

Use of the TurboSiP[©] Software to Predict the Long-Term Reliability of Solder Joints on Photovoltaic Systems

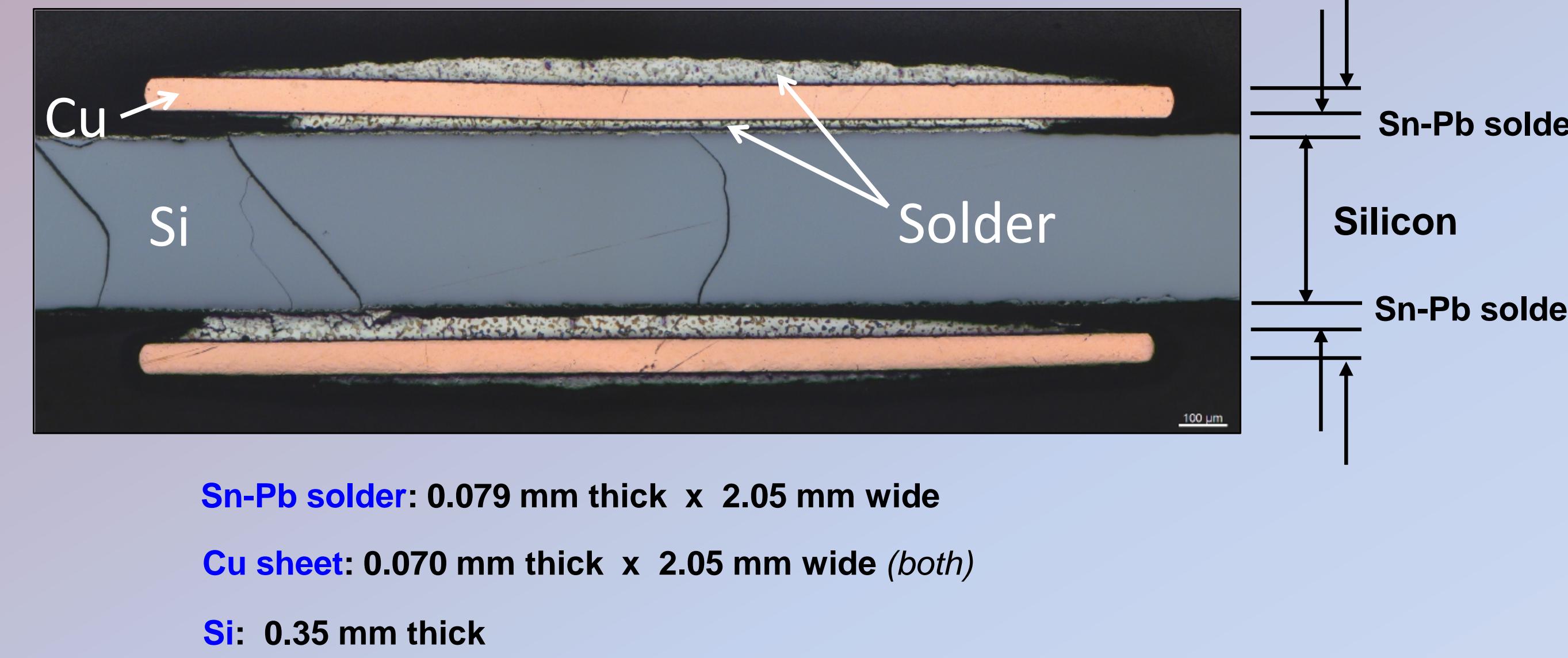
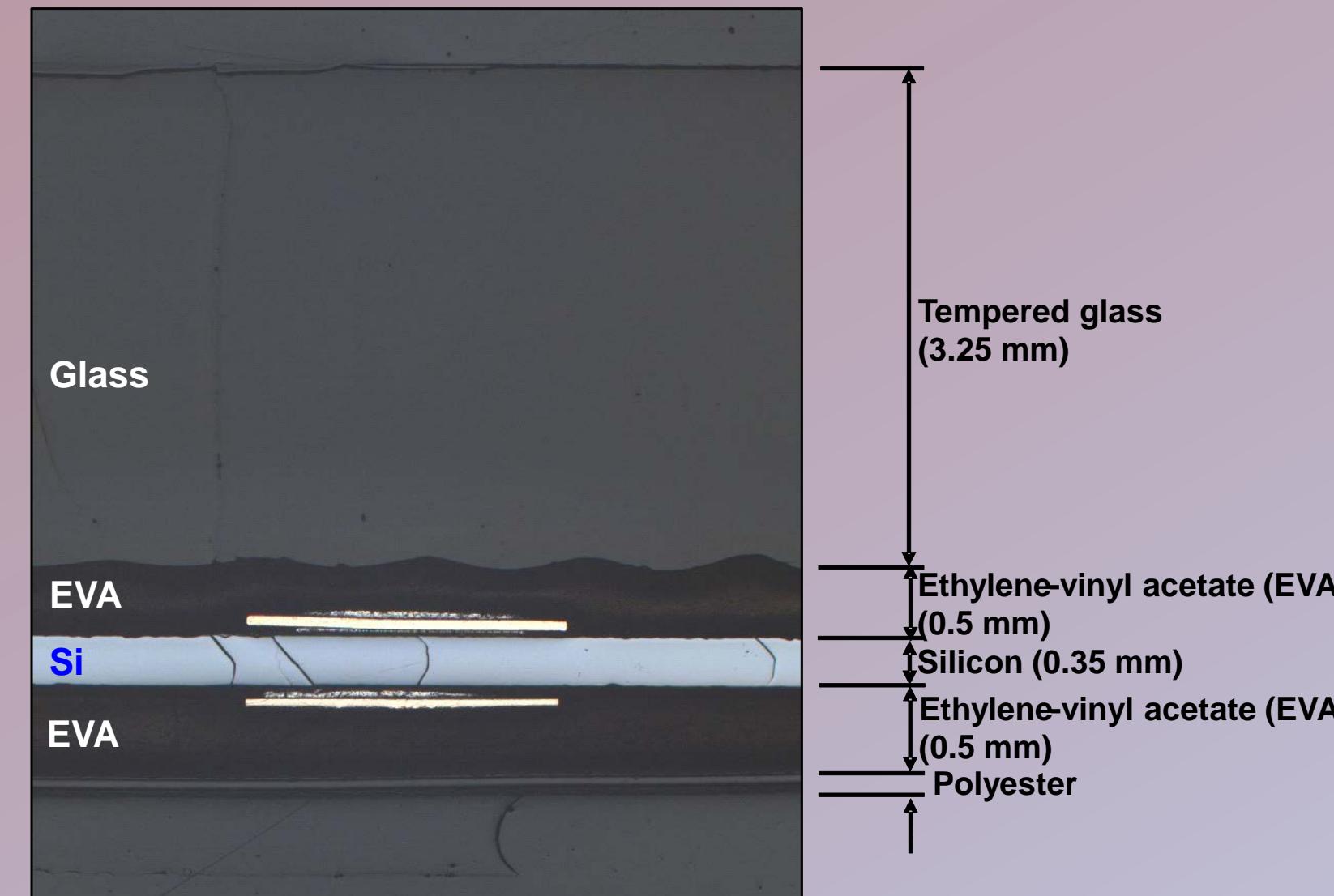
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ABSTRACT

