Continuum mechanical modelling of deformation and failure mechanisms in thermoplastic multilayer composites

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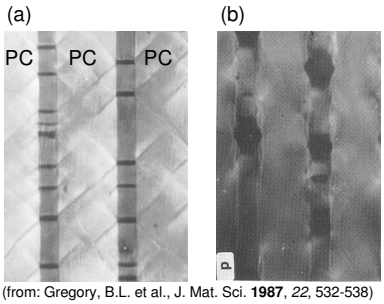
Introduction

- tensile response of PC/SAN multilayer composites controlled by **interacting micromechanisms**
  - shear banding in (ductile) PC
  - crazing / microcracking in (brittle) SAN
  - formation of network-like deformation pattern at small overall strain (a)
- macroscopic behaviour: **brittle** failure of SAN-rich composites (PC content / relative layer thickness < 50%) due to early coalescence of microcracks
  ductile response of PC-rich composites (> 50 %), holes in SAN grown from microcracks are stabilised (b)

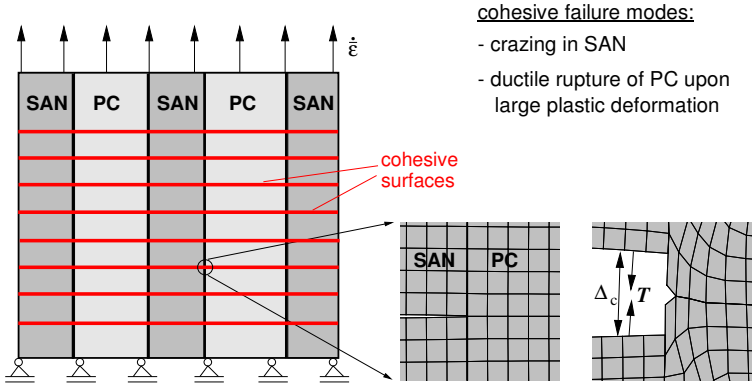


(from: Gregory, B.L. et al., J. Mat. Sci. **1987**, *22*, 532-538)

→ **objective of present study:** gain additional understanding of interrelation between microstructure, micromechanisms and macroscopic behaviour from numerical (finite element) simulations

Modeling

- sample with alternating layers of PC and SAN, plane strain (2D) model
- uniaxial overall loading in terms of prescribed macroscopic strain rate $\dot{\bar{\varepsilon}}$
- cohesive surfaces as potential locations of failure

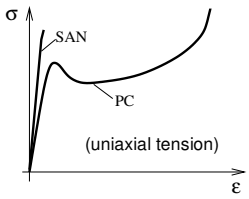


cohesive failure modes:
- crazing in SAN
- ductile rupture of PC upon large plastic deformation

Bulk constitutive models:

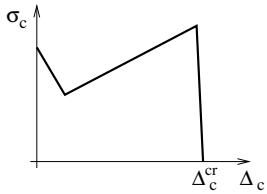
PC: finite strain viscoplasticity, intrinsic softening (→ shear banding), rehardening due to molecular alignment

SAN: linear elastic (tension)



Cohesive zone model for crazing:

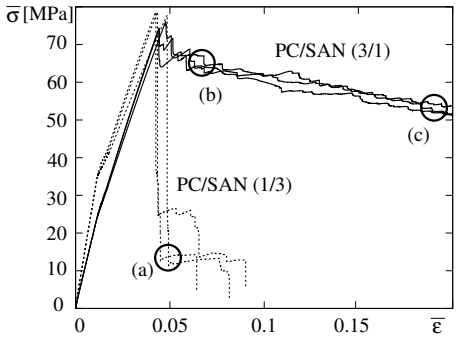
- initiation criterion (crit. normal stress)
- rate-dependent traction-separation law $\dot{\Delta}_C(\dot{T},T;\sigma_C)$
- craze widening resistance $\sigma_C(\Delta_C)$ (micromechanics of fibrillation process)
- craze-breakdown at crit. craze width



Results

- simulations with **different realisations** (statistically equivalent) of **initial defect distribution** in SAN (lower craze initiation stress)
- composition-dependent overall **brittle-to-ductile transition** reproduced
- localisation of damage in SAN-rich composites (a) and early brittle failure
- spatially distributed damage in PC-rich composites (b, c) and ductile overall behaviour
- long-range extension of **shear band network** (scaling with relative PC layer thickness) plays pivotal role for delocalisation of damage

macroscopic response



contours of local plastic strain