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Polymer Prize Lecture: A molecular perspective on the deformation of polymer glasses

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The mechanical properties of polymer glasses, including yield and plastic flow, are important for many applications. In contrast to the flow of polymer melts, plastic flow is poorly understood at a fundamental level. One reason for this is that the deformation of polymer glasses typically occurs in a highly nonlinear regime, e.g., doubling the strain rate has little impact on the flow stress. Eyring proposed that stress increases the rate of molecular rearrangements in solids and this is the source of nonlinearity in many models. Our group has developed an optical technique to measure molecular mobility and shown that mobility during deformation can increase by more than a factor of 1000. In this talk, I will highlight recent progress including understanding the role of deformation temperature and a comparison between molecular and mechanical relaxation times. Results from recent computer simulations and molecular theories will be discussed. Finally, some comments will be made on the deformation of polymer glasses in comparison to colloidal and metallic glasses.