

# REPORT DOCUMENTATION PAGE

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MEMORANDUM FOR PRS (In-House Publication)

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01 May 2003

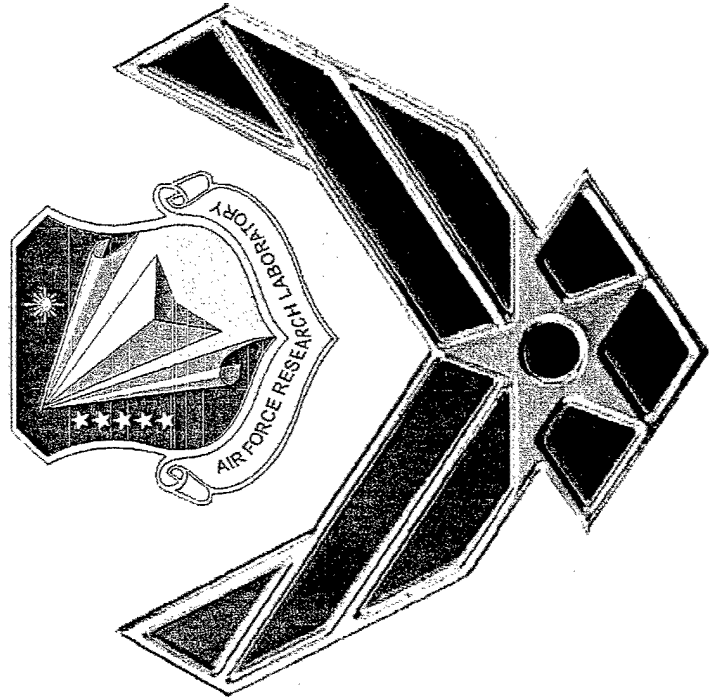
SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2003-117**  
C.T. Liu (AFRL/PRSM) et al., "Multi-Scale Strain Measurements of a Polymeric Material"

5642

**2003 SEM Conf: Exprmtl & Appl Mechanics**  
**(Charlotte, NC, 2-4 June 2003) (Deadline: 25 May 2003)**

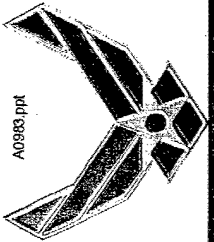
**(Statement A)**

# Multi-Scale Strain Measurements of a Polymeric Material

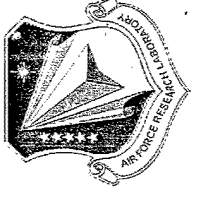


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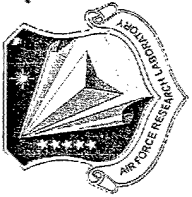
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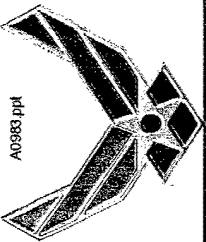
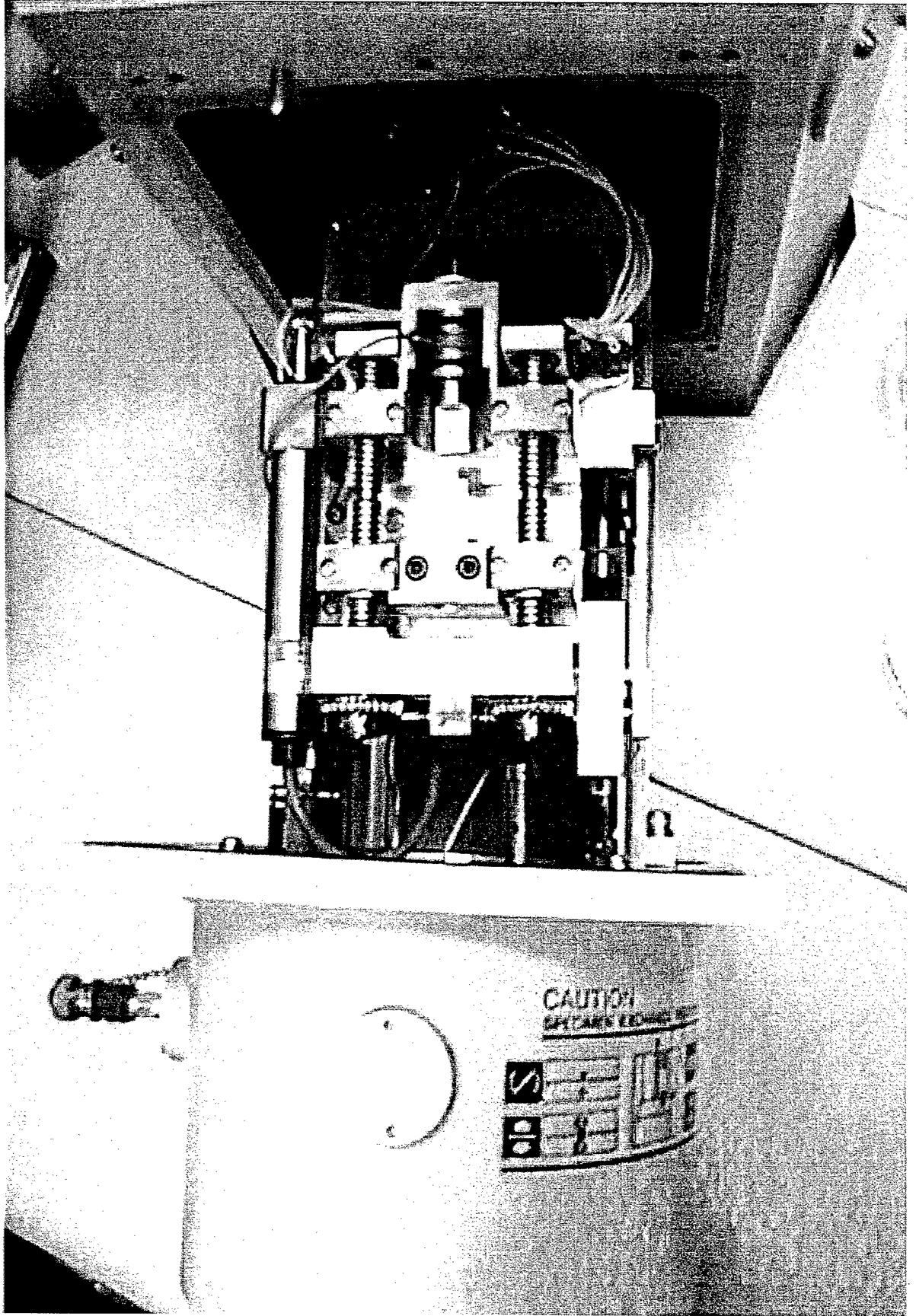
# Objectives

