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DuraMAT
Durable Module Materials Consortium

In-situ Mapping of Deformation in Crystalline Silicon Modules: Understanding the Effects of Viscoelasticity

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Energy Materials Network
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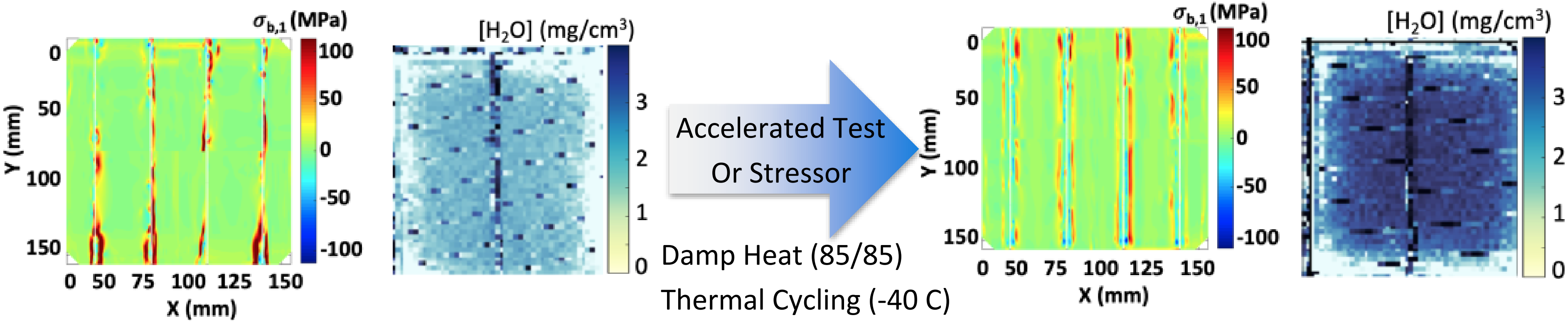
SLAC NATIONAL ACCELERATOR LABORATORY

Motivation: In-situ Module Stress Analysis and Improved Modeling

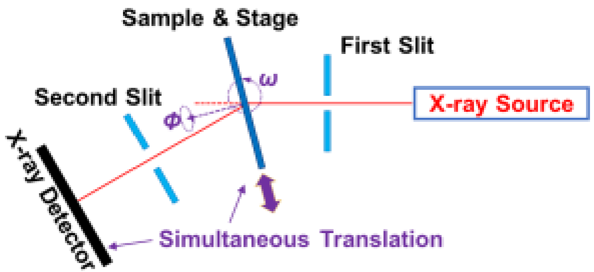
- Stress in cells during module manufacture + operation → cell cracks, moisture ingress, power loss
- **Goal:** Identify how operating conditions affect cell → improve materials, processes to extend module reliability
- **Proposed Methods:** Quantify and correlate stresses in-situ by X-ray Topography (XRT), FEM modelling, and water content by Water Reflectometric Detection (WaRD)

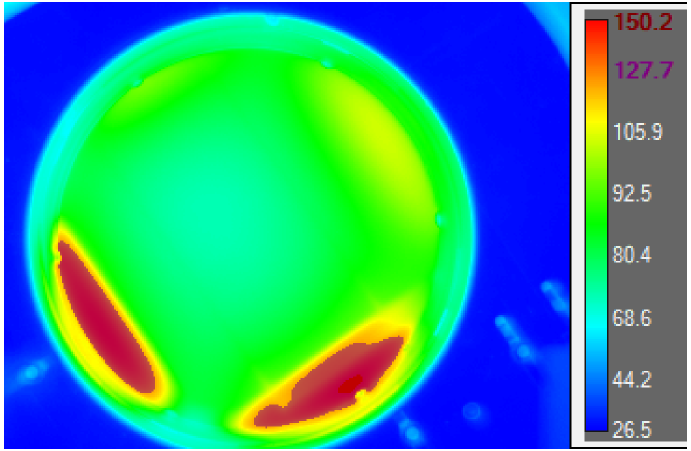


Water Concentration Mapping with WaRD (UCSD Please add)

- Measurement of water signature in infrared
- Example Water Mapping for half-cell, diffusion profile calculations, POE vs. EVA

In-situ Deflection Measurement via X-Ray Topography (XRT)





