Composites Manufacturing & Simulation Center

PREPREG PLATELET COMPOSITE MOLDING & PERFORMANCE WORKSHOP

Material System and Manufacturing Process
Microscopy and CT Scan Analysis
Anisotropic Coupled Flow Simulation
Failure Analysis of Fiber Orientation Informed Models

R. Byron Pipes

PRESENTATIONS AND FORMAT

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- **8:30** Arrival
- **9:00** Description of the Problem **R. Byron Pipes** (Purdue)
- **9:30** Experiments in Platelet Composites **Pascal Hubert** (McGill)
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- **2:45 Discussion Groups**
    - Flow and Fiber Orientation Simulation **Chuck Tucker (UIUC)**
    - Flow and Fiber Orientation Measurements **Tim Osswald (Wisconsin)**
    - Requirements for Certification **Bill Avery (Boeing)**
- **4:00 Summary Reports** R. Byron Pipes
- **4:30** Depart

OUR GOALS FOR WORKSHOP

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- Build the foundation for flight certification of molded platelet composite systems
- Engage the composites community in the issues of molded-structural composites
- Develop the engineering design competency in molded platelet composite systems
- Provide for the widespread and successful application of these materials systems in aerospace and vehicle structural applications

NEEDS OVERVIEW

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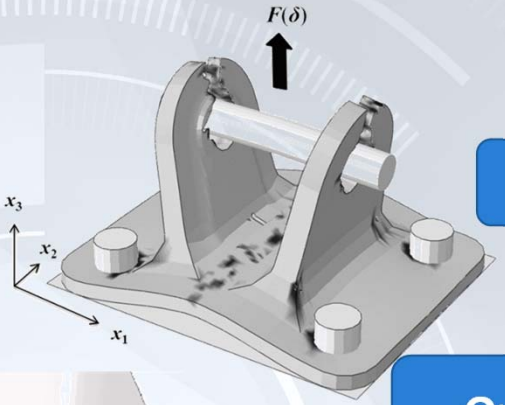
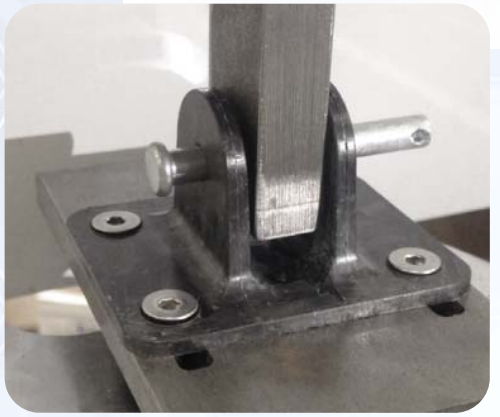
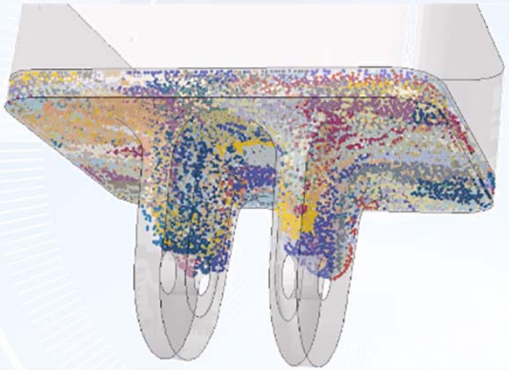