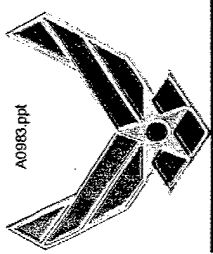


- **Determine the Displacement and Strain Fields in a Polymeric Material**
- **Investigate the Local Damage Mechanisms and Failure Behavior near the Crack Tip**

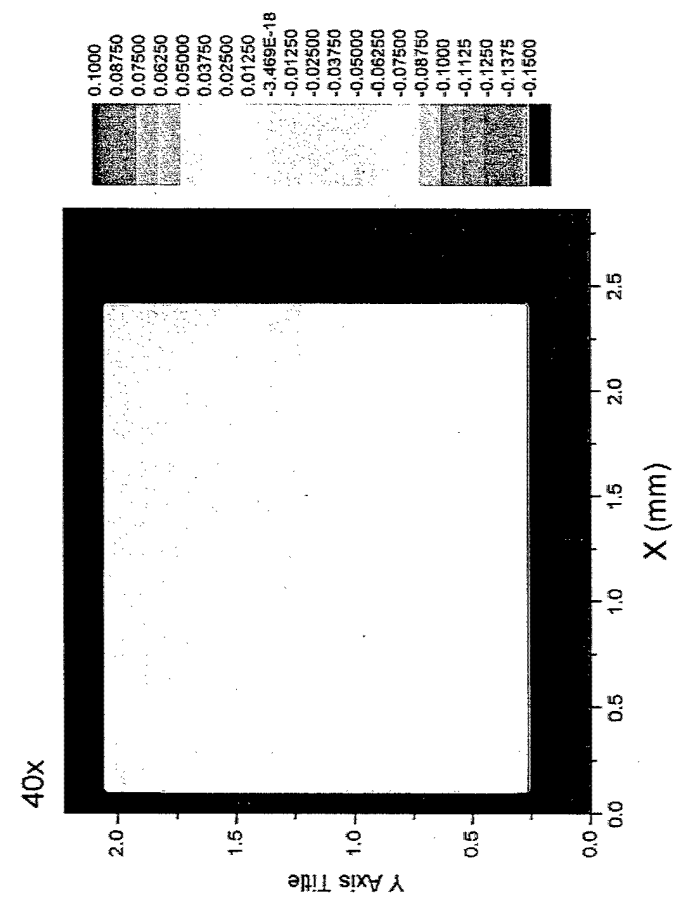
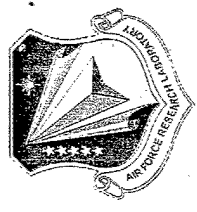


# Testing Set-Up

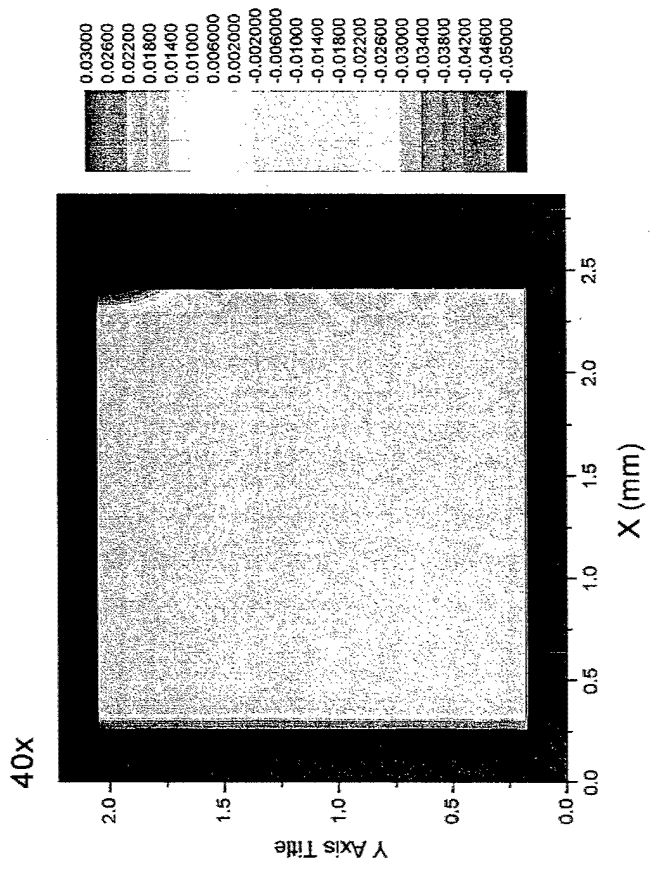




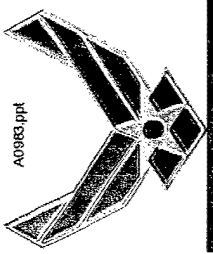
# Strain Distributions (2.5mm x 2.0mm)



