  

POWERHOUSE™ Dow SOLAR

Development of reliable interconnect systems for photovoltaic modules

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Outline

Introduction

Problem statement

- Power degradation in reliability testing

Solution Approach

- Isolating the problem
- Understanding physics of failure
- Component level testing for process development
- Applying solution and validating improvements

Conclusions

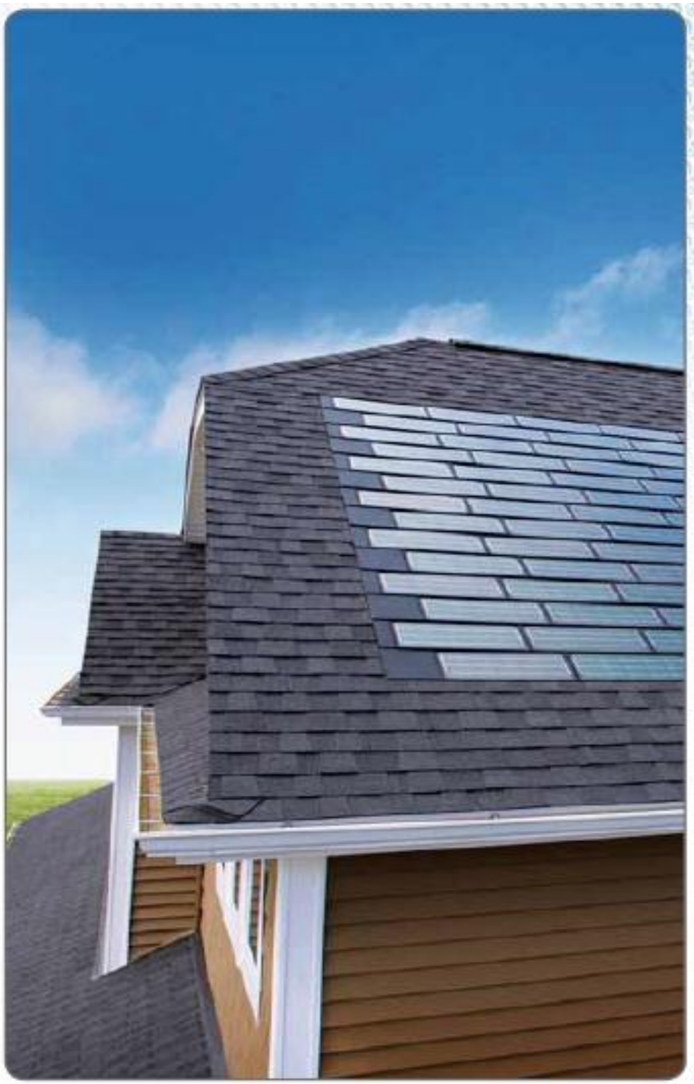
Introduction

Dow POWERHOUSE™ shingle – Reinventing the roof with unique BIPV product

