# Fiber/Matrix Interface Strength vs. Composite Macro-Strengths

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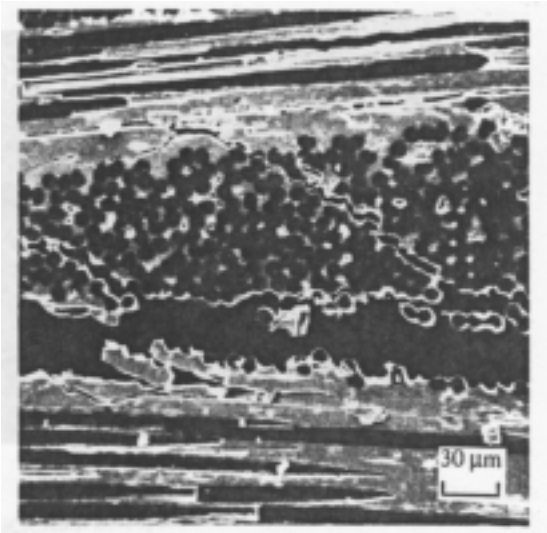
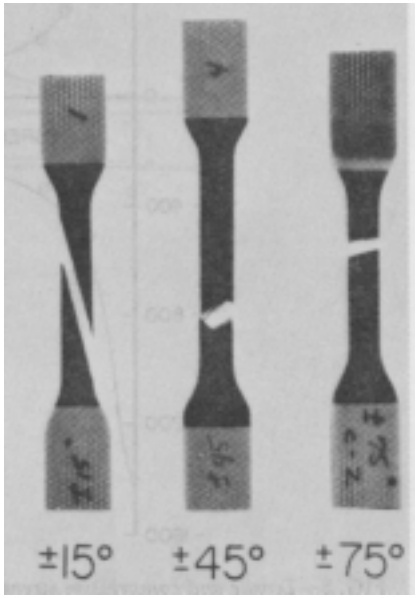
Nick Pagano
Ajit Roy