Manufacturing

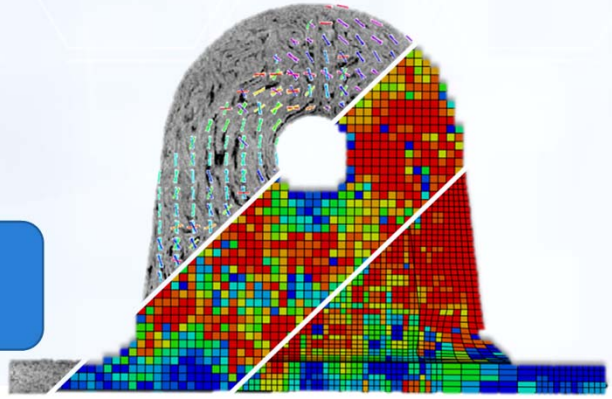
Fracture Test

Failure Analysis

Orientation Mapping

Molding Simulation

CT Orientation Analysis



QUESTIONS FOR CONSIDERATION

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- How does the material system meso-scale interact with the macro scale of the molded structural element?
- What meso-structure descriptors are essential for performance predictions?
- How can flow simulations accommodate an anisotropic viscosity tensor?
- How can fiber orientation fields be predicted and determined for platelet/concentrated systems?
- How are deconsolidation and consolidation important in molding flows?
- How can the meso-scale be characterized with non-destructive and destructive methods (micro-CAT scans, sectioning and polishing, burn off)

COMPETENCIES TO DEVELOP

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- Platelet and similar meso-phase structures in composite molding systems
- Anisotropic viscosities for prepreg platelet composites
- Models for anisotropic flow of hyper-concentrated platelet suspensions
- Anisotropic squeeze flow predictions
- Examples of typical molding anomalies such as knit lines and platelet distortion
- CAT scan detection of in situ fiber orientation fields in molded structural elements
- Strength models for prepreg platelet composites
- Comparisons of strength predictions and experimental tests
- Notch sensitivity of prepreg platelet composites

COMPOSITES PROCESSING

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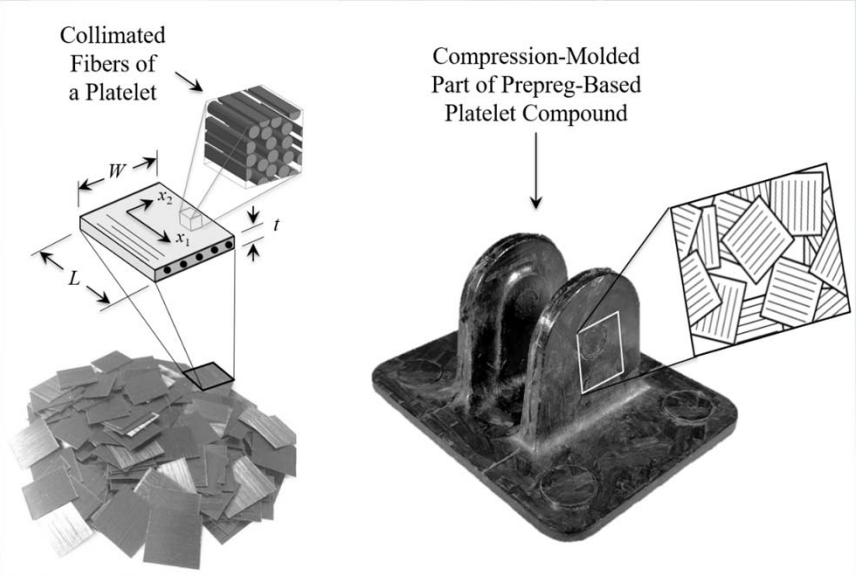
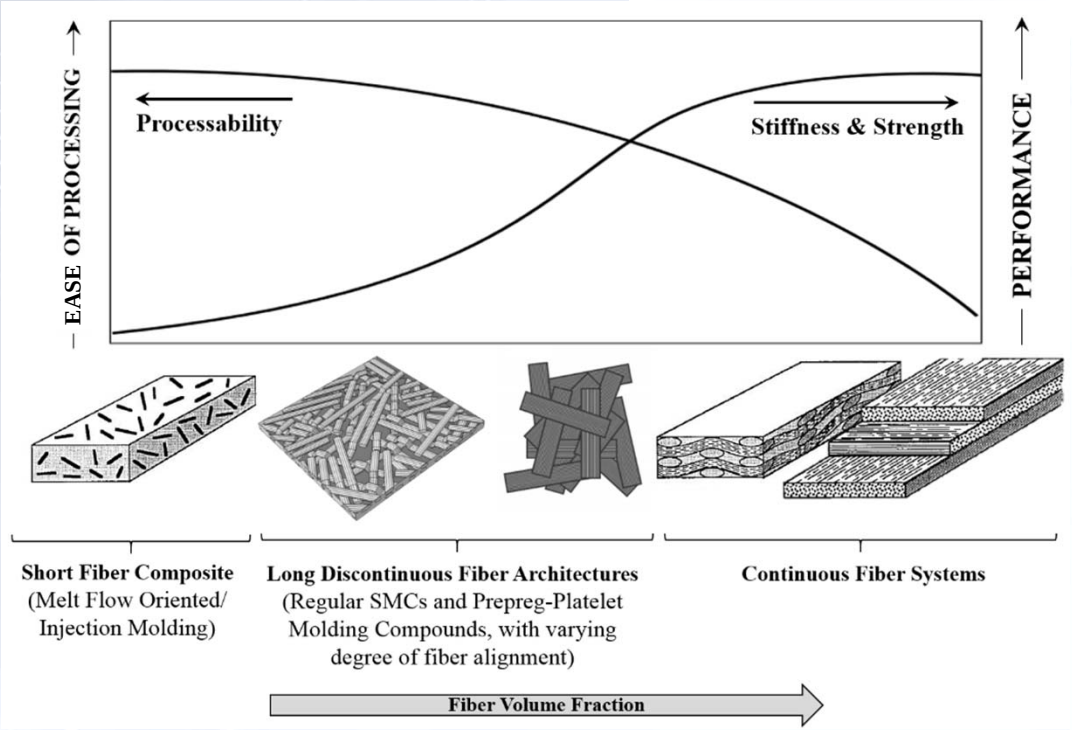
- Pre-impregnated platelet based composite molding systems
- Manufacture complex geometries with good mechanical performance by compression molding