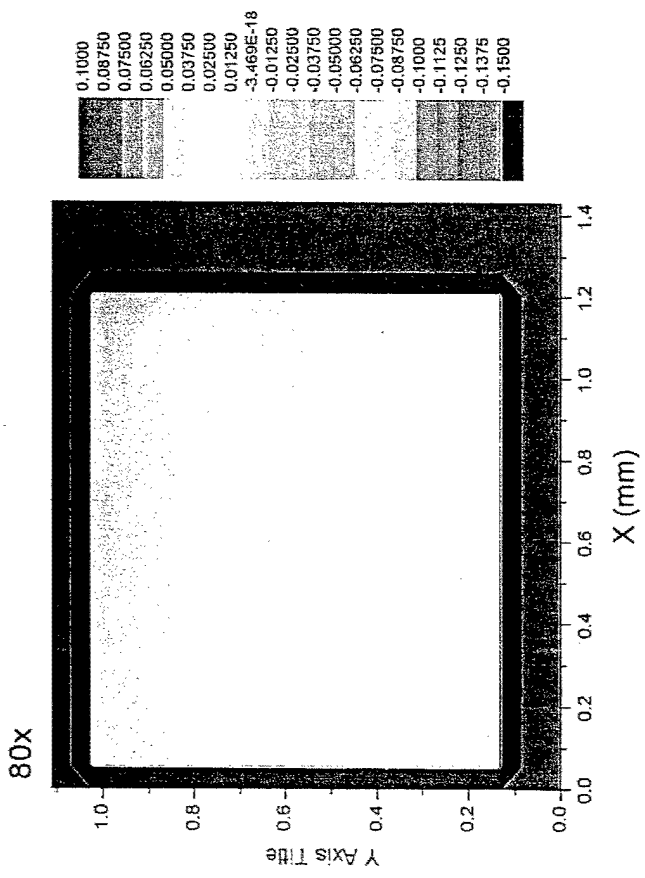
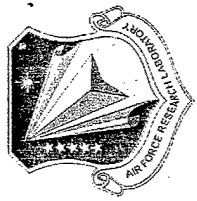
$\epsilon_{yy}$  field, Load = 52 grams



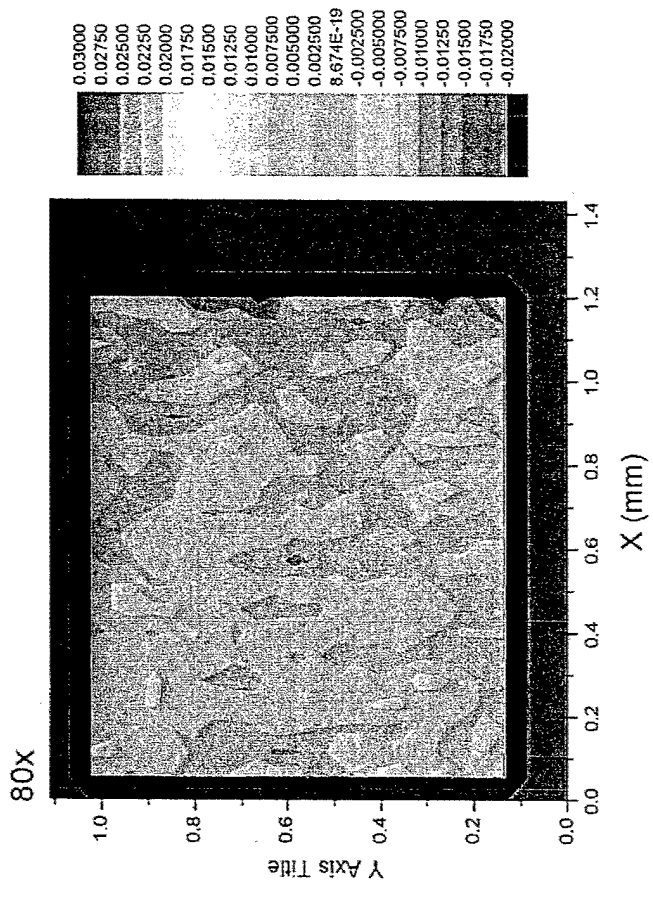
$\epsilon_{xx}$  field, Load = 52 grams



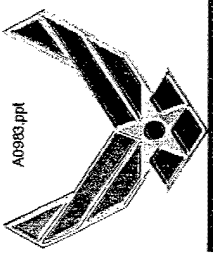
# Strain Distributions (1.2mm x 1.0mm)



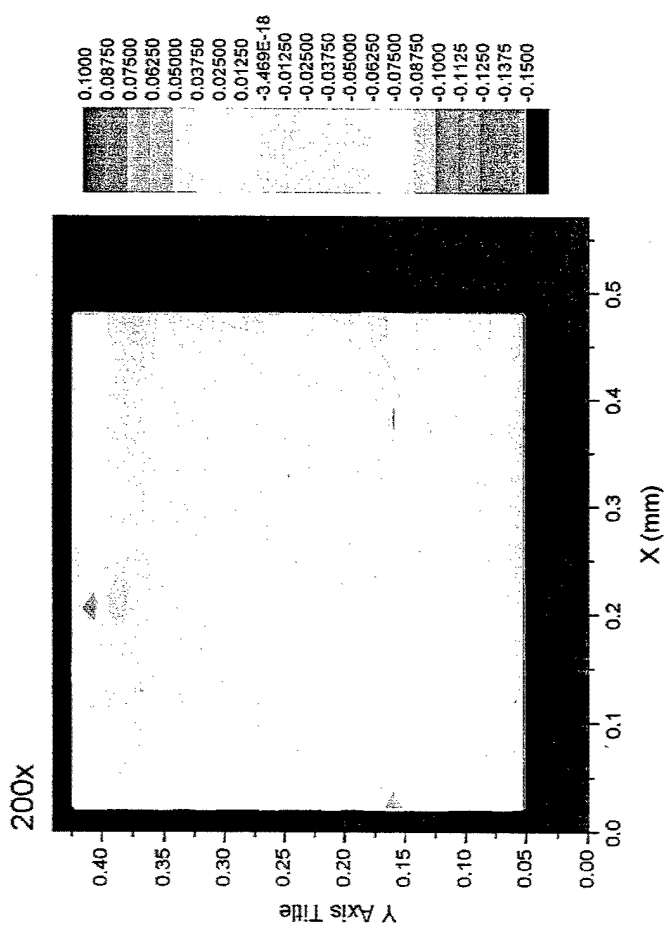
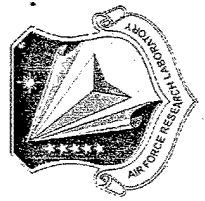
$\epsilon_{yy}$  field, Load = 41 grams



