LECTURE #31 :
3.11 MECHANICS OF MATERIALS F03

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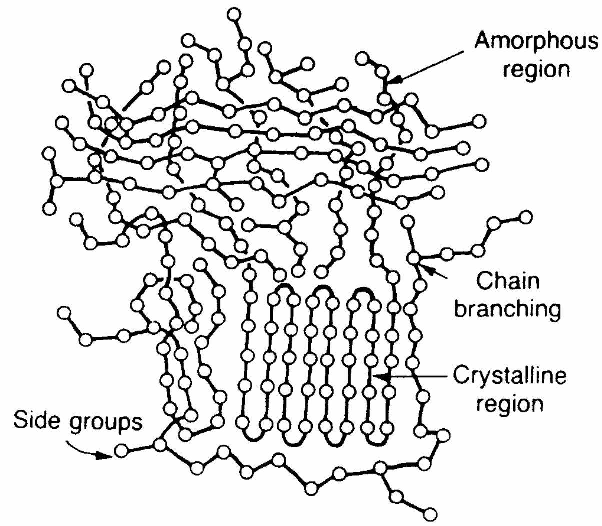
- **PLASTICITY OF POLYMERS III**

Stress vs. Strain Movies :

- http://mse-pma1.eng.ohio-state.edu/~peterand/mse205/lectures.html
- http://www.succeed.ufl.edu/content/Russ%20VIMS/necking.mov
- http://www.succeed.ufl.edu/content/Russ%20VIMS/tensile2.mov

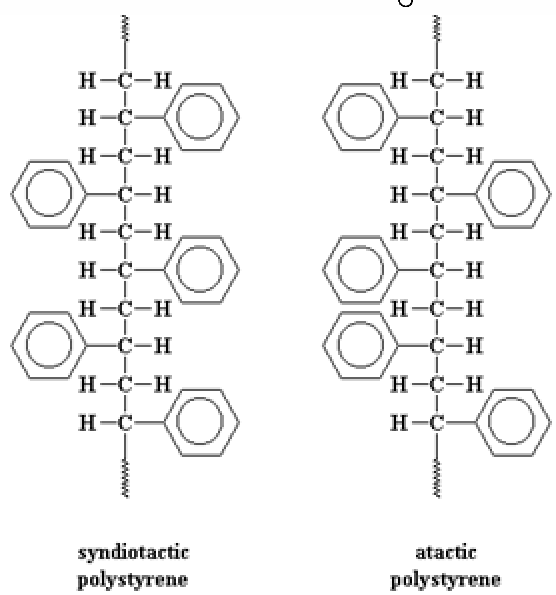
SUMMARY : LAST LECTURE

I. Comparison of Amorphous and Semicrystalline Polymers



A. SEMICRYSTALLINE

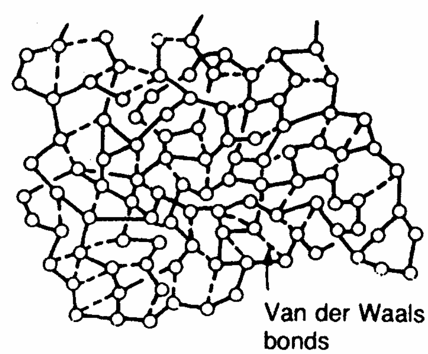
- has crystalline and amorphous regi
- have both a Tg and Tm
- properties depend strongly on % crystallinity
- most are translucent/opaque
- increased plastic deformation relative to amorphous polymers
- Nylon, polyethylene, polypropylene, Kevlar, atactic polystryrene



Syndiotactic polystyrene has a regular structure, so it can pack into crystal structures. The irregular atactic polystyrene can't.

