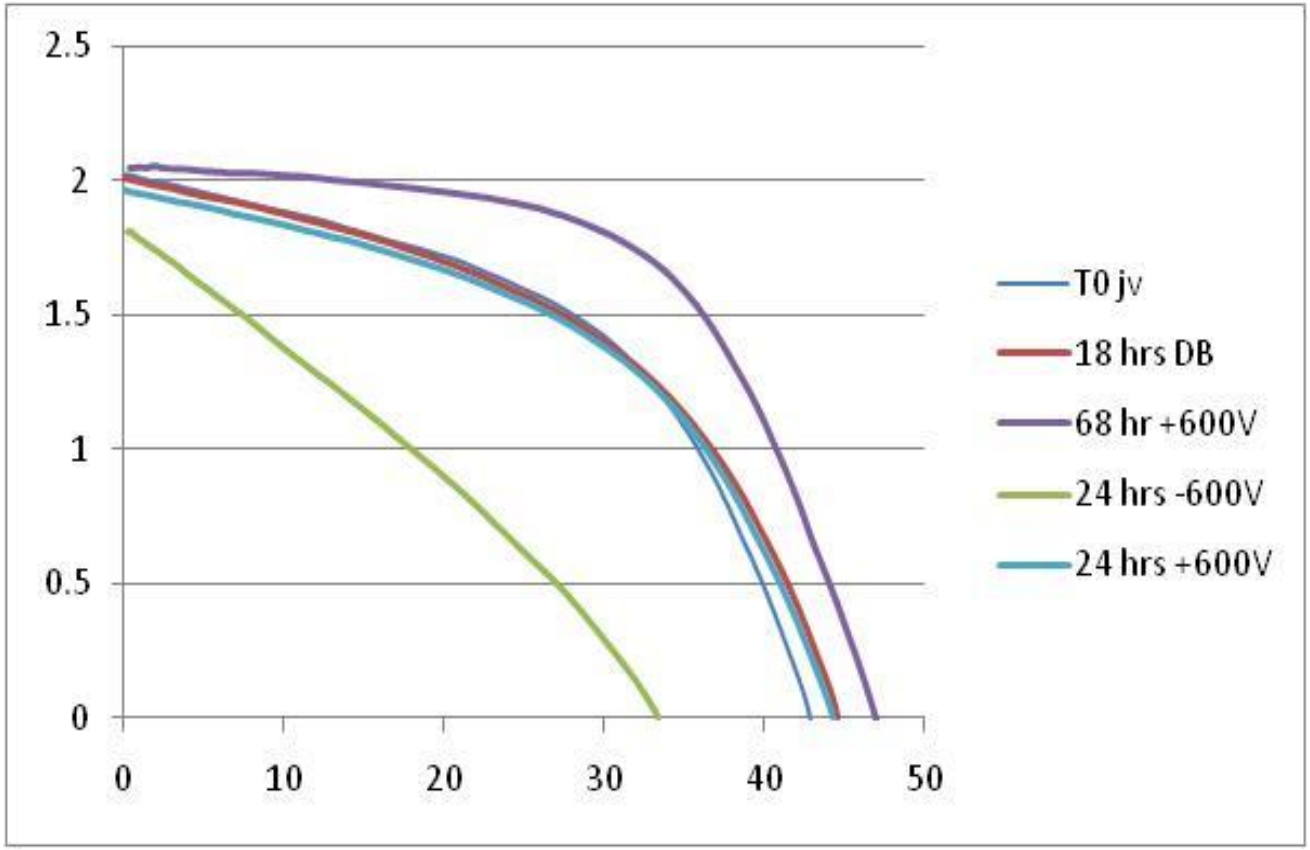
Reversibility of damage



Main degradation is in Rsh and it is a reversible PID type

