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miss it, miss out.



Determination of Temperatures and Stresses inside Space Solar Cells and Special Panel Structures for a Mercury Mission Using Pro/ MECHANICA



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Content

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Purpose

**Solar Generator Basic Design
Pro/MECHANICA Model
Thermal And Structural Results
Summary**

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Milano*

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Purpose

- **Development Of A Solar Cell Assembly Technology For A Mercury Mission (PVA)**
- **Environment:**
 - **Up To 25 Solar Constants (SC)**
 - **At Mercury 10 SC**
- **Goal: Temperatures At Solar Cell Level Below 300 °C**
- **Determination Of Temperatures And Stresses**

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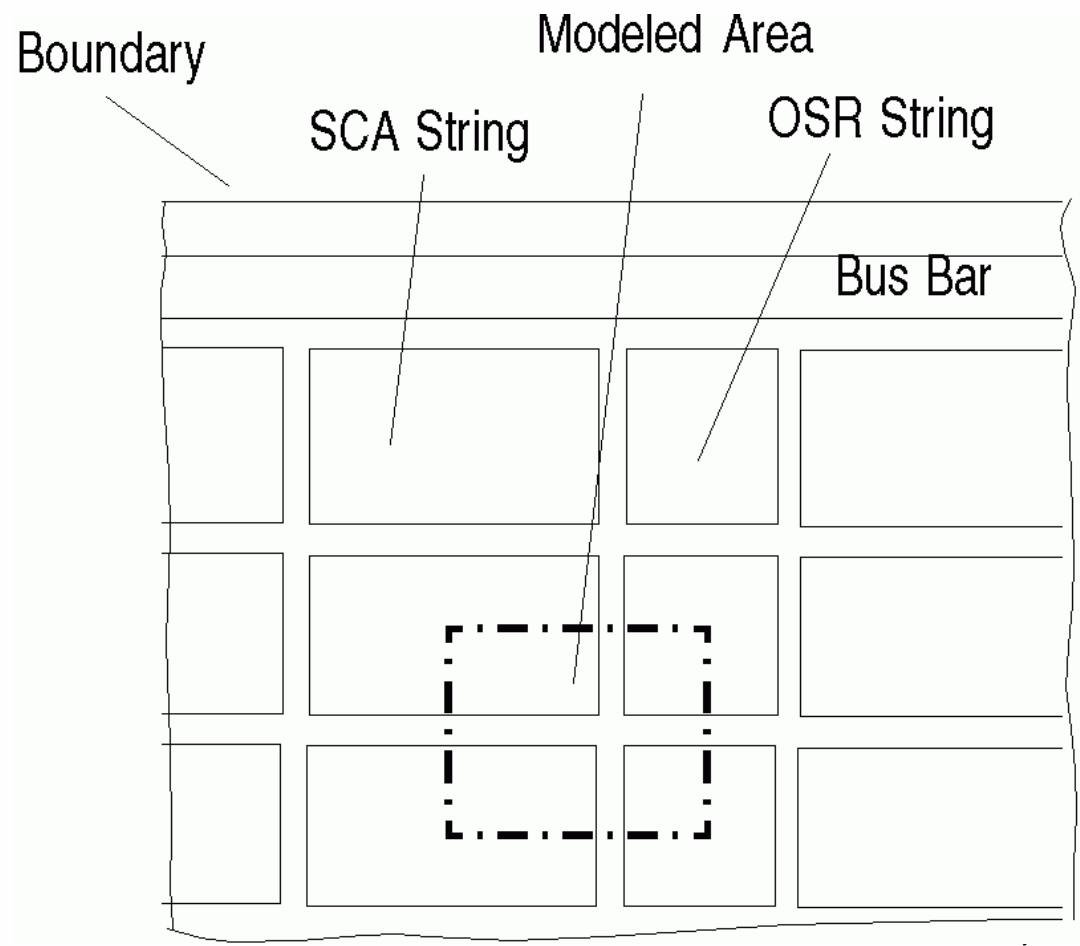
Purpose

- **Investigation Of Different:**
 - **Generator Substrates**
 - **Ratios Between Optical Surface Reflectors (OSR's Or Mirrors) And Solar Cells**
 - **Solar Cell Types**

