DIGITAL IMAGE CORRELATION CALIBRATION FOR HIGH DEFORMATION

UNIVERSITY OF DELAWARE | CENTER FOR COMPOSITE MATERIALS

Nicholas Duncan (BSME)[1], Loren Tomlin (MSME)[1], Dr. Thomas A. Cender[1,2], Prof. Suresh G. Advani, Ph.D.[1,2]
University of Delaware | Center for Composite Materials[1] | Department of Mechanical Engineering[2]

Introduction

- Material behavior in deformation is often experimentally evaluated in a mechanical test frame
- Digital Image Correlation (DIC) is a useful analysis method to describe and quantify deformation
- Changes in images are tracked optically to measure displacements to compute strains
- Materials formability can be quantified by level of uniform strain achieved of a tested sample using DIC

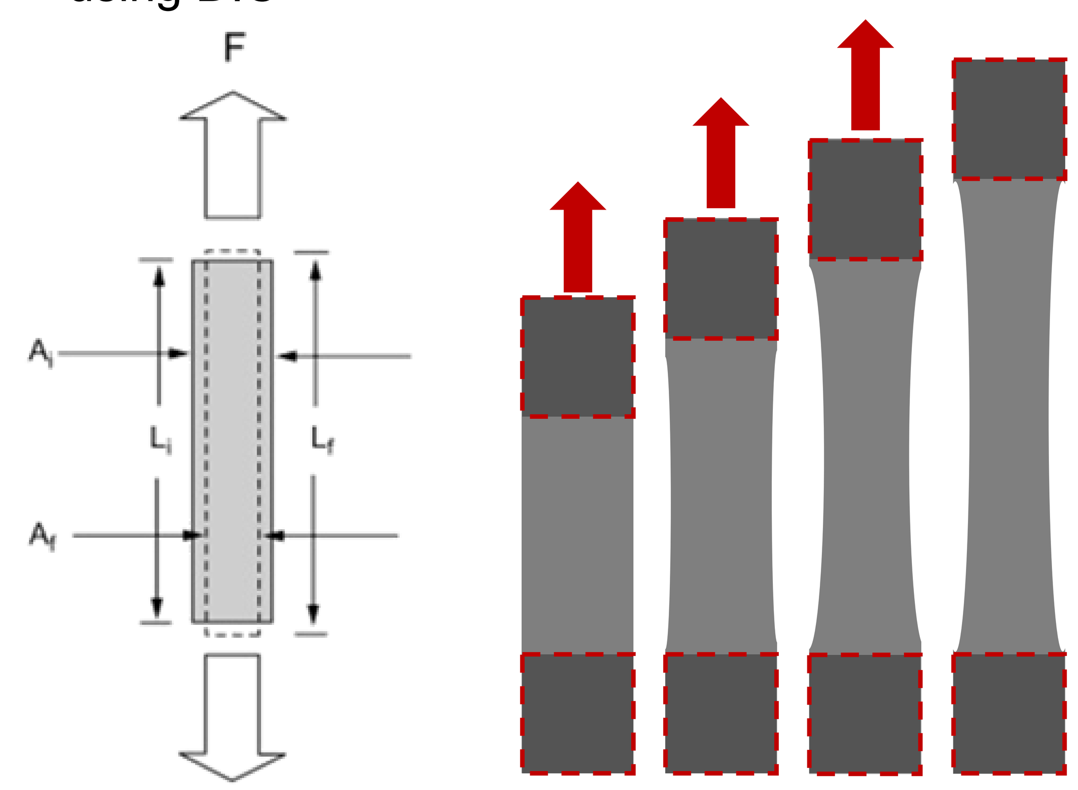

Figure 1: (left) Extension test schematic. (right) Sample coupon extension testing

- For a specific tensile testing methodology, samples of material are tested under true strain control using an Instron Universal Test Machine (UTM)

Goals

1. Validate values of strain calculated with DIC software
   - Cross-check DIC data with parallel measurement to verify value of samples strain
   - Adjust the parameters within the DIC software to better fit the actual strain values calculated

Challenges

- High deformation eliminates the ability to verify strain calculated with DIC by using a strain gauge or extensometer
- Many materials do not strain perfectly uniform, eliminating the ability to verify DIC results with manual measurements