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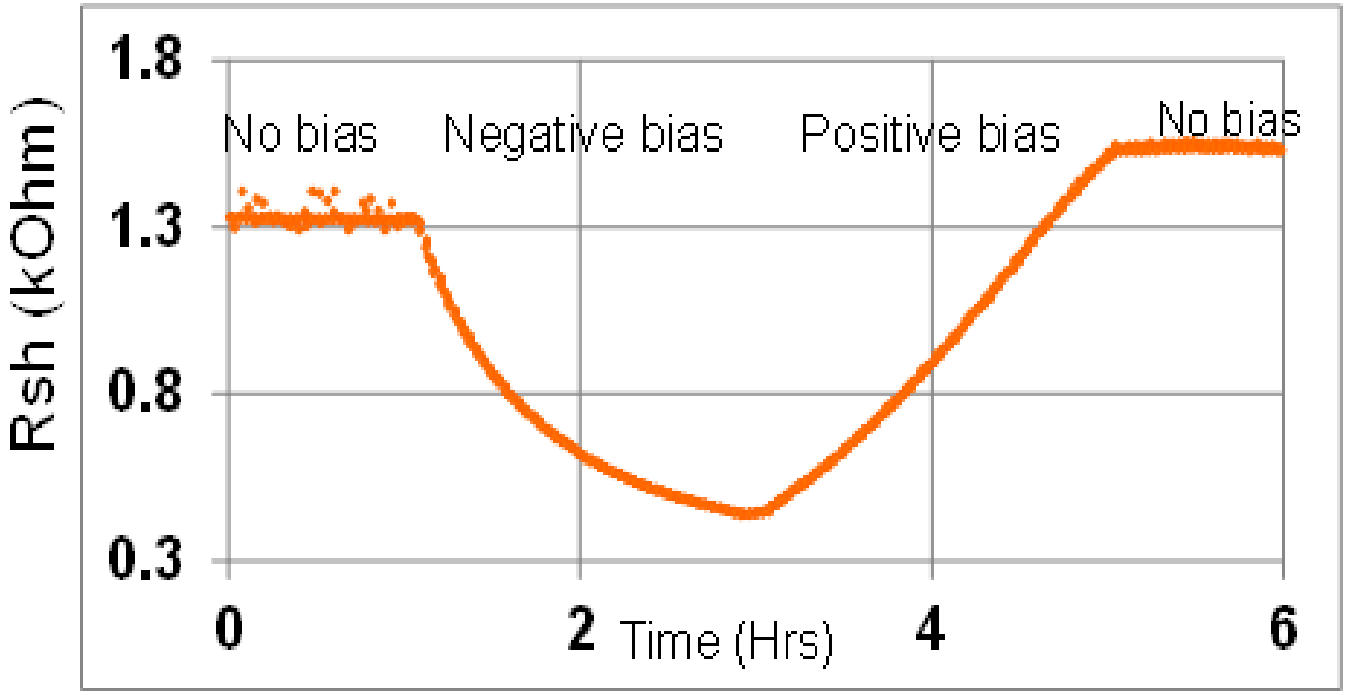
Laboratory PID test on “virgin” modules



