Optical Deformation Chamber using Digital Image Correlation (DIC)

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23rd Annual Rio Grande Symposium on Advanced Materials

Hotel Albuquerque

October 3, 2011
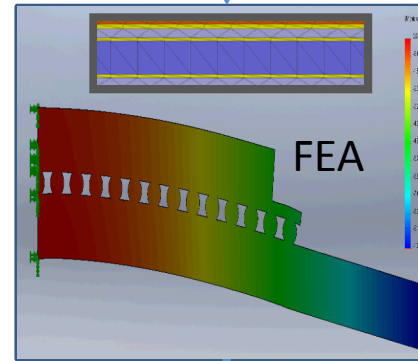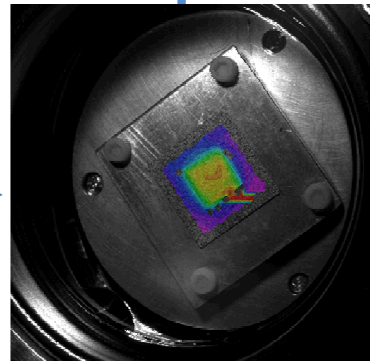
Motivation

Initial Substrate Design

Solder mask, 25 um
Layer 1, 20 um
Prepreg, 40 um
Layer 2, 15 um

BT core 150 um

Layer 3, 15 um
Prepreg, 40 um
Layer 4, 20 um
Solder mask, 25 um

A system was developed to perform experiments which can measure the deformation microsystems components to validate structural models.
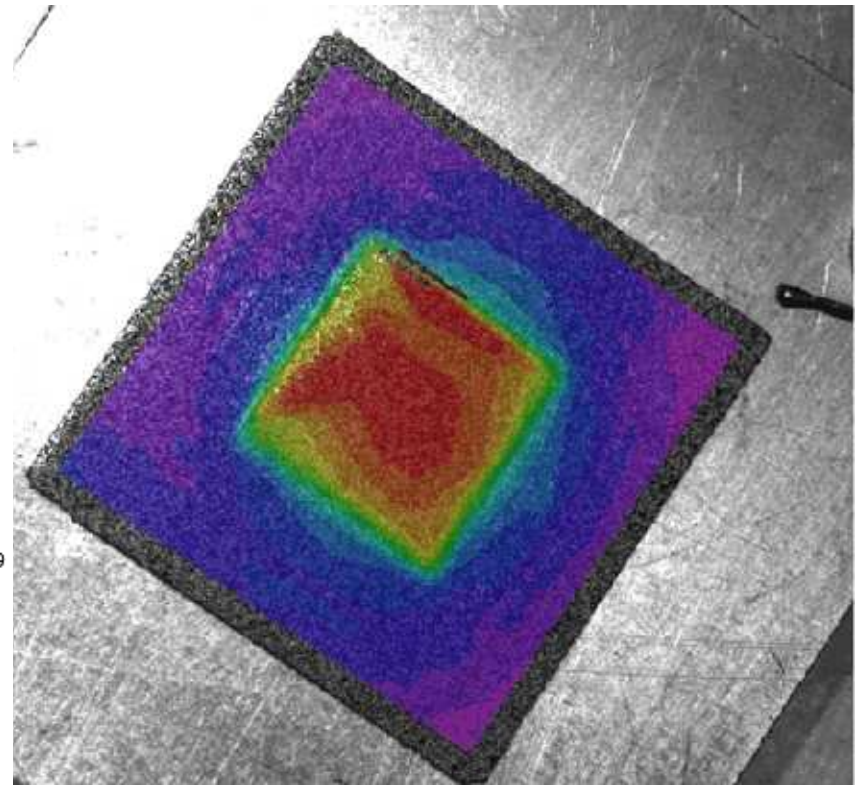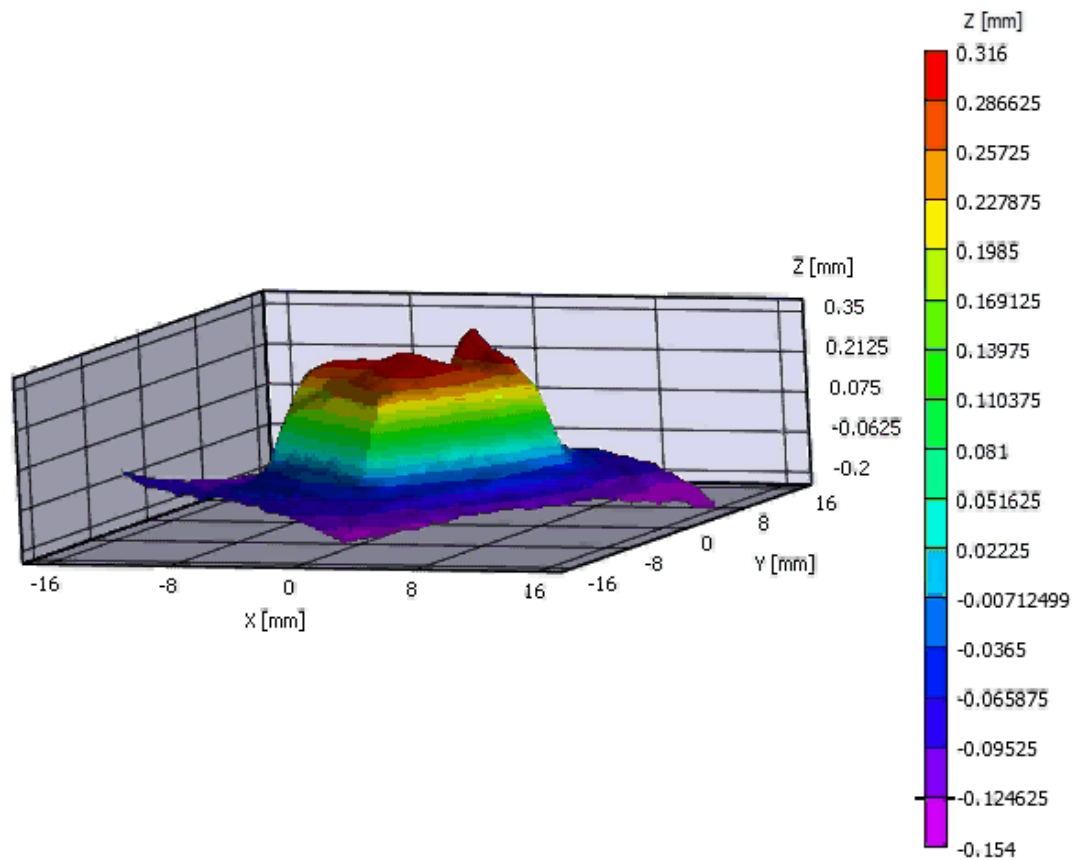
Simulation Based Design