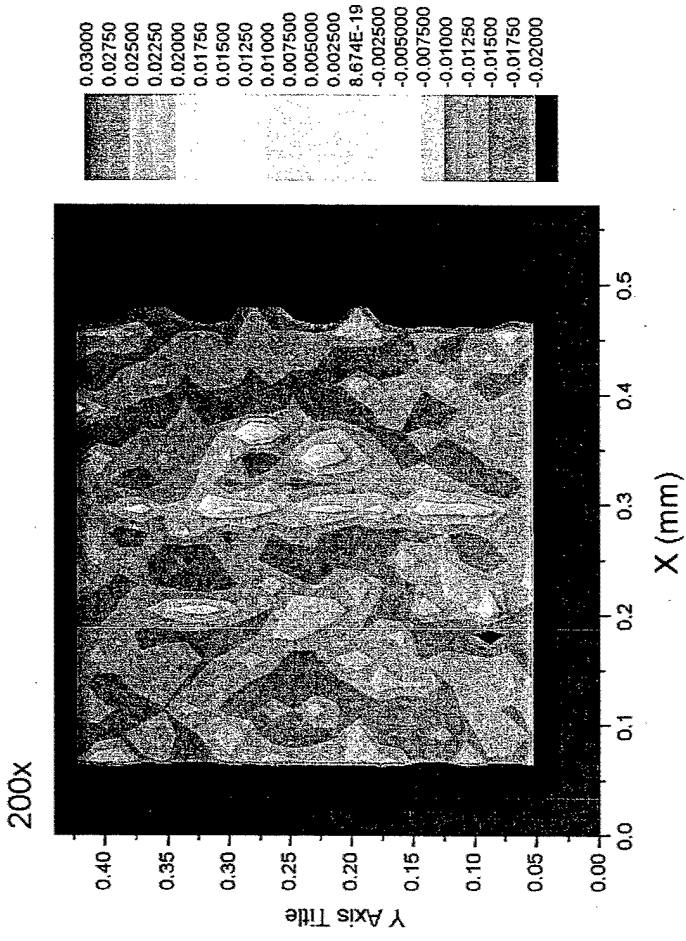
$\epsilon_{xx}$  field, Load = 41 grams



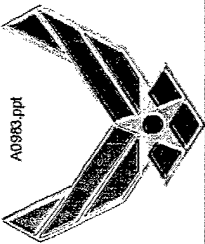
# Strain Distributions (0.5mm x 0.45mm)



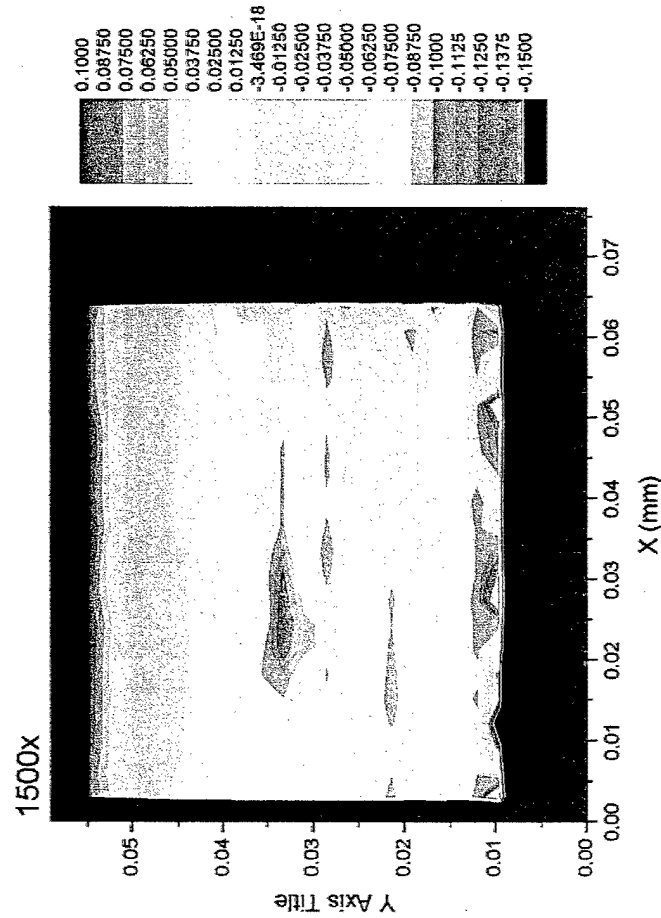
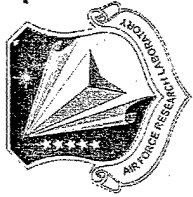
$\epsilon_{yy}$  field, Load = 47 grams



