3D and 2D Deformation Measurements using Digital Image Correlation System

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What is the DIC?

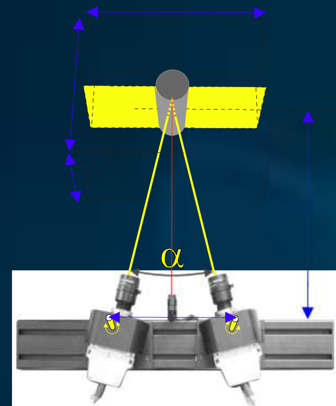
1. Digital Image Correlation System (DIC) :
- To measure both In-plane and Out of plane Deformation induced by thermal or mechanical loading.

2. Advantages of DIC :
- Many applications
  - *Warpage measurement*
  - *Modulus and Poisson's Ratio*
  - *Coefficient of Thermal Expansion (CTE)*
- Availability of Measurement as a function of Temperature
- High sensitivity - 10x8 mm of field of view → 0.3 Microns
  - 100x80 mm of field of view → 3 Microns
- User Friendly

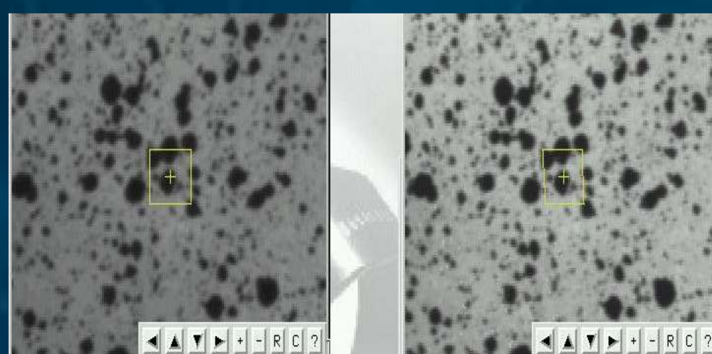
Principle / Methodology

DIC system Configuration

Camera Bar set up

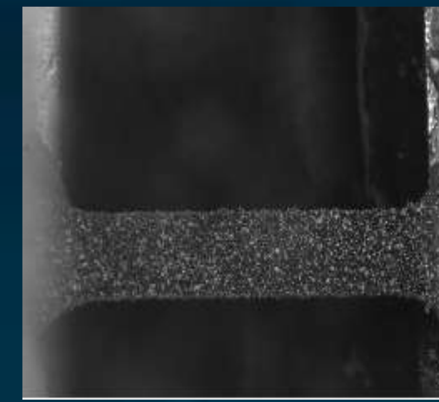


Facet on the sample



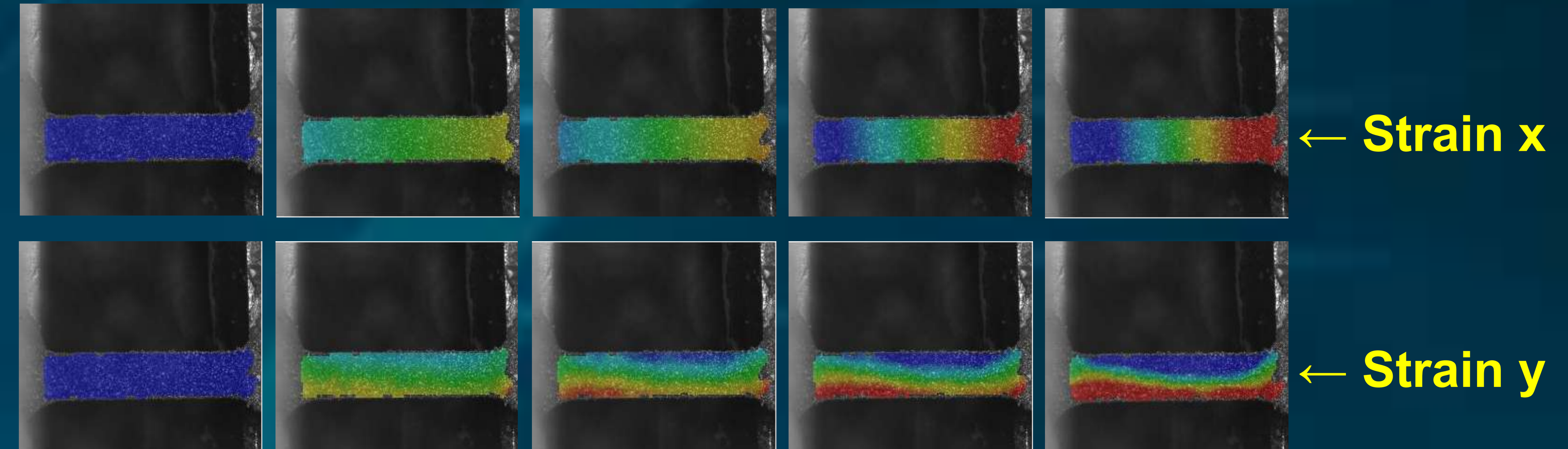
- A pair of cameras capture images and build 3D shape
- Determine deformations and strain by tracking changes of facets
- 3D Image Correlation
  - 3D Coordinates of Facets
  - Each Facet is recognized as an extensometer
    → Measure changes of center of facet and interpolate
    → Compare a reference image to a series of deformed image

