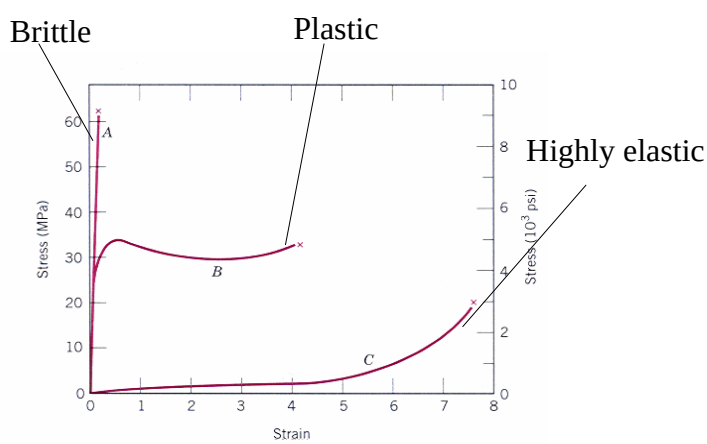
Chapter 16 Polymer properties

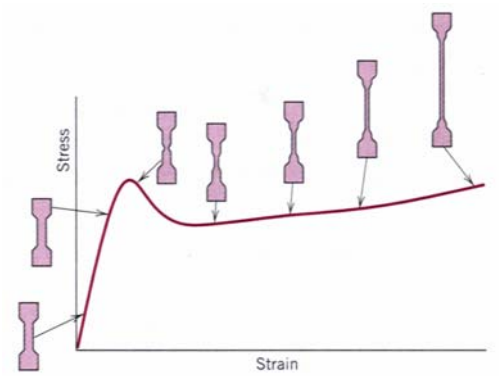
- Stress-strain behavior
- Deformation of polymers
- Factors that influence the mechanical properties of polymers
- Polymer applications

Polymer stress-strain behavior

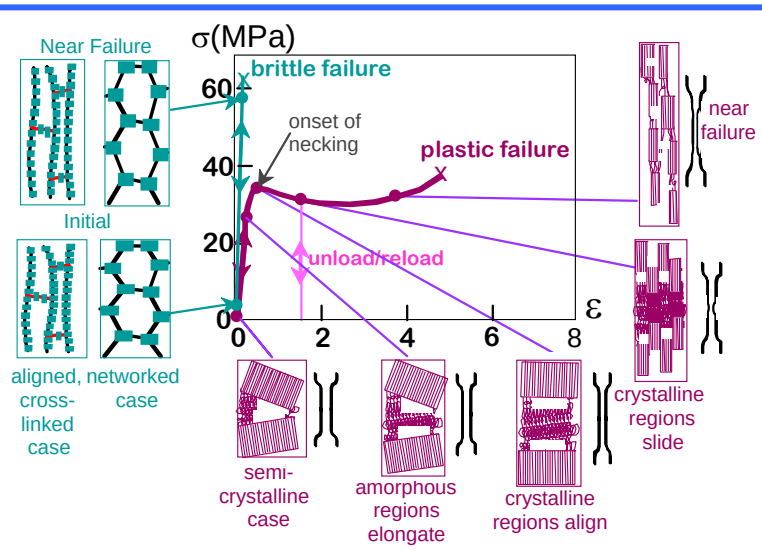


Deformation of semicrystalline polymers

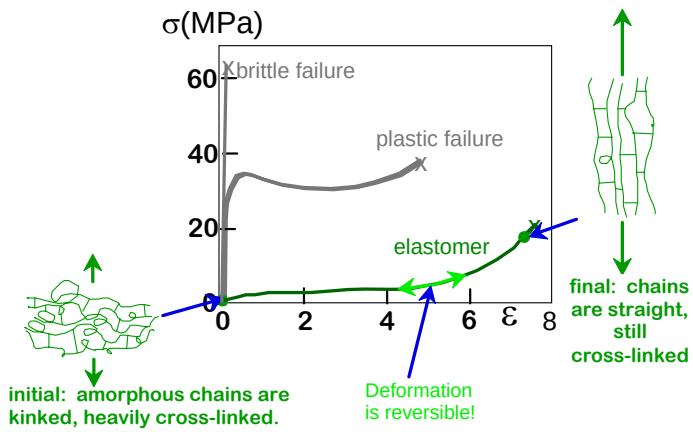
- Mechanism of elastic deformation
- Mechanism of plastic deformation
- Stress-strain curve relation