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Basic PVA Design



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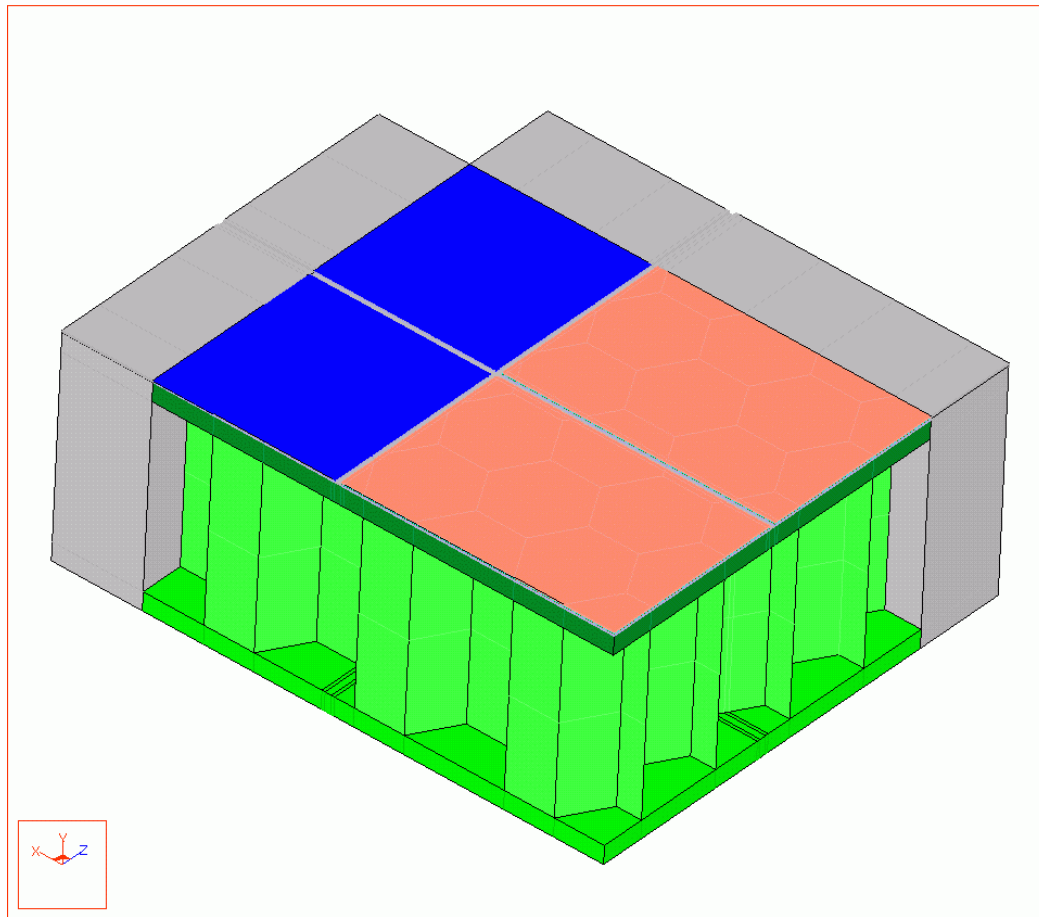
Considered Model Features

- **Parts: Substrate, Adhesive, Solar Cell, OSR, Cover Glass, etc.**
- **Cell Sizes Between 4x4 cm² and 8x6 cm², Thickness 0,15 mm**
- **CFRP And C-C Honeycomb Substrate And Cover Layers**
- **Calculations Should Consider:**
 - **Symmetry Around The Model Boundaries**
 - **Radiation**
 - **Solar Absorption On All Front Surfaces And Edges**
 - **Orthotropic Material Behavior Of The Honeycomb**
 - **‘Correct’ Material Behavior At Elevated Temperatures (300 °C)**
- **Solar Incident Angle 15° (25 SC) And 90° (10 SC)**