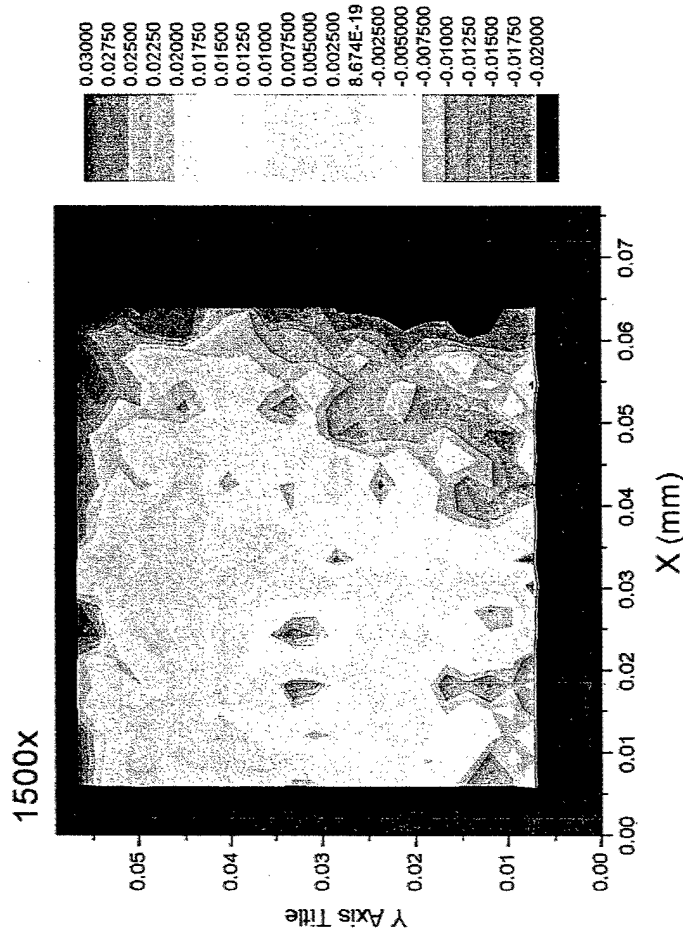
$\epsilon_{xx}$  field, Load = 47 grams



# Strain Distributions (0.065mm x 0.055mm)



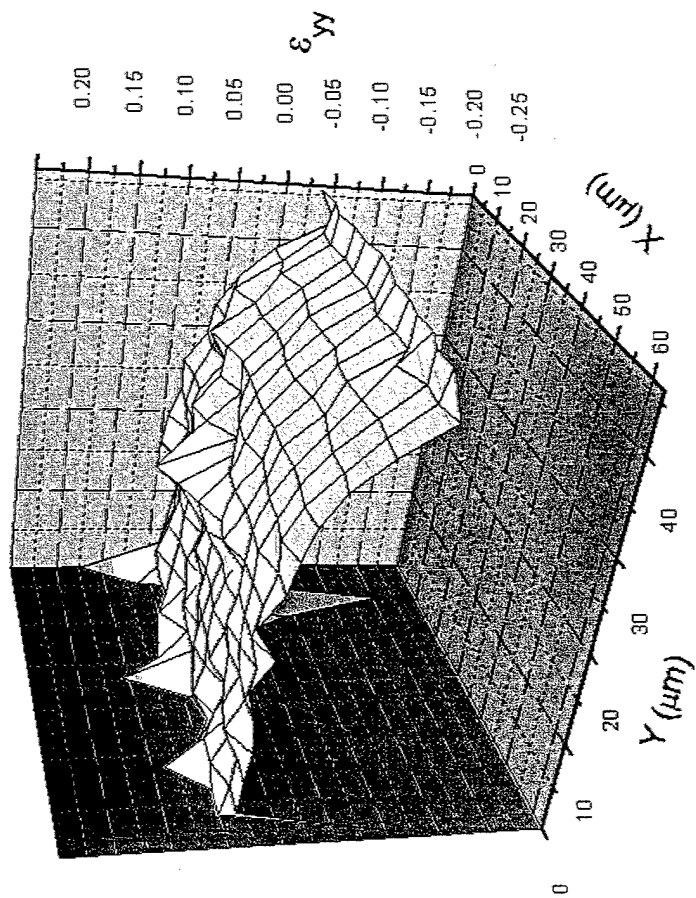
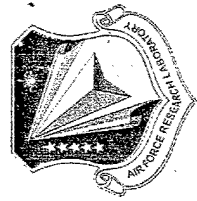
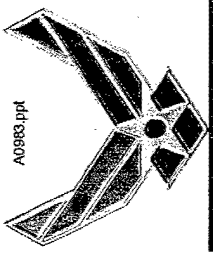
$\epsilon_{yy}$  field, Load = 49 grams



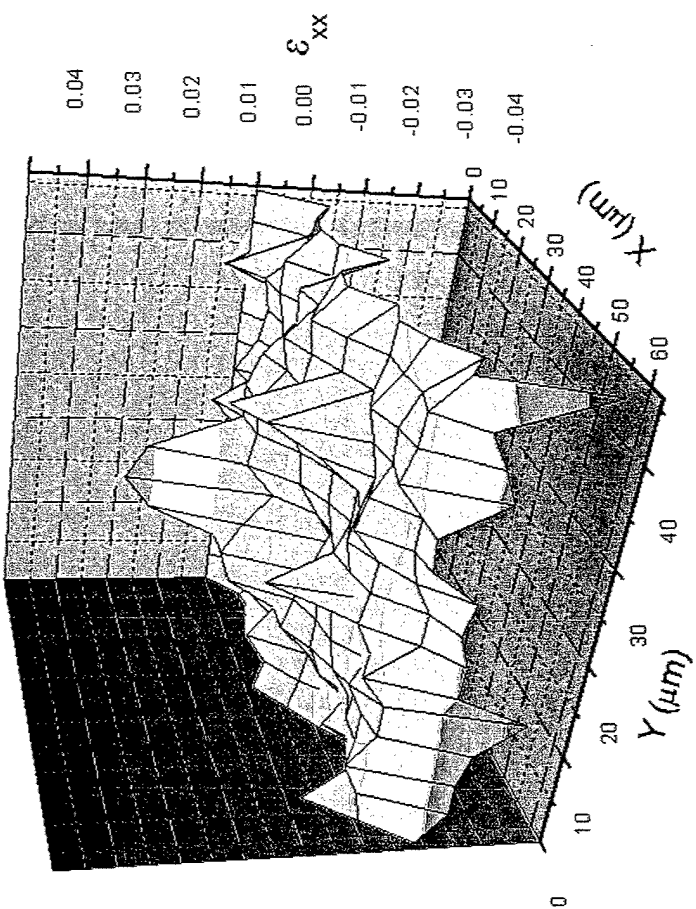
$\epsilon_{xx}$  field, Load = 49 grams

# Strain Distribution (0.065mm x 0.055mm)

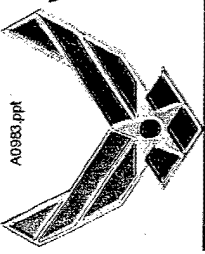
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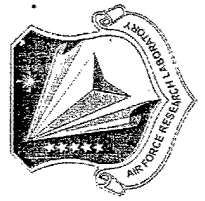
$\epsilon_{yy}$  field (3-D), Load = 49 grams