B. AMORPHOUS

- no order, random coil
- optically transparent
- Tg is an important parameter
- brittle T<<Tg
- polymers that have trouble crystallizing due to their irregular structure : epoxies, poly(methyl methacrylate), poly(vinyl chloride), polycarbonate, atactic polystyrene

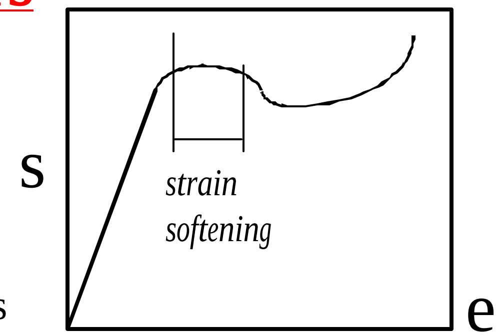


SUMMARY : LAST LECTURE

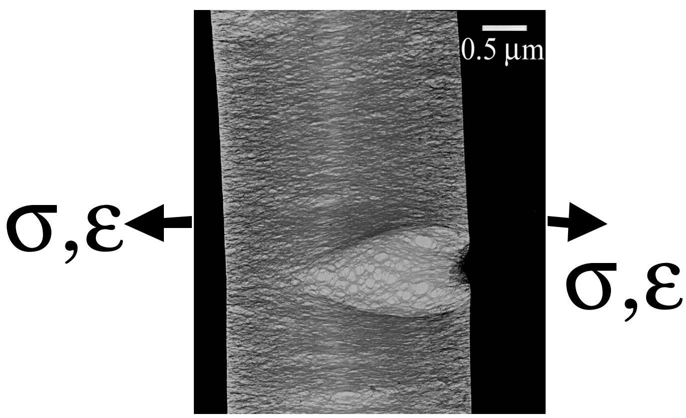
II. Plastic Deformation Mechanisms in Amorphous, Glassy Polymers

• **STRAIN SOFTENING :** drop in stress with increasing strain due to :

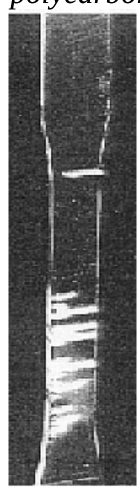
• **STRAIN LOCALIZATION :** nonhomogeneous yielding where strain is localized in distinct regions of the material, dramatic changes in micro- and nano-structure : (1) crazing and (2) shear deformation zones