FEA

The focus of this work was developing a means of validating structural microsystems models. The data from this experiment can be used to gain trust in the model which can then be used to identify better designs.

New Substrate Design with different laminate structures and thicknesses.
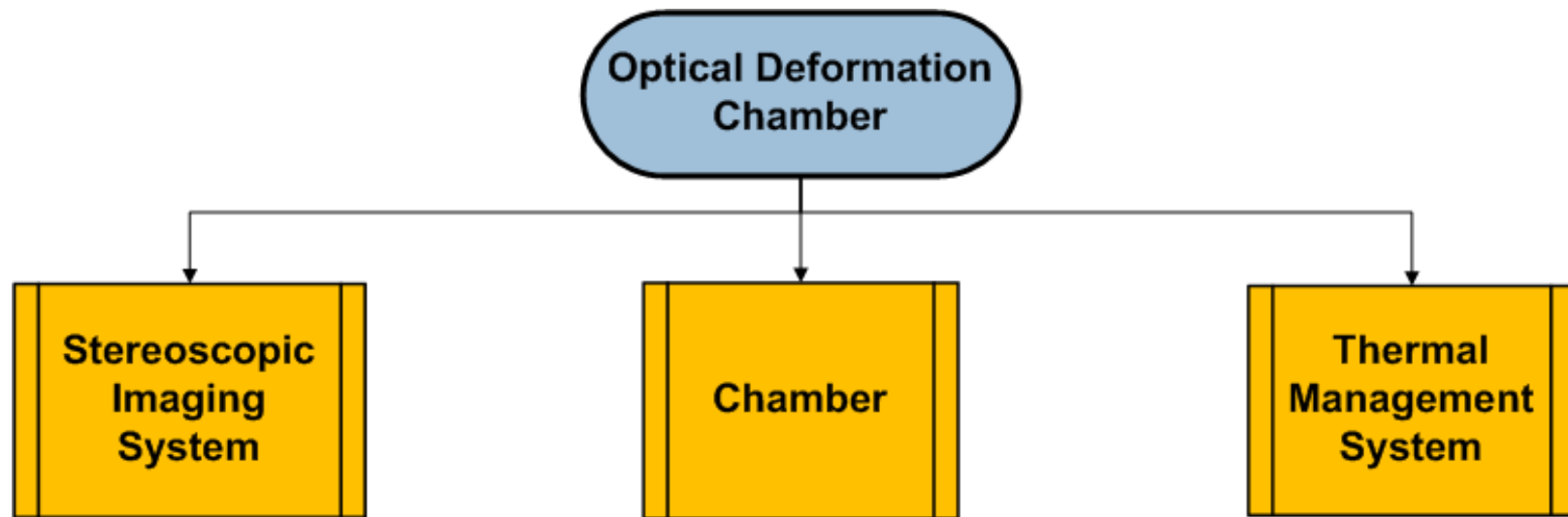
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Full 3D and 2D Characterization

Outline

- **Optical Deformation Chamber Setup**
  - **Chamber Design**
  - **Temperature Cycling System**
  - **Machine Vision Components**
- DIC Method
  - Calibration
  - Image Acquisition
  - Analysis
- Device Testing
  - Thermal Verification
  - Deformation and Strain Analysis
- Concluding Remarks