Ran Kim
G. Tandon
Rollie Dutton

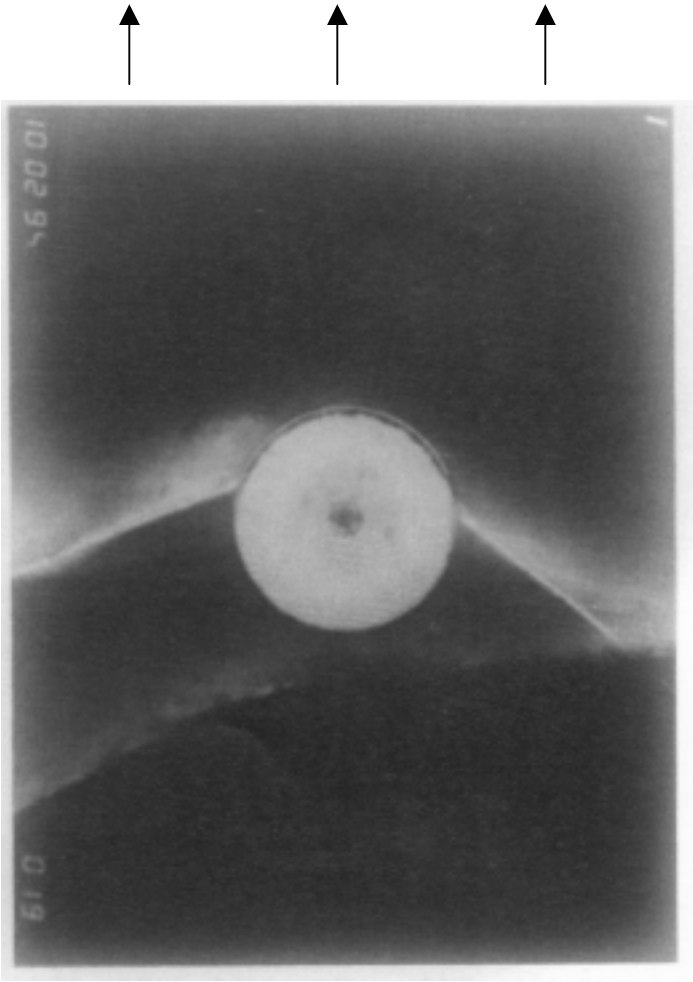


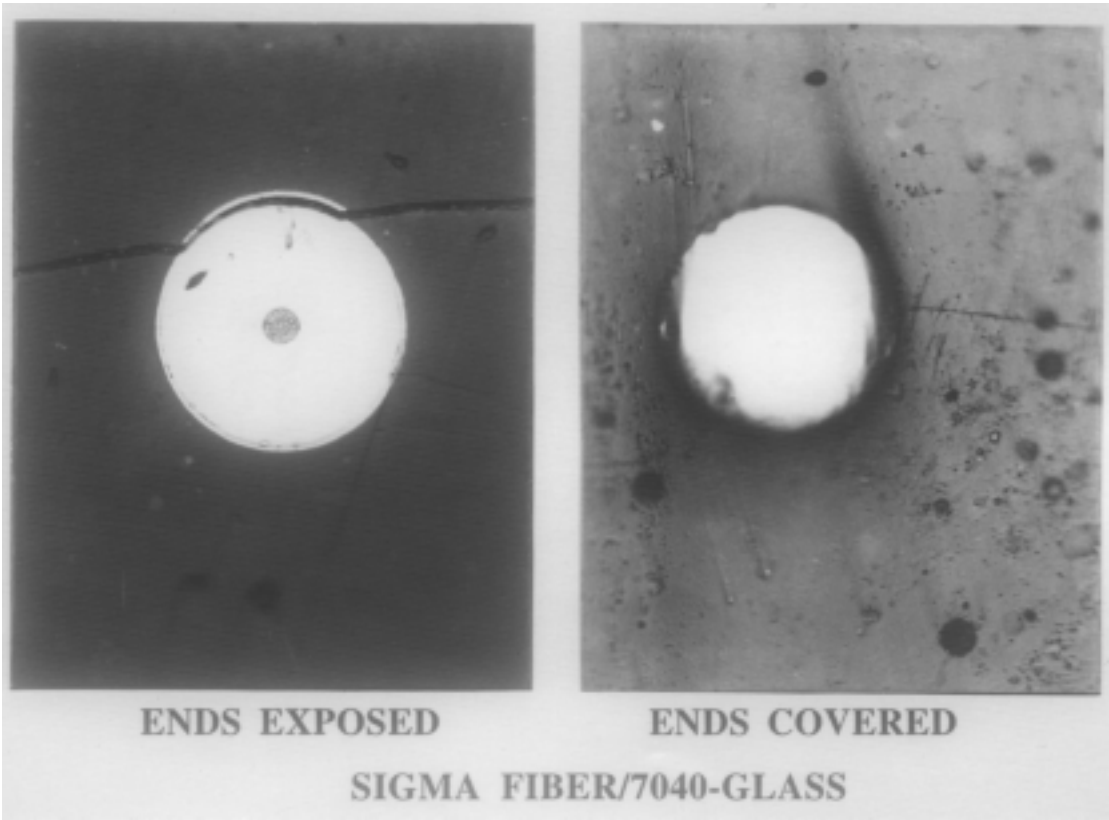
# Transverse Strength

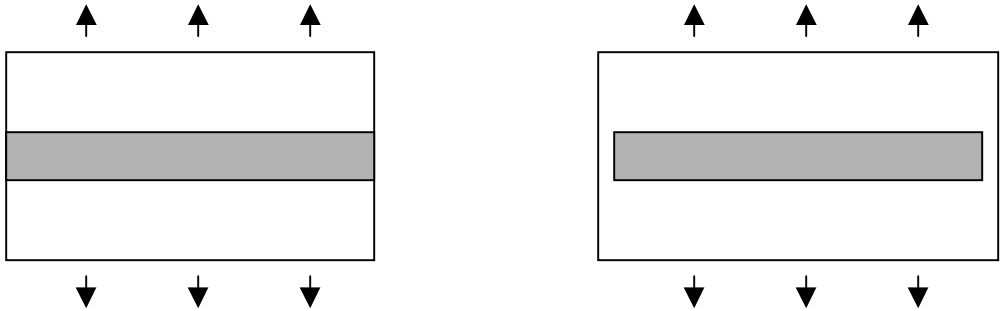
Tandon, Kim, and Dutton, 1997

Sigma (SiC) fiber/glass matrix

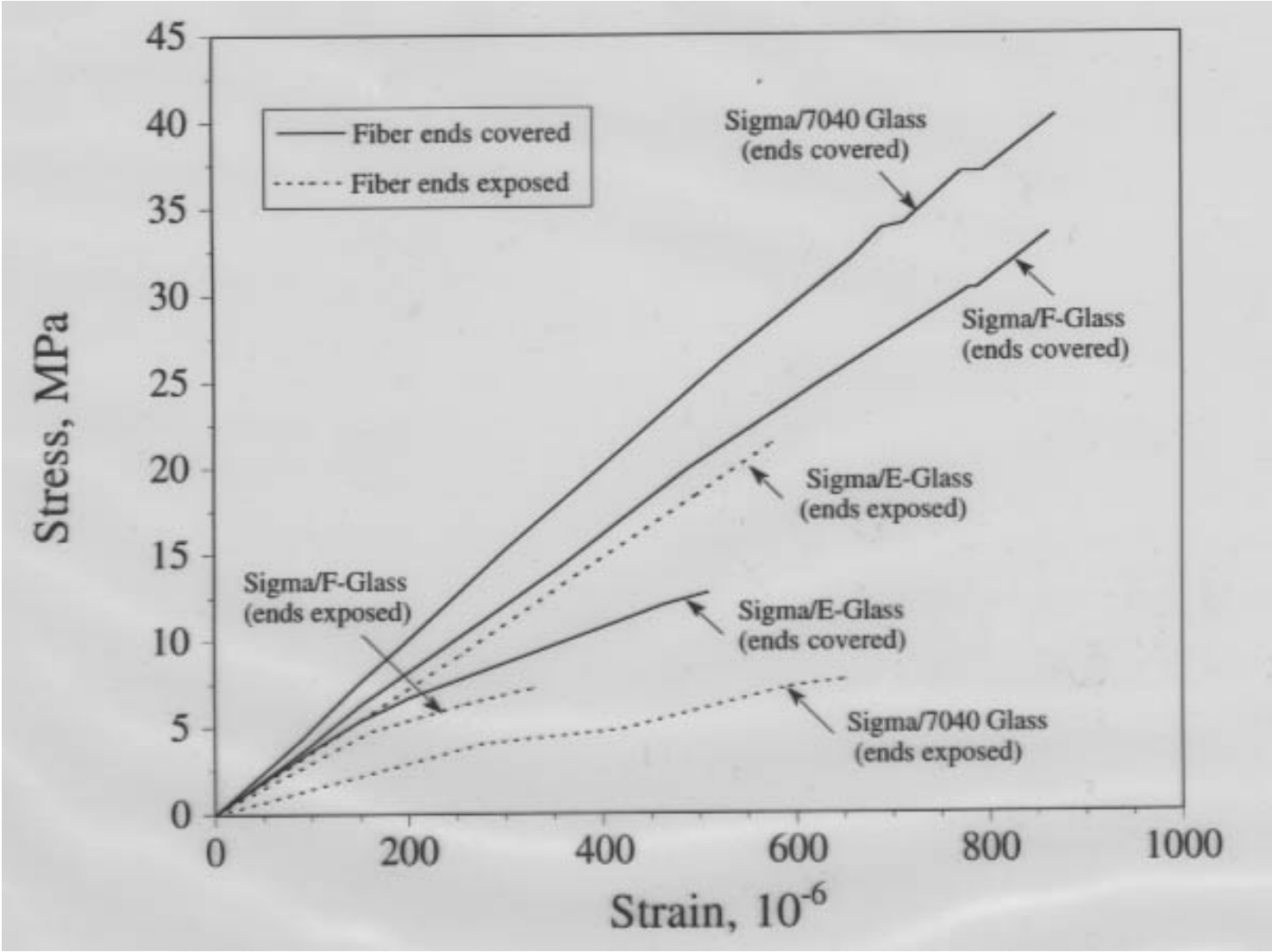


# Micromechanical Failure Mode



# Stress/Strain Curves



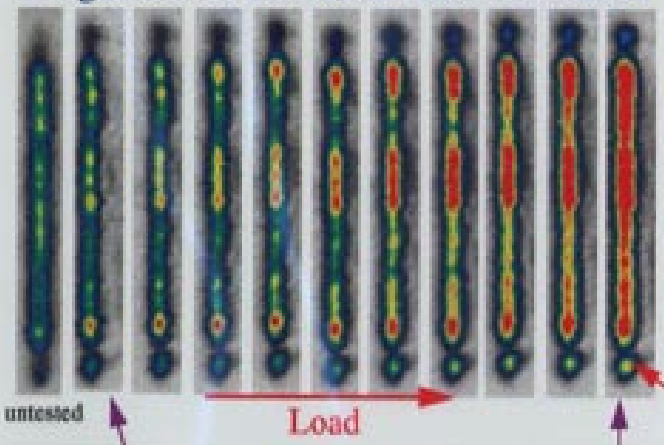
# Improved Composite Strength

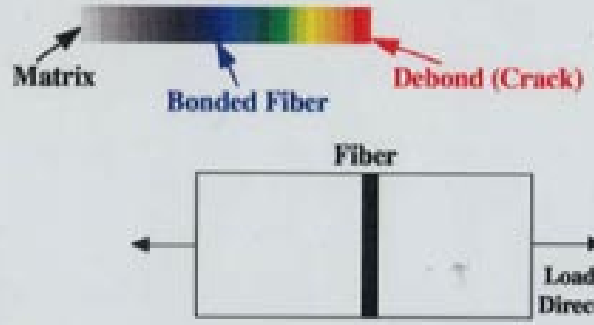
| Specimen | Type | Failure Strength MPa, (Psi) | Failure strain (µmm/mm) | Stress-strain behavior |
|---|---|---|---|---|
| Sigma/7040 | Ends exposed | 8.4 , (1223) | 615 | Non-linear |
| Sigma/7040 | Ends covered | 34.8, (5053) | 657 | Linear |
| Sigma/E-Glass | Ends exposed | 21.9, (3170) | 548 | Linear |
| Sigma/E-Glass | Ends covered | 17.7, (2566) | 455 | Non-linear |
| Sigma/F-Glass | Ends exposed | 25.8, (3739) | 684 | Linear |
| Sigma/F-Glass | Ends exposed | 7.2, (1051) | 330 | Non-linear |
| Sigma/F-Glass | Ends covered | 37.8, (5484) | 706 | Linear |
| Sigma/F-Glass | Ends covered | 17.4, (2521) | 438 | Non-linear |