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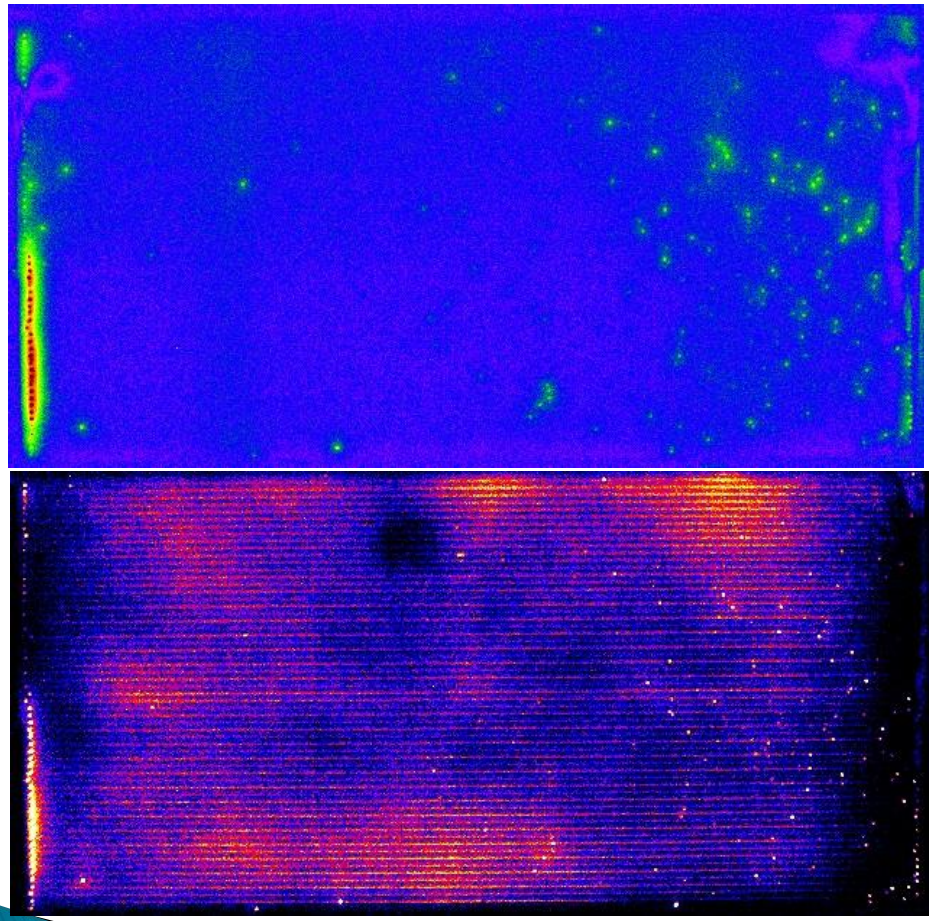
Lock-in thermography of healed module