Modulus and Poisson's Ratio Measurement

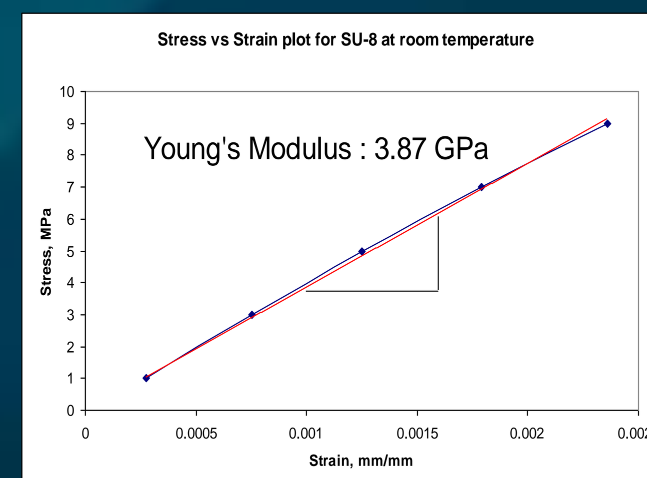


← Sprayed SU-8 material is horizontally mounted on the Micro Tensile Tester and DIC is placed to take images while mechanical loading (pulling) is applied.

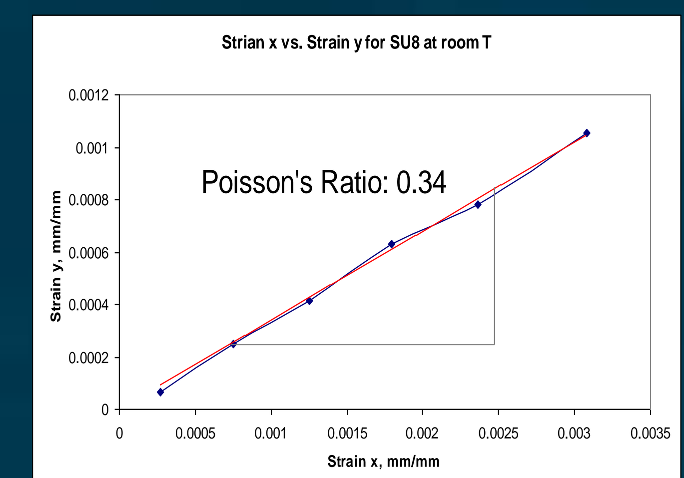
Deformed image series in horizontal (x) and vertical (y) direction



