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**4. TITLE AND SUBTITLE**

Multi-Scale Strain Measurements of a Polymeric Material

**5. AUTHOR(S)**

C.T. Liu

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MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO)


C.T. Liu (AFRL/PRSM) et al., "Multi-Scale Strain Measurements of a Polymeric Material"

2003 SEM Conf: Exprmtl & Appl Mechanics

(Statement A)
Polymeric Material
Measurements of Multi-Scalar Strain
Objectives

- Determine the Displacement and Strain Fields in a Polymeric Material
- Investigate the Local Damage Mechanisms and Failure Behavior near the Crack Tip
Strain Distributions
(2.5mm x 2.0mm)

$\varepsilon_{yy}$ field, Load = 52 grams

$\varepsilon_{xx}$ field, Load = 52 grams
Strain Distributions
(1.2mm x 1.0mm)

\( \epsilon_{yy} \) field, Load = 41 grams

\( \epsilon_{xx} \) field, Load = 41 grams
\( \varepsilon_{yy} \) field, Load = 47 grams  \( \varepsilon_{xx} \) field, Load = 47 grams
Strain Distributions
(0.065mm x 0.055mm)

\( \varepsilon_{yy} \) field, Load = 49 grams

\( \varepsilon_{xx} \) field, Load = 49 grams
Strain Distribution
(0.065mm x 0.055mm)

\[ \varepsilon_{yy} \] field (3-D), Load = 49 grams

\[ \varepsilon_{xx} \] field (3-D), Load = 49 grams
Strain Ratio ($-\varepsilon_{xx}/\varepsilon_{yy}$) Distributions at Different Magnifications

40x "Poisson Ratio" distribution
Average is 0.7913

80x
Average is 0.8047
Strain Ratio ($-\varepsilon_{xx}/\varepsilon_{yy}$) Distributions at Different Magnifications

200x

Average is 0.8558

1500x

Average is 0.1
Side View of Crack Tip at 150x & 400x
Side View of Crack Tip at 500x & 1000x
Crack Tip Top View

07/12/2002
Standard Deviation / Mean of $\varepsilon_{xx}$ Vs. Examined Area

(Standard Deviation) / Mean

Examined Area ($\mu m^2$)
Coefficient of Variation of X-Ray Intensity

Histogram Size and Location

- 2.67 mm Top
- 2.67 mm Middle
- 2.67 mm Bottom
- 0.53 mm Top
- 0.53 mm Middle
- 0.53 mm Bottom
- 0.11 mm Top
- 0.11 mm Middle
- 0.11 mm Bottom
Conclusions

- The strain distributions vary with the size of the area, $A$, in which the data were analyzed.

- When the size of $A$ is smaller or equal to $1.5 \text{ mm} \times 1.5 \text{ mm}$, the nonuniformity of the strain distributions is increased. Especially, when the size of $A$ is equal to $0.065 \text{ mm} \times 0.055 \text{ mm}$, both tensile and compressive strain fields exist in the small area.

- The representative area, which is defined as an area in which the material's microstructure has no significant effect on the strain distribution, of the material considered is $1.5 \text{ mm} \times 1.5 \text{ mm}$.

- A highly damaged region of 20-50 micron long is developed at the crack tip.

- The crack growth mechanism involves voids formation ahead of the crack tip and the coalescence of the main crack tip with the void.