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3D-Model Geometry

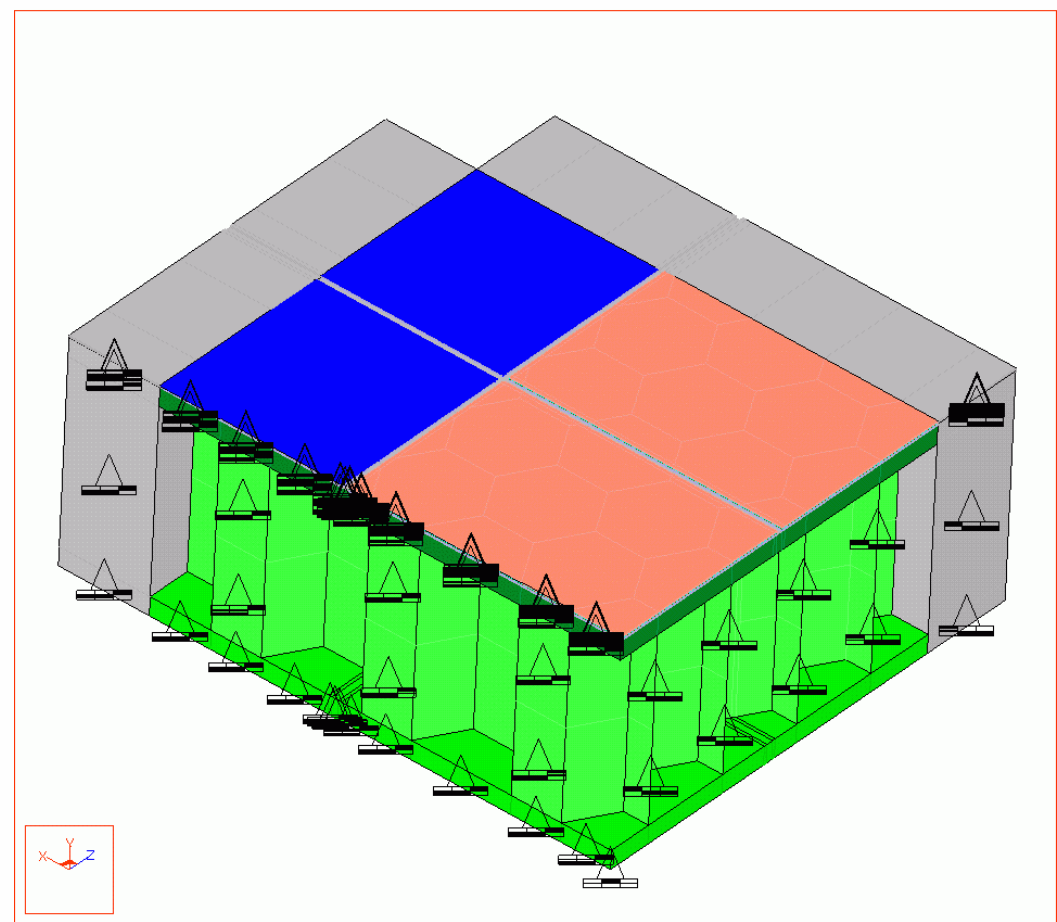


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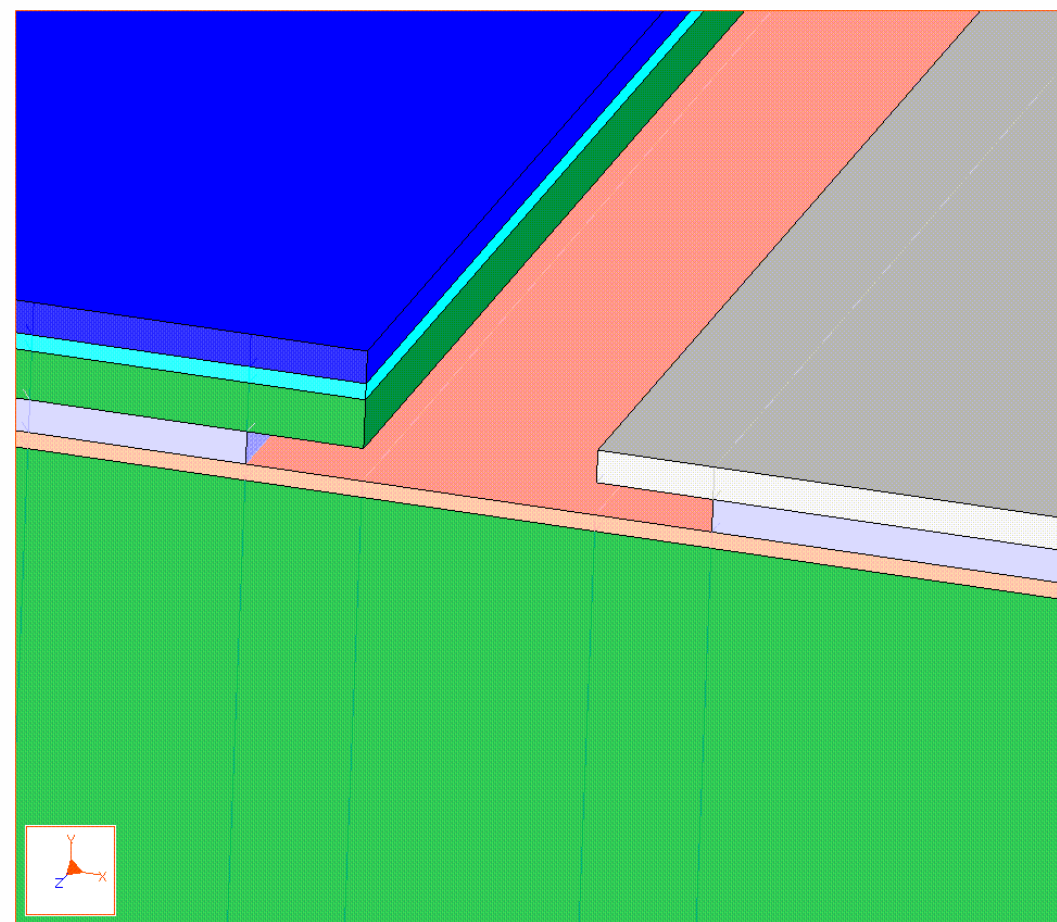
Structural 3D-Model With Constraint Conditions



