Thermal Transport and Flow in Polymer Materials

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The strong coupling of mechanical and thermal effects in polymer processing flows has profound implications on both the processability and final properties of the material. Simple molecular arguments suggest that Fourier's law must be generalized to allow for anisotropic thermal conductivity in flowing polymer melts. In addition, theoretical results suggest a linear relationship between the thermal conductivity tensor and the stress tensor, or a stress-thermal rule. Using a novel optical method based on Forced Rayleigh Scattering (FRS) developed in our laboratory, we obtain quantitative measurements of all components of the thermal diffusivity tensor in polymers subjected to deformation. These data have been used to carry out the first (and only) tests of the stress-thermal rule, which we have found to be valid for several polymer chemistries in both shear and elongational deformations. More recently, we have developed a novel technique based on Infrared Thermography (IRT) that complements FRS, and allows for the study of a wider range of polymeric materials. The IRT technique also allows us to investigate the dependence of heat capacity on deformation. These experiments are used to develop an understanding of the molecular origins of thermal transport in polymers.