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Optical Deformation Chamber

Optical Deformation Chamber

- **Stereoscopic Imaging System**
- **Chamber**
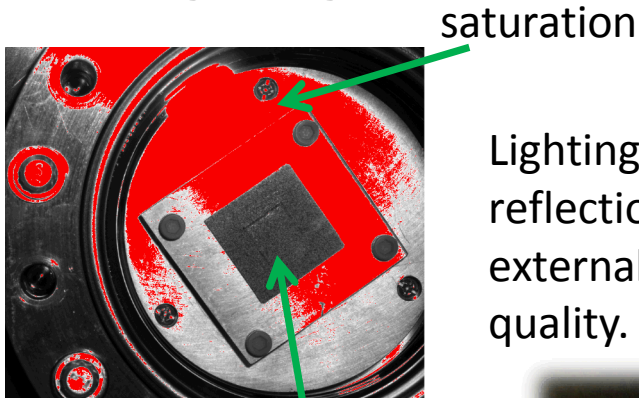- **Thermal Management System**

Controlled imaging environment
-Eliminate external lighting variation
-Minimize internally reflected light
-Uniform illumination

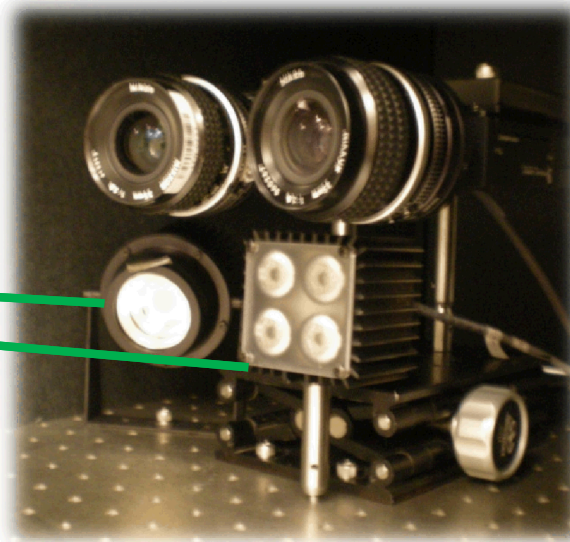Flexible and easy device setup

-55°C to 125 °C Device Temp

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Machine Vision System

Lighting

saturation

Diffuse

Lighting selection, minimizing reflections and eliminating external lighting enhance image quality.

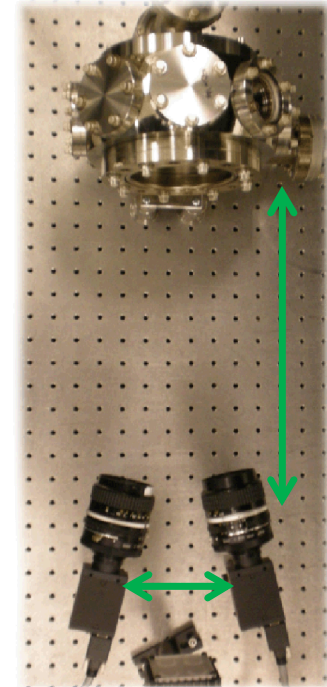Multiple White LED light sources

Imaging Software

Vic3D from Correlated Solutions was selected due to its simplicity and ease of use.

Stereoscopic Cameras

Extrinsic parameters define camera orientation.

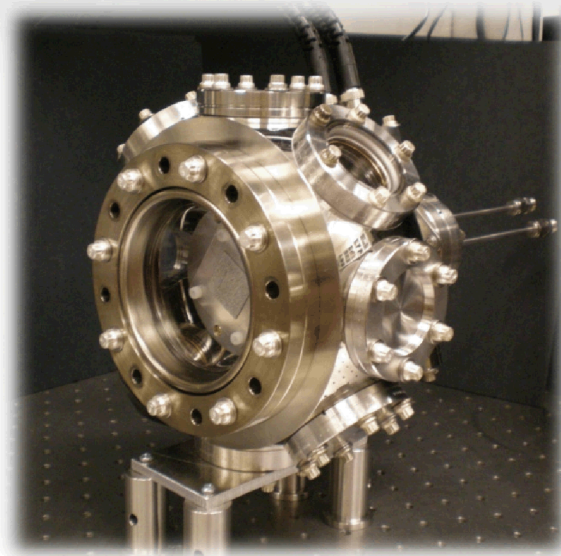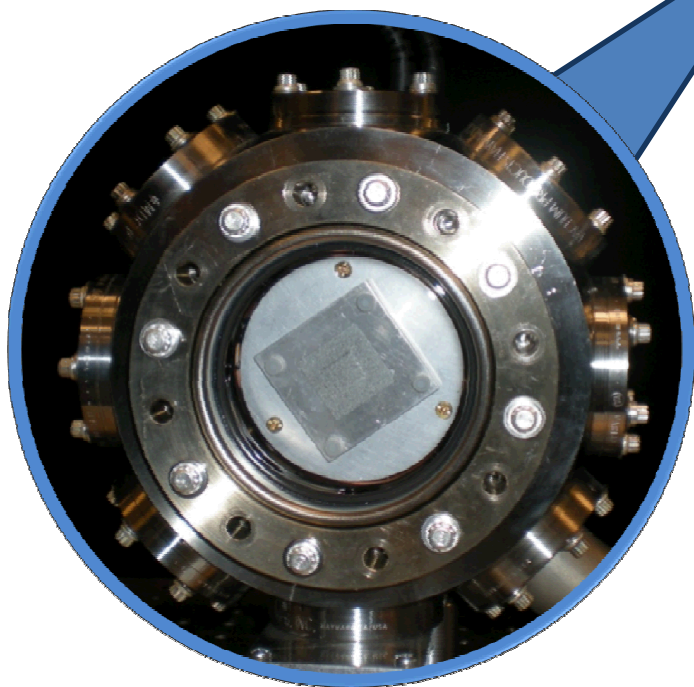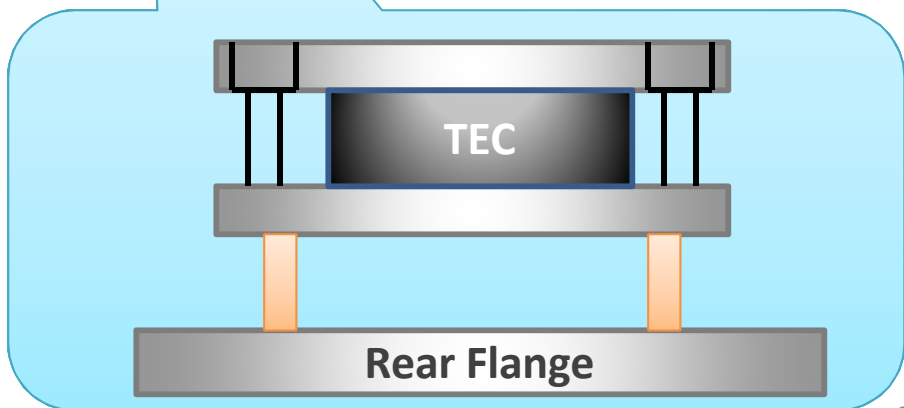Intrinsic parameters define image point to camera reference frame.