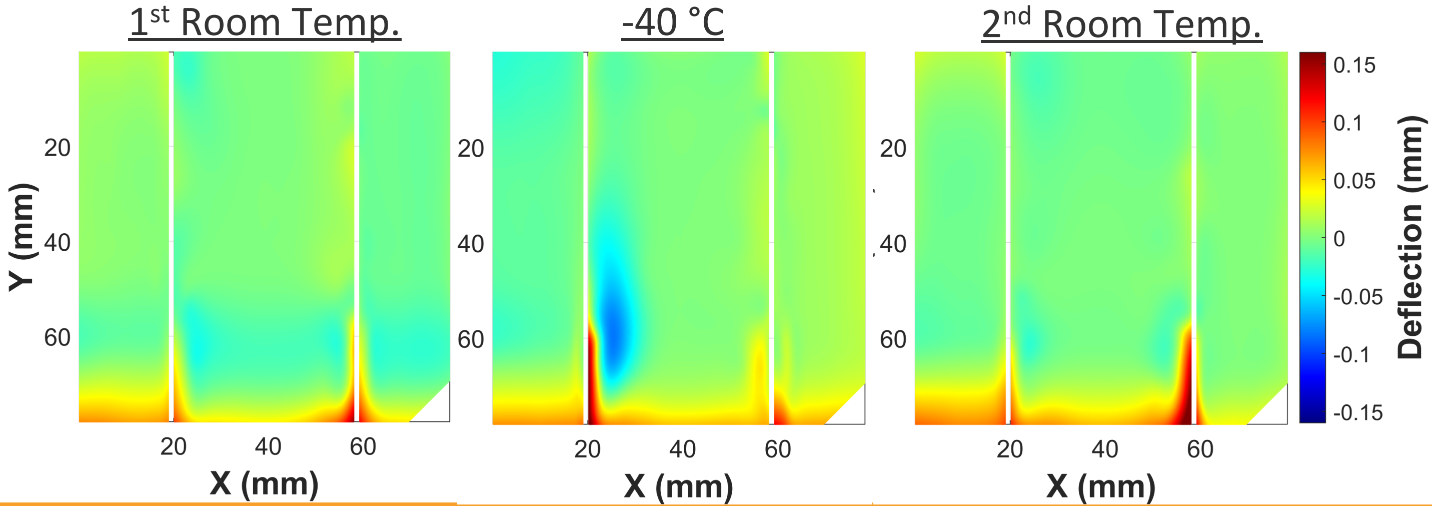
- Sample held 85C after drying in N_2 atmosphere

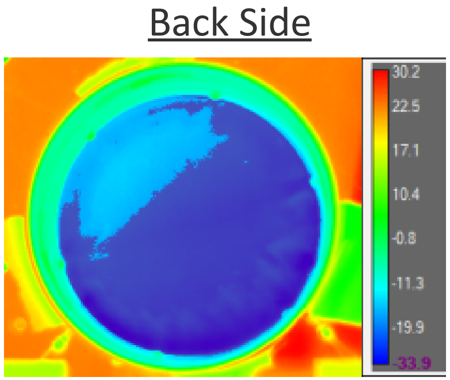
- Add representative XRT map

In-situ Deflection Mapping at Low Temperature

Objective: To map deflection below the glass transition temperature of the encapsulation materials

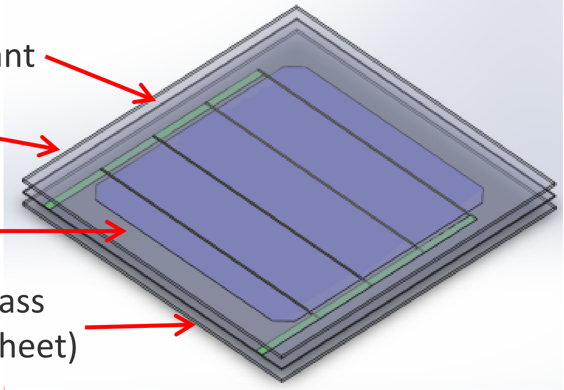
Progress: Measurements across a thermal cycle show deflection change between low and room temperatures