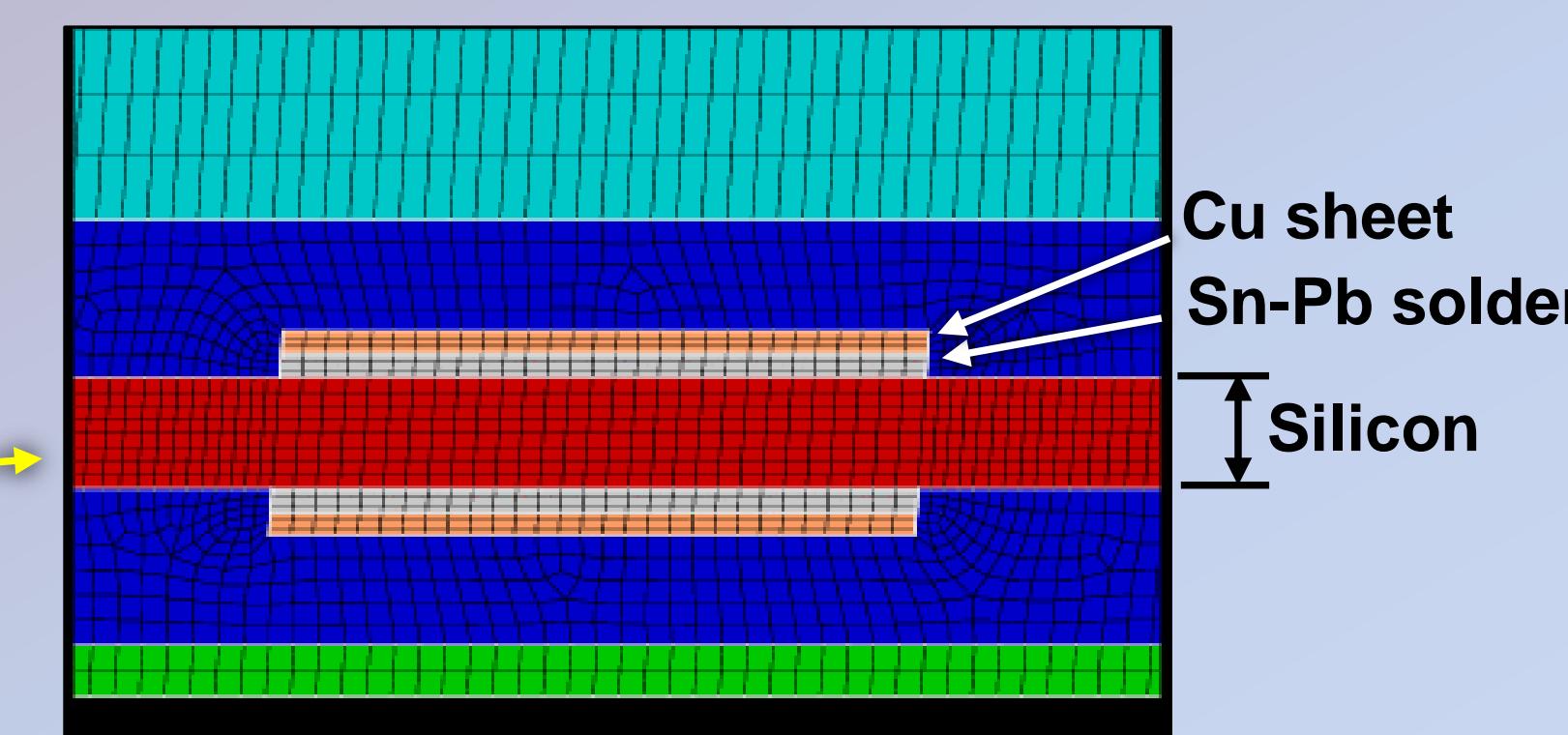
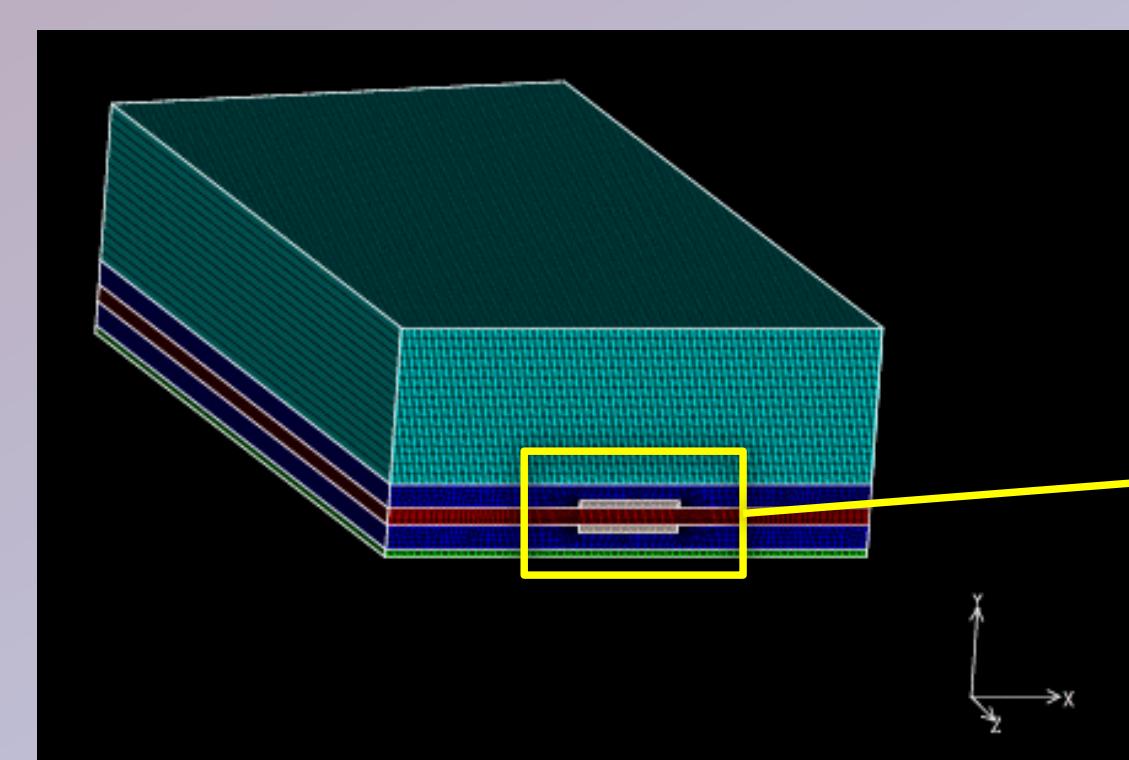
The TurboSiP[©] software predicts the thermal mechanical fatigue (TMF) of commonly used solder joints. The input parameters are package materials, interconnection design, solder alloy (Sn-Pb or Pb-free), and the environment. This computational tool was used to predict the TMF lifetimes of (a) collector circuit solder joints used in photovoltaic solar panel systems as well as (b) 1206 chip capacitor and (c) 14 I/O SOIC package solder joints on the printed circuit boards of the inverter module. All interconnections were analyzed as having the eutectic Sn-Pb solder. A service temperature cycle was defined from data logger parameters. Accelerated aging test conditions were also evaluated in the software. The TurboSiP[©] predicted lifetimes for the collector circuit as well as convention component solder joints that were more-than-adequate to meet the customer's requirements.