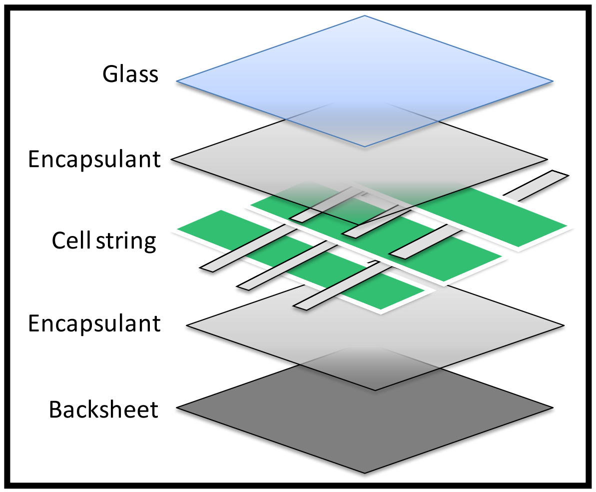
Safe, Durable and Reliable

Ease of Installation, aesthetically appealing

Empowering home owners with clean energy



Interaction between design and reliability performance

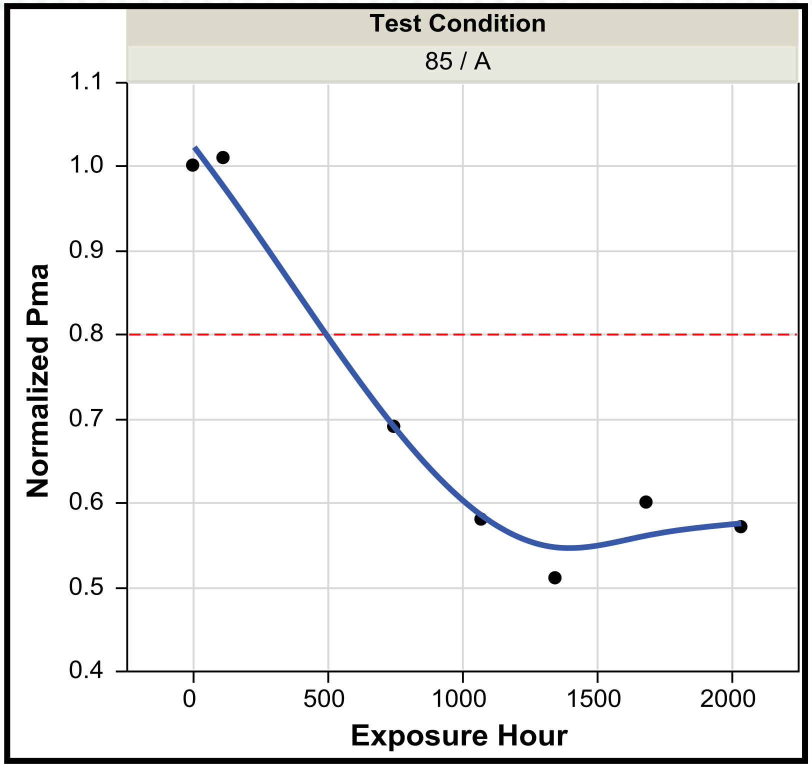


Design Considerations

Environmental Chambers
-Thermal Cycling
-Damp Heat
-Dry Heat etc.

Reliability Testing

Observed power degradation driven by Rs increase



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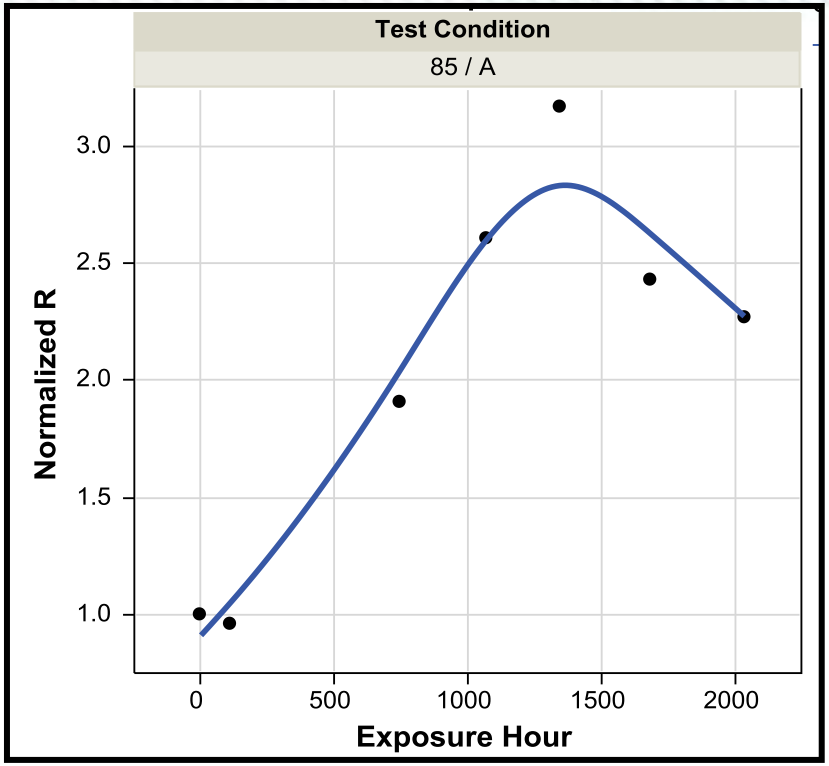
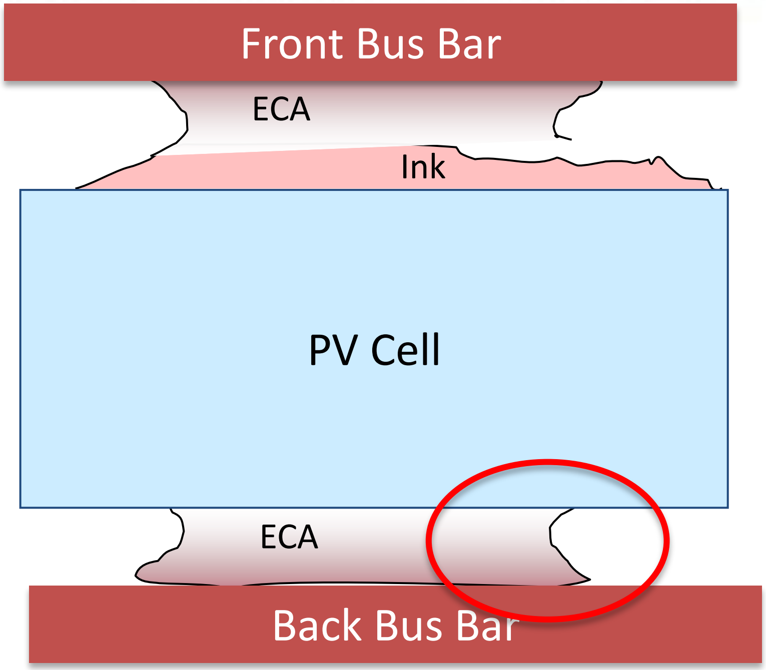


