Scanning X-ray Scattering Study on Structural Changes at Crack Tips in PVDF

Guenther A. Maier[a], Gernot Wallner[b], Reinhold W. Lang[b], Peter Fratzl[c], *[a]Material Center Leoben, Institute of Metal Physics, University of Leoben, Leoben, Austria. [b]Polymer Competence Center Leoben and Institute of Materials Science and Testing of Plastics, University of Leoben, Leoben, Austria. [c]Max Planck Institute of Colloids and Interfaces, Dep. of Biomaterials, Potsdam, Germany.* E-mail: guenther.maier@unileoben.ac.at

Scanning small angle X-ray scattering approaches have been demonstrated to provide structural information at the supra-molecular level with positional resolution in the micron range. We use this technology on a lab-system with a beam size of 0,1mm to study deformation mechanisms around crack tips in poly(vinylidene fluoride) (PVDF), a semi-crystalline polymer which is known to show deformation-induced phase transitions. Fracture in semi-crystalline polymers is accompanied by the formation of a plastic zone, consisting either of shear bands, micro cavities or crazes. The supra-molecular deformation processes around the crack tip are essential for the progression of the crack and, hence, in defining the toughness of the material. Due to the enormous stress gradients around the crack tip they are difficult to assess and –in most polymers– only poorly understood. The use of position resolved scatting methods for investigations of the crack tip area provides detailed information of the structural changes during crack propagation. Our study shows a localized transformation of α-PVDF into the β-modification near the crack tip. The β-modification is forming fibers bridging crazes and cracks and, hence, considerably contributing to the toughness of the material.

Keywords: polymers, fracture, scanning-SAXS WAXS