



U.S. AIR FORCE

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USSF

# Development of Single Case Studies for Micromechanics Damage Evolution in UD Composites

**Mark Flores**

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## Search and Destroy (One and Done)

### What is it?

- One study where we infer statistical relevancy to a broader study.

### What value do you get from one study?

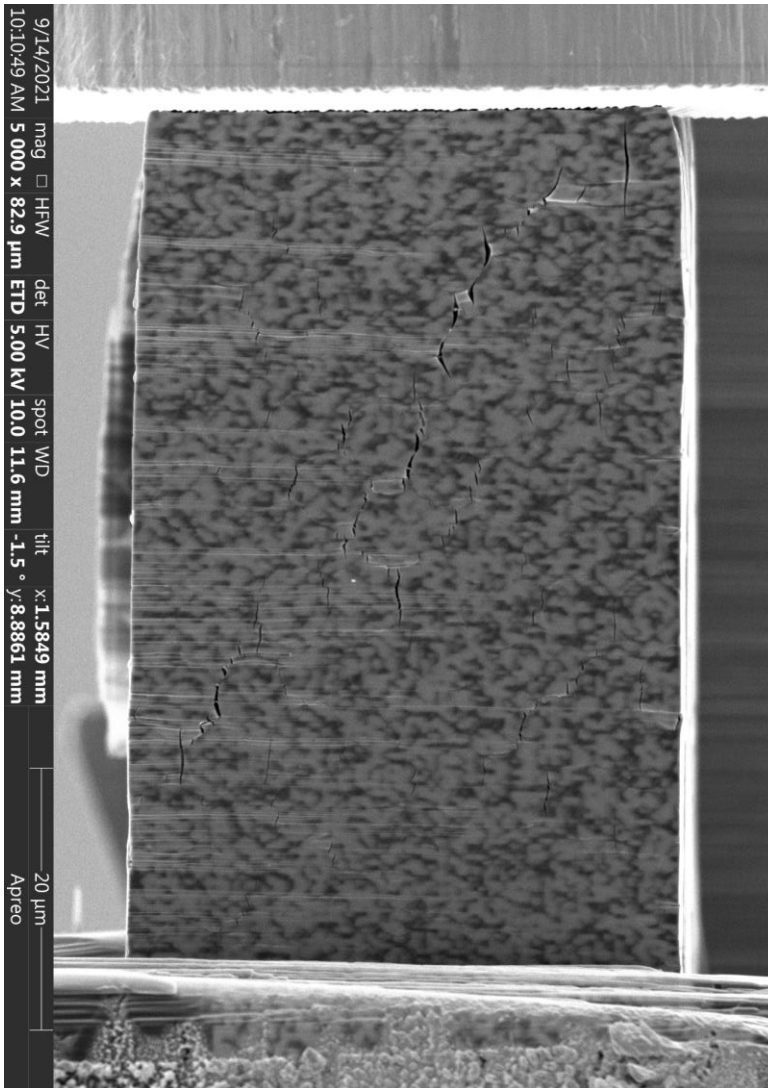
- A movie speaks volumes

### Why perform one study?

- Micromechanical testing at this scale is extremely scarce to non-existent
  - Often requires post mortem analysis of the microstructure
- Multiscale Design
  - Many micromechanical models have never been fully validated when it comes to progressive failure (even those that use AI/ML)
- Integrated Computational Materials Science and Engineering
- Multi-physics relationships (specifically modelling)