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Detail In The Gap Region



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h, Reul / Klockmann, 12.05.02

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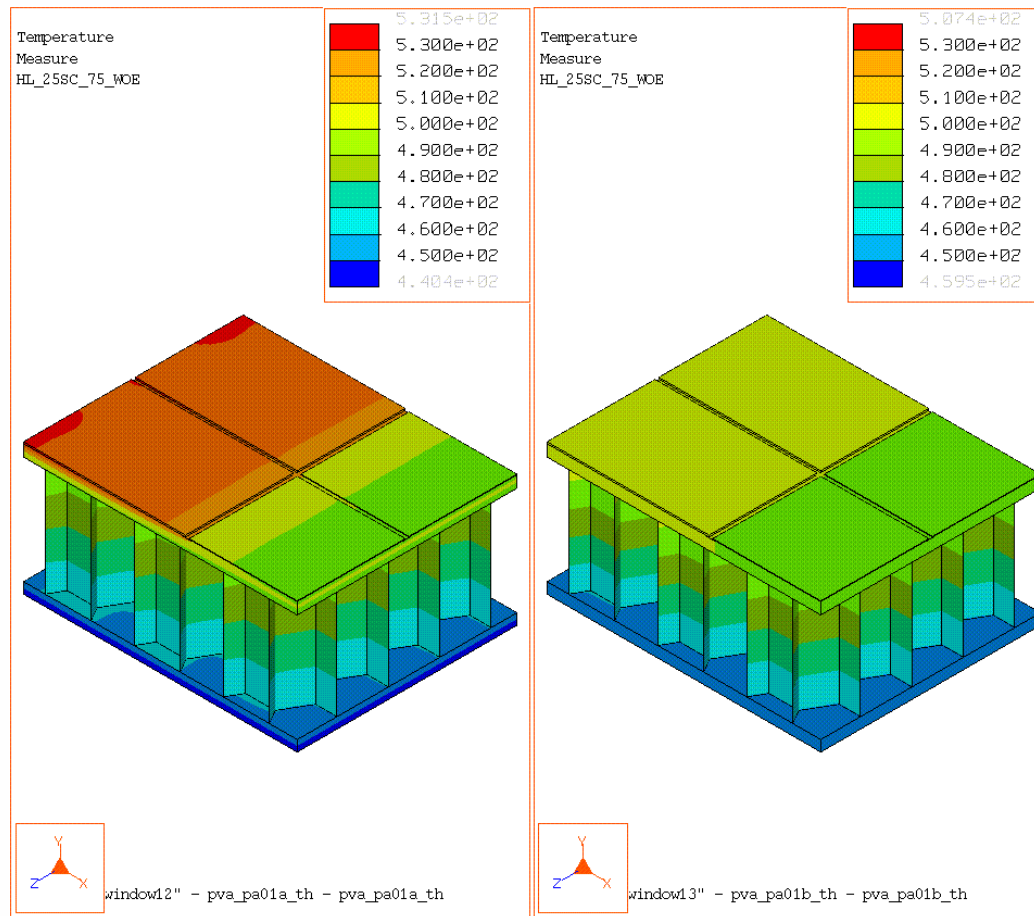
Simulation Analyses