PLATELET MICROSTRUCTURE

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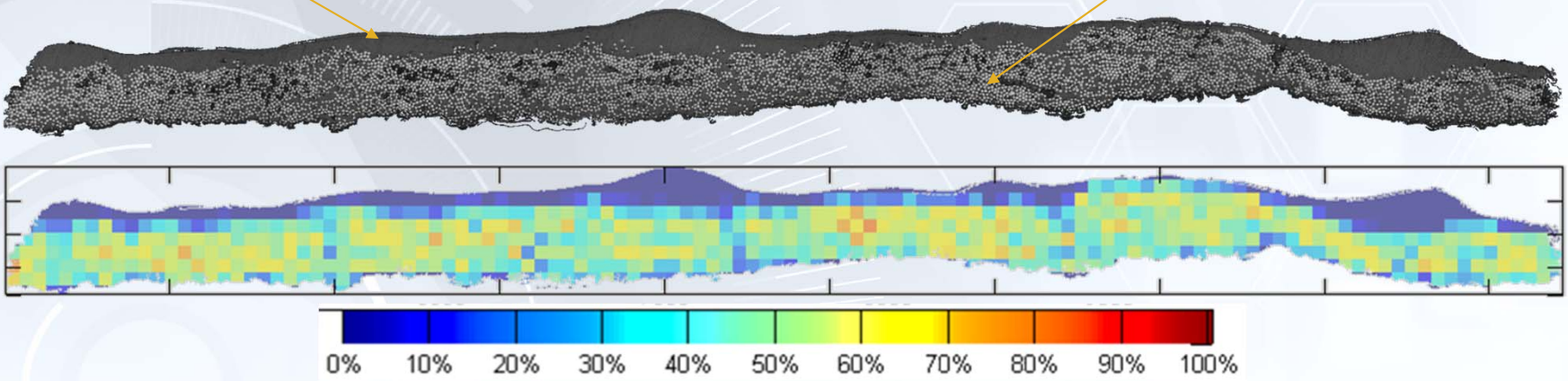
~12% is Matrix Rich Layer

