Anisotropic thermal conduction in polymers

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Abstract
The strong coupling of mechanical and thermal effects in polymer flows have a significant impact on both the processing and final properties of the material. Simple molecular arguments suggest that Fourier's law must be generalized to allow for anisotropic thermal conductivity in polymers subjected to deformation. In our laboratory we have developed a novel, optical method to obtain quantitative measurements of components of the thermal diffusivity (conductivity) tensor in polymers subjected to deformations. In this seminar we report measurements of anisotropic thermal diffusivity and stress in molten, cross-linked and solid polymers subjected to several types of flows. The deformed samples have significant anisotropy in polymer chain orientation that results in significant anisotropy in thermal conductivity. Stress and thermal conductivity data support the validity of the stress-thermal rule, which is analogous to the well-known stress-optic rule. However, results for a semi-crystalline polymer do not obey the stress-thermal rule when significant crystallization occurs. We also report measurements on solid polymers with isotropic polymer chain orientation that are under stress, which display rather unexpected behavior. These measurements are used to develop an understanding of the molecular origins of anisotropic thermal transport in polymers.