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Chamber Design

Components of the chamber
1-Viewing Window
2-Rear flange
3-Mounting plate

Thermal Management Design

TEC

Rear Flange

The thermoelectric device provides easy integration into the chamber.
Flat mounting plate is used for the device under test (DUT).

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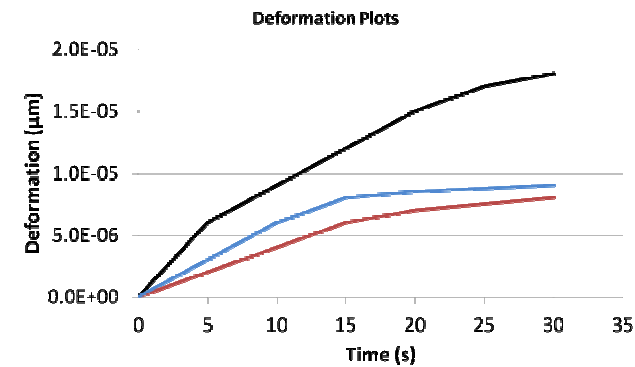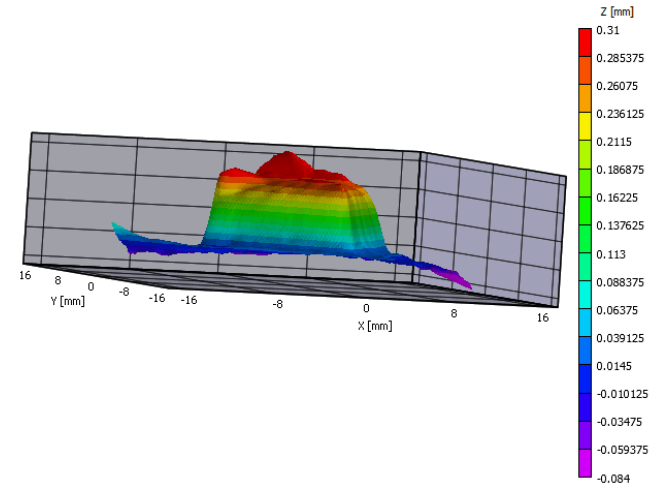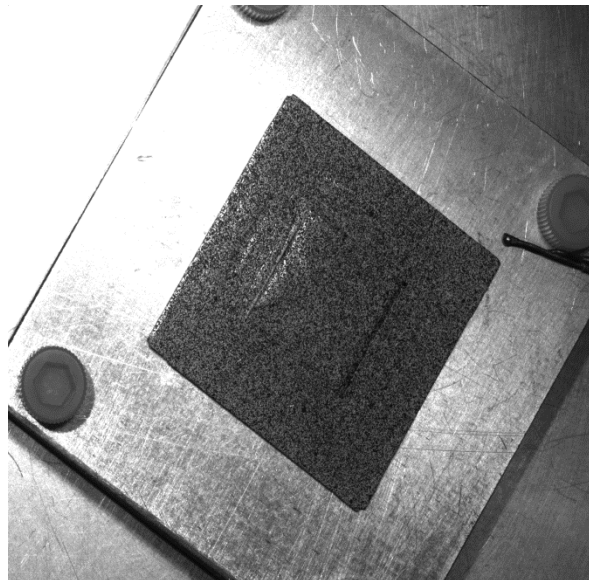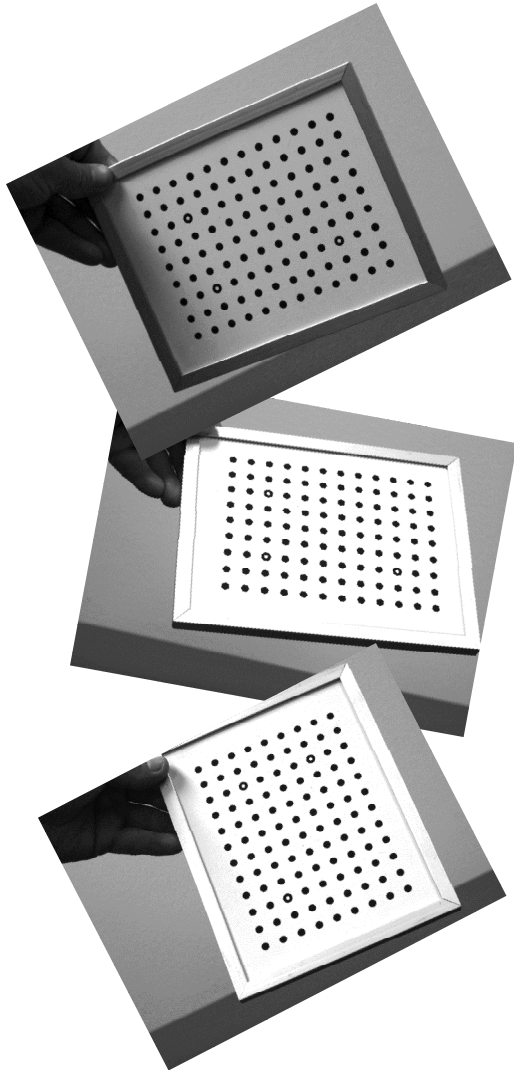
- Concluding Remarks