After positive bias healing

Before

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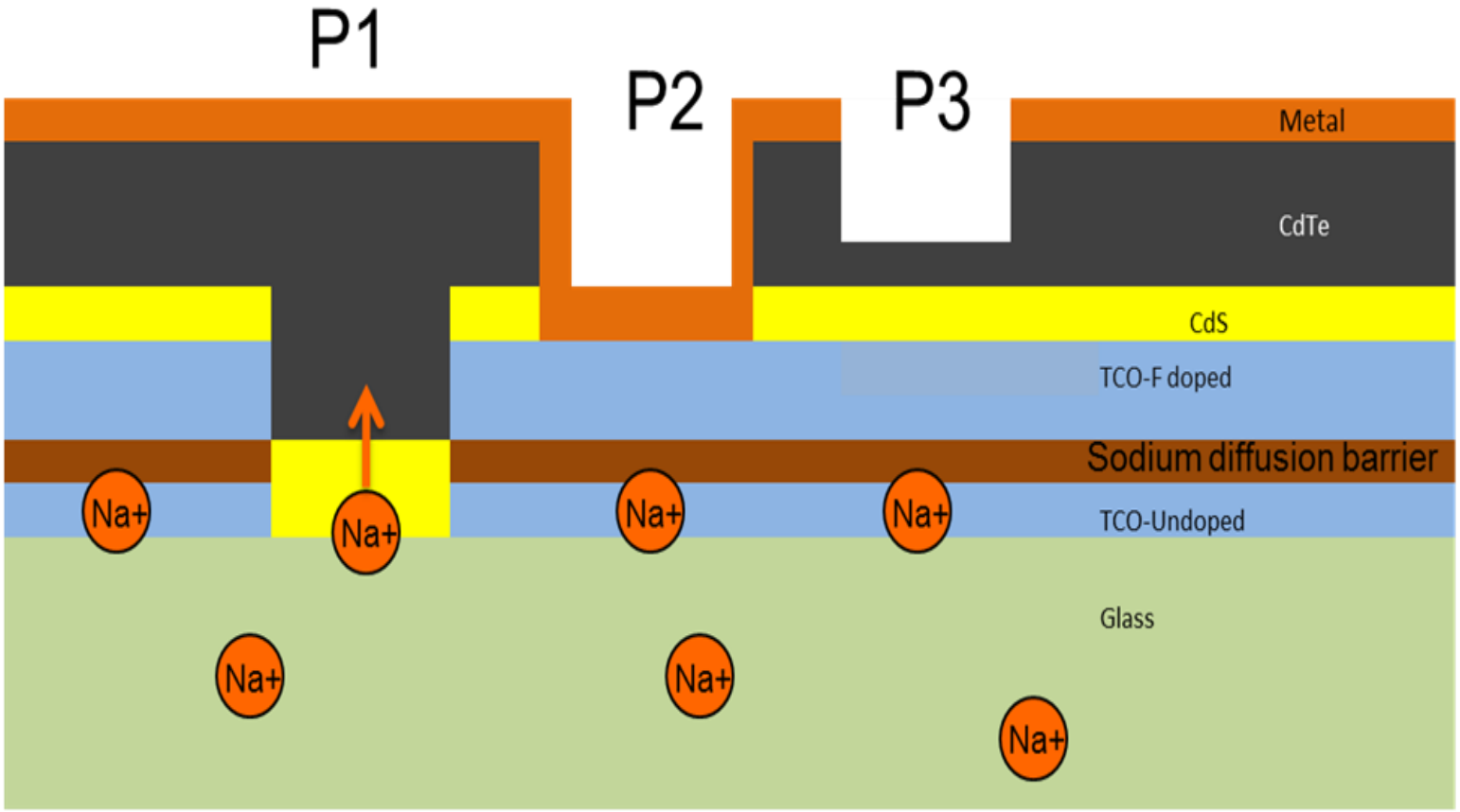
Degradation Model