# Assessment of Interfacial Behavior During Various Loading Configurations:

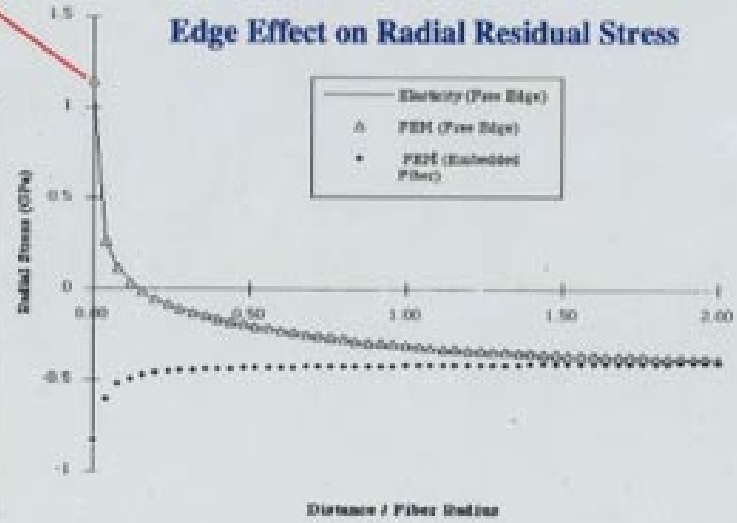
## Ultrasonic Evaluation of the Transverse Test

Progression of Interfacial Fracture vs. Load



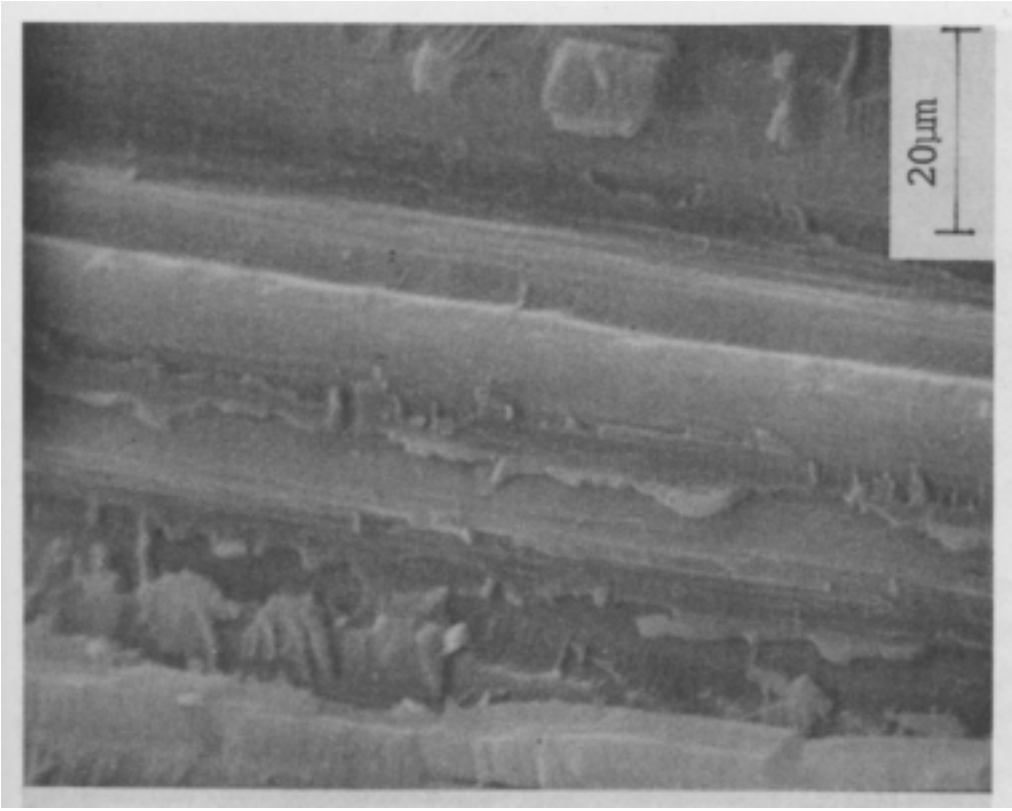



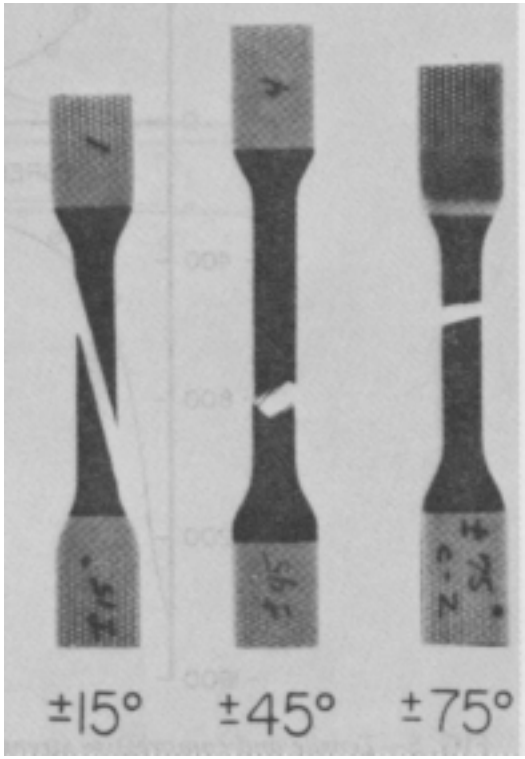
Edge Effect on Radial Residual Stress




Hu, Karpur, Matikas, Shan & Pagano 1995 Karpur, Matikas, Tandon & Kim

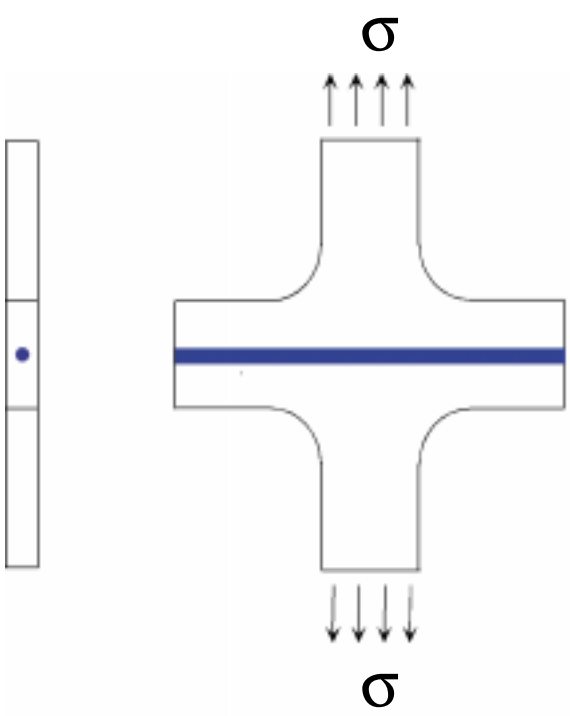
# AS/3501-5A gr/ep (75 deg off axis)