DIC Method

Calibration

Translation of target grid determines intrinsic properties of imaging setup.

Image Acquisition

Calibration ➡ **Image Acquisition** ➡ Analysis
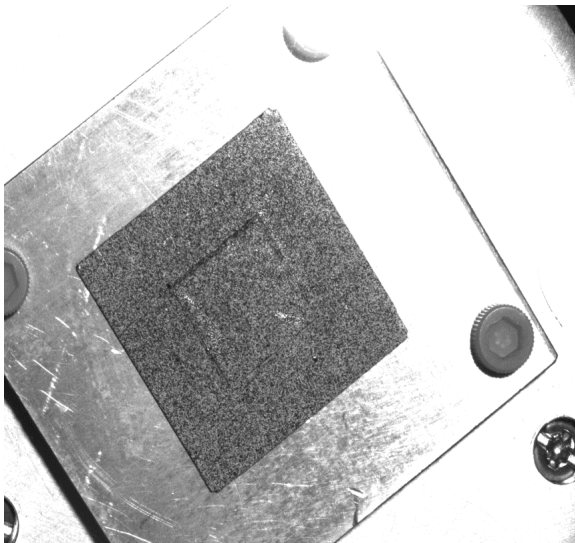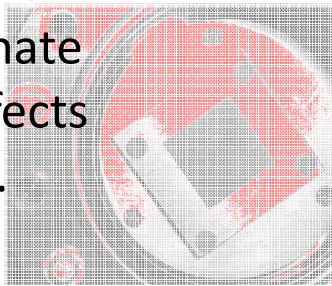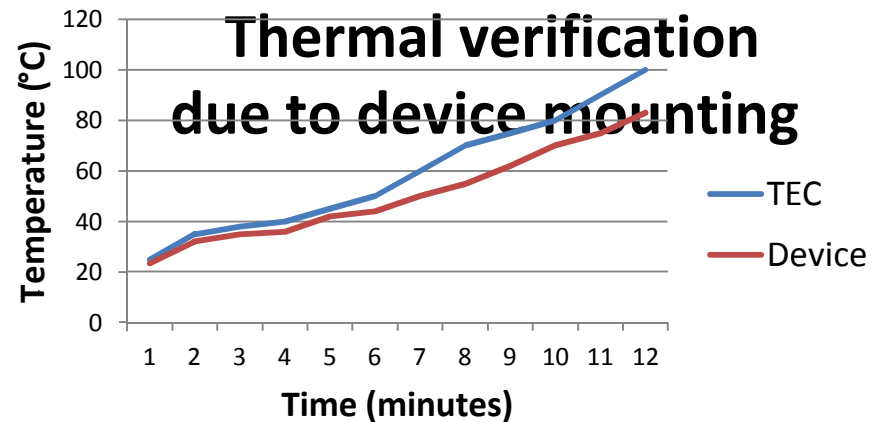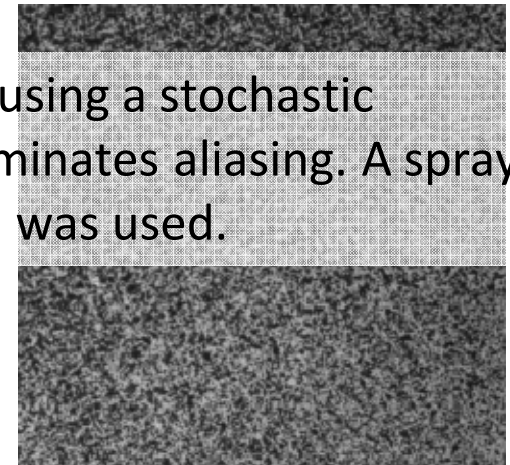
Final lighting adjustment can sometimes eliminate unwanted lighting effects and aid in calibration.
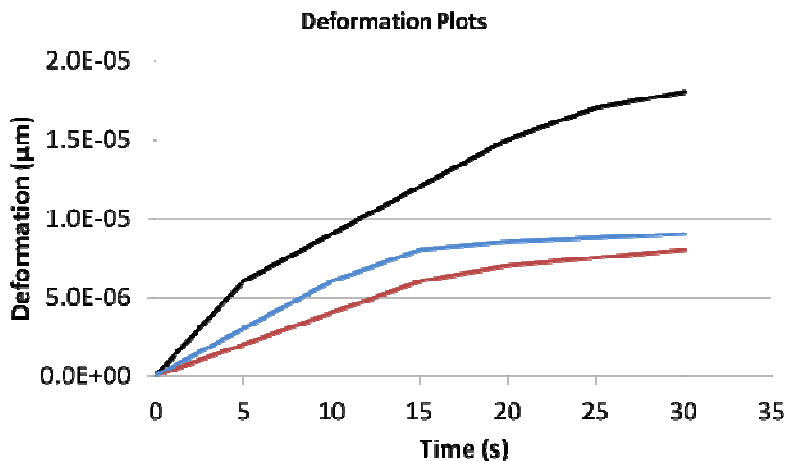
Device Temperature Profile