Location of Rs increase necessary to understand the problem

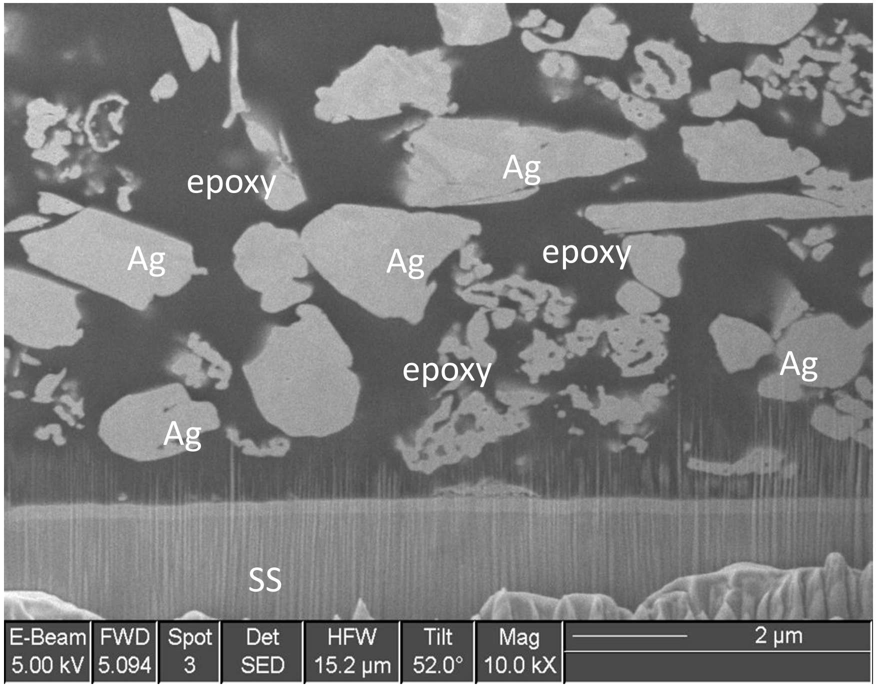
Several failure modes can contribute to Rs increase

- **Cell**
  - Junction
  - TCO
- **Interconnect**
  - ECA
  - Ink
- **Interfaces**
  - Front Bus – ECA
  - ECA – Ink
  - Ink – TCO
  - Within Cell
  - Cell back – ECA
  - ECA – Back Bus