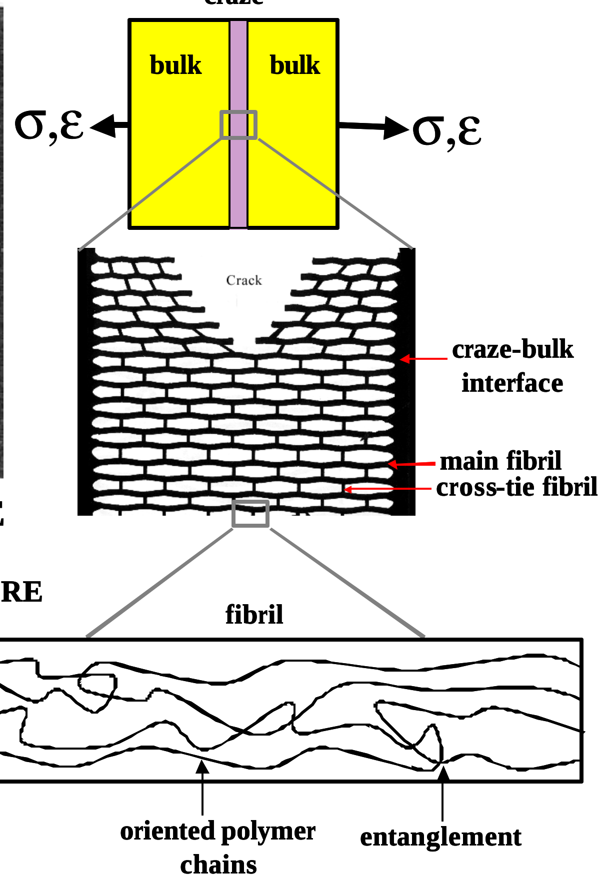
CRAZE

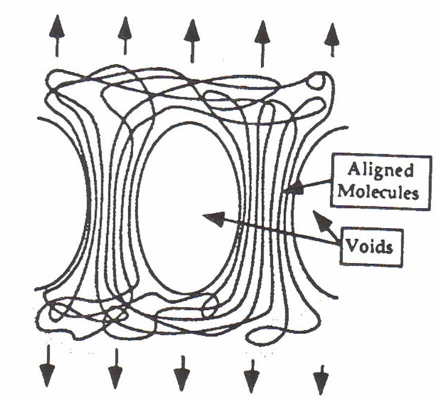


polycarbonate



CRAZE NANO STRUCTURE





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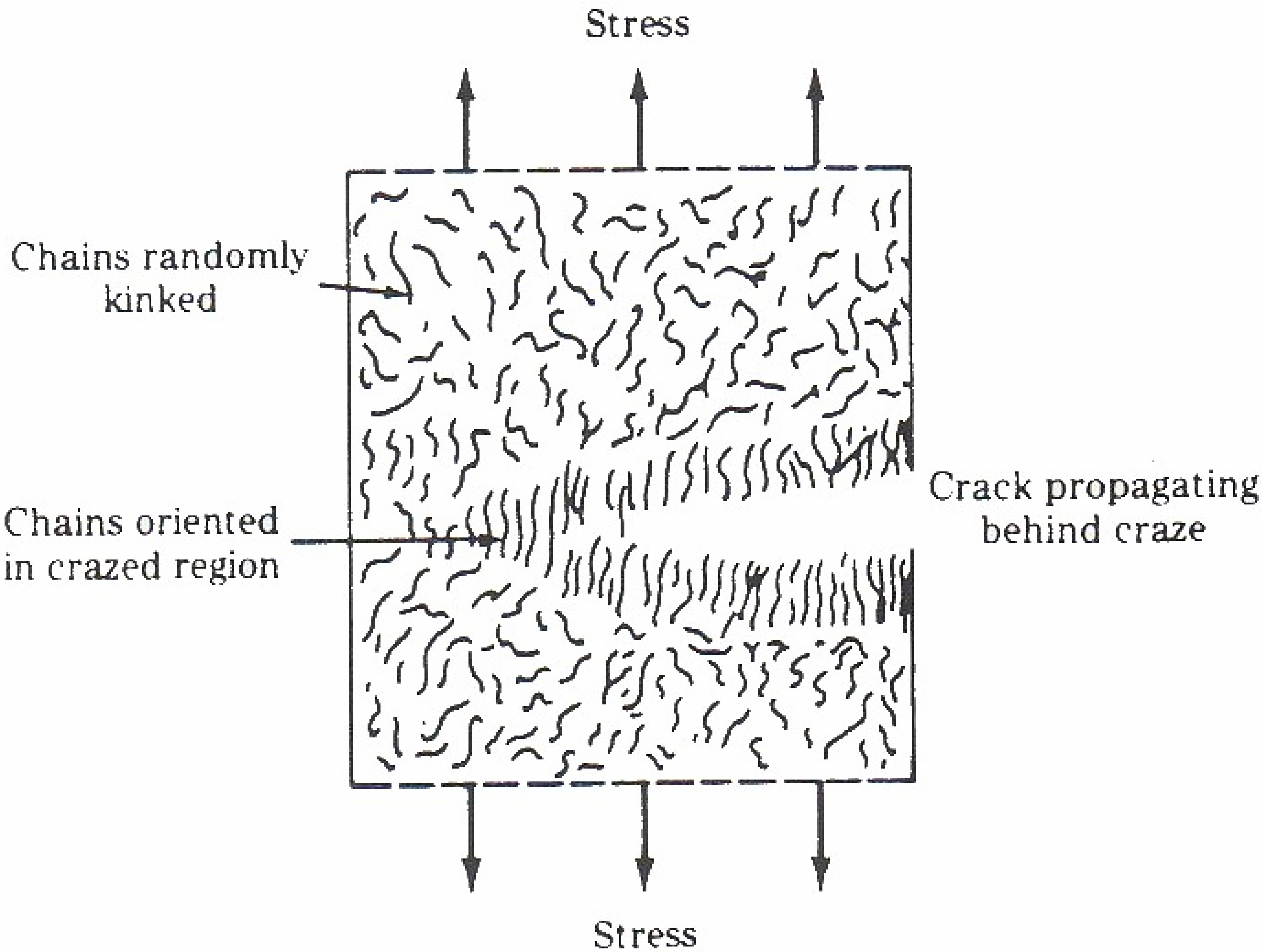
• **CRAZE :** elongated, localized region of plastic deformation created via a tensile cavitation process, the craze faces are spanned by a huge number of polymer fibrils (50% void, 50% polymer), craze dimensions and structure ⇒ low ν_x