Thermal verification due to device mounting

Speckling using a stochastic pattern eliminates aliasing. A spray application was used.

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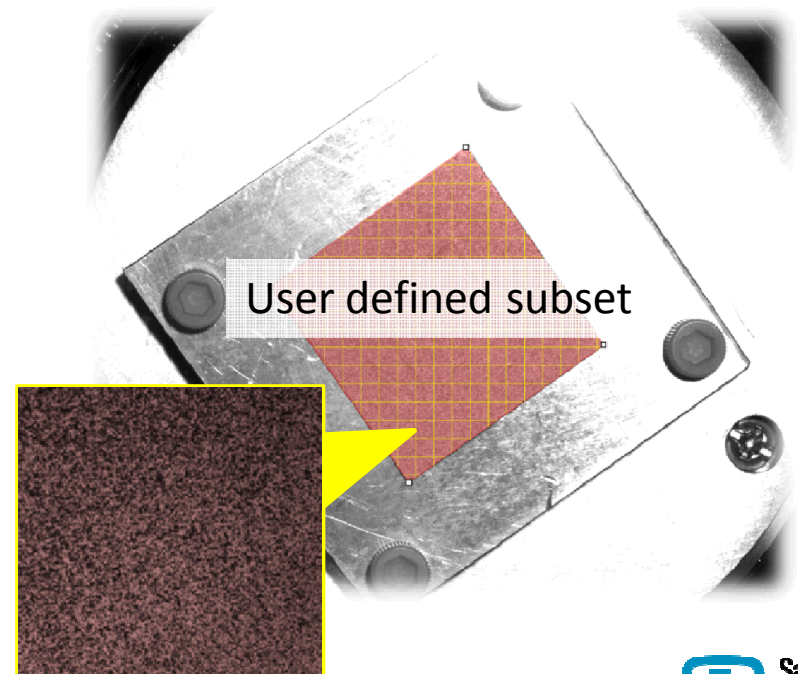
Post Process /Analysis

Calibration ➡ Image Acquisition ➡ Analysis

- ## Deformation measurement on an object surface.

- ## Monitors grey values "speckle pattern" for user defined subset.