Analysis

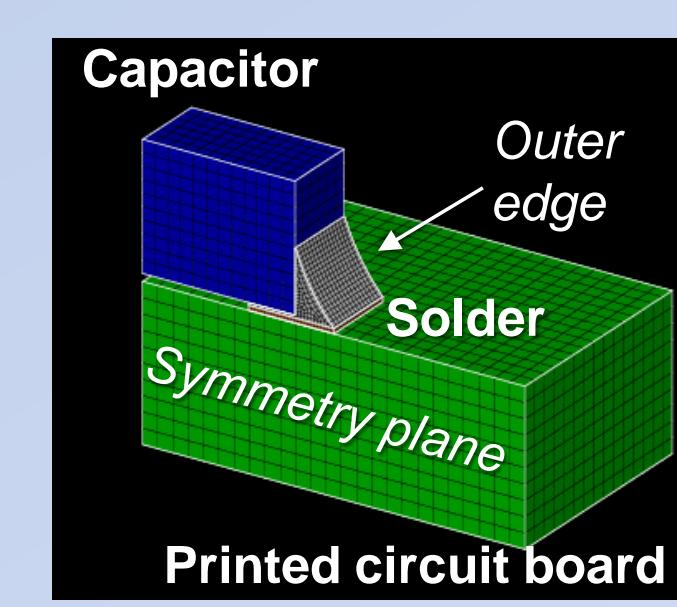
Module Current Trace



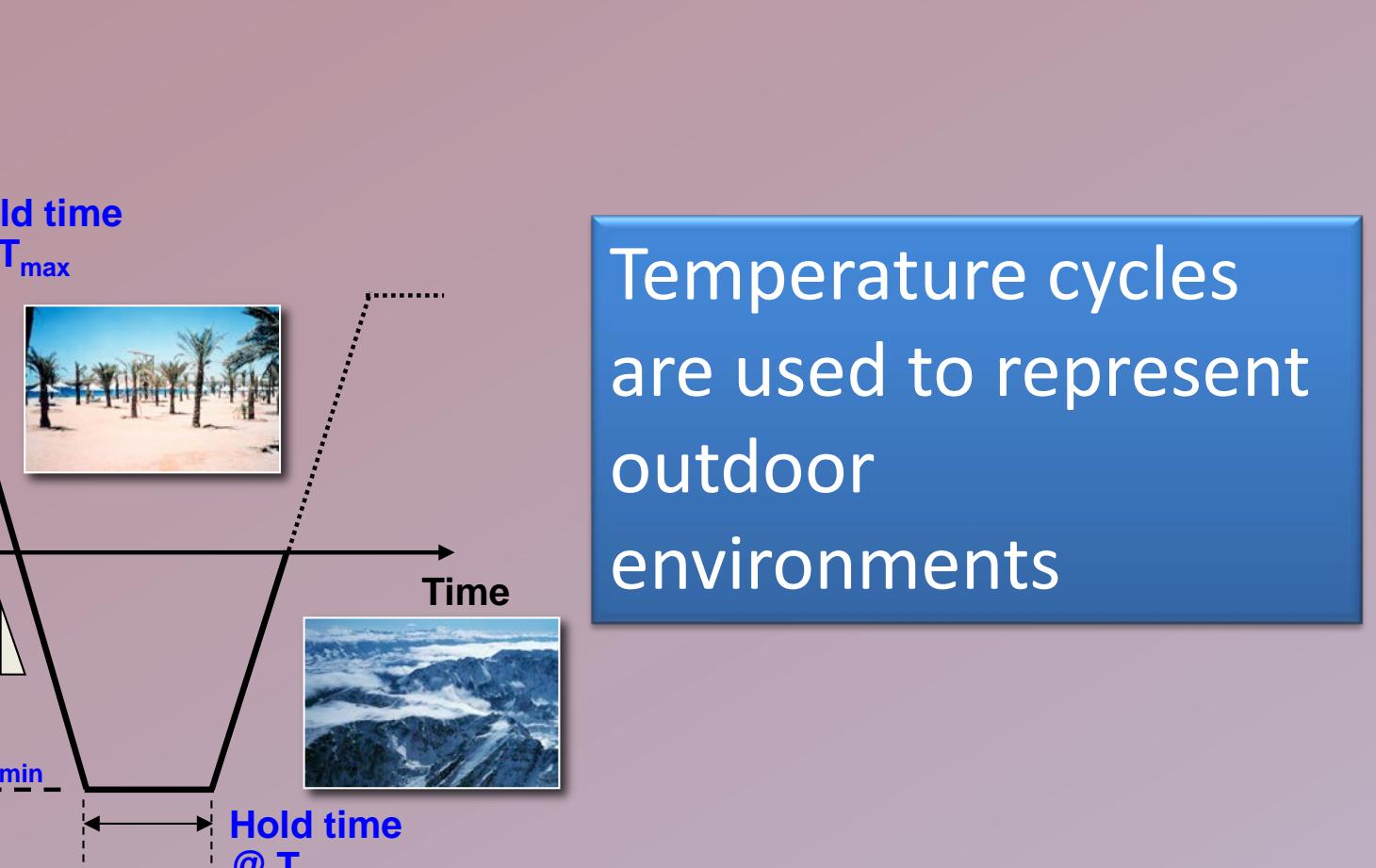
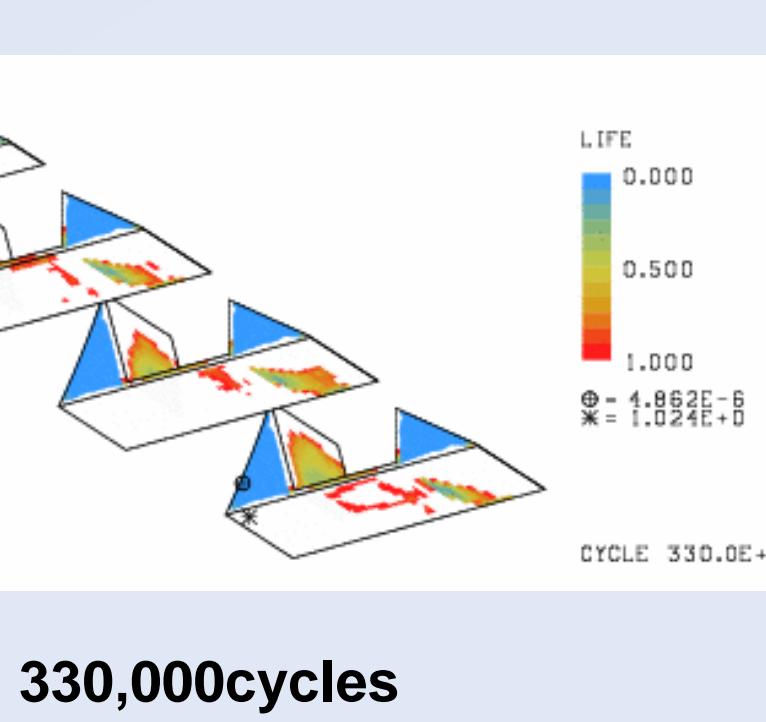