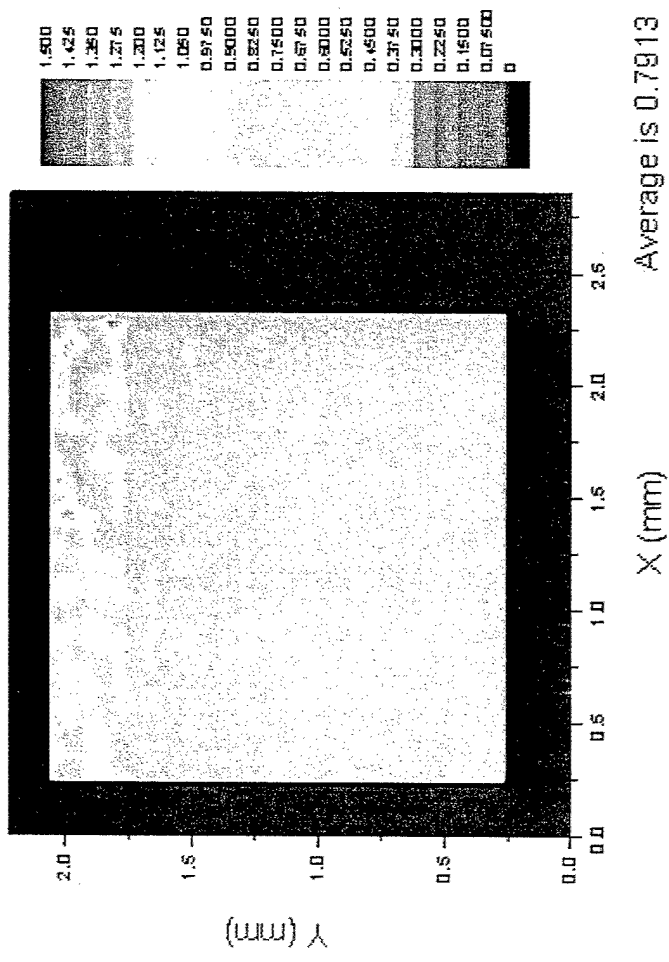
$\epsilon_{xx}$  field (3-D), Load = 49 grams



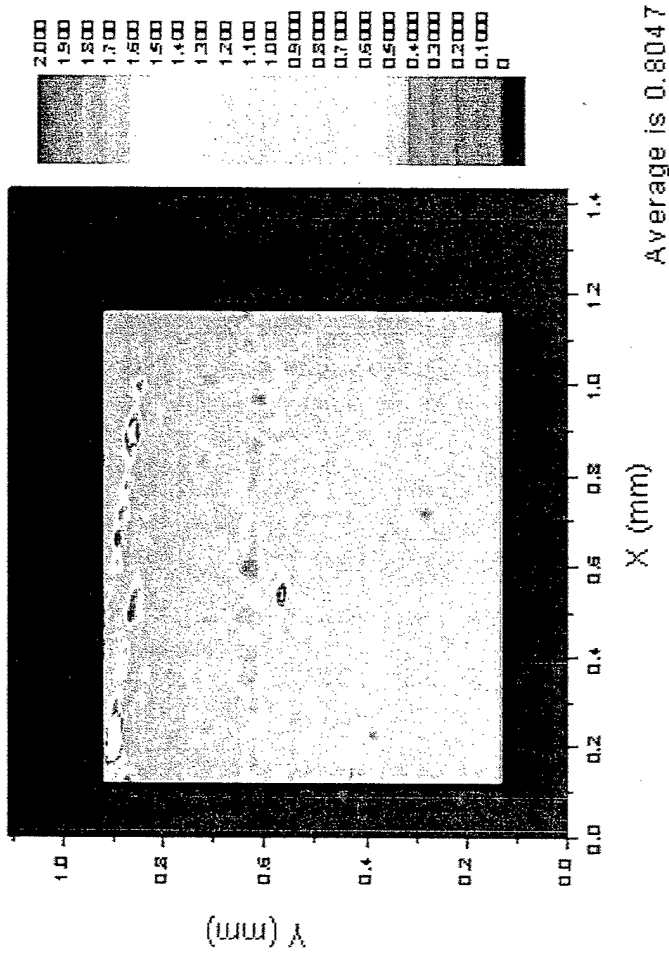
# Strain Ratio ( $-\epsilon_{xx}/\epsilon_{yy}$ ) Distributions at Different Magnifications



40x "Poisson Ratio" distribution



80x



A0989.ppt

# Strain Ratio ( $-\varepsilon_{xx}/\varepsilon_{yy}$ ) Distributions at Different Magnifications

200X

4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.5000
0.0000
0.4000
0.2000
0.0000

X (mm)

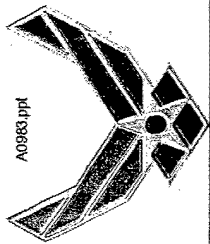
Average is 0.8558

1500X

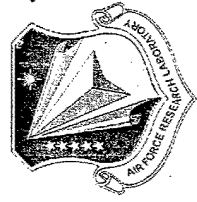
1.000
0.8750
0.7500
0.6250
0.5000
0.3750
0.2500
0.1250
0
-0.1250
-0.2500
-0.3750
-0.5000
-0.6250
-0.7500
-0.8750
-1.000
-1.125
-1.250
-1.375
-1.500

