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Abstract for an Invited Paper for the SES11 Meeting of the American Physical Society

## Chaotic Advection in Multi-component Melts for the Manufacture of Composite Materials<sup>1</sup> DAVID ZUMBRUNNEN, Clemson University

Several forces arise when different liquids are placed into contact. The relative importance of these forces depends on the sizes and shapes of liquid domains and also on molecular characteristics of the liquids. When the liquids are agitated and in the absence of interdiffusion, a composite structure results that is defined by the spatial extent and size of each liquid domain in the presence of the other. Shaking a bottle with about equal parts of water and oil gives a structure that resembles a household sponge, for example. If the oil volume is much smaller than the water volume, oil droplets result instead. In polymer blends and composites, the structure can have feature sizes at the micron scale or smaller. Little has been known about the variety of structural types that can be formed because current information is based on mixing machinery that intrinsically restricts structural outcomes. This shortcoming has important consequences because physical properties of composite materials obtained by solidifying the structured liquids depend appreciably on structure characteristics. A recent approach to overcome this shortcoming makes use of *chaotic advection* to establish conditions that organize liquid domains into numerous thin layers. A multi-layer construction undergoes morphological changes in situ. Progressive structure development arises, whereby a specific structure leads in sequence to a morphologically different structure. A new manufacturing technology has resulted which allows control of the internal structure in extruded plastic materials. Micro- and nanostructured materials have been obtained. On-line process control allows rapid optimization of physical properties. In this presentation, the underlying physics will be described, examples of novel materials and their applications will be shown, and research opportunities will be highlighted.

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