~88% is Actual UD Fiber/Matrix Composite

1/8” Wide Platelet Cross Section



Local Fiber Volume Percent

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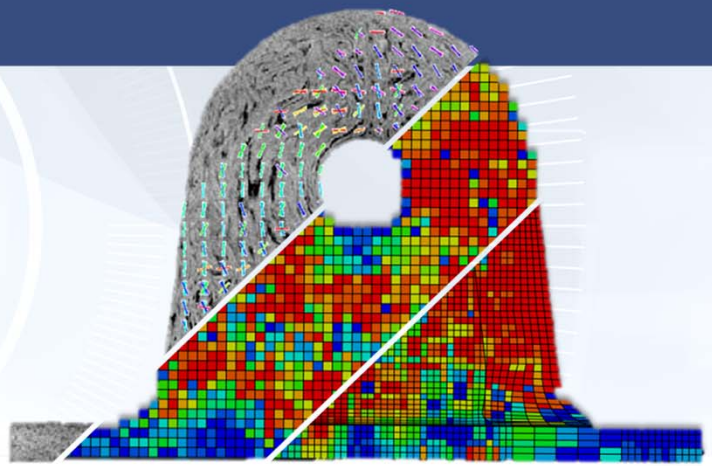
MEASURING FIBER ORIENTATION



CT SCAN ANALYSIS FOR FIBER ORIENTATION

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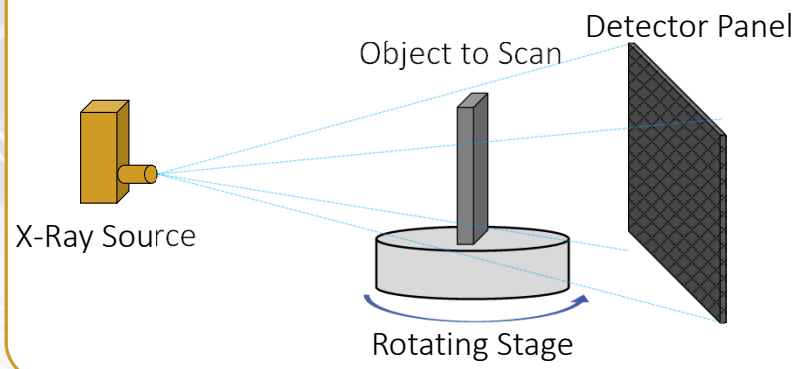
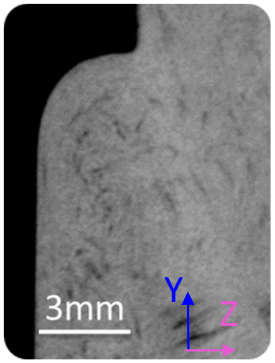
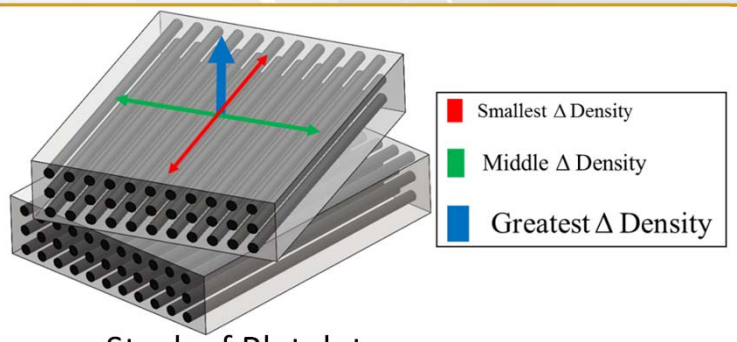
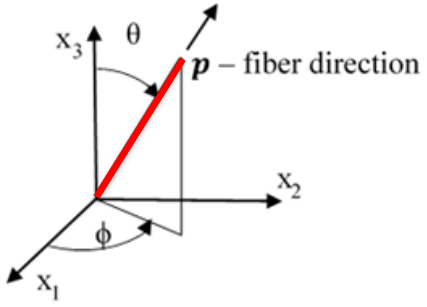