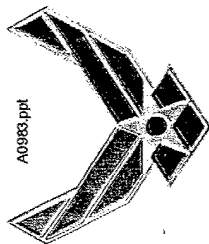
X (mm)

Average is 0.1

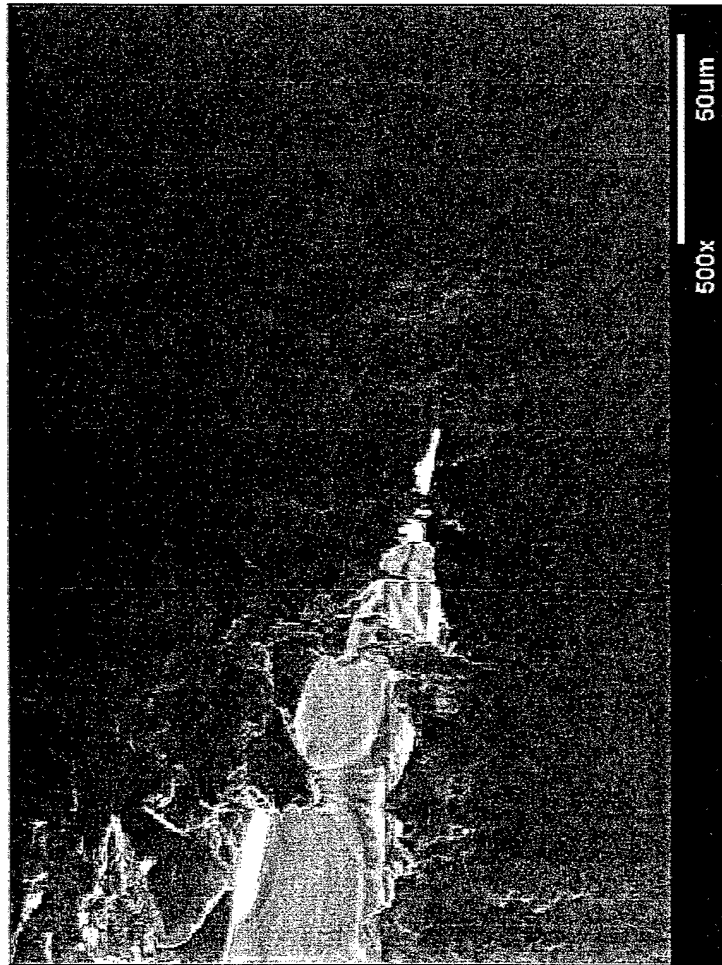
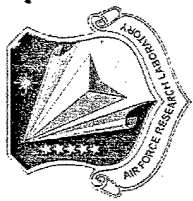