Tensile response brittle & plastic



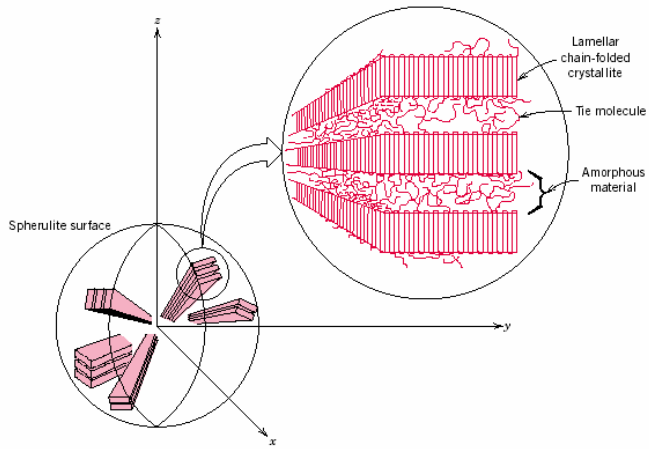
Tensile response: elastomer case



- **Compare to responses of other polymers:**
  --brittle response (aligned, cross linked & networked case)
  --plastic response (semi-crystalline case)

Deformation of semicrystalline polymers

- Detailed structure of a spherulite



Factors that influence the mechanical properties of polymers

- Molecular weight
  - σ_{TS} often increase with Mw
  - Longer chains are entangled or anchored better
- %crystallinity: % of material that is crystalline
  - σ_{TS} and E increase with %crystallinity
  - Annealing increases with %crsystallinity

Predeformation by drawing

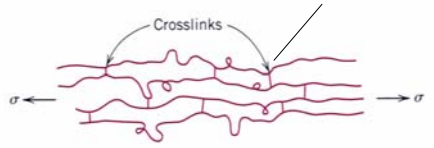
- Drawing: aligns polymer chains to the stretching direction
  - E and TS increases in the direction of tension and reduces in other directions
  - Ductility is reduced
- Annealing after drawing
  - alignment decreases

Deformation of elastomers

- Polymeric structures
  - amorphous, highly twisted, kinked and coiled
  - free rotation of chain bonds
- Deformation of elastomers
  - rubberlike elasticity
  - driving force for elastic deformation: entropy

Unstressed state

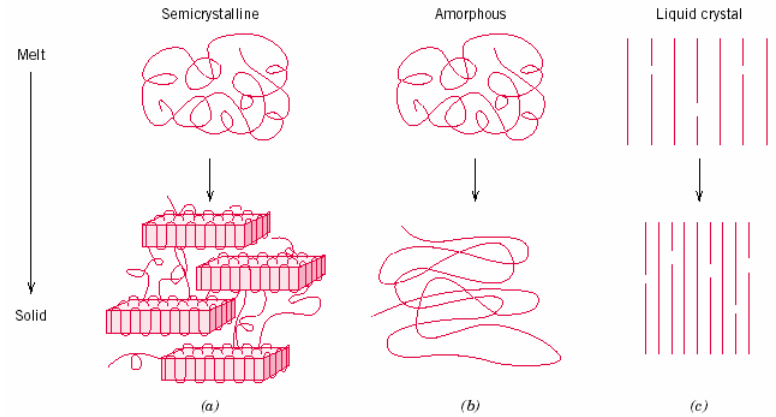
Stressed state



Polymer applications

- Plastics, elastomers, fibers, coatings,
- Polymer additives
  - fillers
  - plasticizers
  - stabilizers
  - colorants
  - flame retardants
- Advanced polymers
  - ultrahigh molecular weight polyethylene
  - liquid crystal polymers
  - thermoplastic elastomers

Polymer applications



Summary

- General drawbacks to polymers
  - E, σ_y, Kc, $T_{application}$ are small
  - T-dependent deformation
  - Result: polymers benefit from composite reinforcement
- Thermoplastics (PE, PS, PP, PC)
  - smaller E, σ_y, $T_{application}$
  - larger Kc
  - easier to form and recycle
- Elastomers (rubber)
  - large reversible strains
- Thermosets (epoxies, polyesters)
  - larger E, σ_y, $T_{application}$
  - smaller Kc