Plastic Deformation Mechanisms in Amorphous, Glassy Polymers



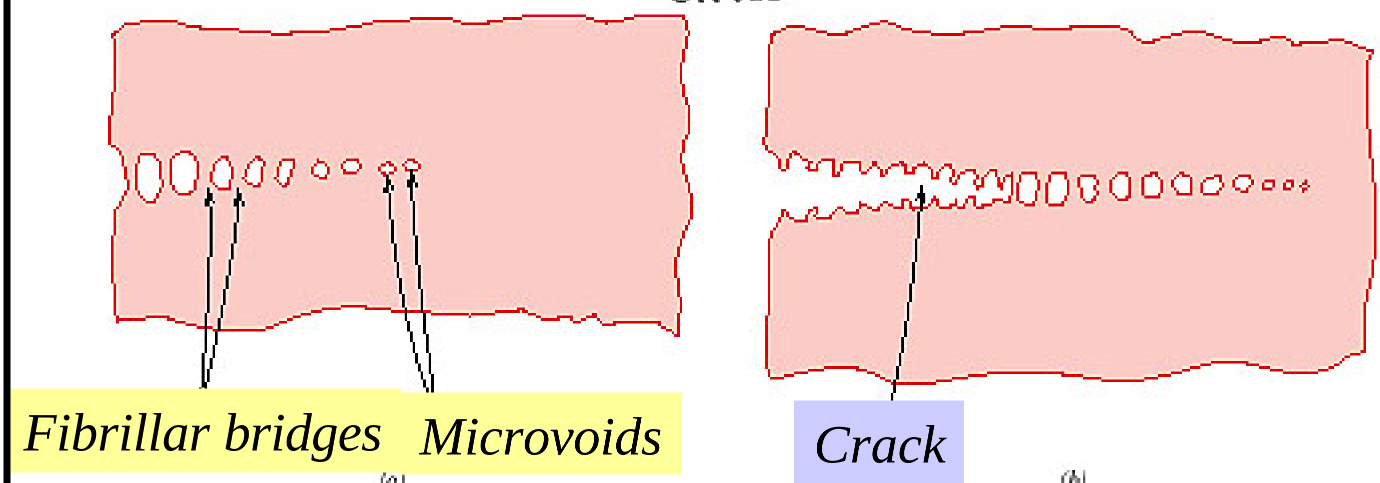
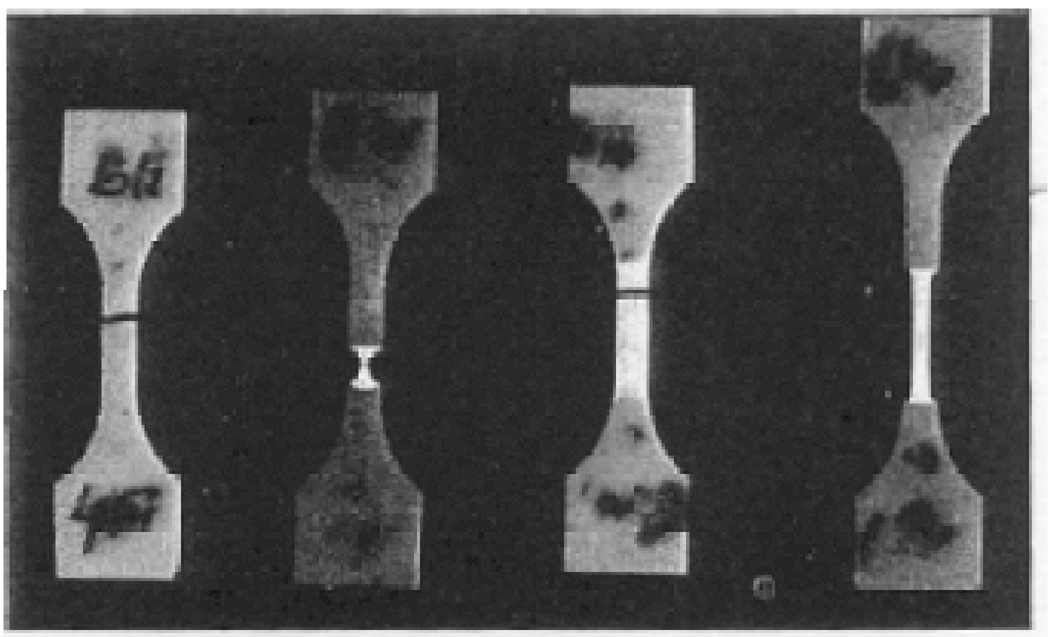