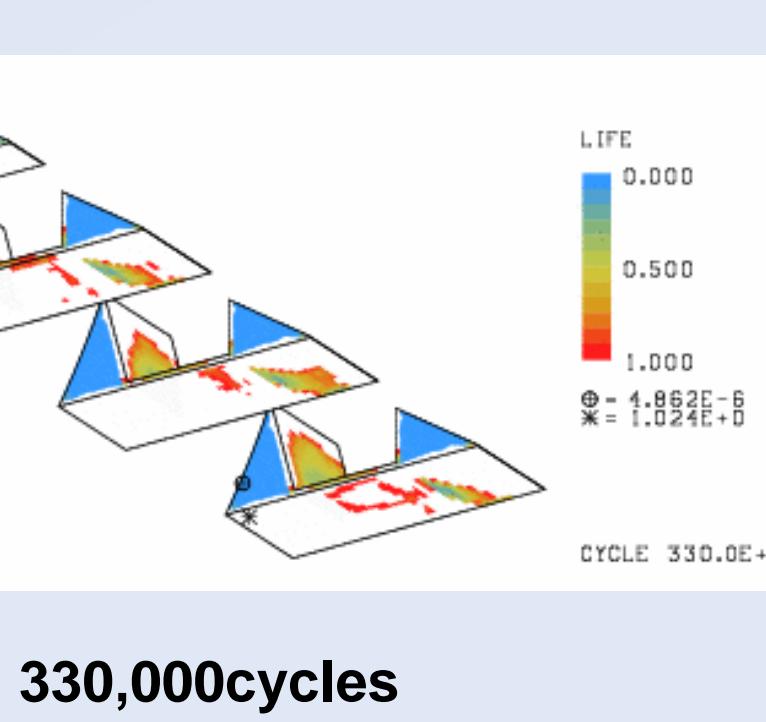
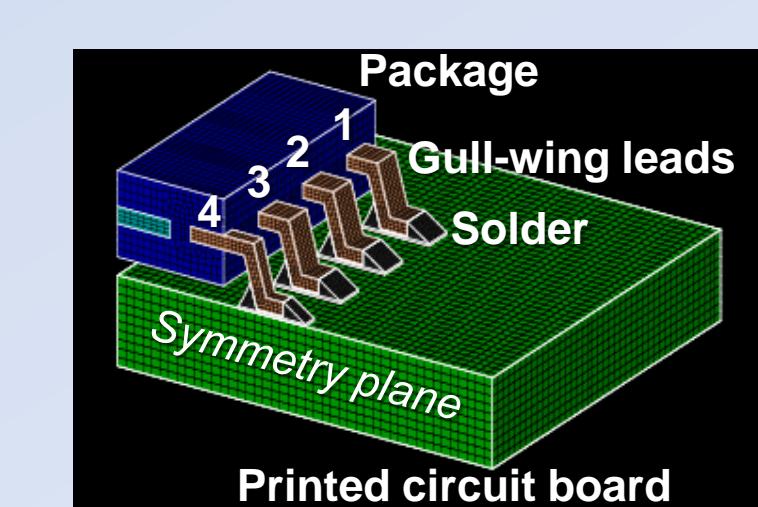
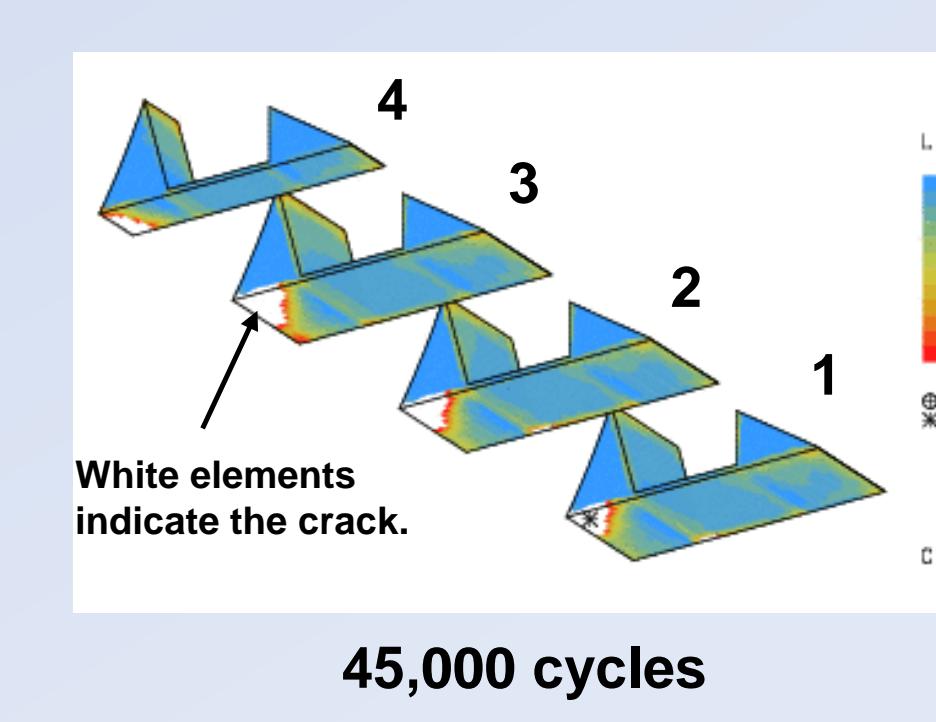