- Low Density – Air – Black
- High Density – Fiber/Matrix – Light Gray
- Resolution: 53 µm per voxel edge
- Fiber Diameter: ~7 µm
- Platelet Thickness: ~100 µm
- CAN NOT DISTINGUISH INDIVIDUAL FIBERS



Stack of Platelets



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MOLDING FLOW SIMULATION

ANISOTROPIC VISCOSITY

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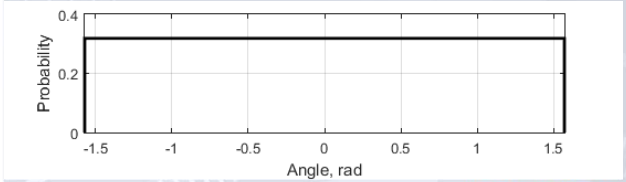
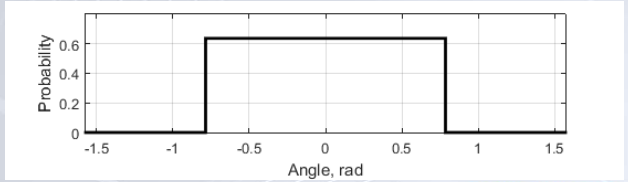
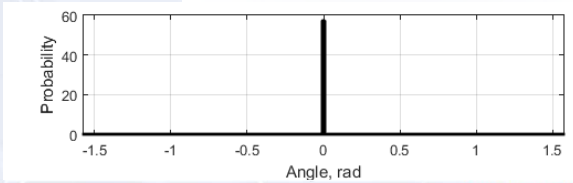
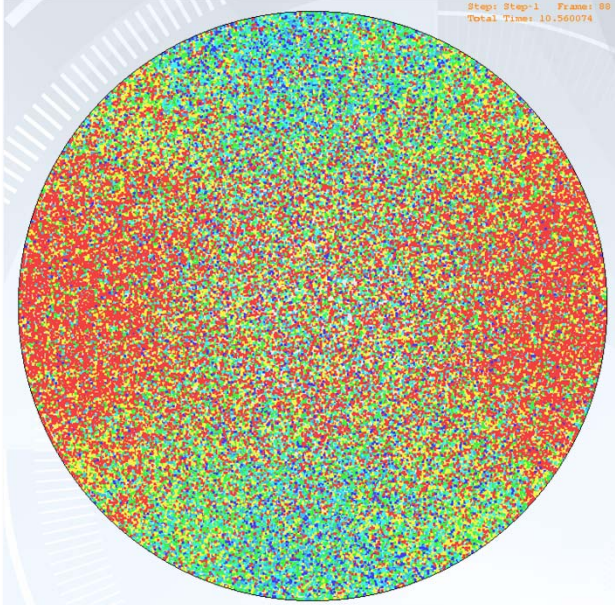
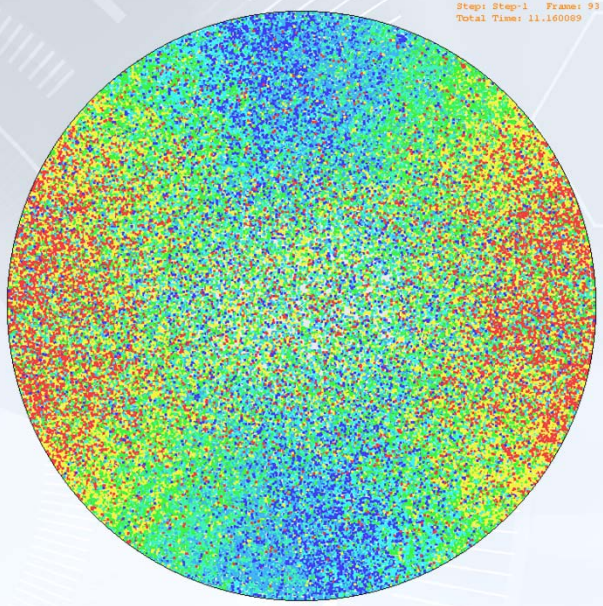