Deformation Plots

User defined subset
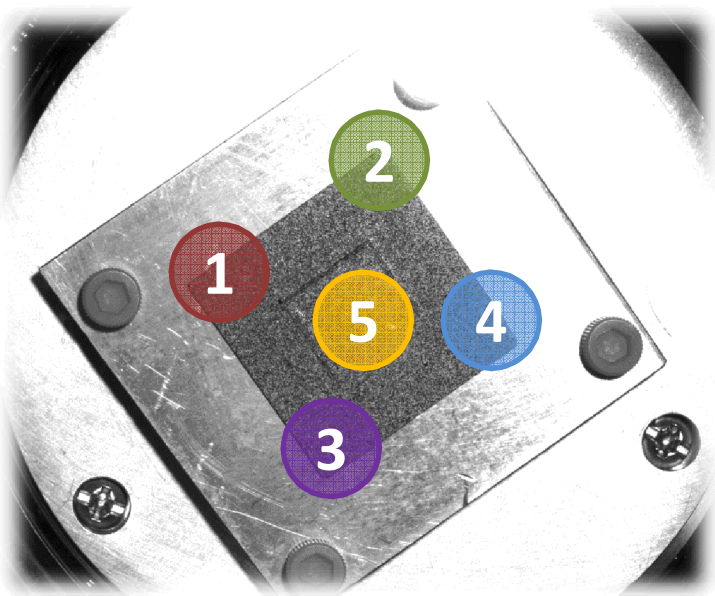
Update plot ^

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Outline
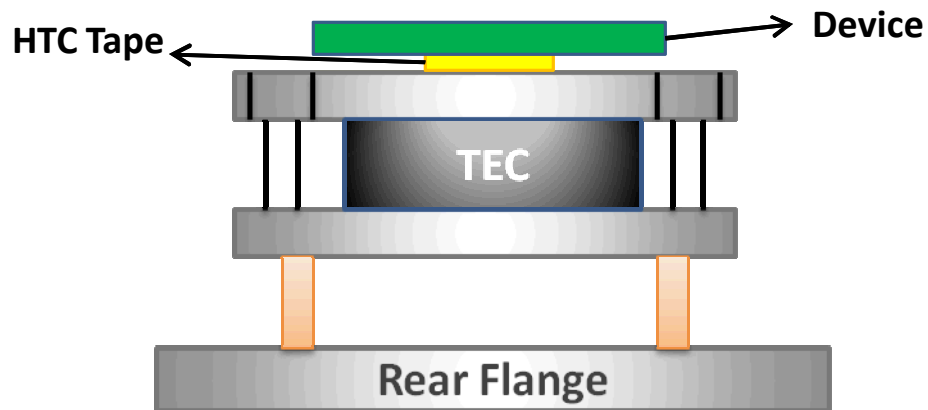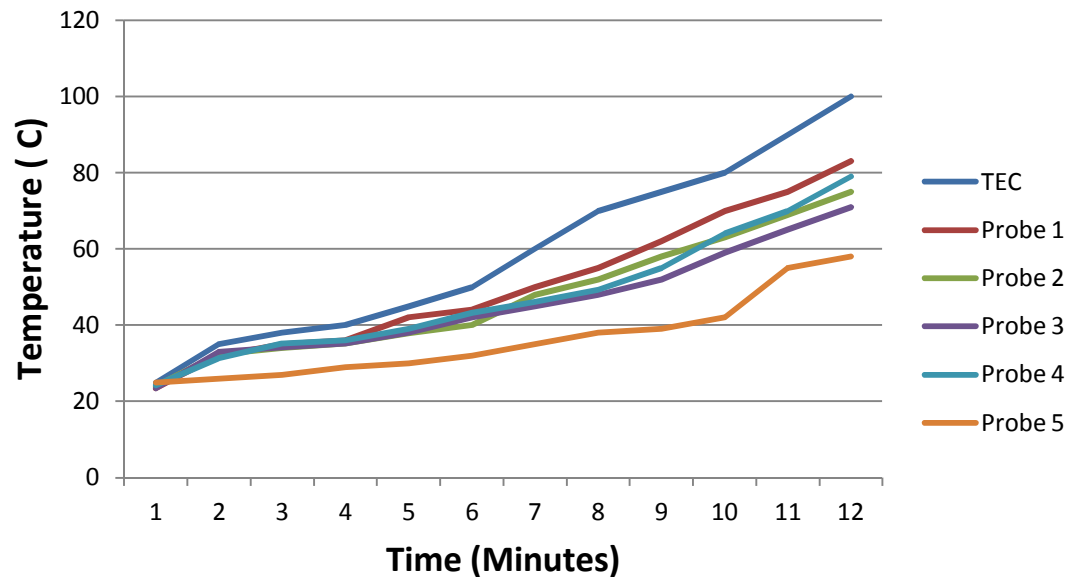
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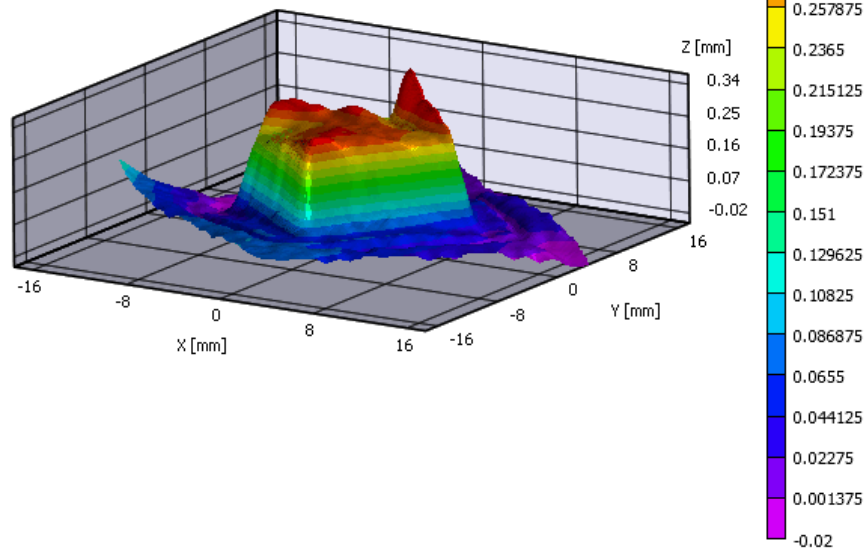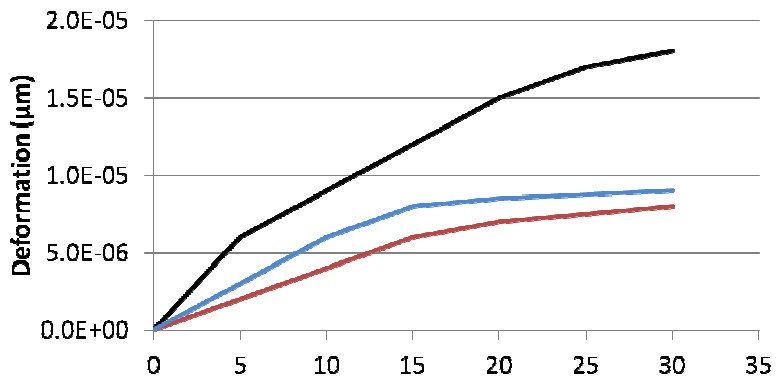- **Concluding Remarks**