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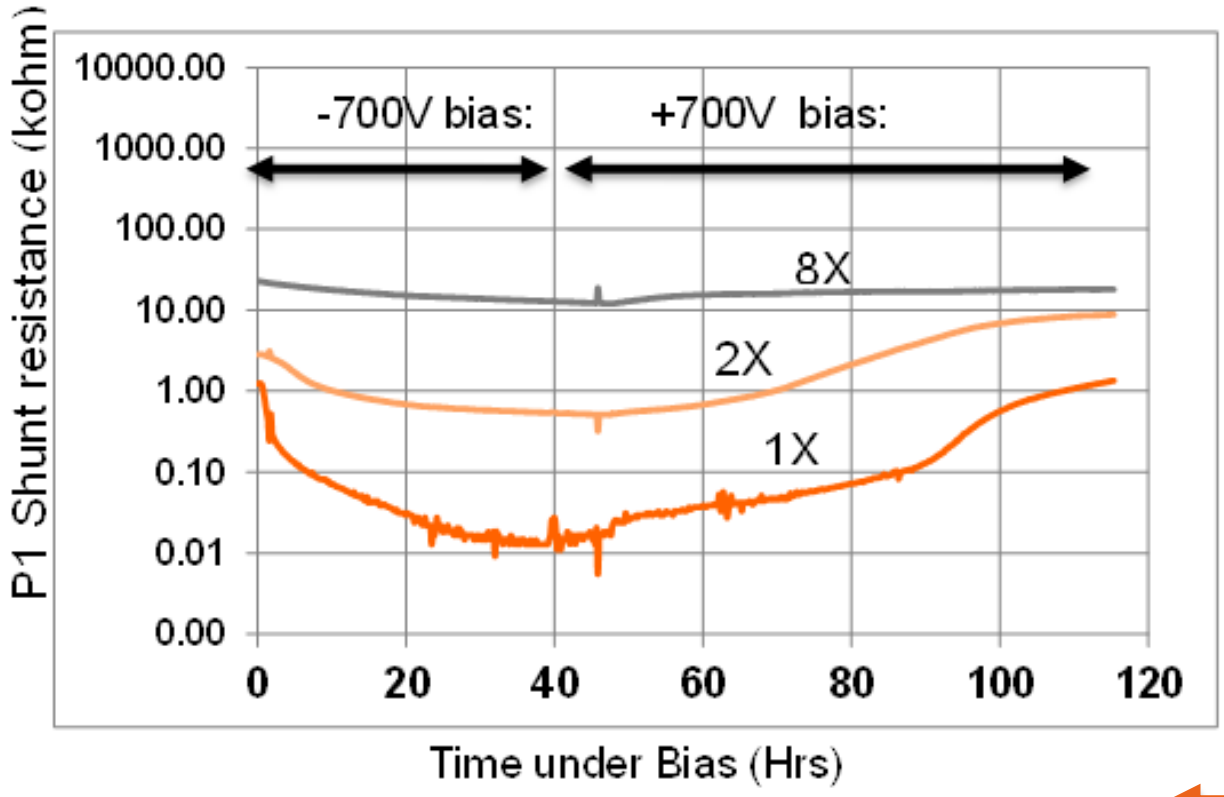
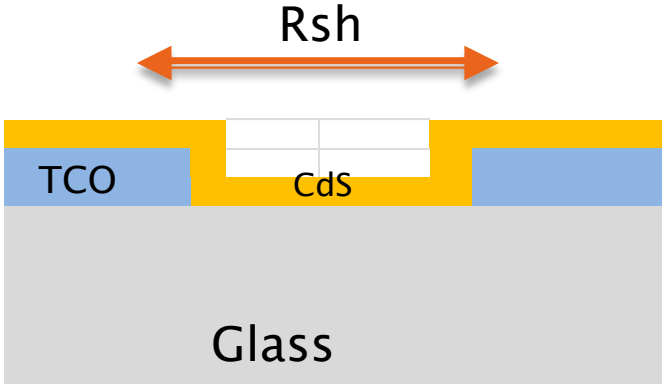
Verification experiments





Acceleration Factors

Time for P1 shunt resistance to drop 50%

	No Bias	-750V
41C	?	~20 hrs
57C	40 hrs	3.5 hrs
77C	8 hrs	0.5 hrs

Both temperature and voltage are strong drivers

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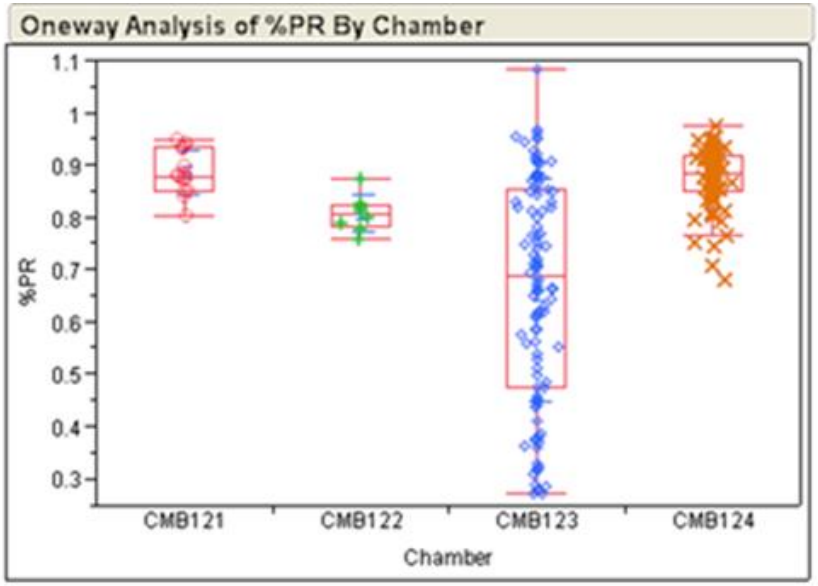
Severely Degraded Modules:
manufacturing excursions

All the severely degraded modules came from only one of 4 production chambers and only from a specific time period.