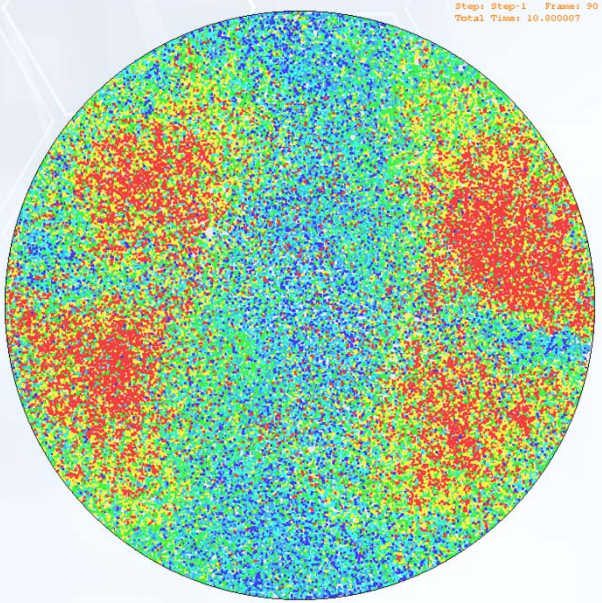




Symmetric Orientation State



Final Orientation State: Center Gated Disks



Knit Lines

MOLDING SIMULATION

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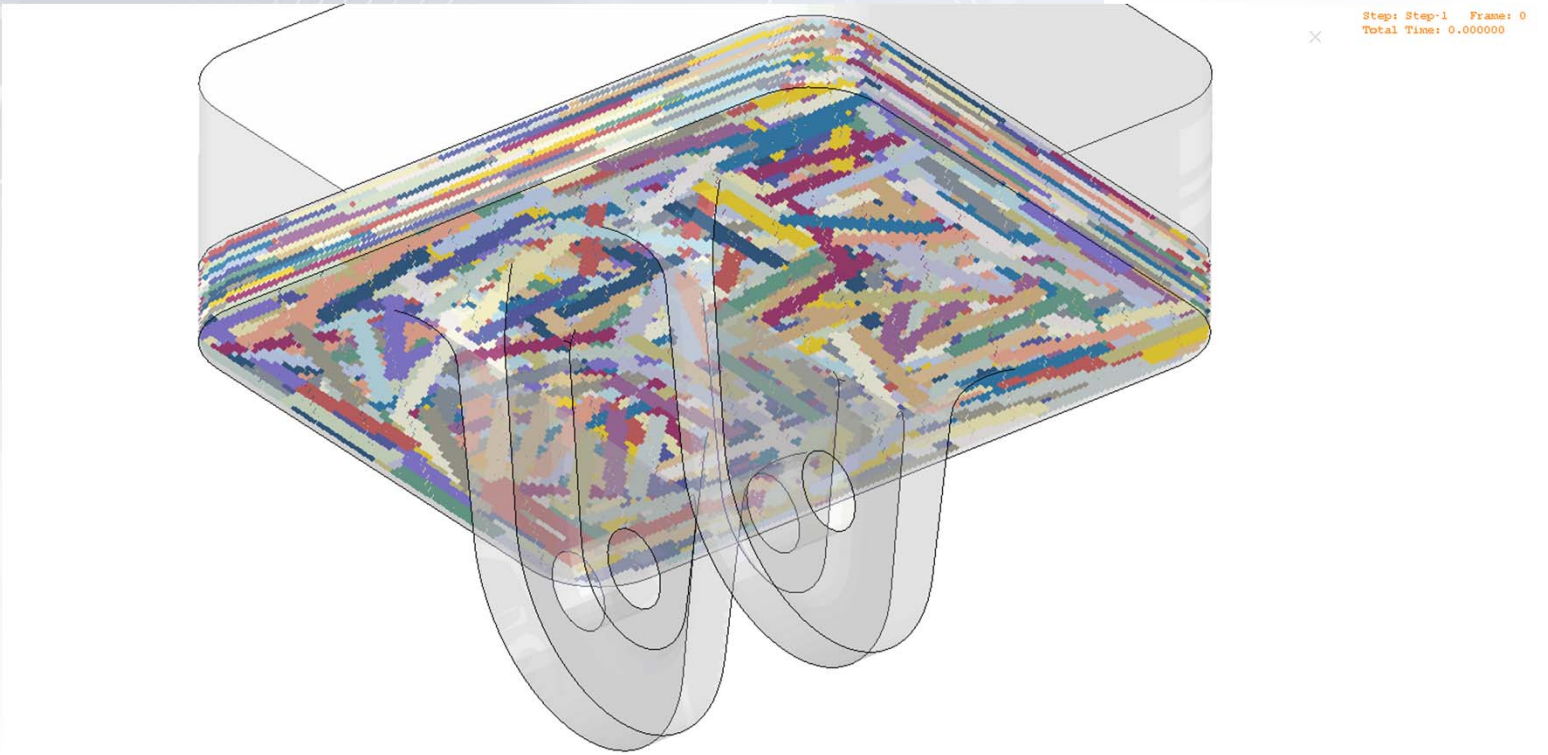