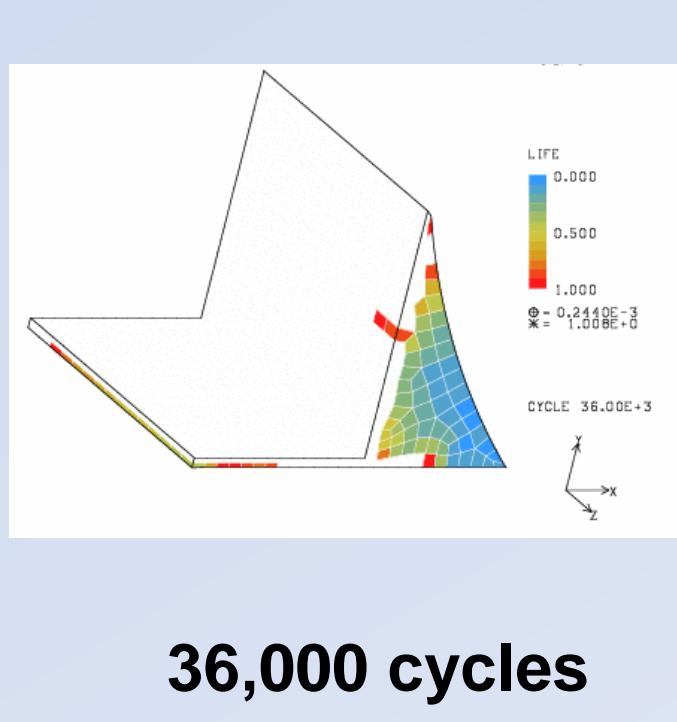
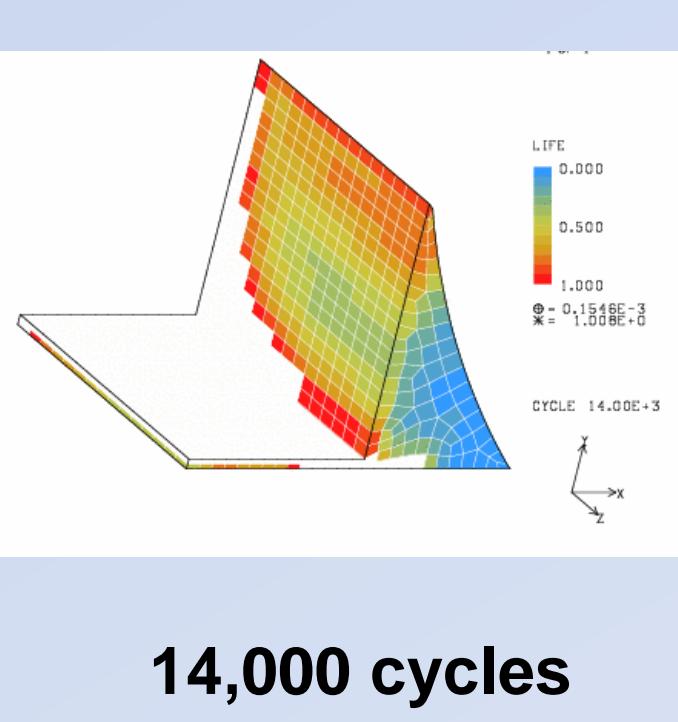
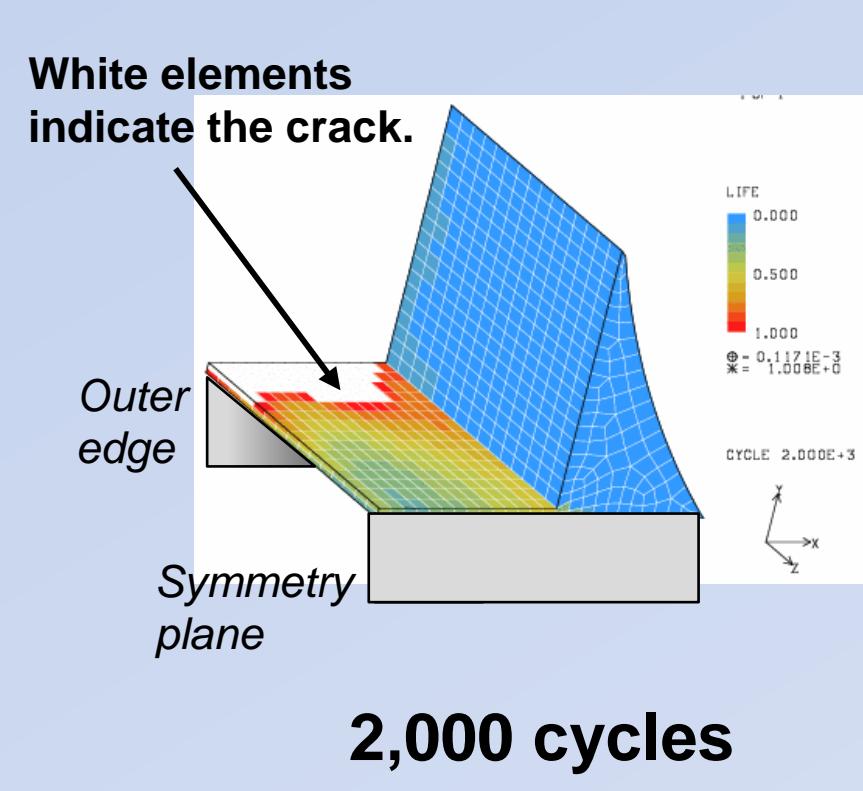
Modeling Results