Unloading → *Maximum loading*

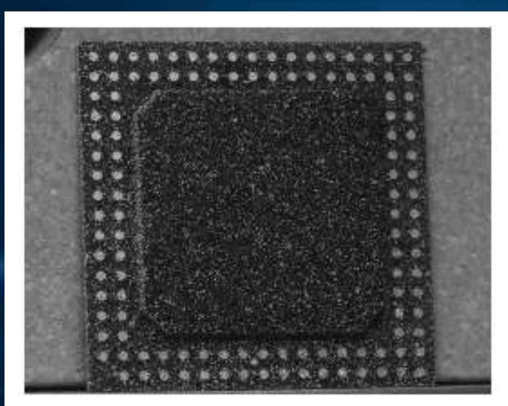


Young's Modulus
$E = \sigma/\varepsilon_x$



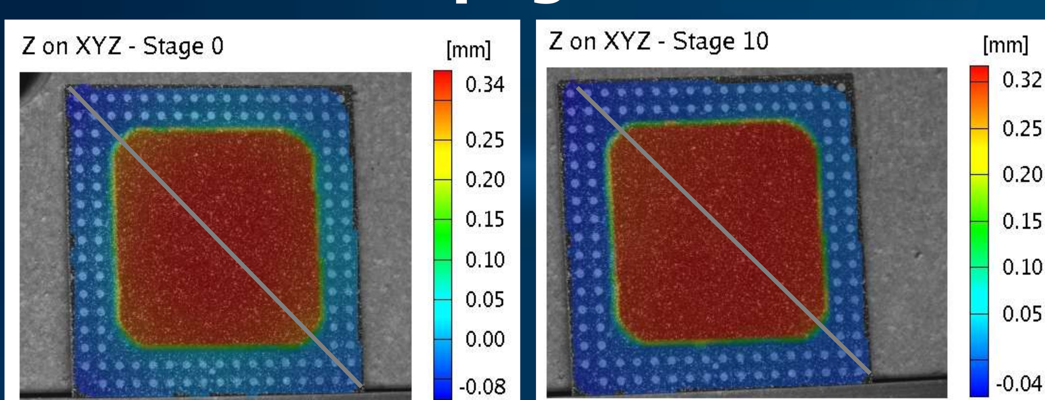
Poisson's Ratio
$\nu = \varepsilon_y / \varepsilon_x$

Warpage Measurement

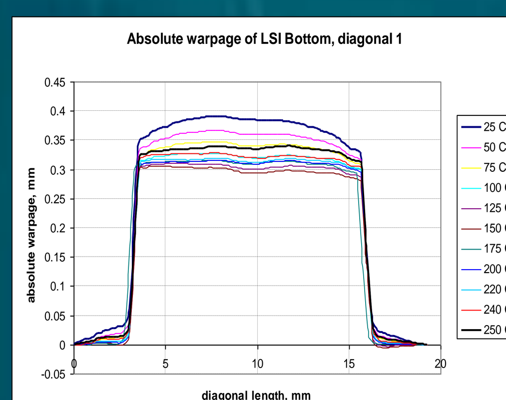


Top surface of bottom LSI package sprayed to provide enough contrast for DIC before the measurement