MAPPING TO STRUCTURED MESH

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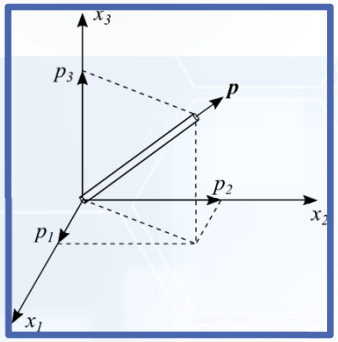
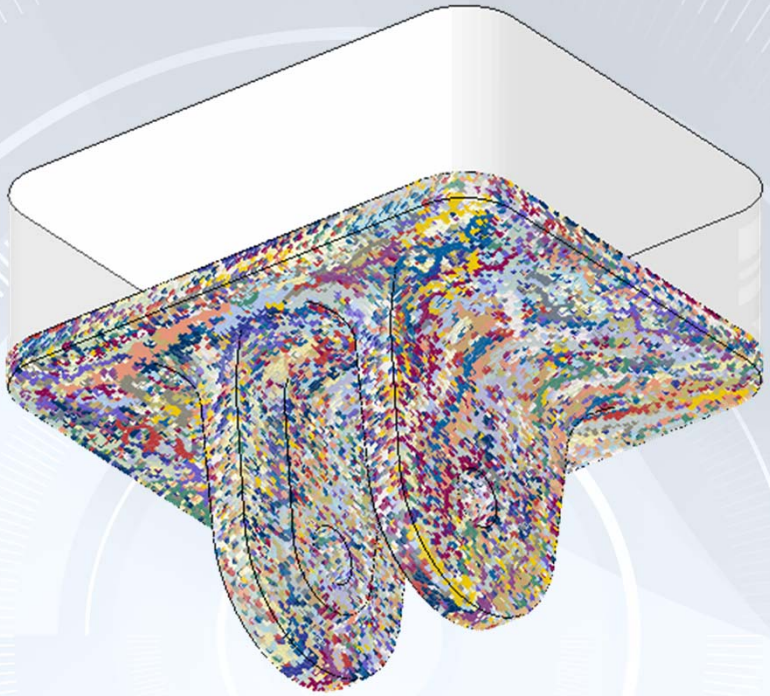
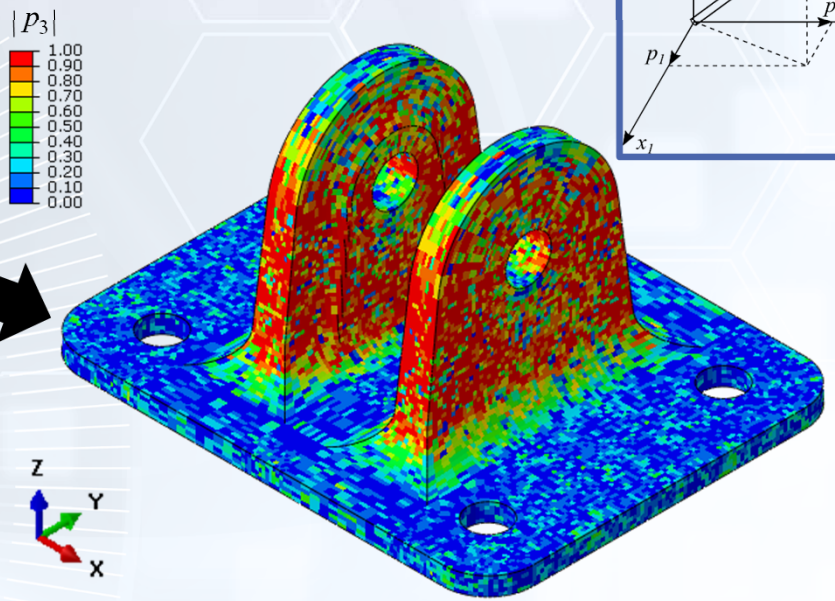
Fiber orientations are mapped from the flow simulation to a mesh for PFA