Methodology

Sample Preparation

- Homogeneous A30 silicon is chosen
- Samples are cut to dimensions of 8” x 1”
- A random speckle pattern is applied to samples using Edding 751 paint marker for DIC processing
- G10 fiberglass end tabs L = 2.25 are used making the gauge length 3.5”

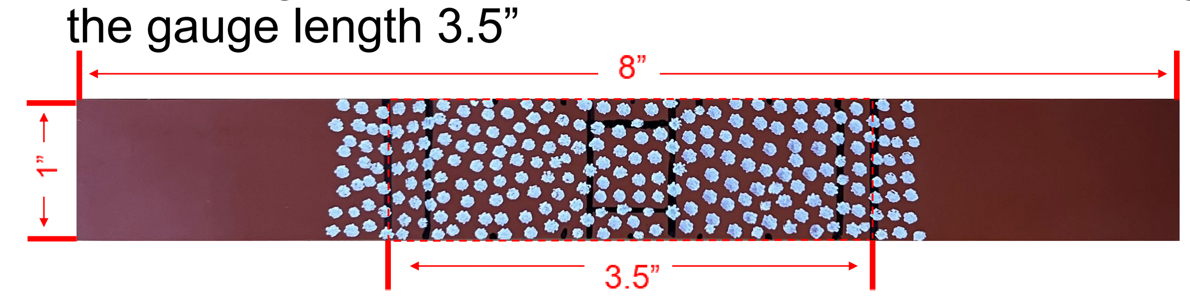

Figure 2: Prepared silicone sample

Uniaxial Extension Testing

- Instron 4484 is used for samples where process conditions can be controlled ($\dot{\varepsilon}_L$, T)

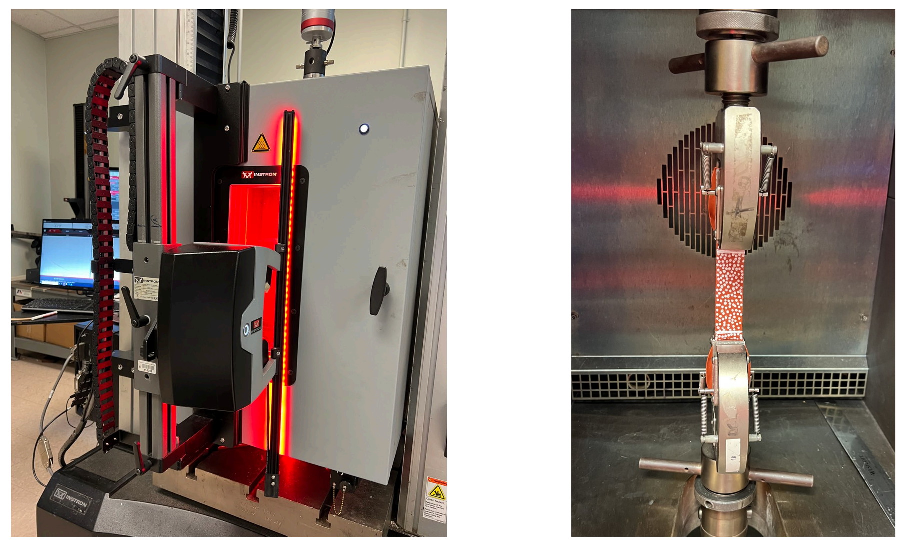

Figure 3: (left) Instron 4484 with environmental chamber and mounted video extensometer. (right) Sample setup inside Instron chamber

Digital Image Correlation

- Single video extensometer used to image samples
- DIC software averages strain in a selected region