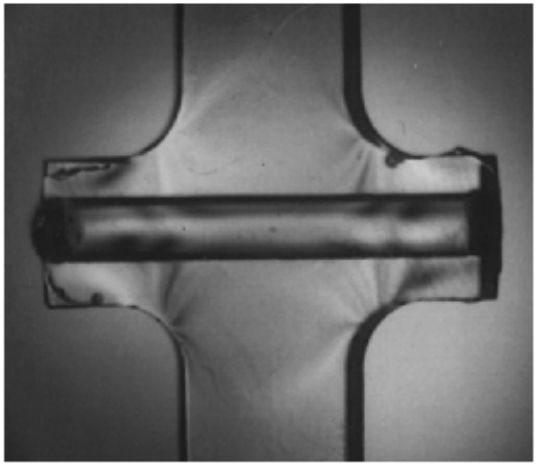




Ran Kim, AFRL

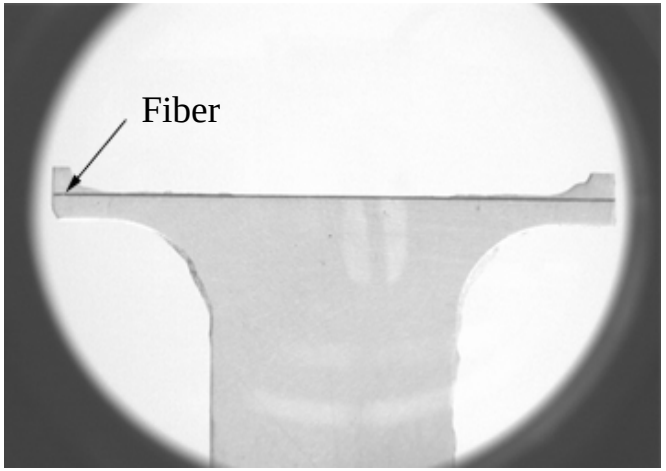
# Cruciform Testing




Schematic

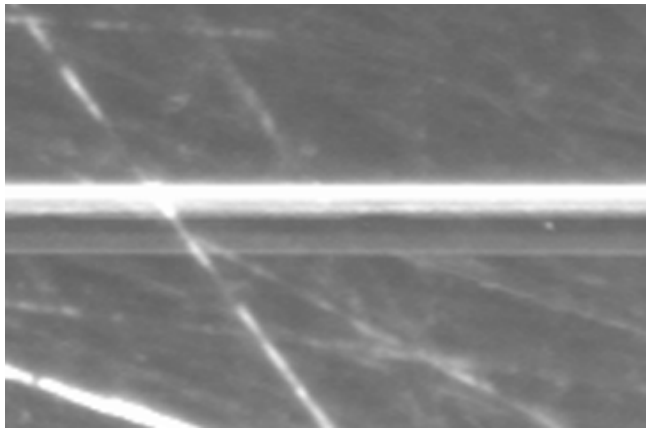


Glass/Epoxy

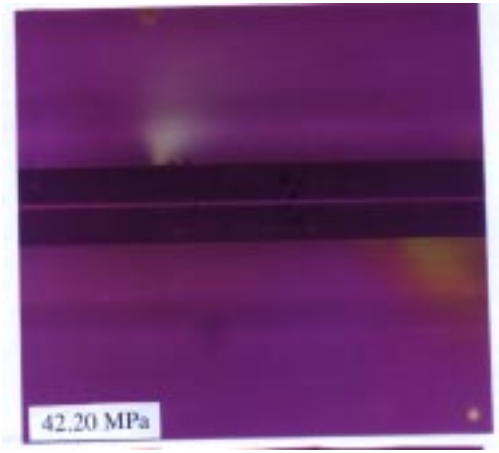



SiC/Epoxy

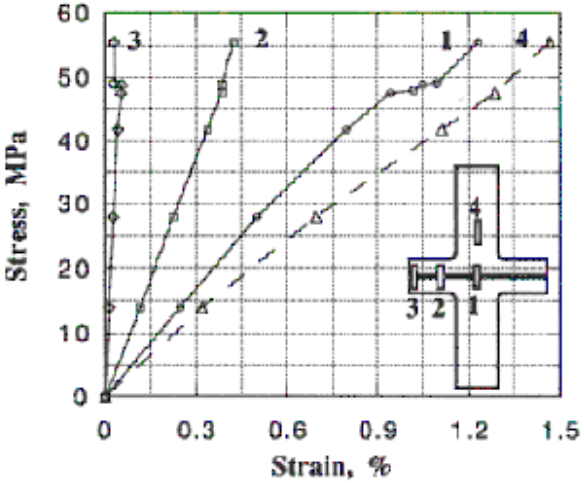