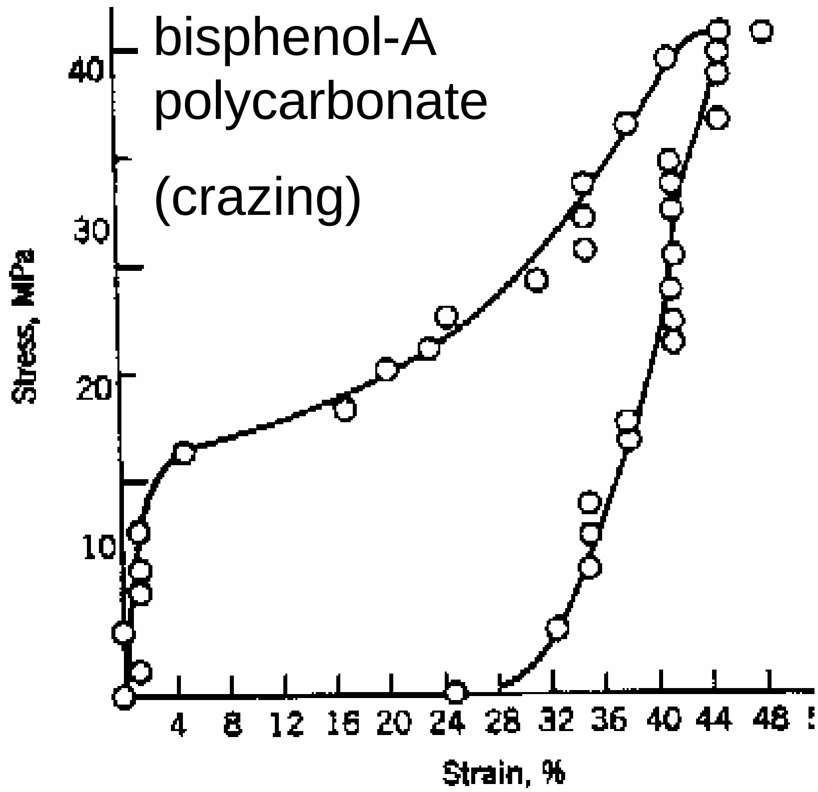
FIGURE 16.15 Schematic drawings of (*a*) a craze showing microvoids and fibrillar bridges, and (*b*) a craze followed by a crack. (From J. W. S. Hearle, *Polymers and Their Properties*, Vol. 1, *Fundamentals of Structure and Mechanics*, Ellis Horwood, Ltd., Chichester, West Sussex, England, 1982.)

