

X-ray scattering for the study of deformation and fracture of polymers

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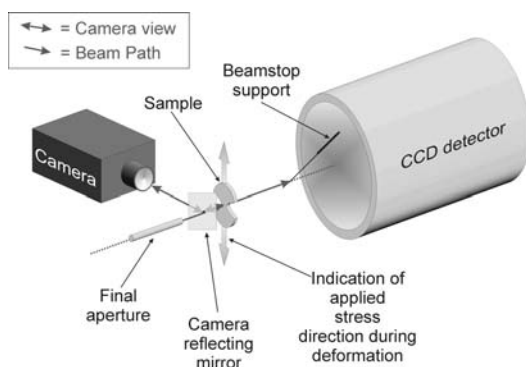
Polymers are largely used because of their favourable mechanical properties. During deformation of polymer materials structural changes occur at microscopic scale which ultimately will cause failure of the sample. Those changes can be investigated by x-ray scattering techniques at different scales. By the use of synchrotron sources it is possible to study these changes *in-situ* with x-ray microbeam, which allows scanning over the sample with microscopic resolution. In this way x-ray patterns of the structure, morphology and defect state of the sample are obtained, which provide a spatially resolved picture as well as the time evolution of structural aspects of the deformation and fracture state in the sample. The sample can be an amorphous or crystalline polymer but also a blend or composite.

In this way the mechanical behavior of semi-crystalline polymers is investigated, which is influenced by the crystalline and amorphous phases. A comprehensive relationship between structure and mechanical properties of semi-crystalline polymers is still largely missing. By the combination of three different techniques, tensile testing, synchrotron x-ray microbeam scattering at small and large angles, and optical microscopy, the influence of thermal treatment on the mechanical properties and crystallographic structure is investigated. The combination of mechanical and structural data provides new insight into the structure – properties relationship, where elastic, plastic and strain hardening are identified as well as competitive mechanisms like crystalline fragmentation and cavitation. In addition it is possible to visualise defects in composite materials, where early stages of failure and void formation at interfaces can be detected. So the breakage of an embedded glass fiber during deformation is detected by the void formation in the vicinity of the braking points. The x-ray microbeam technique will be a useful tool for the study of deformation and fracture in various polymer materials and provides structural as well as morphological information at different length and time scales. To still investigate larger structures, crazes and voids one has to use ultra-small angle x-ray scattering (USAXS). Because of intensity and resolution reasons the sample has to be illuminated with a larger spot. Different deformation and fracture processes are seen in this way in a more averaged way, when *in-situ* experiments are performed at different stages of deformation.

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Schematic experimental set-up (up), sample geometry with embedded fiber (left) and array of scanned x-ray scattering patterns of sample with broken fiber (right).