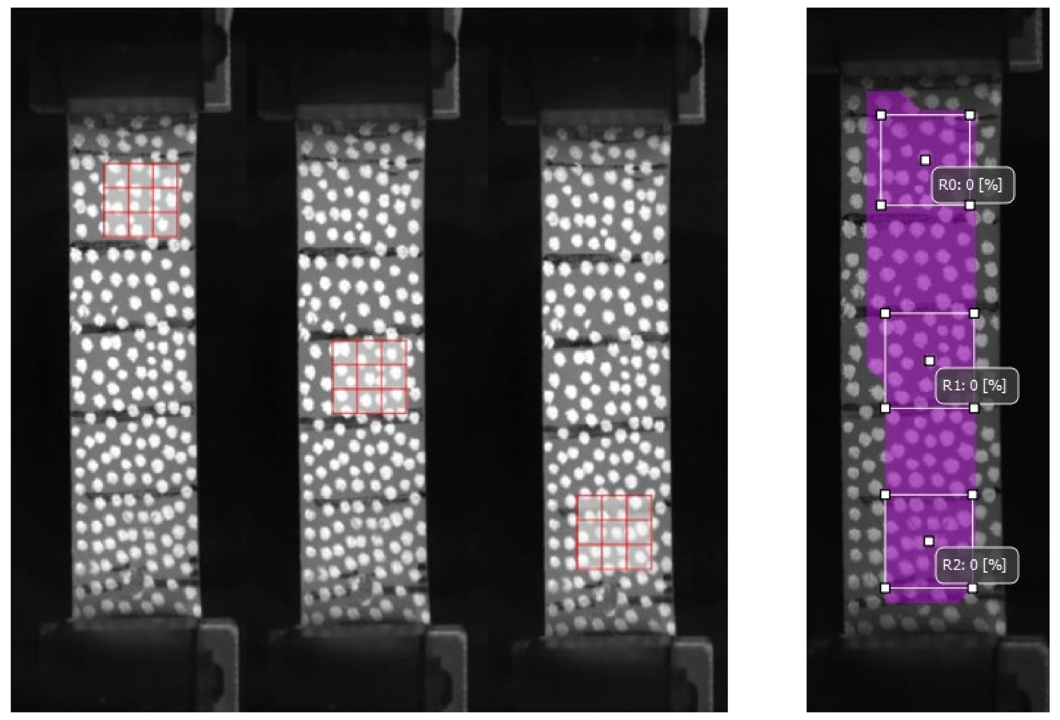

Figure 4: (left) Instron DIC software strain regions for quantitative analysis at 3 sample locations. (right) Vic - 2D DIC software strain regions

DIC Strain Validation

- DIC results are validated with manual measurements
- Set of lines 3” apart about center, and three boxes (top, middle, bottom) are applied to samples to manually measure strain by length change
- All line separation lengths were measured as well as the sample thickness and width at 6 locations
- Sample test was stopped at 5 different true strains (0.1, 0.2, 0.3, 0.4, 0.5) to take manual measurements

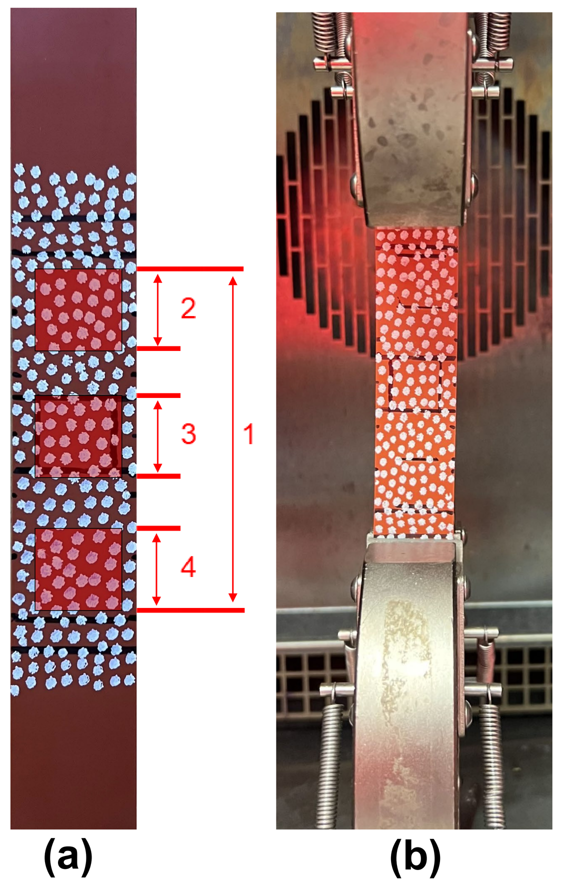

Figure 5: (a) Silicone sample with pattern and all strain regions **(b)** Silicone in grips - ready to test