- **Pro/MECHANICA Thermal Does Not Support Radiation**
- **Black Body Radiation Can Be Modeled By Using Convective Boundary Conditions**
- **The Convection Coefficient Is Than Temperature Dependent And Must Be Calculated Using An Iterative Process**
- **Within The Iterationts Emissivity Is Changed**
- **Thermo-Mechanical Coupling Calculated In Two Steps:**
 - **Quasi-Static Thermal Analyses With Pro/MECHANICA Thermal**
 - **Quasi-Static Structural Analyses With Pro/MECHANICA Structure**
- **Pre-Analyses For Honeycomb Replacement With Bulk Material**

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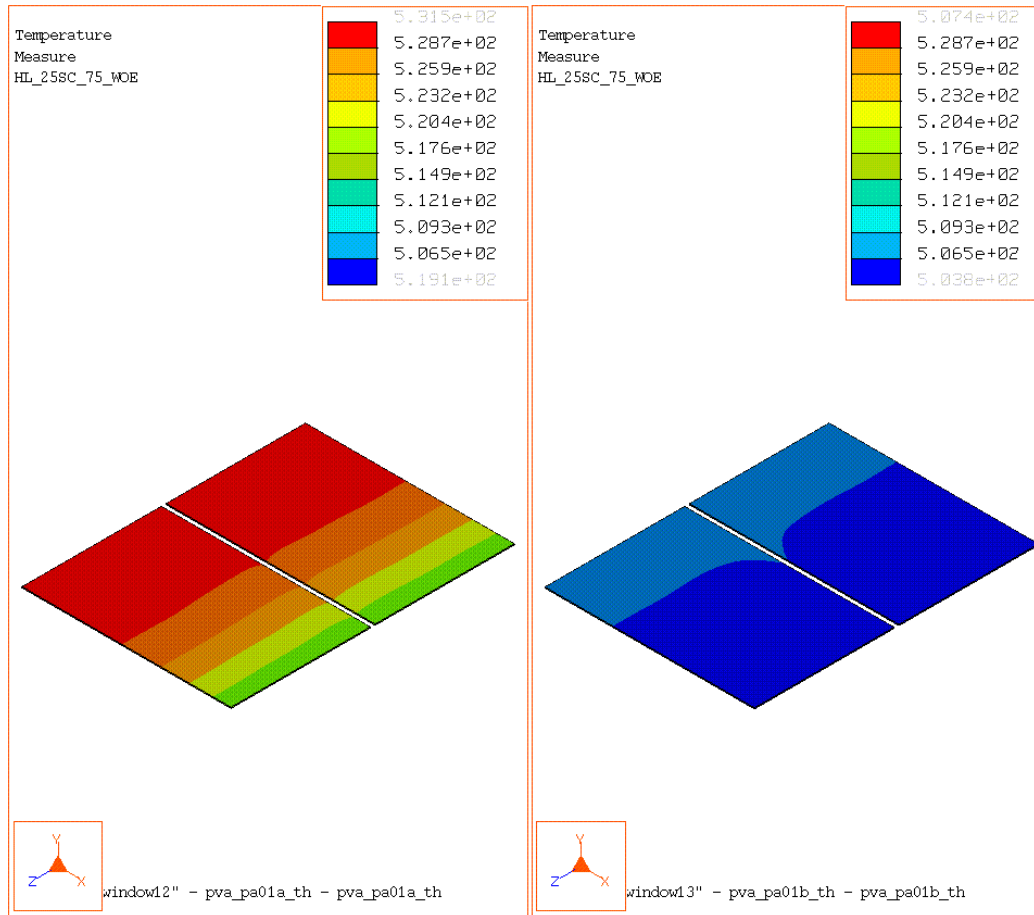
Temperatures; Left: CFRP Substrate, Right: Al Substrate