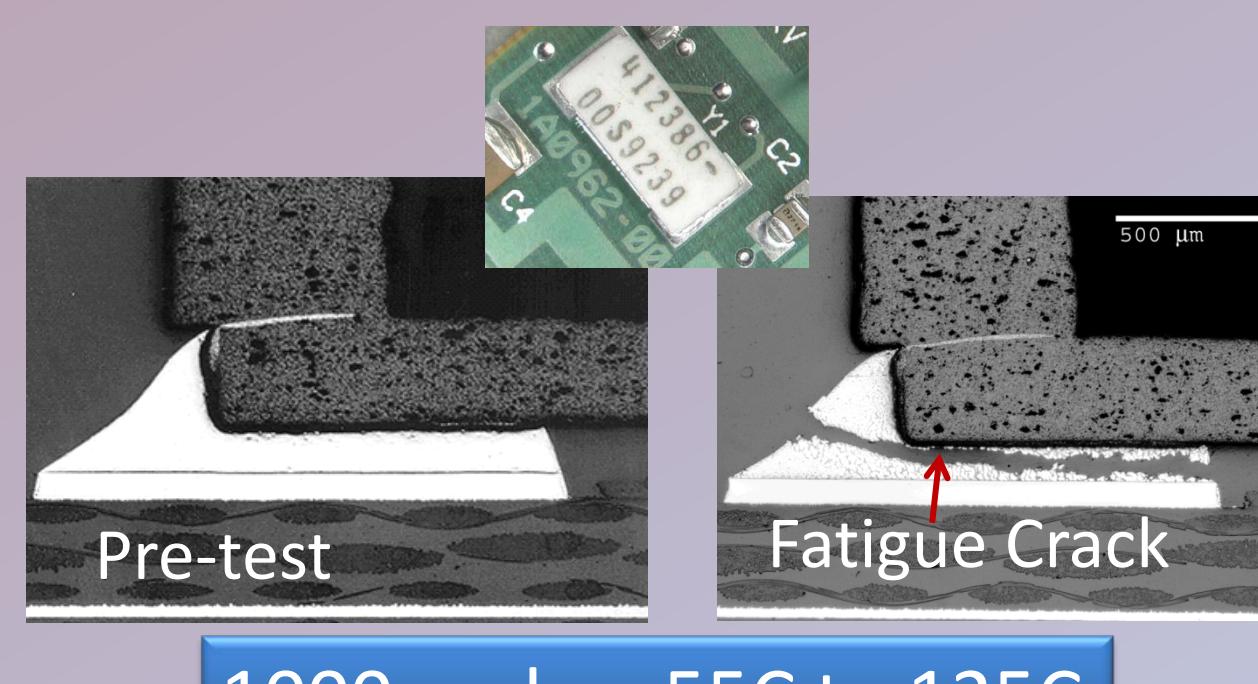
Metallography techniques were used to determine materials "stack-up"