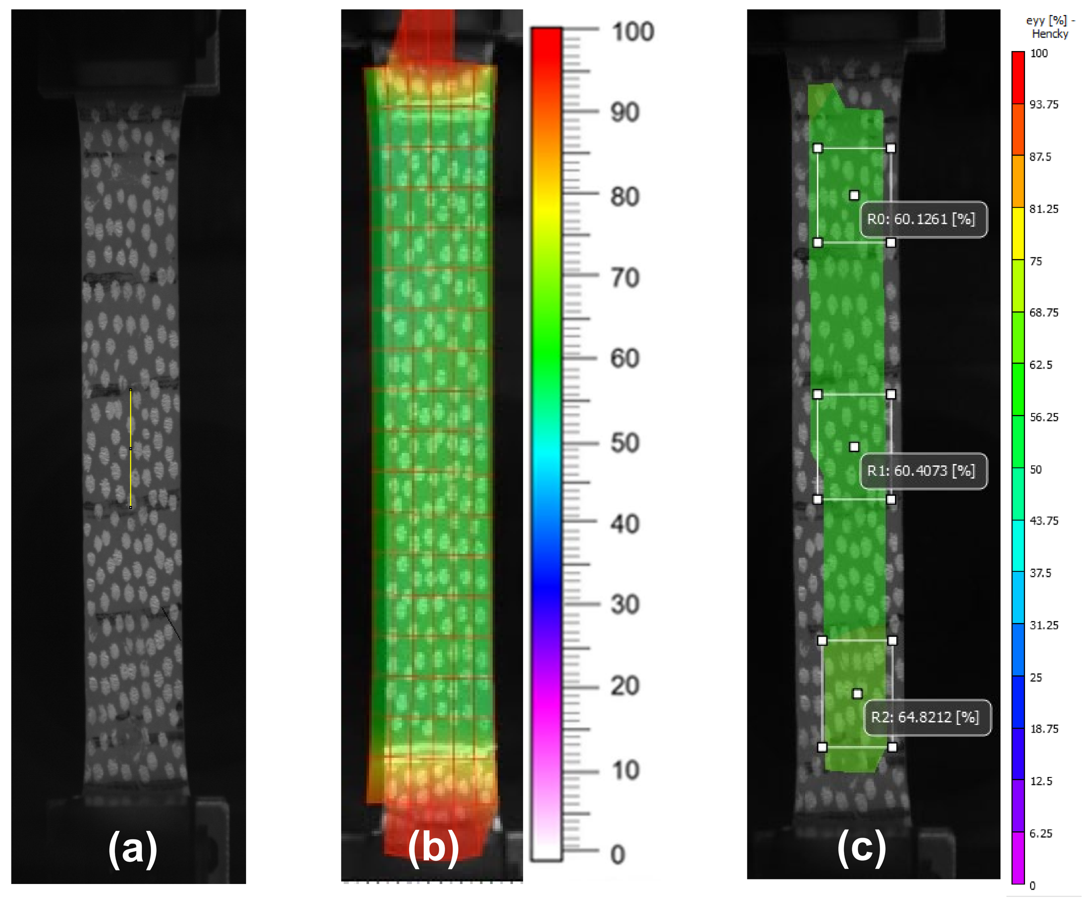

Figure 6: Silicone sample fully strained at 0.50 true strain (65% engineering) **(a)** Sample strain measured manually. **(b)** Strain measured by the Instron DIC software **(c)** Strain measured in VIC-2D software