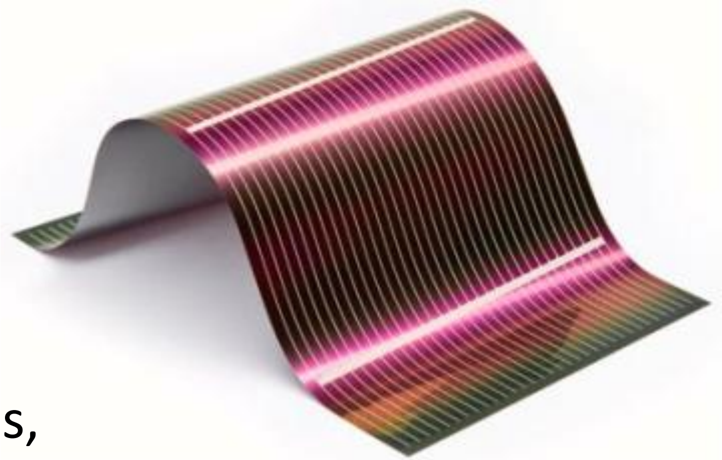


Component level testing helped identify back contact degradation as root cause

Electrically Conductive Adhesive (ECA)



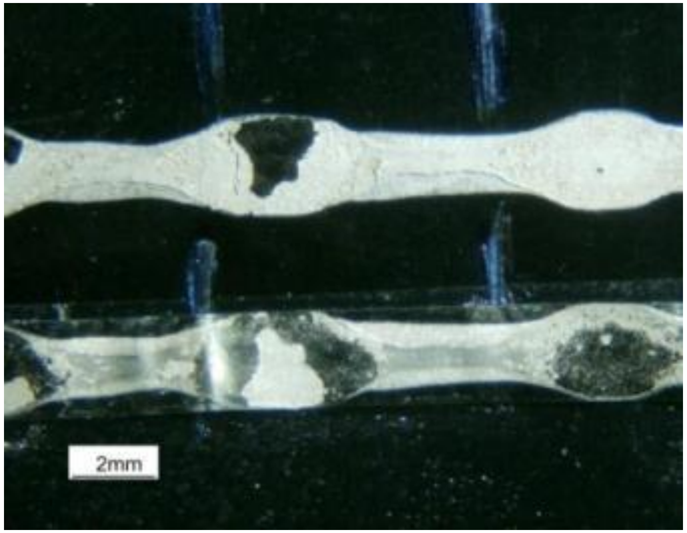
- Epoxy resin with more than 70 wt% silver flakes
- Provides mechanical bonding and conductive path
- Properties readily tailored



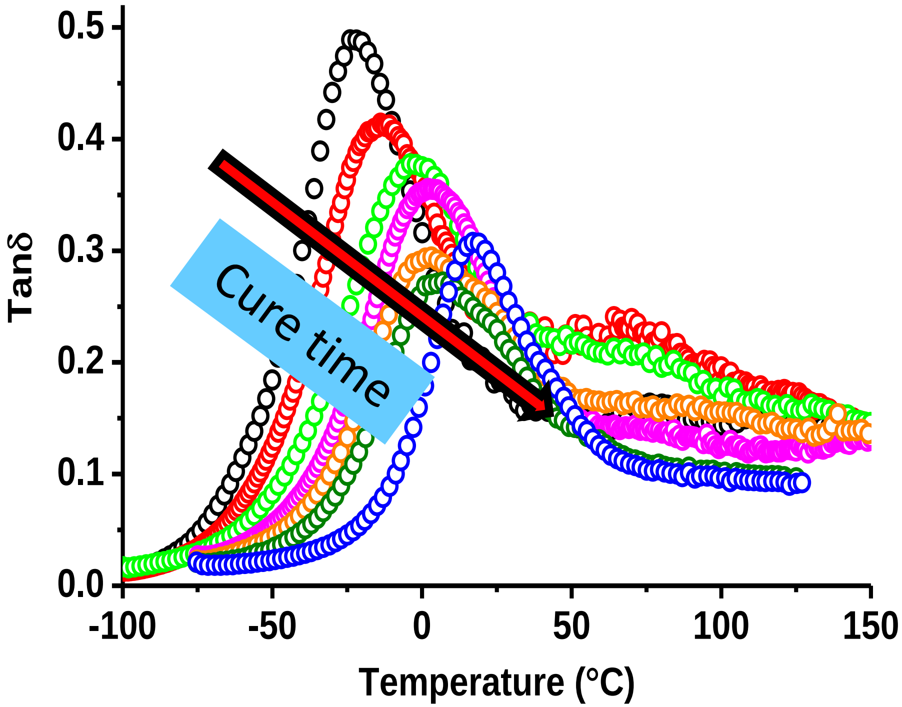
ECA selection considerations: product and process attributes, such as substrate surfaces, curing conditions, stresses, reliability, ease of dispense…