### It took 5 years for all of the Transverse Compression work

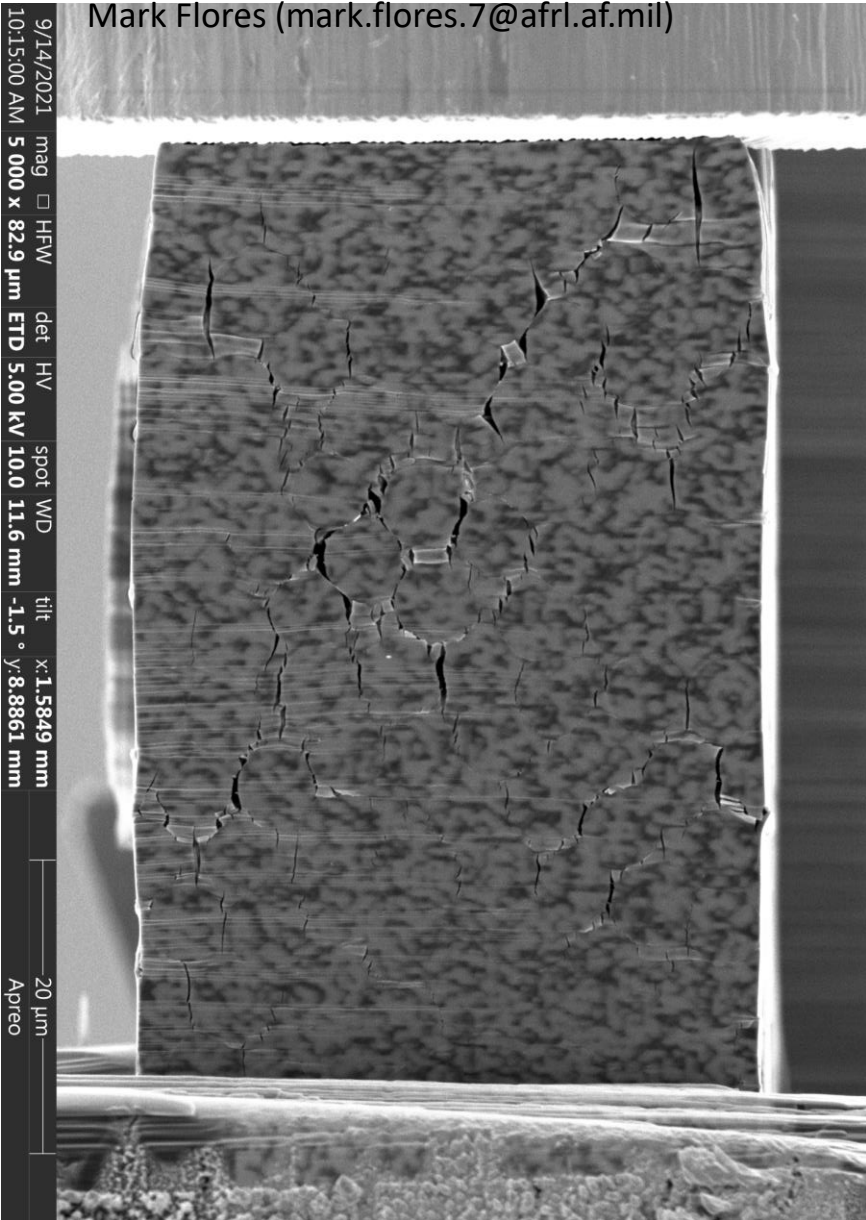
- What about YT,  $S_{12}$ ,  $S_{23}$ , E22T,  $G_{12}$ ,  $G_{23}$ ,  $G_{IC}$ ,  $G_{IIC}$







Mark Flores (mark.flores.7@afrl.af.mil)



## Requirements

1. The microstructure under loading must be in the field of view
  - Where fiber locations and diameter can be recorded
2. The experiment must be able to capture the damage initiation and propagation of said microstructure
3. Force vs time data
4. Experiments will be conducted on neat resin at the same scale if possible.
5. **Develop a Digital Twin of the experiment**

