559e Multiscale Modeling of Melt Infiltration in Random Fibrous Materials

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Computational modeling of melt infiltration in fibrous materials is difficult because the characteristic scale for interfacial effects (which plays an important role in the physics) is much smaller than the characteristic scale of the displacement itself. Consequently, continuum-scale simulations do not effectively capture microscale phenomena such as void formation and capillary instabilities.

To address this problem, we model microscale behavior using a network model of random fibrous materials. This model can be used to better understand the role of fiber orientation, fiber aspect ratio, wettability effects, and material heterogeneities on microscale fluid displacements. This approach (network modeling) is an approximate technique, and therefore lacks the rigor of a full computational fluid dynamics simulation at the microscale. The positive tradeoff, however, is that it can operate over much larger characteristic scales, and therefore is a good technique for implementation into a multiscale modeling framework.

In this presentation, we present a technique for creating computer-generated fibrous materials, which are used to quickly and easily vary material microstructure to understand the effects on fluid infiltration. We also explain how a similar approach can be used to model real materials (e.g., based on microtomography images). Using model fibrous materials, we present simulations of melt infiltration, which are used to understand the effects of key parameters on displacement phenomena. Finally, we demonstrate how microscale modeling is integrated into a multiscale model, which ultimately will aid in the design and optimization of net-shape fabrication processes for fibrous composite materials.