Used multi-pronged approach for issue resolution

- **Material Properties**
  - ECA selection
  - Surface treatment
- **Process Parameters**
  - ECA coverage
  - ECA cure
  - Bondline thickness
- **Performance Measurement**
  - Power & resistance measurement
  - Failure Analysis
  - Mechanical Testing
  - Environment aging



Established technique for *in situ* cure estimation



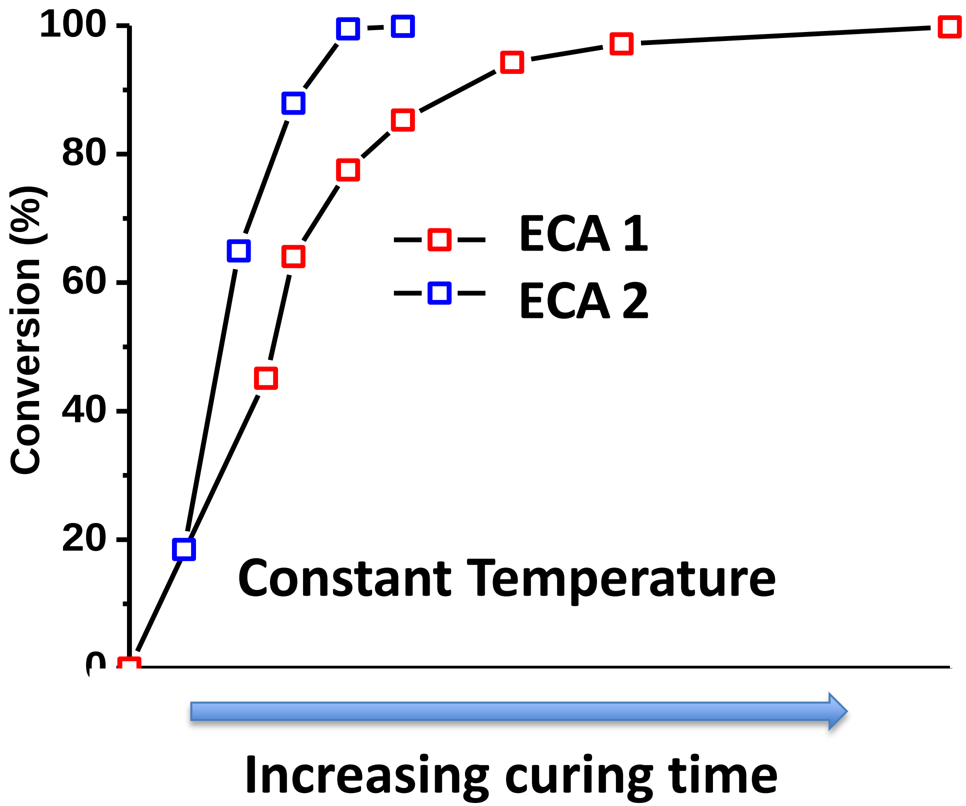
Torsional Dynamic Mechanical Analysis

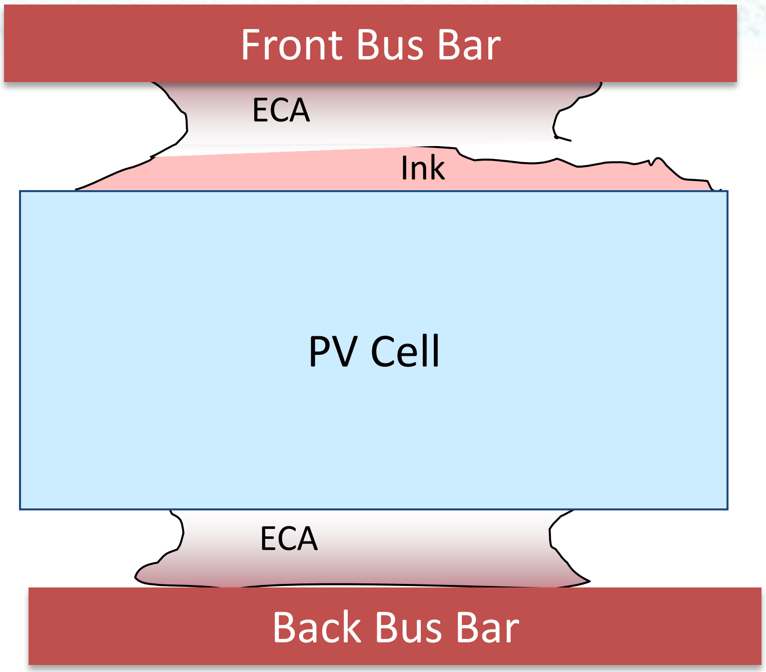
Developed DMA based techniques to understand evolution of ECA curing vs. process conditions