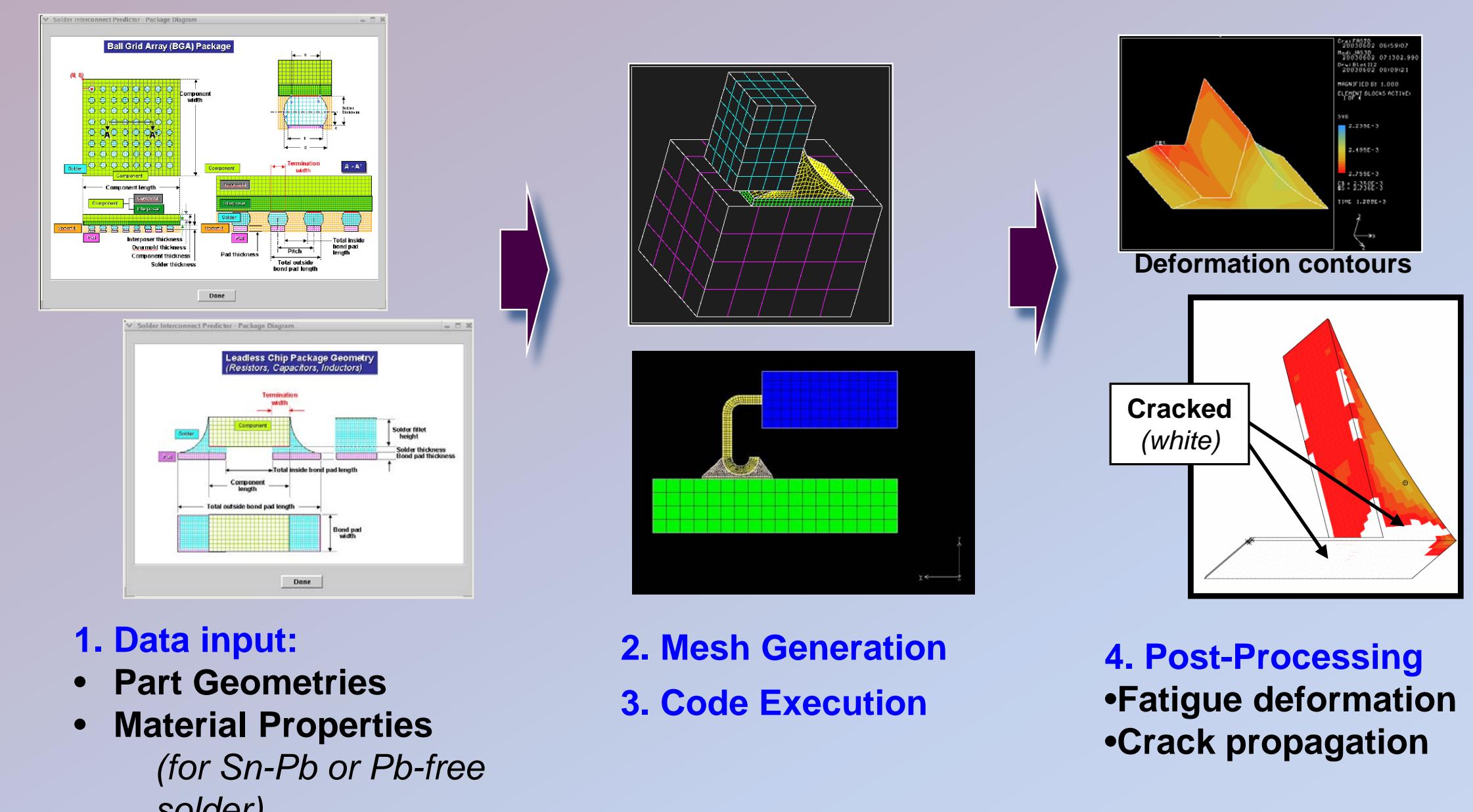
TurboSiP predicts solder joint evolution, including crack initiation and propagation.