Temperature Dependence of Mechanical Properties of Polyethylene

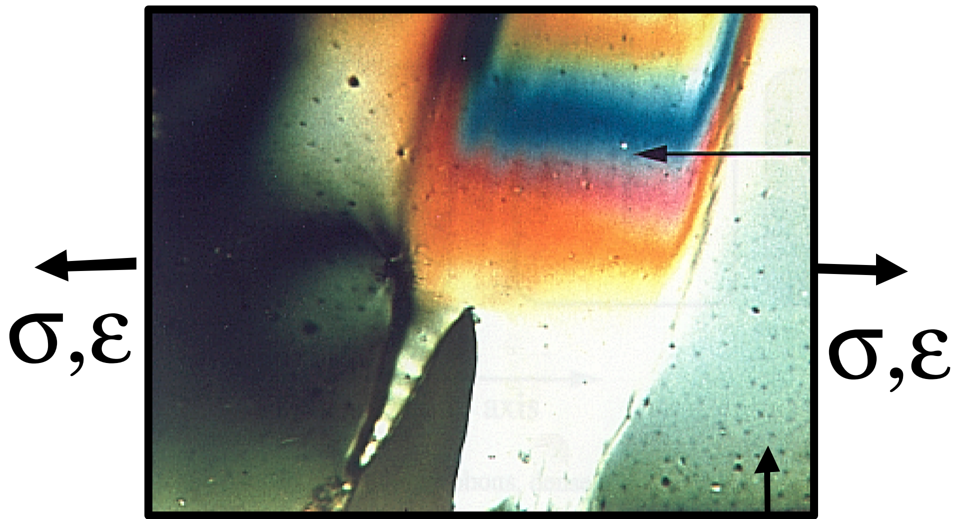


(a) (b) (c) (d)

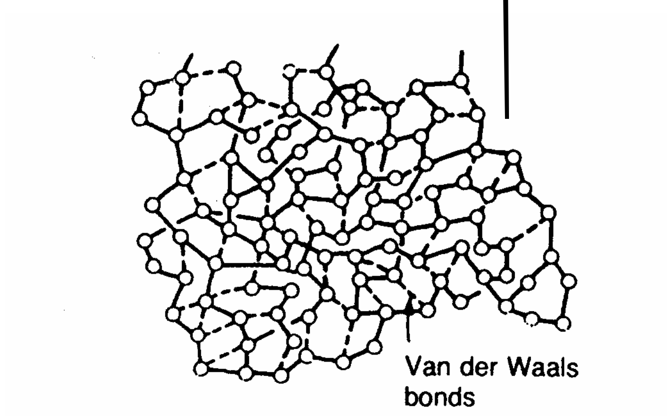
CONSEQUENCES FOR IMPACT RESISTANCE



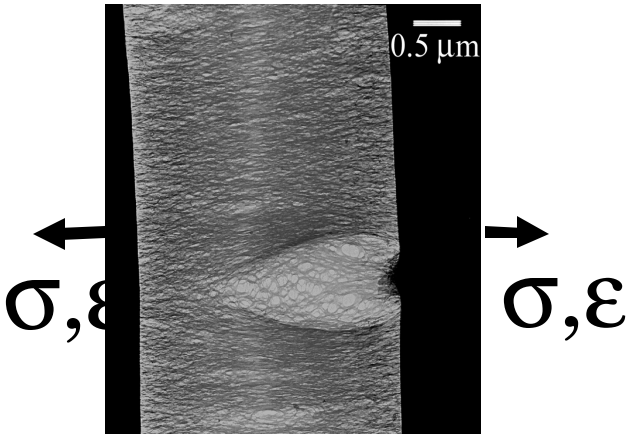
Shear DZ's in Amorphous, Glassy Polymers (T<Tg)