Results

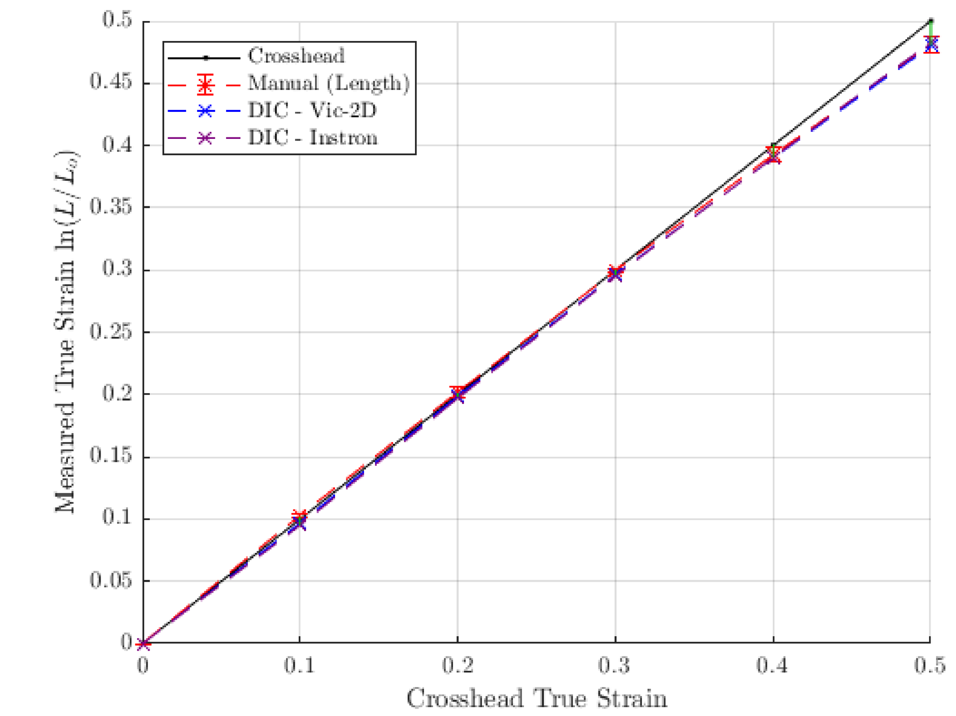

Figure 7: Measured true strain of different analysis techniques compared to true strain baseline from crosshead

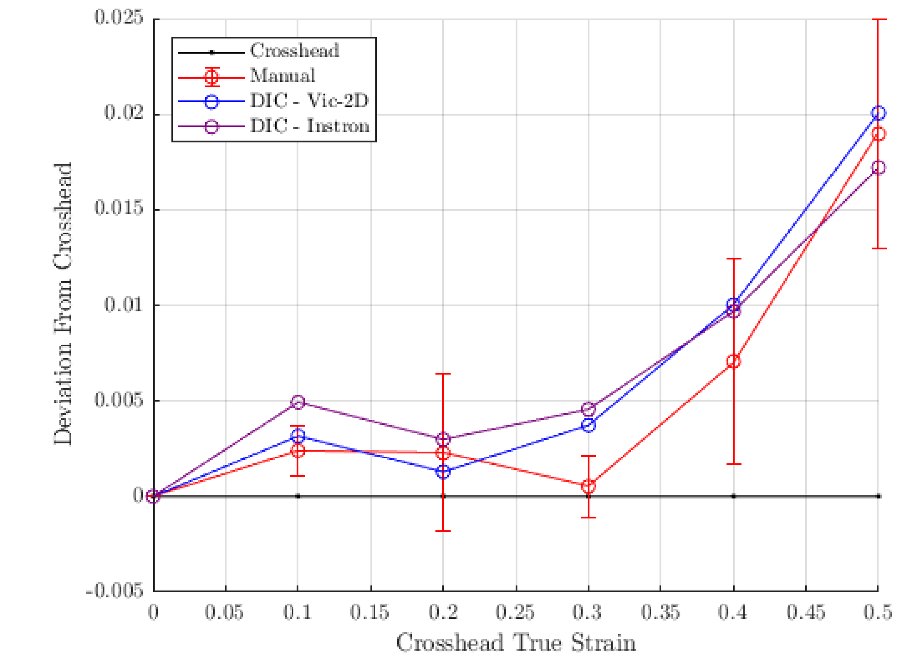

Figure 8: Plot of the deviation of different analysis techniques from the crosshead

- Figure 7 illustrates the differences in calculated true strain between the Instron DIC software the VIC 2D software and manual measurements
  - DIC can be adjusted to match manual measurements
- Figure 8 reports the deviation from the crosshead. All measurement methods follow the same trend. Results show that with the specified DIC settings, strain is accurate to within 2%

Discussion & Path Forward

- Now have assurance that the values obtained by using DIC are reliable and accurate
- Use data to calibrate DIC software parameters to better fit the manual measurement curve
- Develop better manual measurement techniques to reduce error propagation
- Use to test the repeatability of the forming process to investigate possible sources of variability aside from silicone material