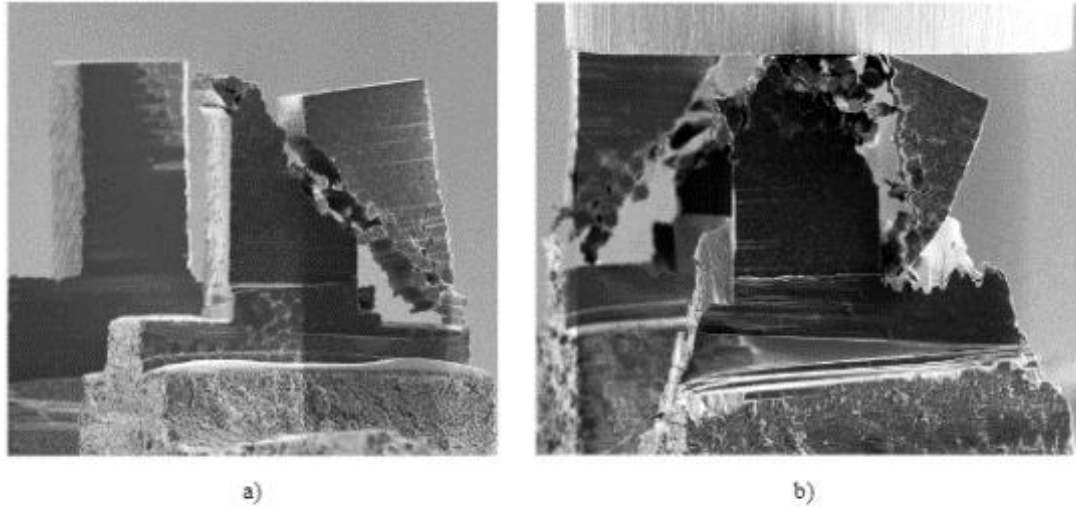
## Ancillary Requirements

1. Full-field measurements from digital image correlation
2. Effective strain from the piezoelectric actuator
3. Repeats not necessary, try studying different sizes instead

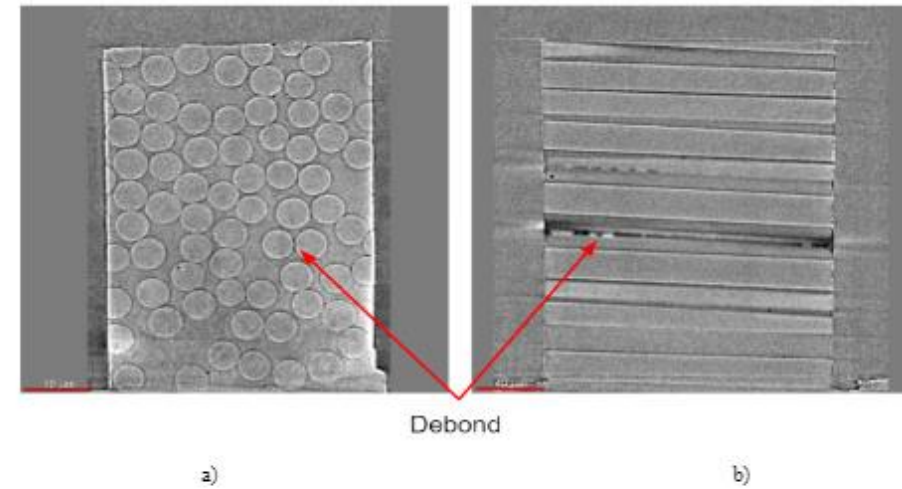
## Not Requirements

1. Procuring a uniform stress distribution across the microstructure (DIC could help in the initial state)
2. Performing side studies to validate correct loading mechanisms
3. Reducing the influences of edge effects

Flores, Mark, et al. "Experimental analysis of polymer matrix composite microstructures under transverse compression loading." *Composites Part A: Applied Science and Manufacturing* 156 (2022): 106859.



**Figure 12.** Transverse compression failure between two similar microstructures a) TC-3 with an undamaged TC-4 and b) TC-4 with a damaged TC-3 for comparison.



**Figure 14.** a) Damage of TC-2 microstructure after observed initiation of a debond and matrix crack b) X-ray nCT quantification of unloaded TC-2 damaged specimen.