Thermal Verification

Device Temperature Verification

Thermocouples readings at points of interest (1-5).

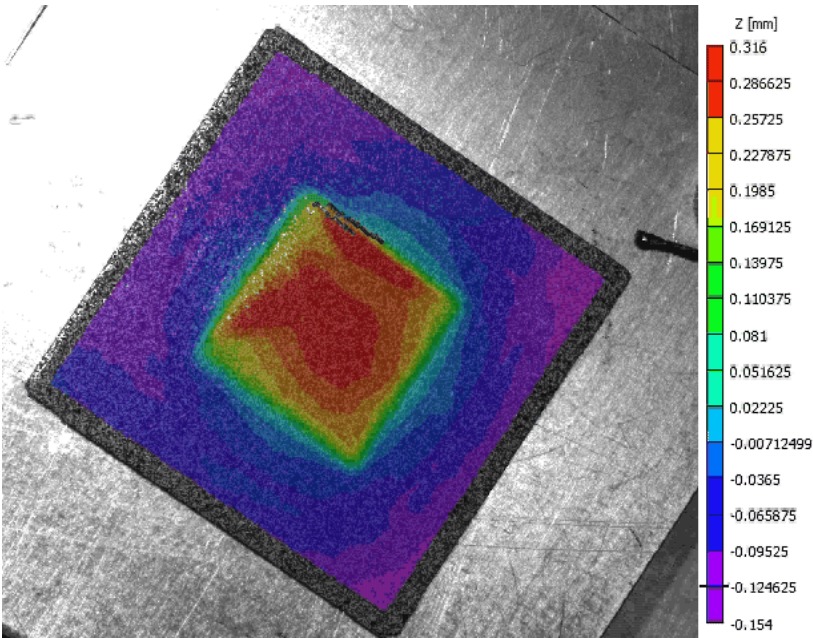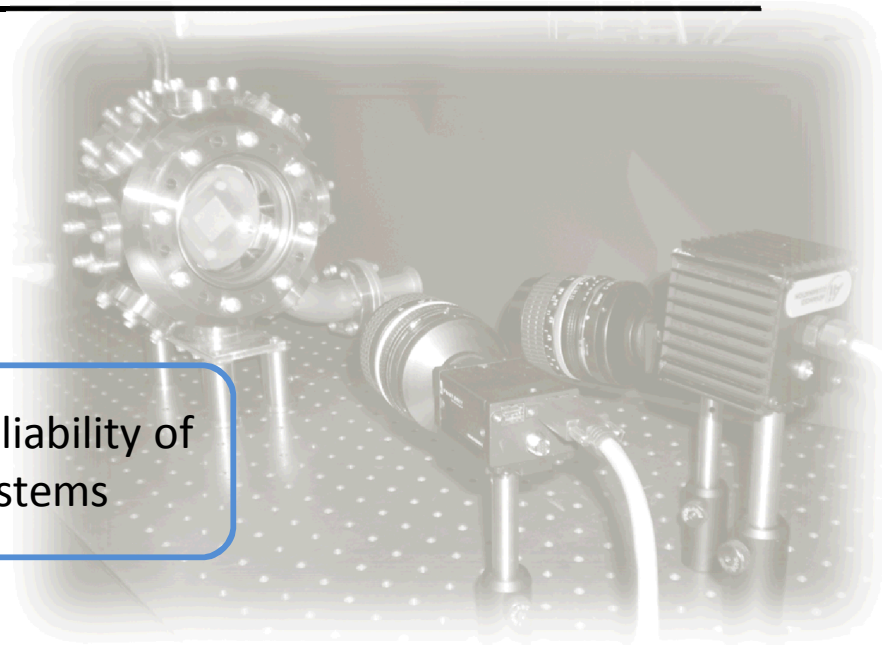# Deformation Analysis

Concluding Remarks

Thermal Induced Deformation Characterization

Structural Model Validation

Enhanced reliability of microsystems

Z [mm]
0.316
0.286625
0.25725
0.227875
0.1985
0.169125
0.13975
0.110375
0.081
0.051625
0.02225
-0.00712499
-0.0365
-0.065875
-0.09525
-0.124625
-0.154

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