# Debond Detection



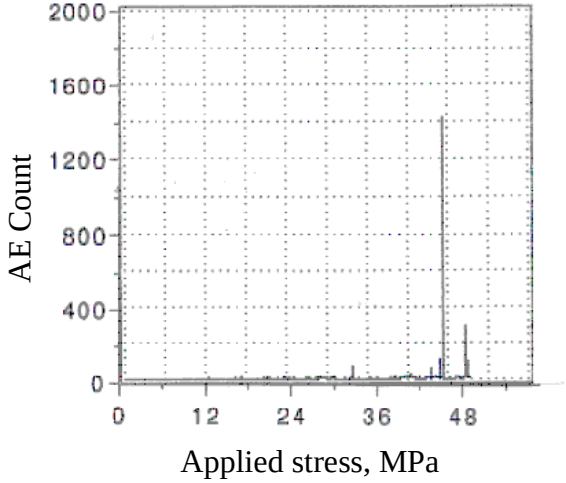
Reflected Light




Photoelasticity

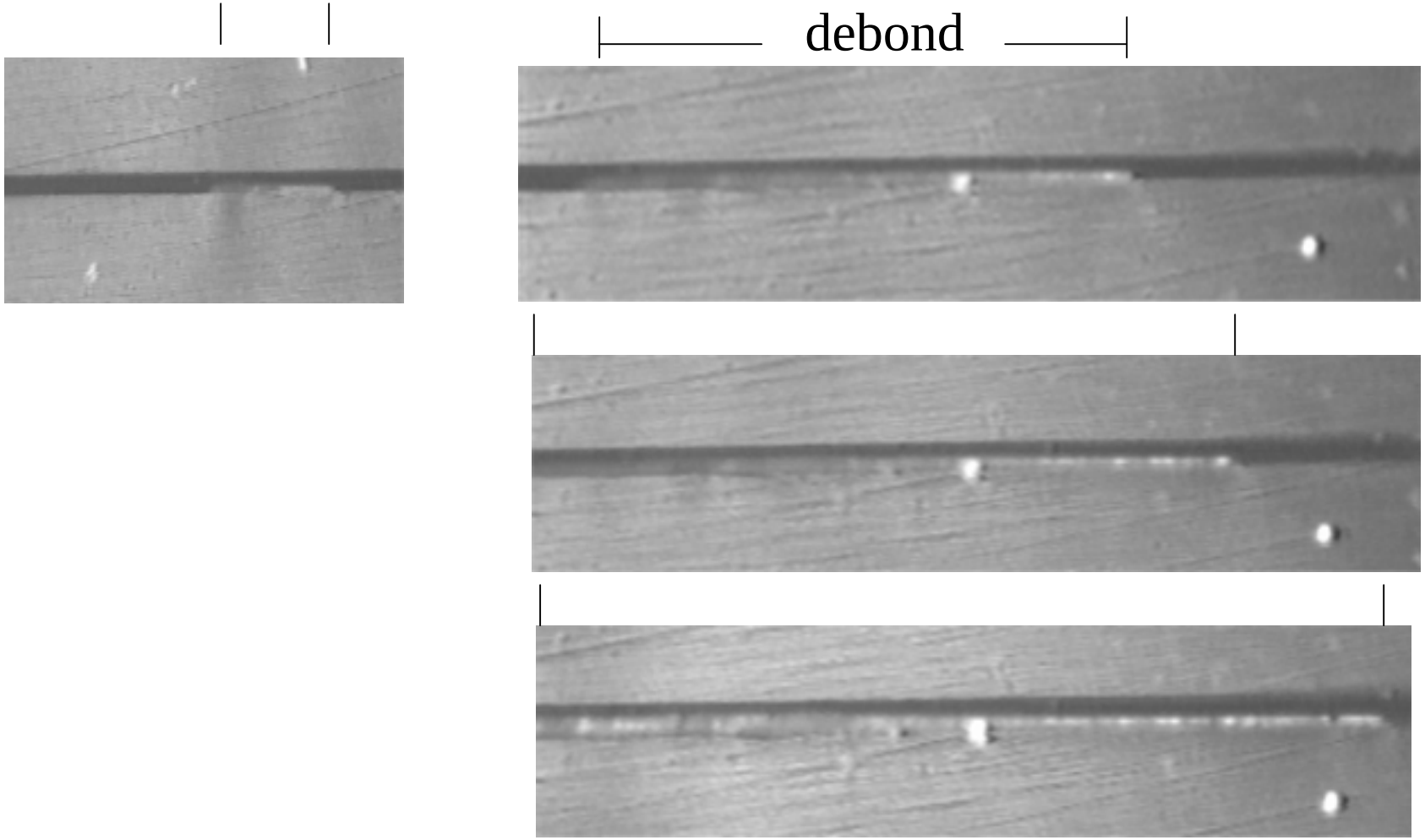



Local Strain

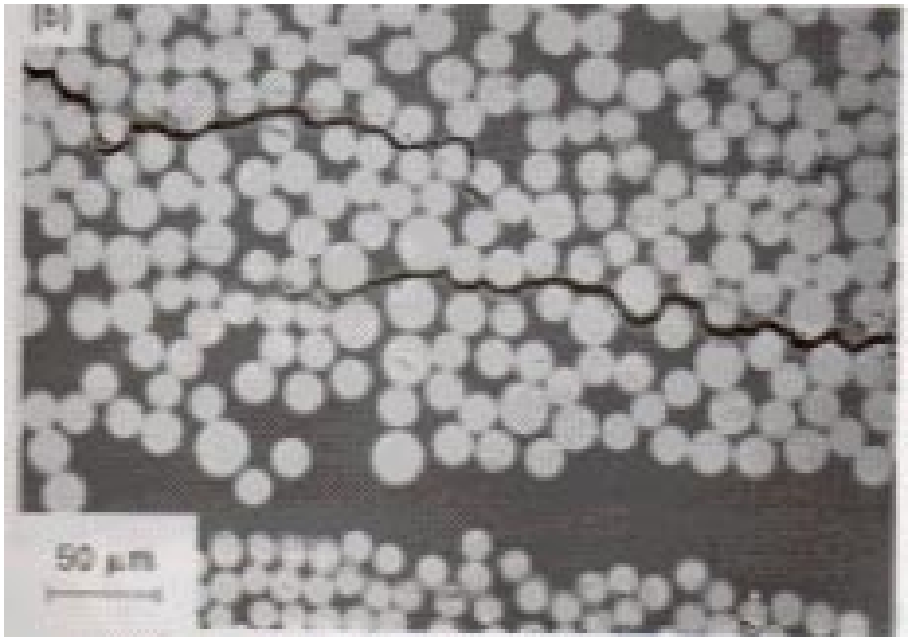


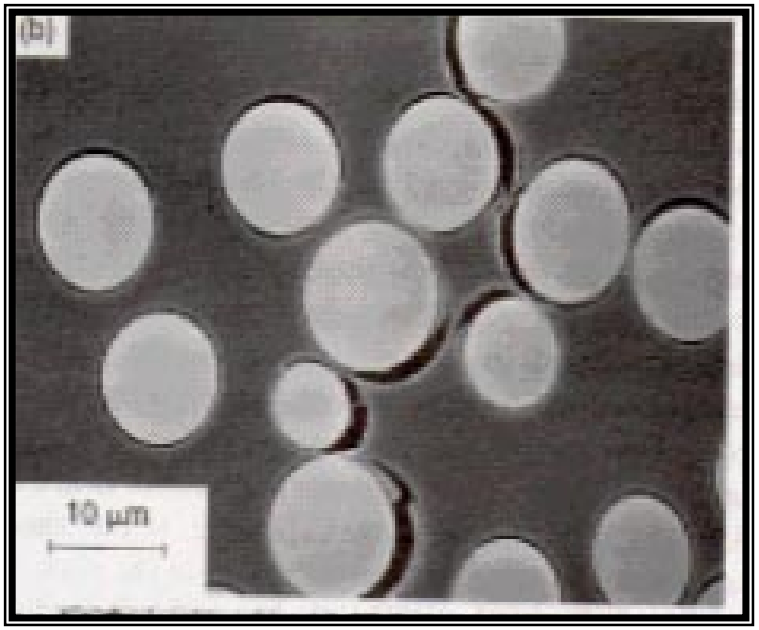

Acoustic Emissions

# SiC Debond Growth



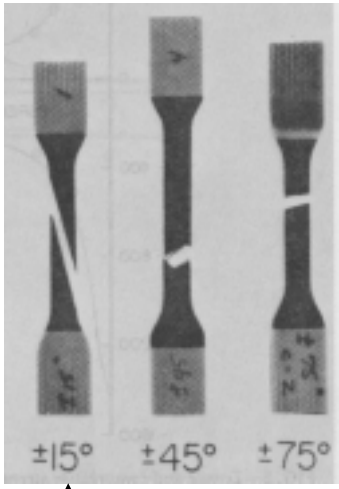