• Absolute Warpage

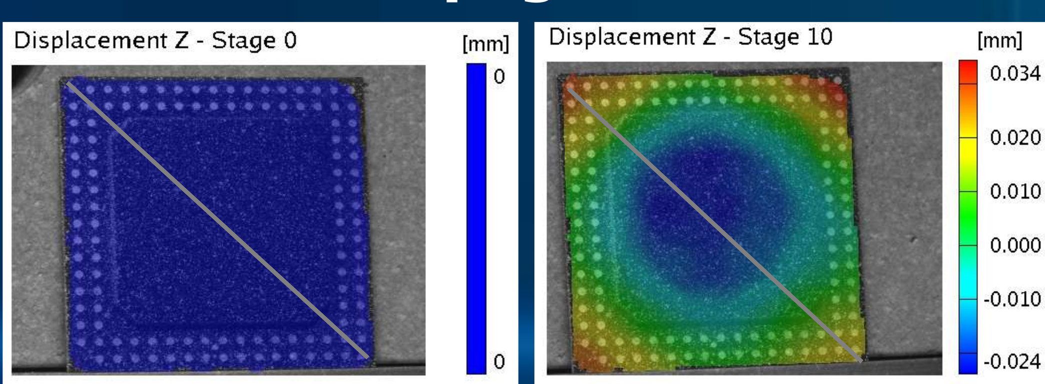


At 25°C At 250°C



Warpage diagram at various temperature

• Relative Warpage



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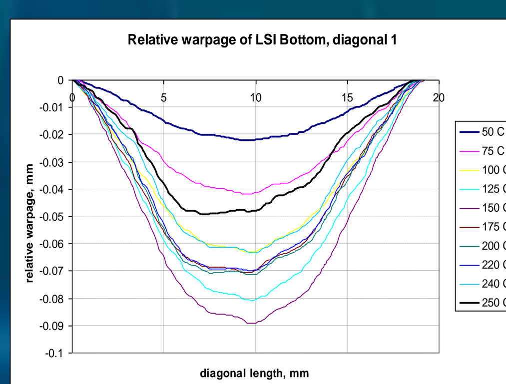
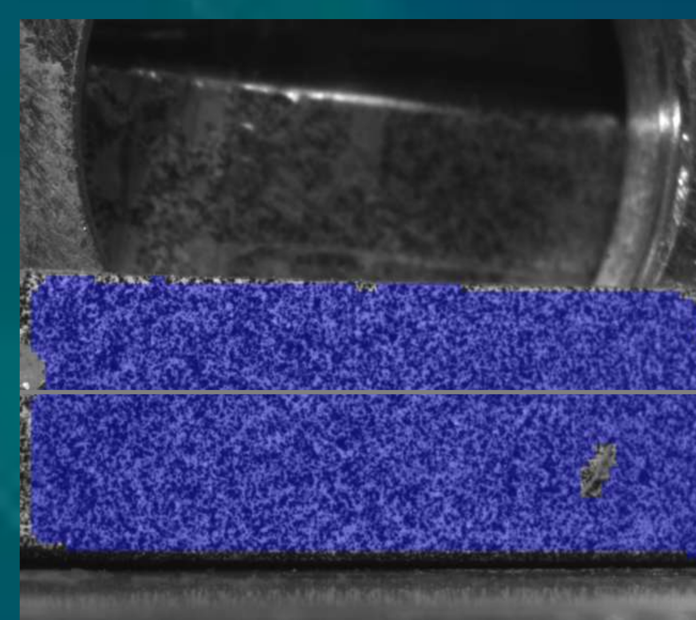


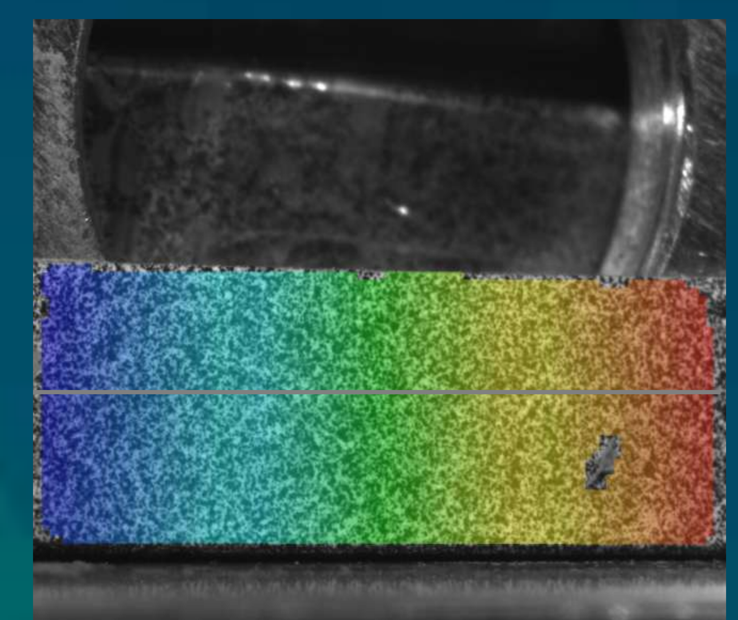
The LSI sample is warped away from the view up to 150°C then it started to warp coming toward at higher temperatures.

CTE Measurement

Die attachment material named AB8290 is free-heated from room temperature to 175°C.

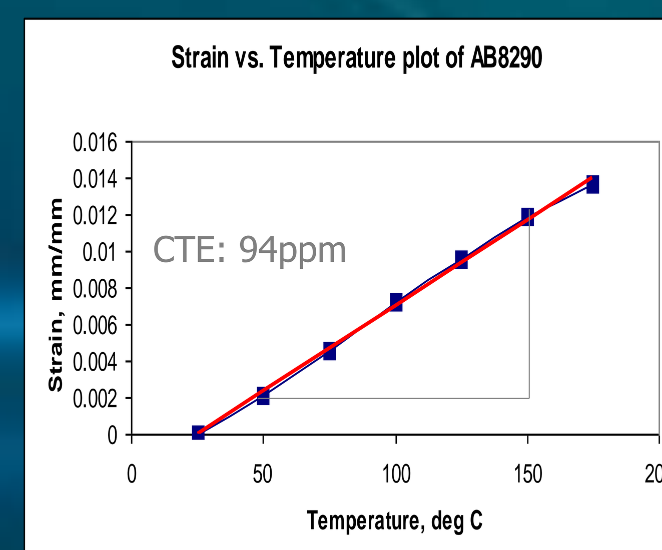


At 25°C



At 175°C

Strain vs. Temperature plot can be obtained so that CTE value is determined by linear curve fitting.



Coefficient of Thermal Expansion
$\alpha = \varepsilon_x / \Delta T$

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