SFB TRR 102

Polymers under Multiple Constraints

Polymer- & Soft-Matter-Seminar

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“Deformation instabilities and lamellae fragmentation during plastic deformation of polyethylene”

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at: **4.15pm**

VDP 4 1.27, Von-Danckelmann-Platz 4
06120 Halle

The outstanding mechanical performance of semicrystalline polymers can be attributed to their unique morphology and the robust phase interconnectivity through numerous chains intersecting the amorphous-crystalline interface. Deformation of a semicrystalline polymer is a complicated process, involving all elements of their complex morphology. In this process, different micro-mechanisms are activated at various stages. Furthermore, the active mechanisms can be adjusted with advancing strain due to interactions between adjacent amorphous and crystalline layers, which are tightly connected and therefore are forced to deform jointly. These interactions can also lead to some deformation instabilities, which in turn, may effect in opening new deformation paths and/or launch alternative mechanisms previously inaccessible, and therefore may appear very important part of the deformation sequence.

In this lecture two deformation instabilities: microbuckling and lamellae fragmentation, observed during deformation of semicrystalline polyethylene, will be discussed. The particular attention will be paid to the influence of the topology of the amorphous phase and phase interconnectivity.

The microbuckling instability, leading to cooperative kinking of lamellae, occurs at the true strain of e=0.3-0.4 in the lamellar stacks parallel to the direction of compression. This instability, most frequently seen in compression, manifests macroscopically as the ‘second yield’ in the stress-strain curve. Microbuckling is driven by the different stiffness of the hard and soft layers and their strong connectivity. The critical strain for microbuckling was found dependent primarily on the ratio of the amorphous and crystalline layer stiffness.

At true strain of e=0.6-1.0 the lamellae fragmentation due to the localization of crystallographic slip is commonly observed. This instability is triggered by stress concentrations generated at lamella faces by stretched ‘stress transmitter’ (ST) chains in the deformed adjacent amorphous layers. Accordingly, the fragmentation was found to depend on the surface fraction of STs at the amorphous-crystal interface: low concentration of STs resulted in fewer but stronger stress concentrations, prompting earlier slip localization and subsequent lamellae fragmentation. Extensive fragmentation reduces deformation constraints and allows formation of a new crystal ordering along the flow direction.

The discussed instabilities, either lamellae kinking or fragmentation, influence profoundly the deformation process as well as the resultant structure. Both phenomena relieve much of the structural constraints imposed on deforming lamellae and make further strain accommodation easier.