# Macro-crack initiation at micro-level

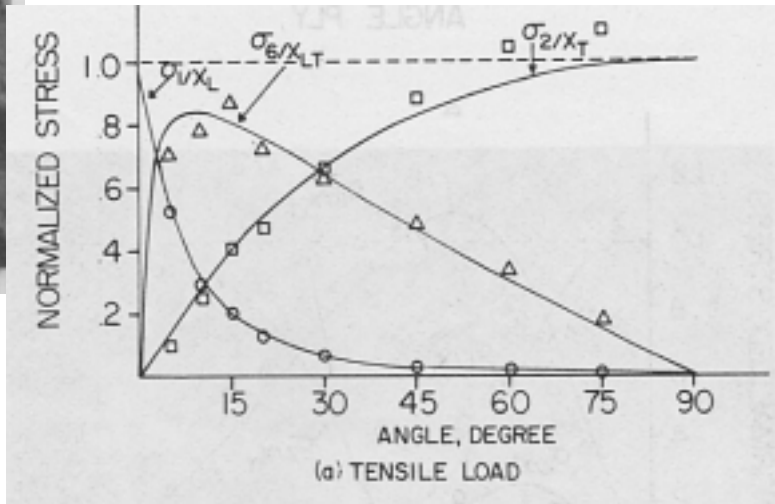



Mouritz, *et. al*. CST, V57

# AS/3501-5A gr/ep (15 deg off axis)

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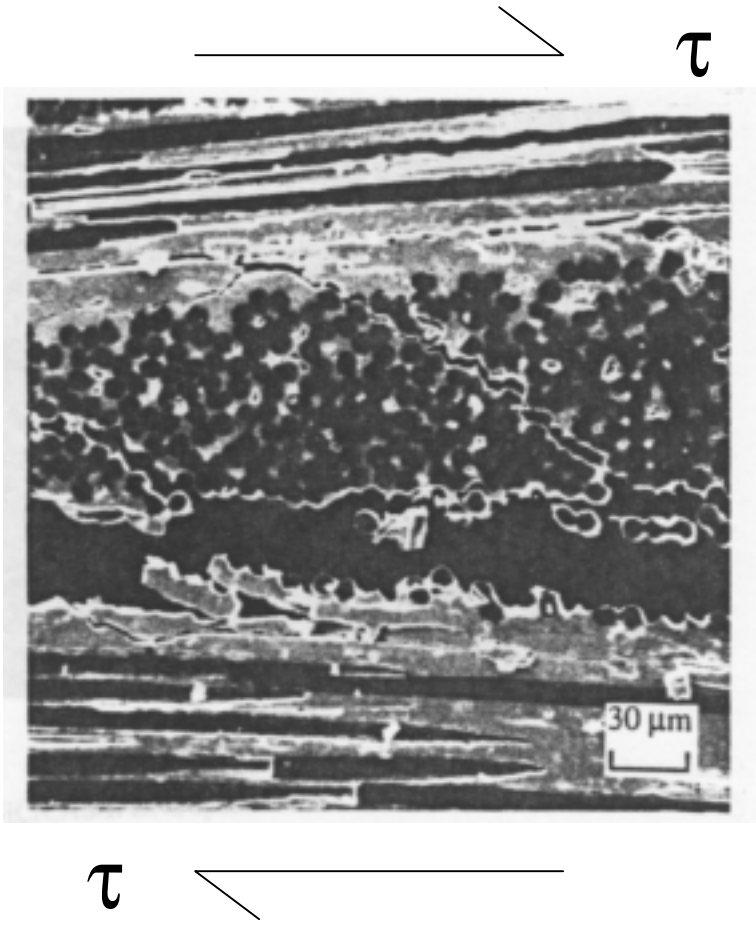
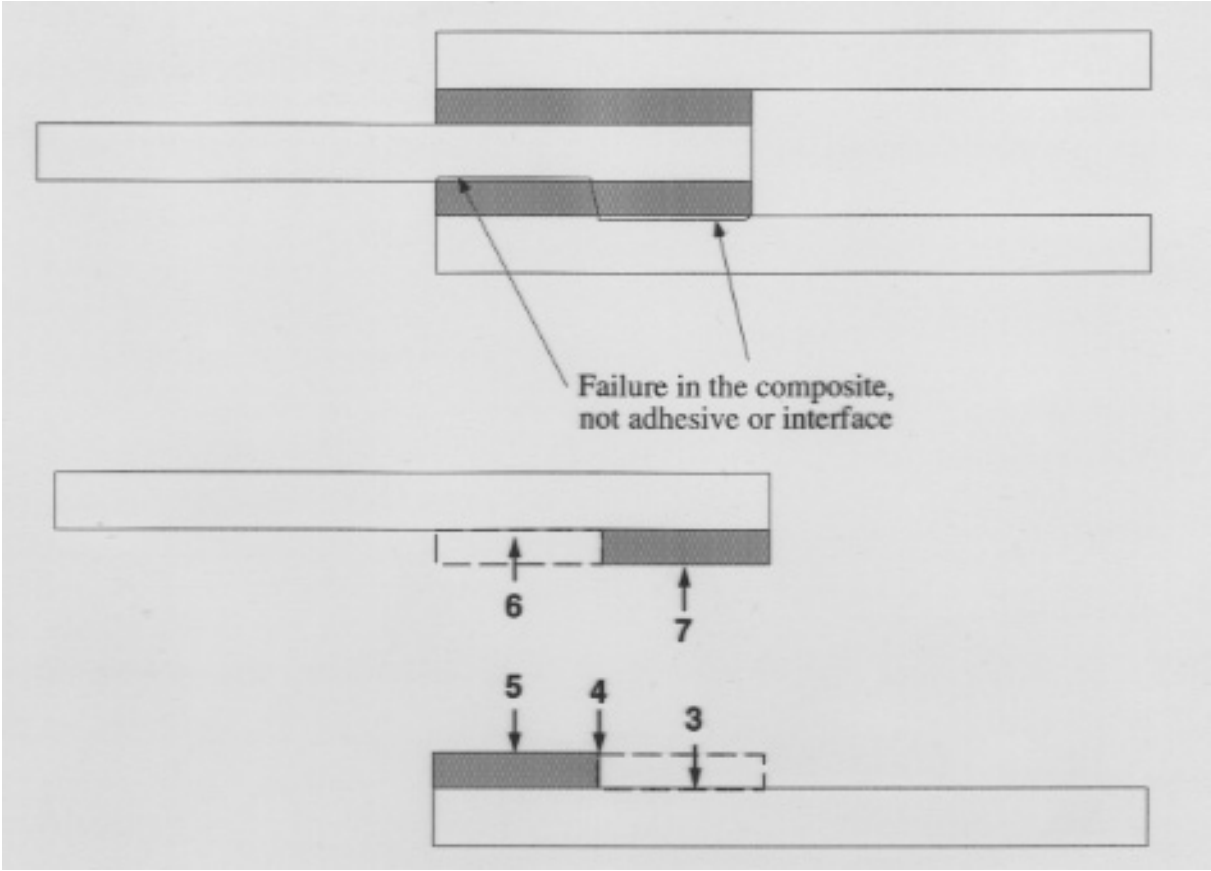
# Interlaminar Shear (DNS testing)

