20th European Mechanics of Materials Conference - EMMC20
Florence, Italy | May 27th-29th, 2026
www.emmc20.unifi.it

Micro-sized shear bands in annealed glassy polymers

Daniel Reitmair[1], Anne-Wil Snepvangers[2], Zifan Wang[3], Hans van Dommelen[4], Tom Engels[5], Frederik Van Loock[6]

[1] TU Eindhoven, Netherlands. d.reitmair@tue.nl
[2] TU Eindhoven, Netherlands. a.g.m.m.snepvangers@tue.nl
[3] Diamond Light Source, United Kingdom. zifan.wang@diamond.ac.uk
[4] TU Eindhoven, Netherlands. J.A.W.v.Dommelen@tue.nl
[5] TU Eindhoven, Netherlands. t.a.p.engels@tue.nl
[6] TU Eindhoven, Netherlands. f.van.loock@tue.nl

Paper ID: 211
Symposium S1: Mechanical behavior of polymers and biopolymers: theory, simulations and testing

Abstract

Shear bands are a form of strain localization where narrow, localized zones of intense plastic deformation form inside a material loaded above the elastic limit. They are often the precursor of failure and can be observed in many material systems, including amorphous and (poly)crystalline metals, granular materials, oxide glasses and natural rock. The presence of micro-sized shear bands in deformed amorphous polymers has also been reported repeatedly, indicating the relevance of loading conditions, sample geometry and thermomechanical history of the polymer. However, most work on this topic remains anecdotical, i.e. revealing the existence of the micro-sized shear bands but with limited insight into many fundamental aspects including (1) conditions for the bands to form, (2) the characteristic dimensions of the bands and (3) their influence on the macroscopic deformation and failure response of the polymer. The aim of this work is to shed light on conditions for micro-sized shear bands to manifest themselves and to characterize the resulting 3D shear band network within a deformed glassy polymer. To this end, we map out testing and thermomechanical conditions for the formation of micro-shear bands within different grades of annealed polycarbonate deformed in uniaxial tension. In addition, we detail the progress of our efforts to quantify characteristic length scales of the shear band network at the nano- to microscale. Finally, we use our observations to benchmark a mesoscale constitutive finite element model which naturally predicts the nucleation and growth of shear bands in the deformed polymer at the relevant length scale. The model predicts the viscoplastic deformation response of glassy polymers via explicit simulation of activations and interactions of shear transformation zones corresponding to local deformation events of a collection of parts of polymer chains.

Keywords:

micro-sized shear bands amorphous polymers thermomechanical history micromechanical characterization and modelling finite element modelling