Root cause:
Broken glass on top of heater coils in the deposition chamber: Excellent source of sodium.



Missing Rows 31
Excluded Rows 59

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
CMB121	14	0.887643	0.043081	0.01151	0.86277	0.91252
CMB122	8	0.810250	0.034997	0.01237	0.78099	0.83951
CMB123	105	0.662857	0.212916	0.02078	0.62165	0.70406
CMB124	79	0.876544	0.056592	0.00637	0.86387	0.88922

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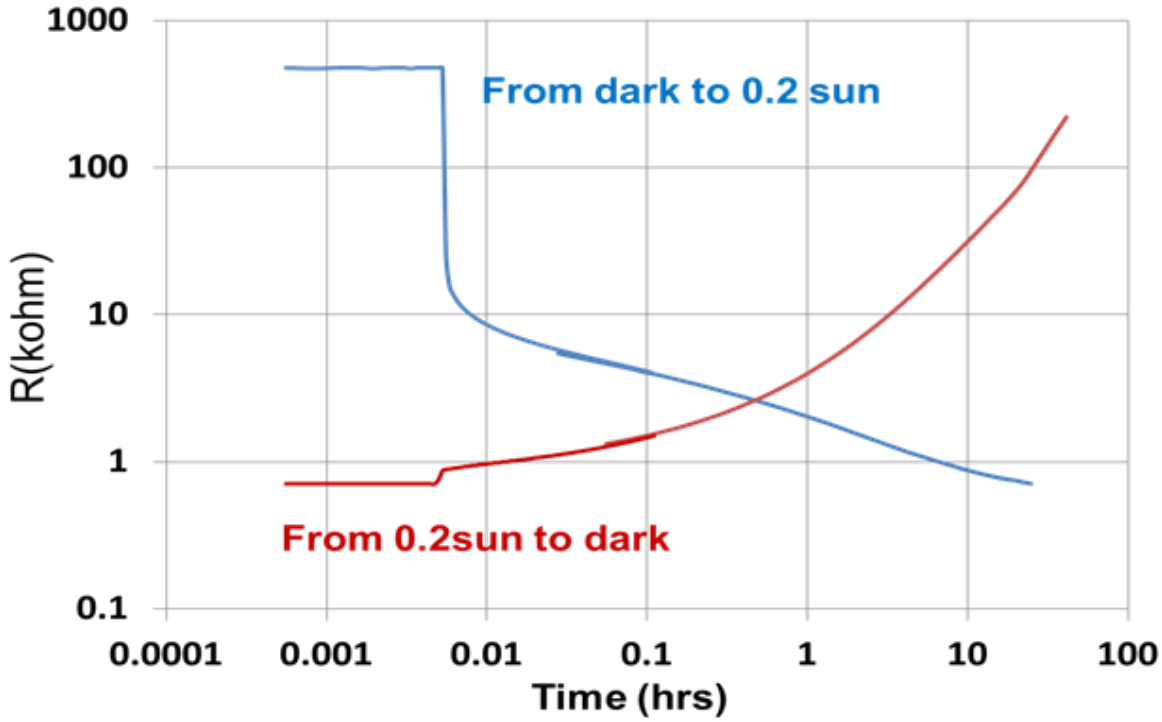
Photoconductivity in CdS



CdS photoconductivity is very dynamic and may take many Hrs to fully develop

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Conclusions

- We have characterized a new type of reversible PID caused by field assisted diffusion of mobile ions into the P1 scribe lines in thin film modules.

It is a bad idea to leave semiconductor material in the P1 scribe.

- Corrective Action
  - Switch P1 scribe and semi deposition process order
  - Backfill P1 with inert material

Thank You

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