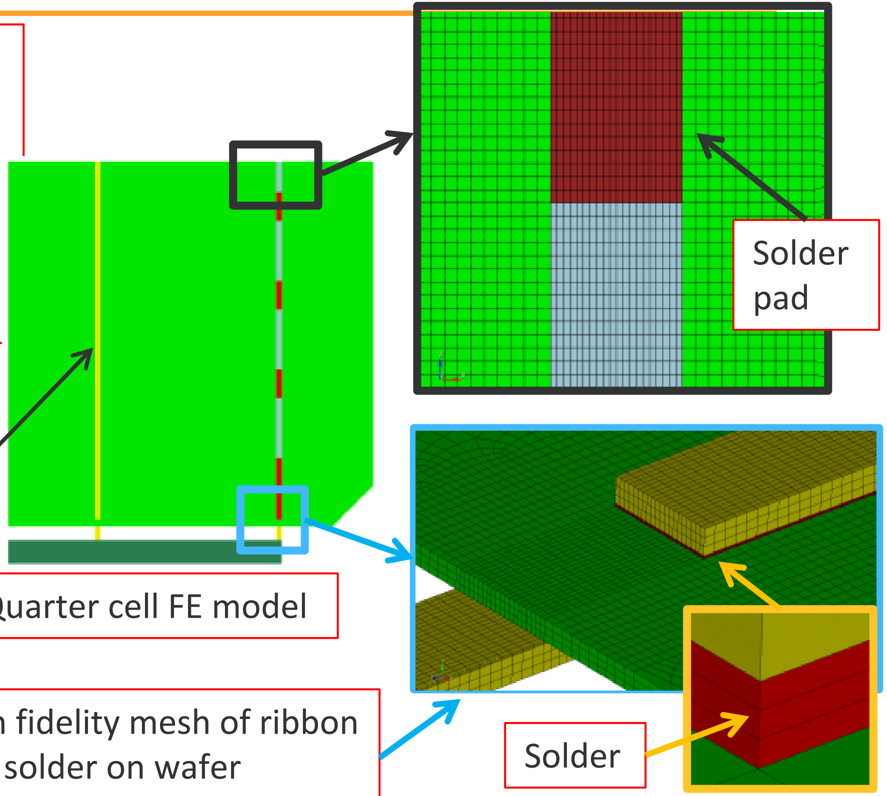


FEA to Predict Manufacturing Process Induced Residual Stresses in Solar Cells

- Detailed FE model of solar module is developed to simulate residual stresses due to soldering and lamination processes including effect of encapsulant's viscoelastic property
- FE model results will be compared against XRT deflection maps determined with actual solar module for validation

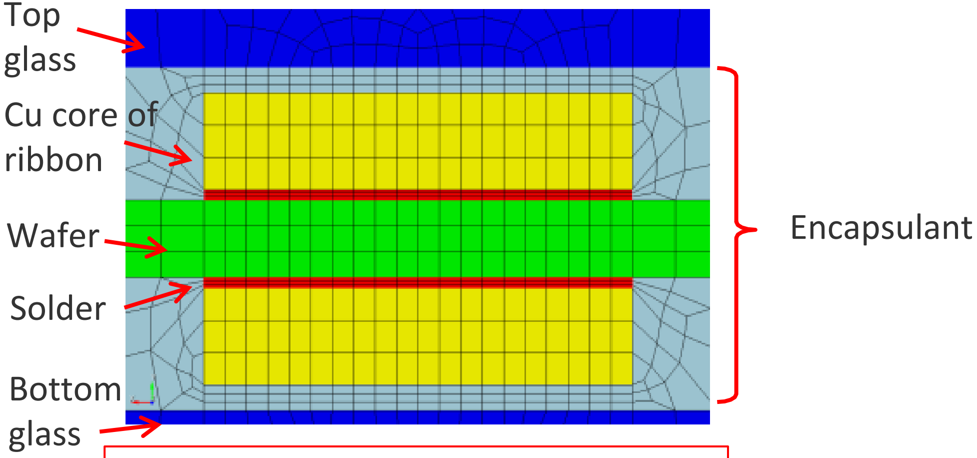


3D CAD of single-cell solar module

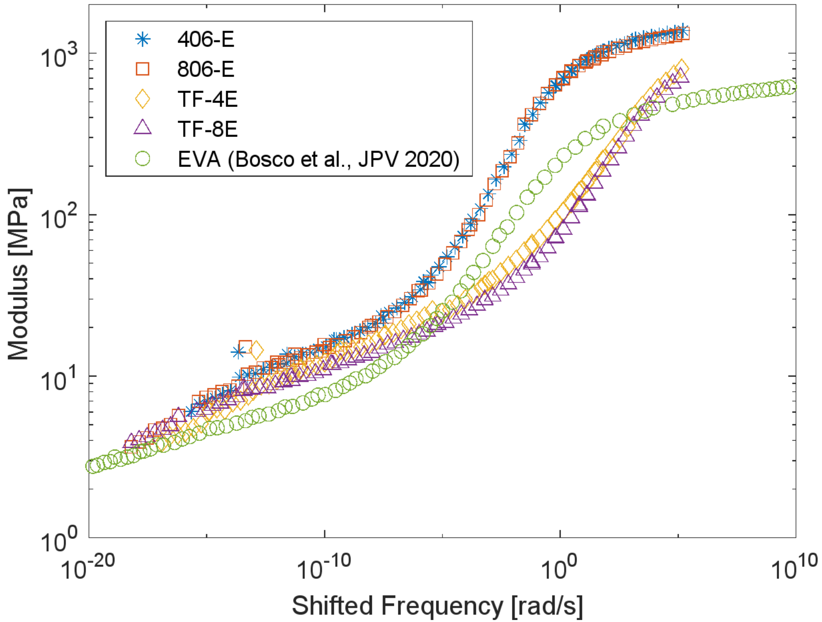


FEA to Predict Manufacturing Process Induced Residual Stresses in Solar Cells

- Measured mechanical properties for two EVA and two POE encapsulants
- Experimental master curves will be implemented in a higher fidelity material model for finite element simulations



X-section of FE model of solar module



Measured master curves for encapsulant materials used in minimodule samples

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