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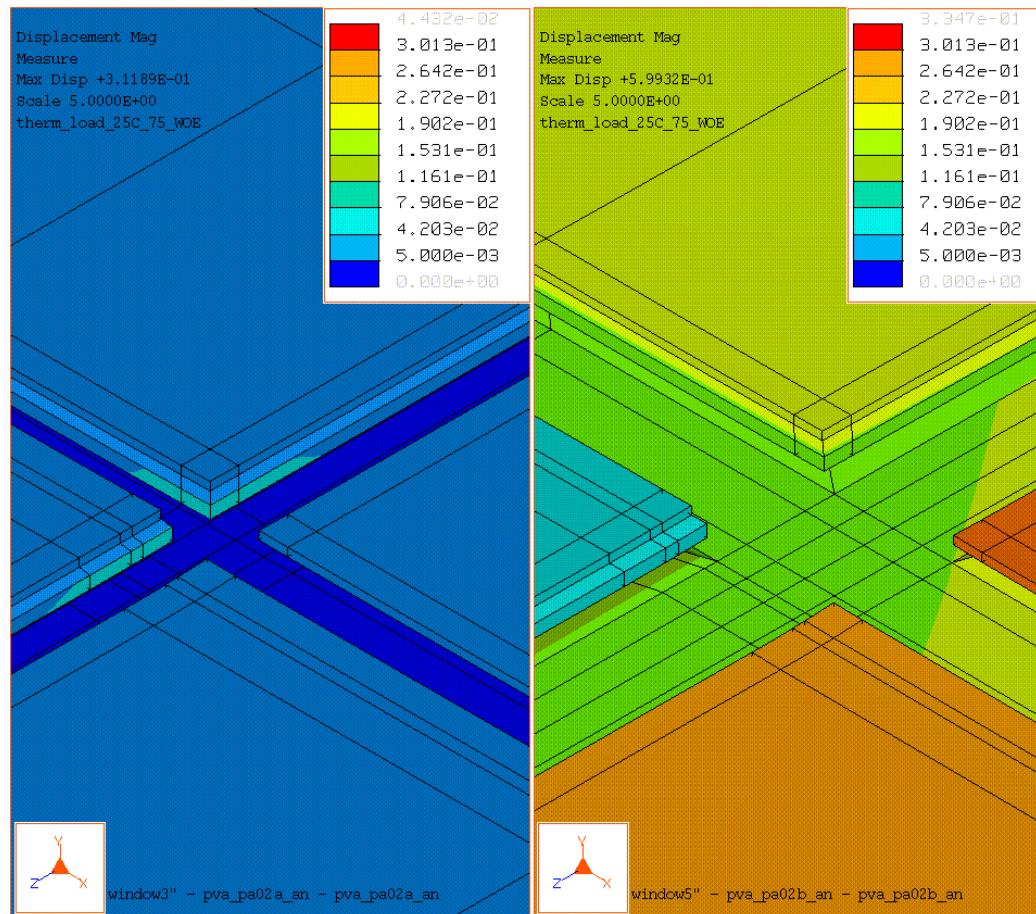
Temperatures On Cells; Left CFRP Substrate, Right: Al Substrate