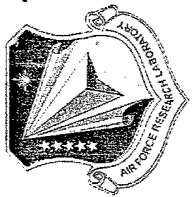
# Side View of Crack Tip at 150x & 400x



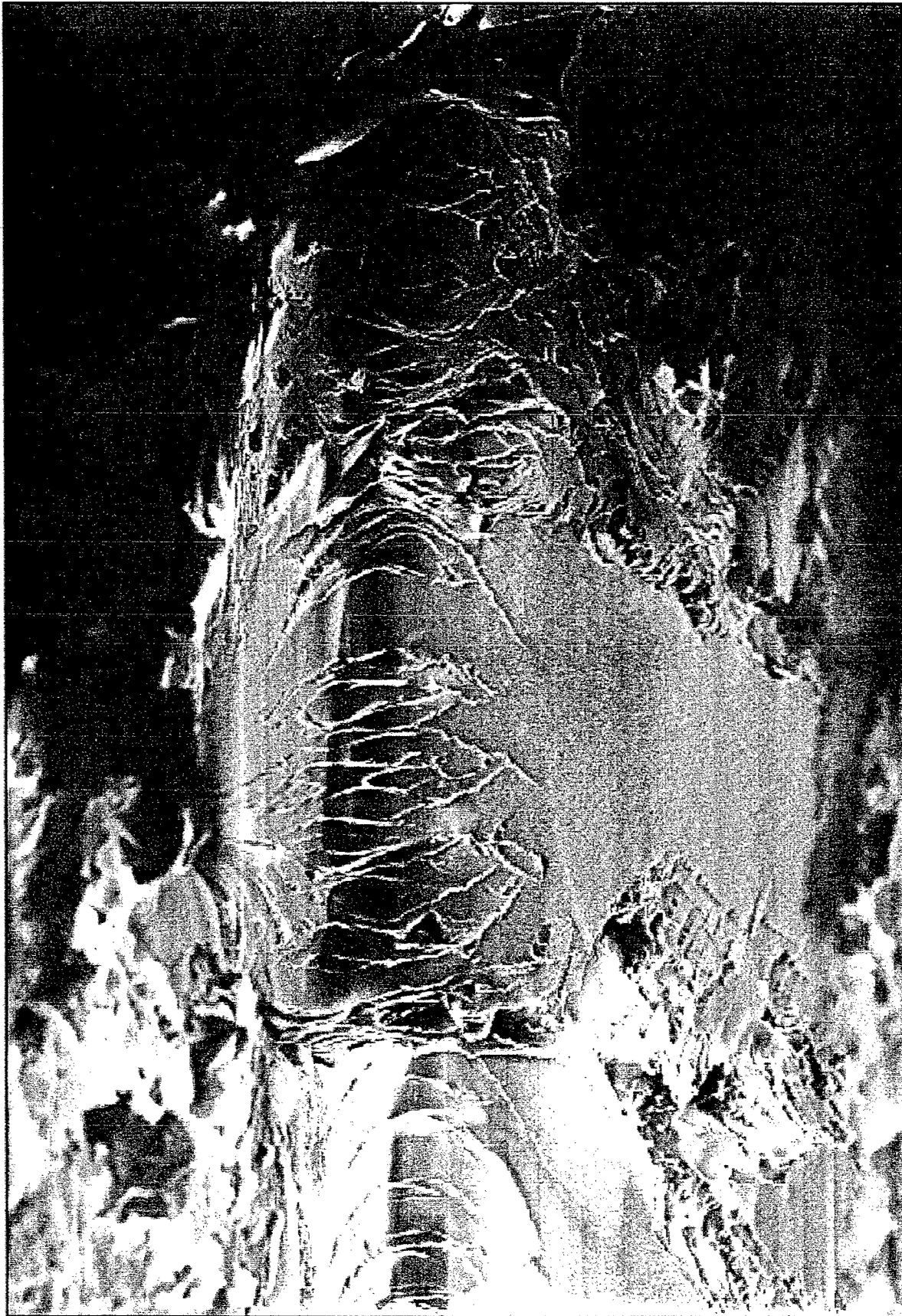


# Side View of Crack Tip at 500x & 1000x





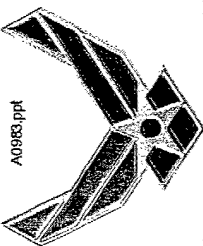
# Crack Tip Top View



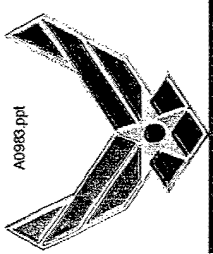
200um

150x

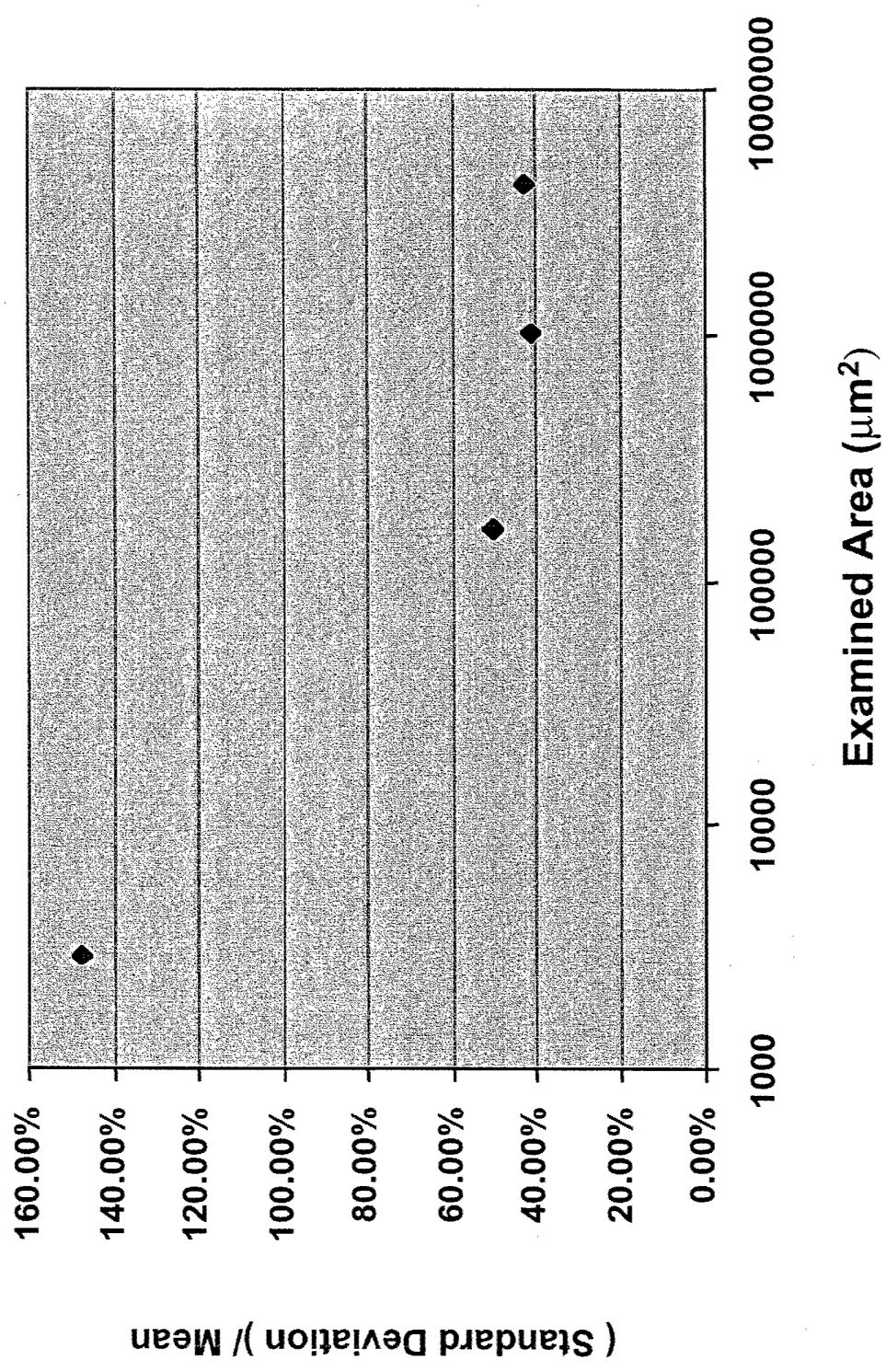
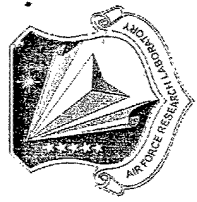
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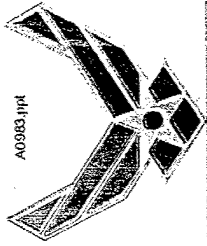
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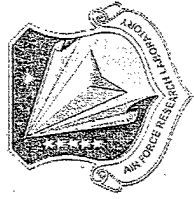
# Standard Deviation / Mean of $\epsilon_{xx}$ Vs. Examined Area







# 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.