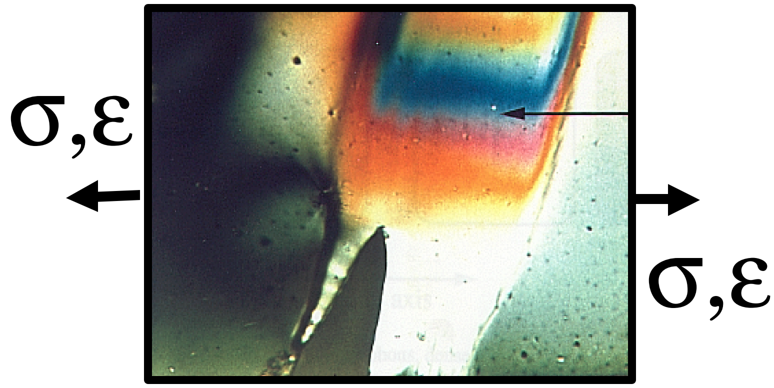


Microscopic structure

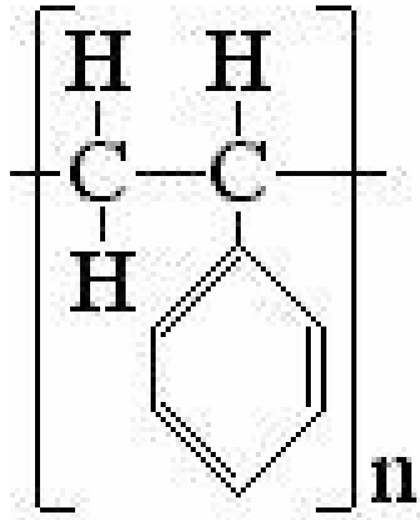


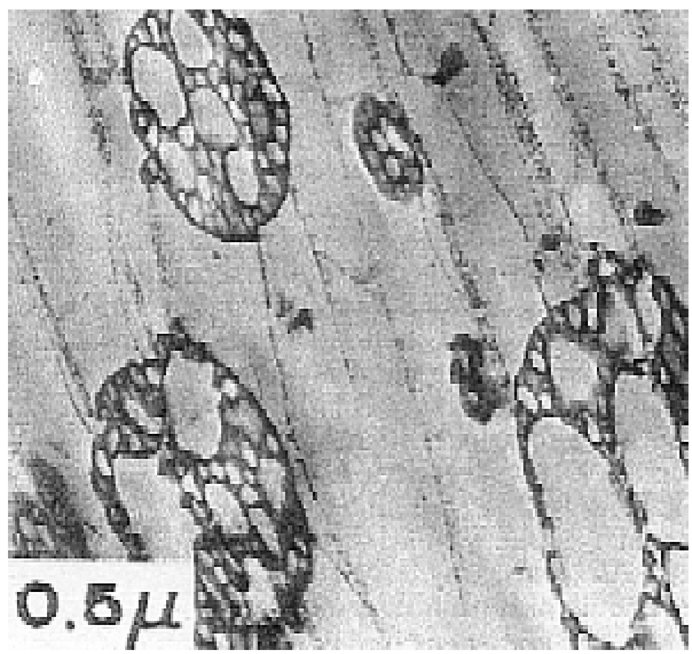
CRAZING OR SHEAR DZ's?





TOUGHENING OF AMORPHOUS POLYMERS





TOUGHENING OF AMORPHOUS POLYMERS

Typical uniaxial tensile stress-strain behavior of polystyrene (PS), medium-impact PS (MIPS), high-impact PS (HIPS), and poly(acrylonitrile-co-styrene-graft-butadiene) ABS.