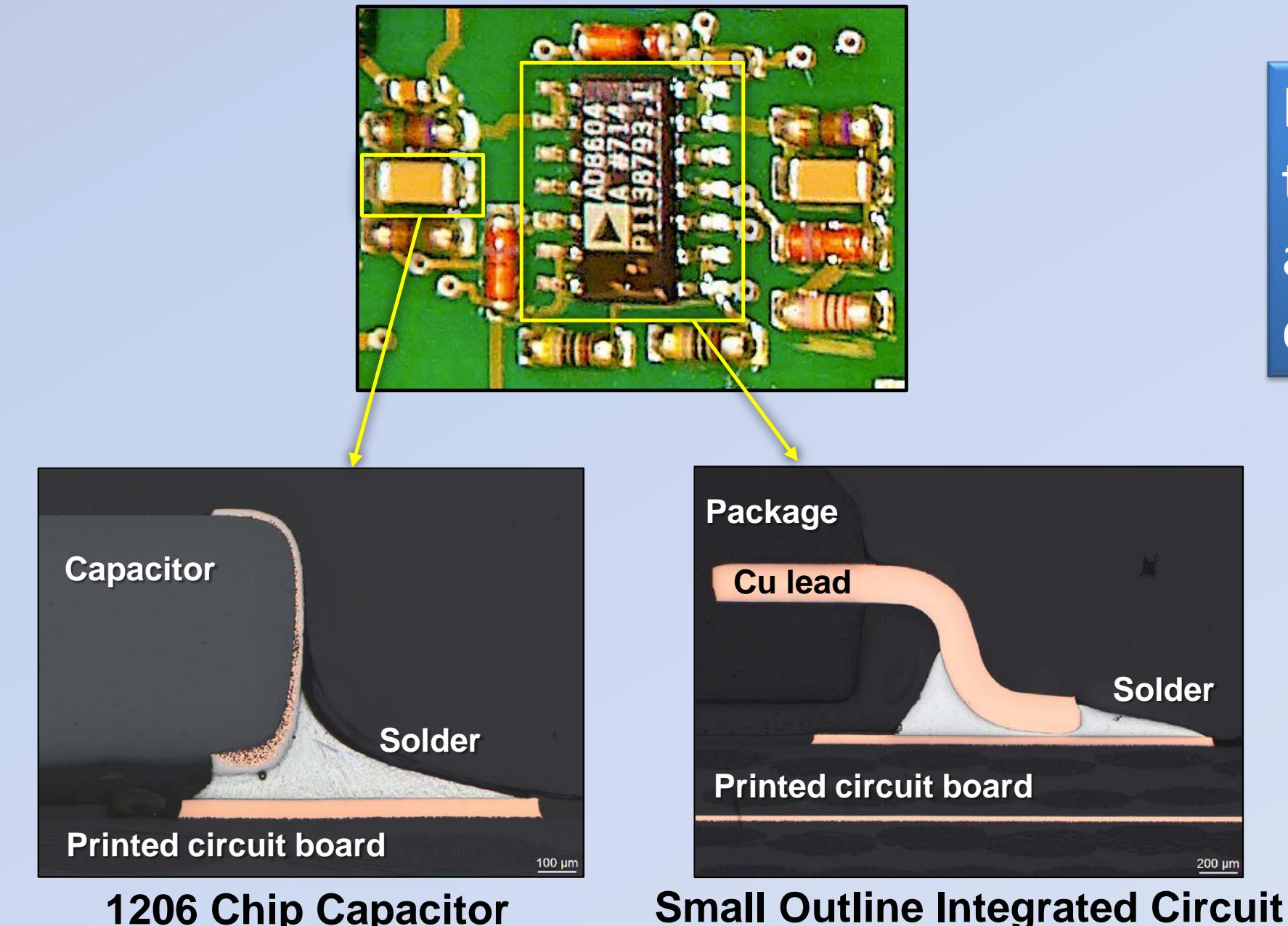
Thermo-mechanical fatigue of solder joints is observed during thermal cycling.



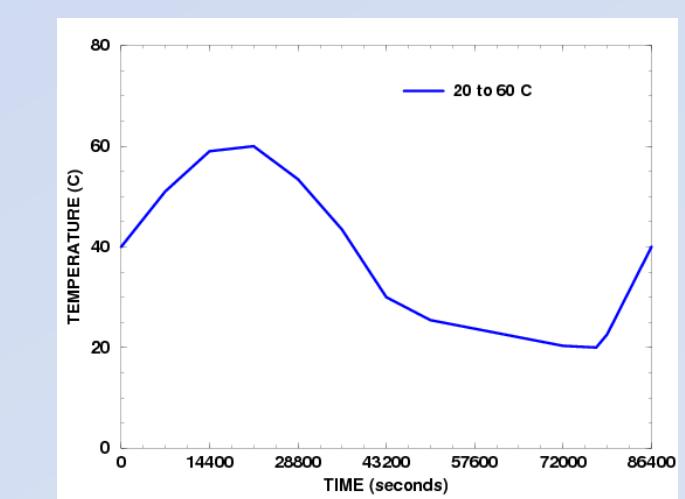
TurboSiP is used to calculate component response to thermal cycling stress



Inverter Electrical Components



Measured inverter thermal profiles were analyzed to provide daily temperature cycle.



Component	Temperature Cycle (°C)	Cycles to Start the Crack	AF – Start the Crack	Cycles to Finish the Crack	AF – Finish the Crack
Collection Circuit	20°C/60°C (service)	43,000	1	165,000	1
	0°C/100°C	2,400	17.9	20,000	8.25
	-55°C/125°C	425	101	6,000	27.5
1206 Chip Capacitor	20°C/60°C (service)	19,600	1	240,000	1
	0°C/100°C	1,500	13.1	36,000	6.67
	-55°C/125°C	300	65.3	11,000	21.8
14 I/O SOIC	20°C/60°C (service)	552,600	1	4,000,000	1
	0°C/100°C	35,000	15.8	330,000	12.1
	-55°C/125°C	5,300	104	62,500	64.0

Summary

- The TurboSiP[©] software is a tool for predicting the thermal mechanical fatigue (TMF) of commonly used solder joints. The input parameters include package materials, interconnection design, solder alloy (Sn-Pb or Pb-free), and the environment.
- This software was used to predict the TMF lifetimes of collector circuit solder joints used in photovoltaic solar panel systems. The specific cases were the TMF reliability of 1206 chip capacitor and 14 I/O SOIC components soldered to a printed circuit board. All interconnections were made with the eutectic Sn-Pb solder. A service temperature cycle was defined for the TurboSiP[©] software using data logger conditions. Accelerated aging test conditions were also exercised in the software.
- The TurboSiP[©] predictions clearly showed that both the collector circuit as well as the 1206 capacitor and SOIC component solder joints on a printed circuit board possessed more than sufficient service lifetime to meet the customer's operational expectations.

Future Work

- Validate model predictions using solder joints from fielded inverters.
- Apply rainflow counting algorithms to obtain higher fidelity input data (temperature) files.
- Model components from additional modules.
- Model components from commercial / utility scale inverters.