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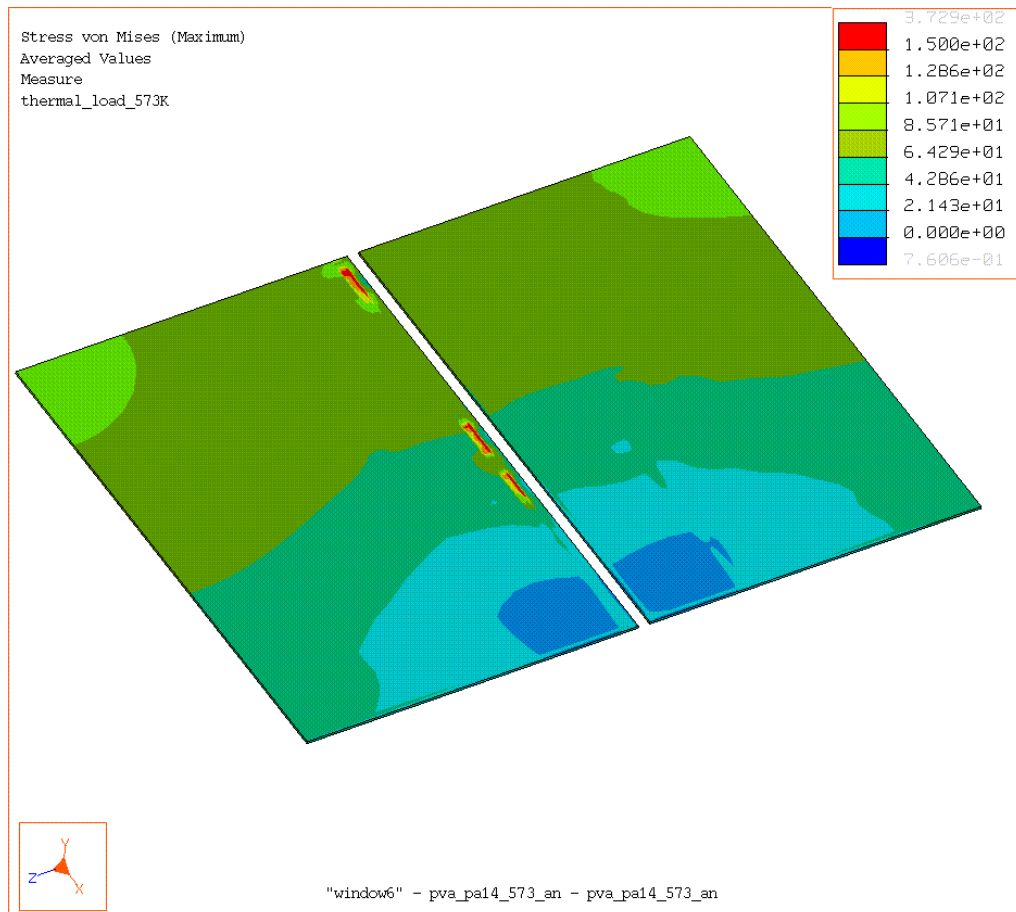
Displacements; Left: CFRP Substrate, Right: Al Substrate



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Typical Stress Results For A Ge/GaAs Solar Cell



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Results Summary

- **Temperatures Within The PVA's With C-C Skins Are Lower Or Even The Same Than With Al Skins**
- **The Temperatures Within The SCA's Depend Highly On The In-Plane Thermal Conductivity Of The Substrate Skins**
- **Aluminum Skins Introduce High Stress Levels Within SCA's And OSR's**
- **Stress Levels Introduced By CFRP And C-C Skins Are 30 % To 50 % Lower**
- **Gap Filling With Adhesive Results In Additional Corner/Edge Stresses**

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Results Summary

- **A PVA With C-C Skins, 6x4 cm² SCA's And 4x4 cm² OSR's Seems To Be An Optimal Configuration**
- **Increase Of Silver Layer Thicknesses And Honeycomb Core Wall Thickness Improves Thermal Conductivity**
- **PVA's Can Be Calculated With Pro/MECHANICA Thermal And Structure**
- **Radiation Can Be Considered Only By Using An Iterative Process**

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Thank You !