Fang and Chou, 1993
U. Delaware

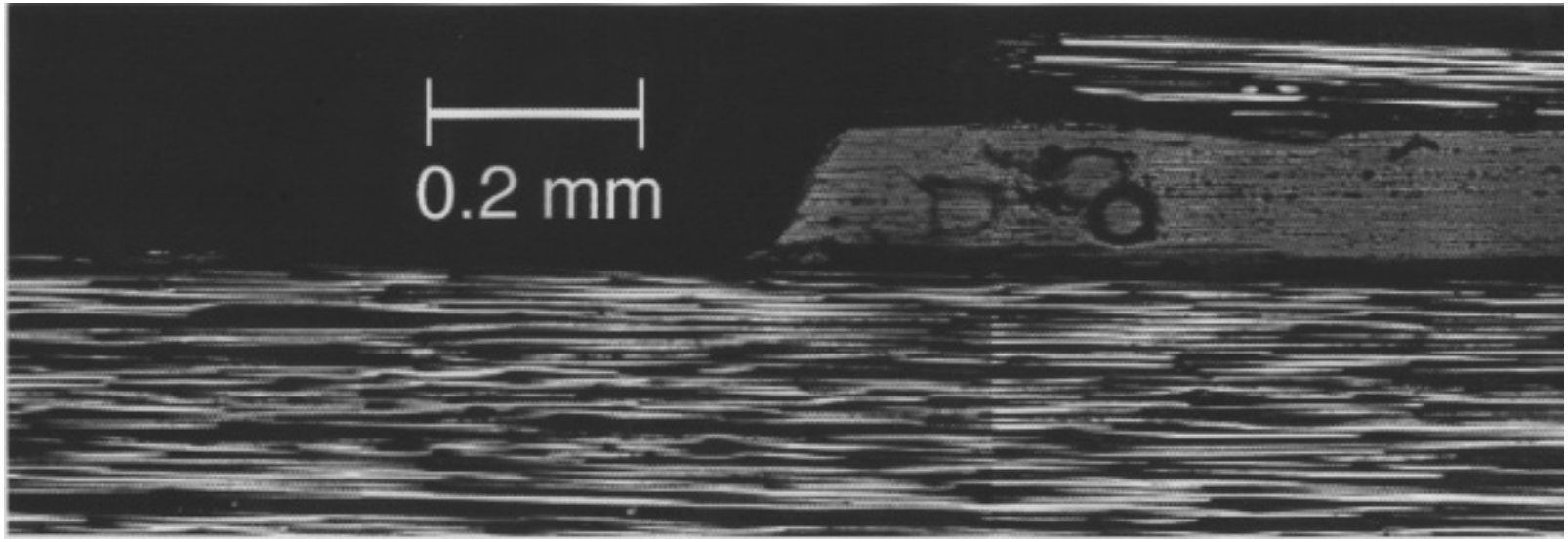
C/SiC
cross-ply
laminate



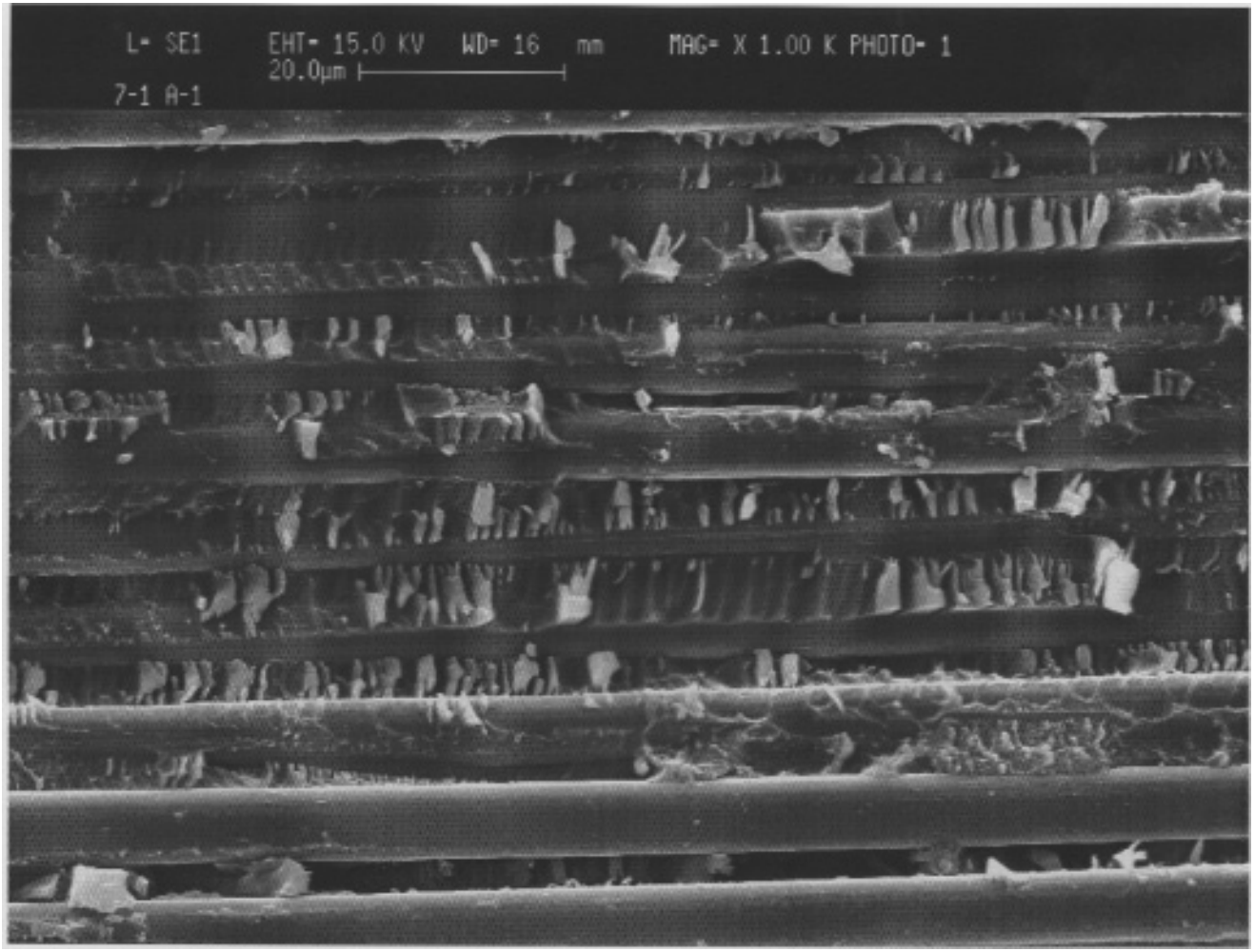
# Fracture Path



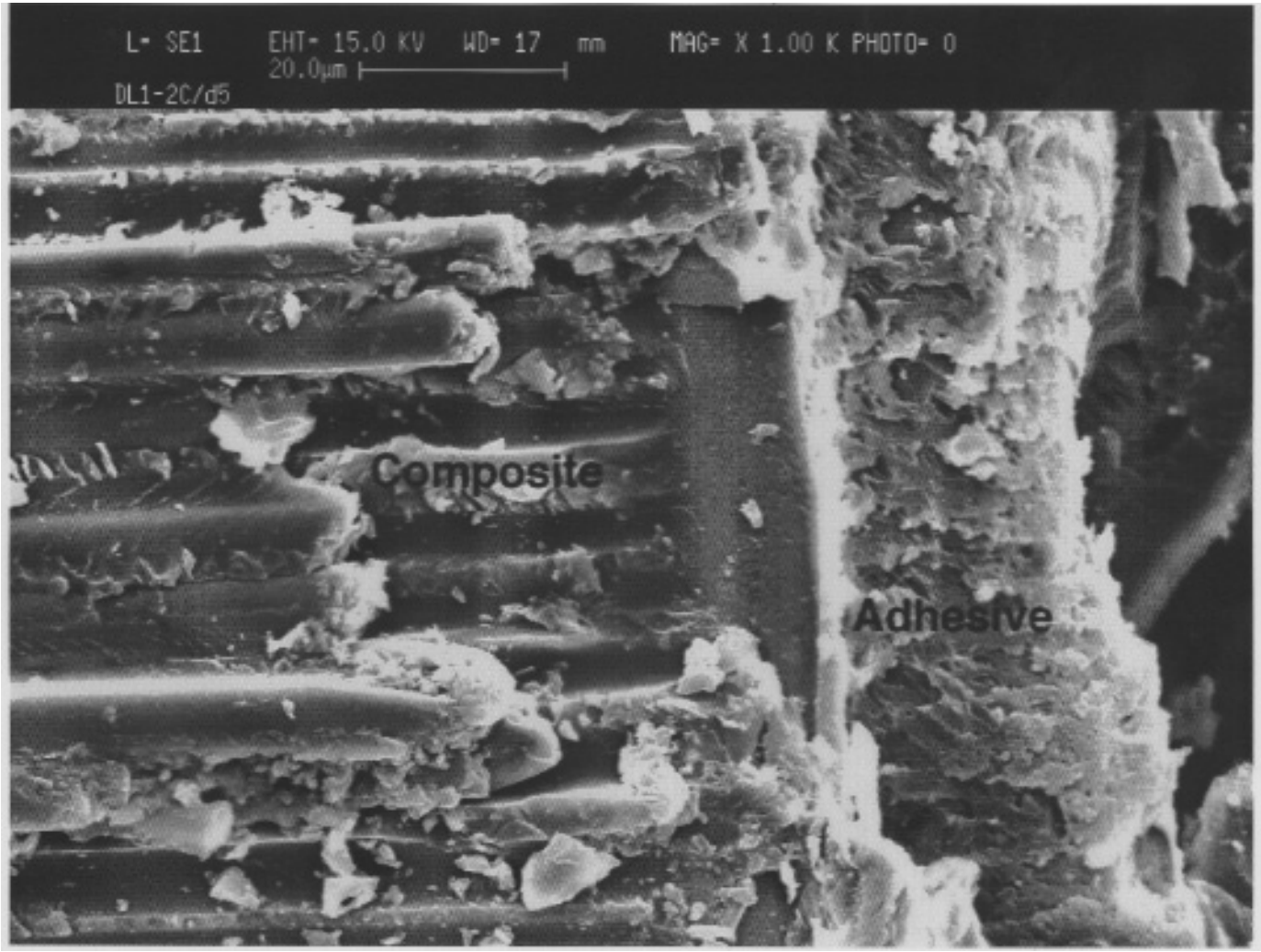
# Failure Mode



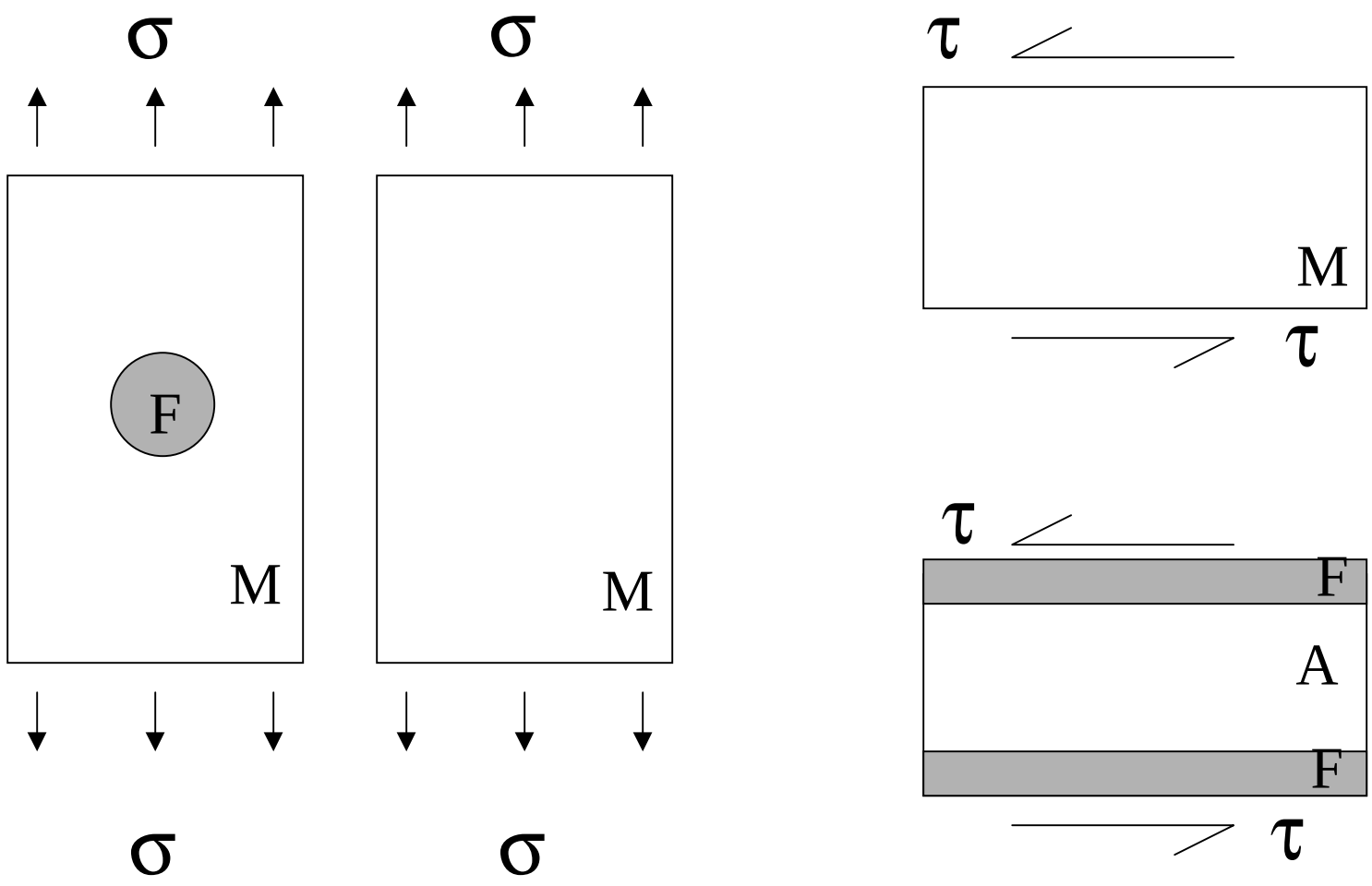
# Failure Surface w/i composite



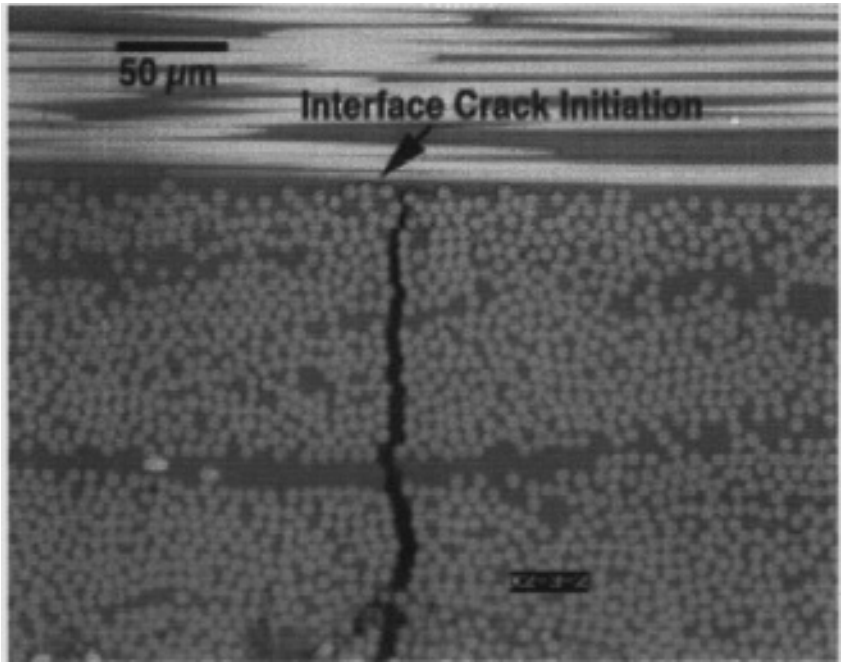
# Failure Surface near adhesive crack

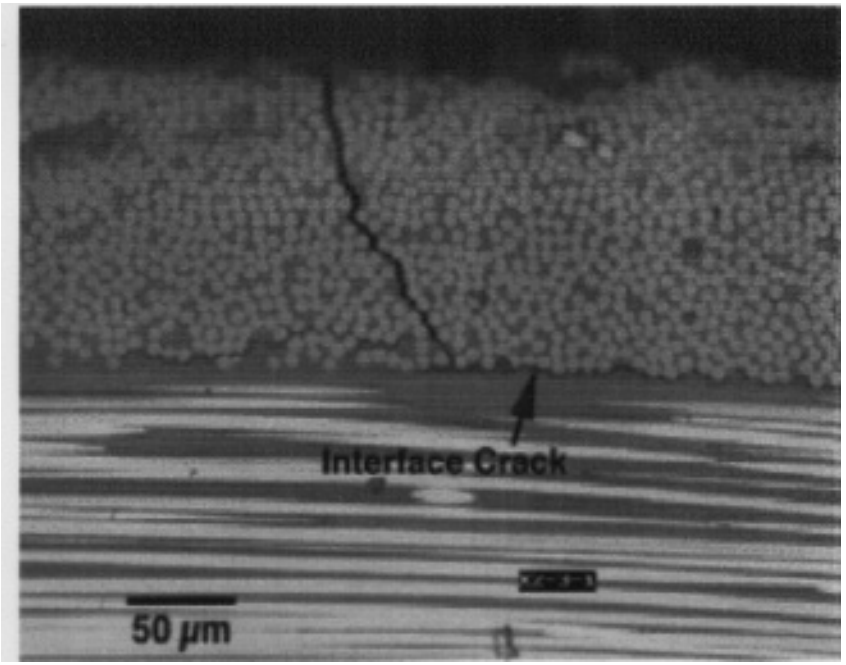


# Crack Path



# Damage Initiation in a Model Laminate ($[90_2/0_2]_s$ , $[90_2/0_290]_s$ ; 0.027)



# Summary

- Large amount of evidence in the literature that interface strength is *one* of keys to composite strengths
  - transverse strength
  - shear strength
  - adhesive joints
  - textile composites
  - axial strength

- Obviously not the only thing to look at:
  - matrix strength & toughness, fiber strengths, interphase ...