Platelet element sets

Mapping



z-component of the fiber orientation vector (red perfect alignment, blue no alignment)

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PLATELET MOLDED COMPOSITE SYSTEM STRENGTH PREDICTION

COMPRESSION-MOLDED COMPONENTS

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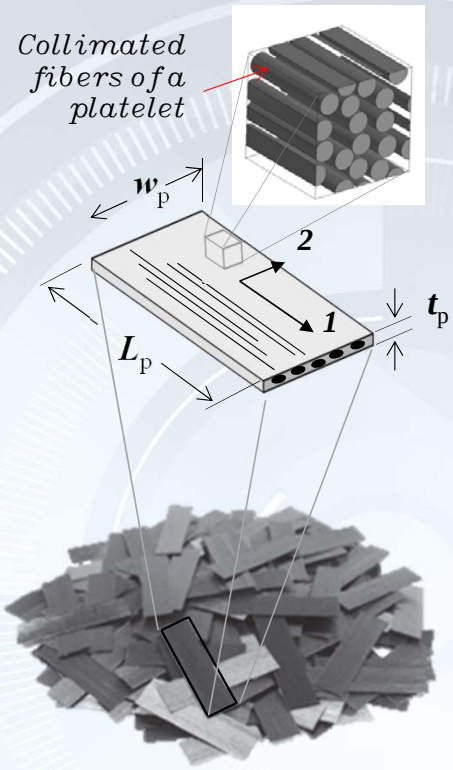
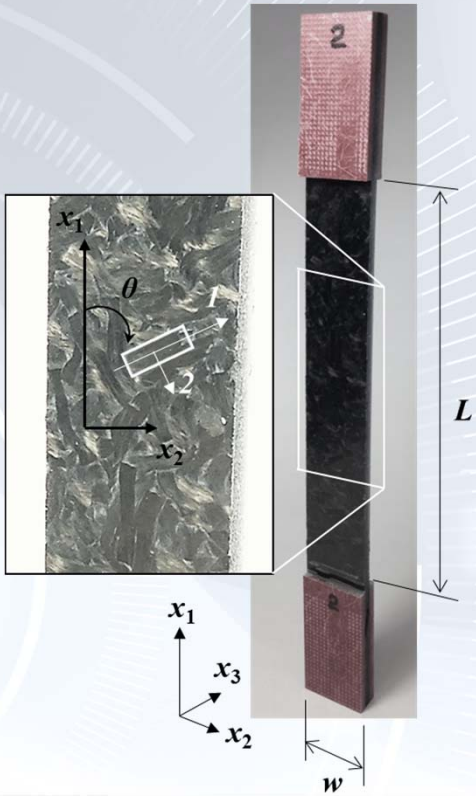
Collimated fibers of a platelet



Tensile bar of prepreg–platelets



Compression–molded part of prepreg–based platelet compound

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