NORTHWESTERN UNIVERSITY

Microstructure-Property Relation and Evolution for the Design of Advanced Hierarchical Materials

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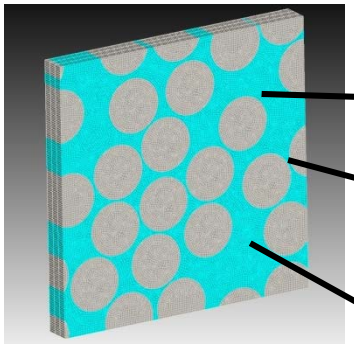
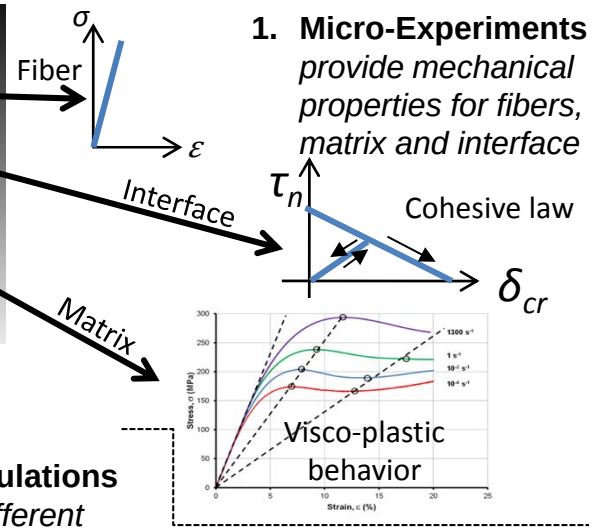
RESEARCH OBJECTIVE

Enable material design based on the microstructure conformation and properties. Two materials were evaluated: **composites** and **metal alloys**

Polymer Matrix Composites:

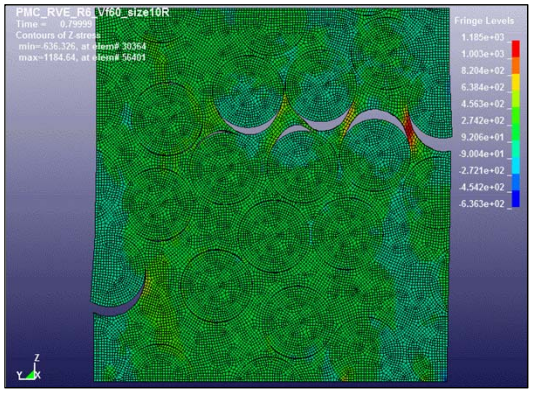
Design made possible through performance prediction for different mechanical properties of the micro-constituents





1. **Micro-Experiments** *provide mechanical properties for fibers, matrix and interface*

2. **Finite Element simulations** *are performed for different properties of the constituents*



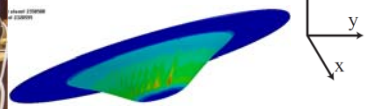
3. **Macro-Experiments** *are carried to validate the results*

Metal alloys:

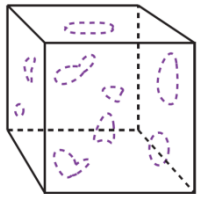
Microstructure-based prediction and design of alloy materials through finite-element simulation.

1. **ADSIF Machine** *experimental data acquisition*

2. **Full-scale FEA** *Process mechanics and tool-path planning*



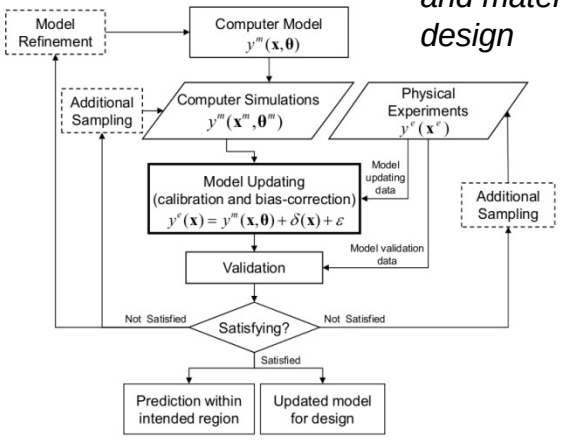
3. **Microstructural Evolution** *Shear-modified GTN*

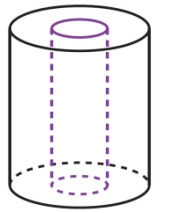


$$f_0 = \sum_{\alpha=1}^{n} \frac{V_\alpha^{void}}{V}$$

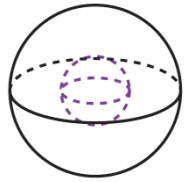
where n = number of voids

4. **Model-Updating** *Model calibration and materials design*





$$f_0^{cyl} = \frac{V^{cyl-void}}{V^{cyl}} = f_0$$



$$f_0^{sph} = \frac{V^{sph-void}}{V^{sph}} = f_0$$