"Glass transition temperature as an *in situ* cure index of electrically conductive adhesives in solar photovoltaic module interconnect assemblies", Dakai Ren et al., Solar Energy Materials & Solar Cells 107 (2012) 403 - 406

ECA can be optimized differently for top / bottom

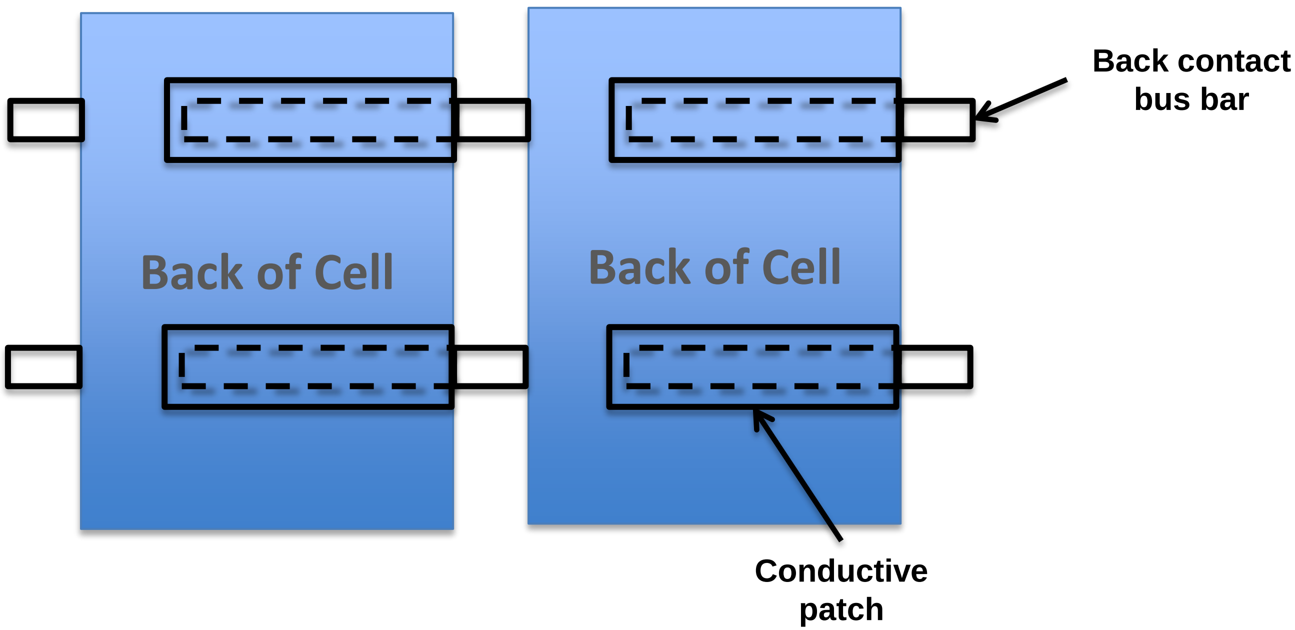
Need to optimize cure conditions





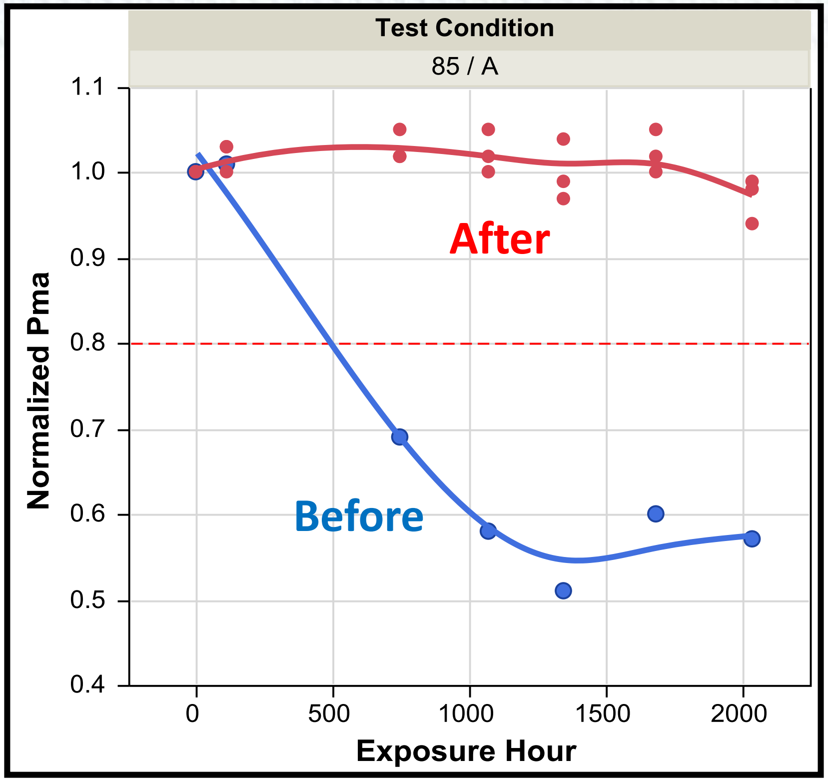
Challenge: balance the cure temperature profile for even cure performance

Conductive patch added on back of the back ribbon



Added "layer of protection" to minimize back contact degradation

Conductive fixes improve power performance



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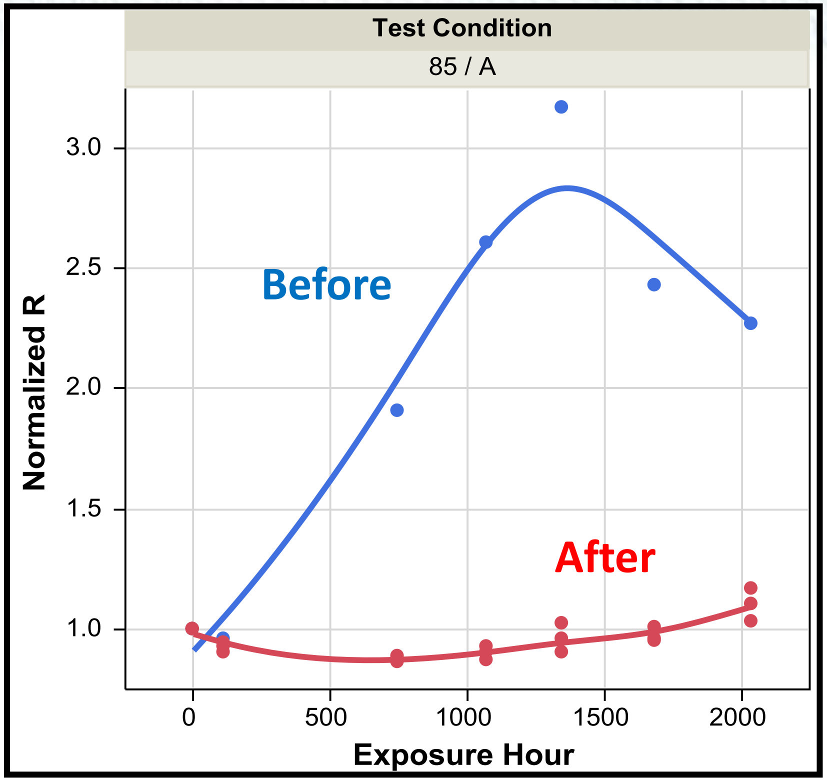

Stable power performance Pmax reflected in stable series resistance Rs

Conclusions

Technical:

Selection of appropriate ECA for performance is important

ECA cure important for performance… especially reliability

ECA adhesion important for reliability performance

Conductive fixes improved reliability performance

Problem solving:

Reliability demonstration takes time… start early

Proper isolation of problem location critical to narrow scope of investigation

Component level testing can accelerate mechanism identification

Understanding physics of failure key to improve reliability performance

Broadened thinking needed for timely “out of the box” solutions