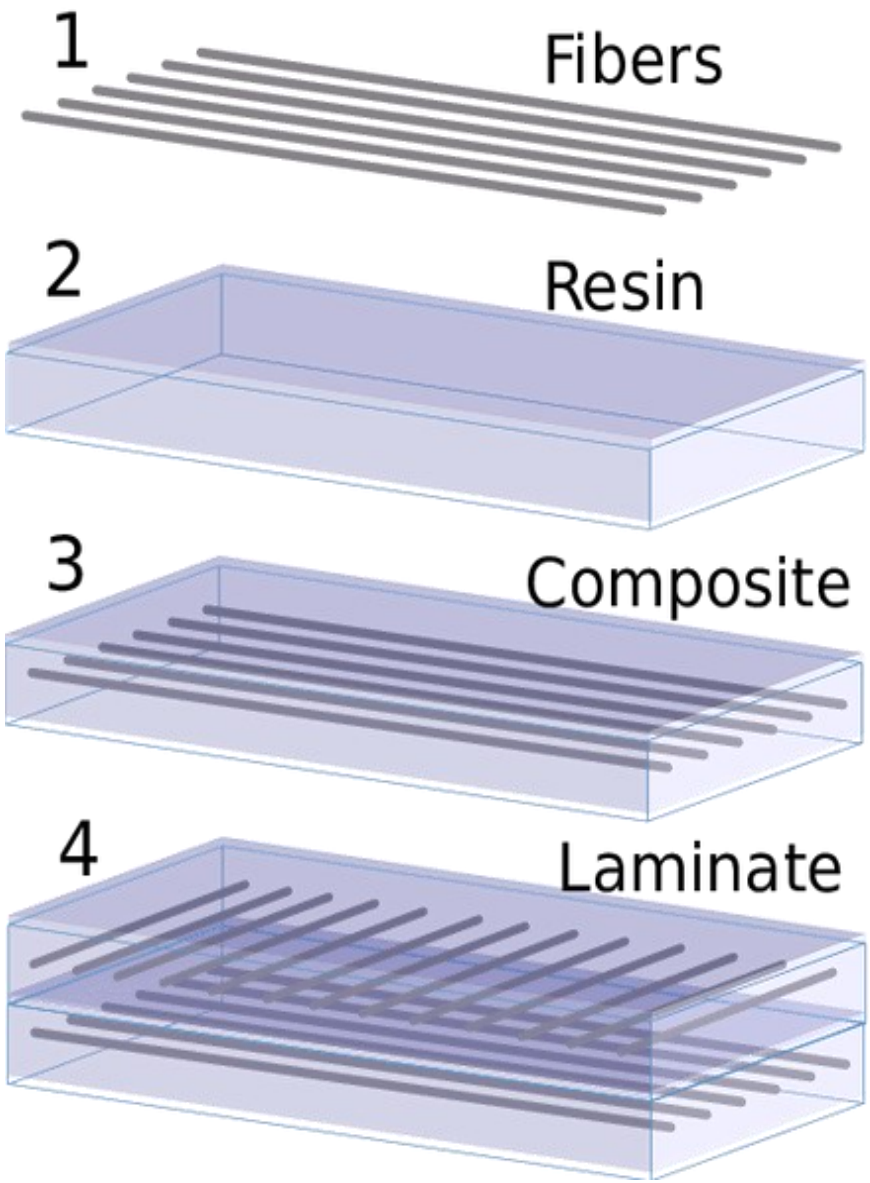
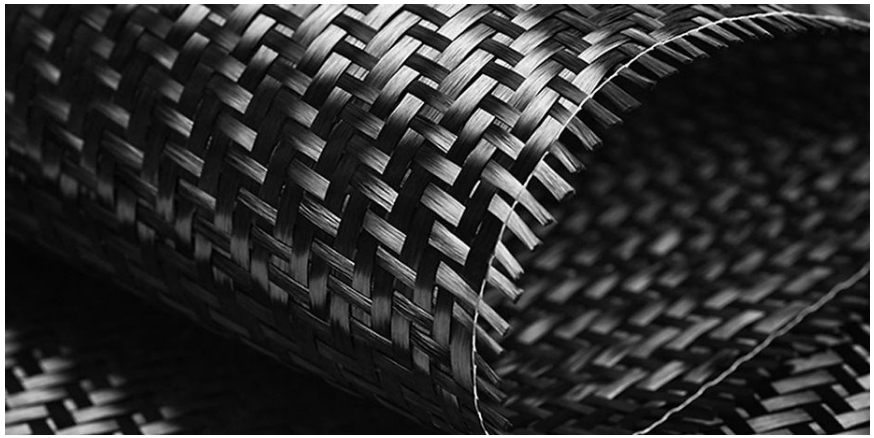
ME 330: Engineering Materials

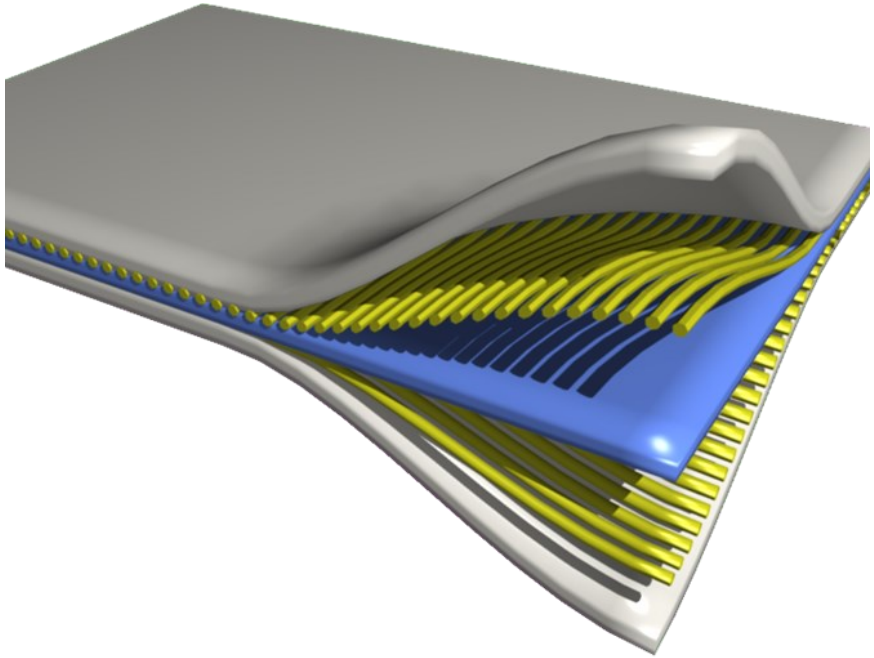
Lab - 9

Polymer and Composite Tensile Testing

Composite Materials

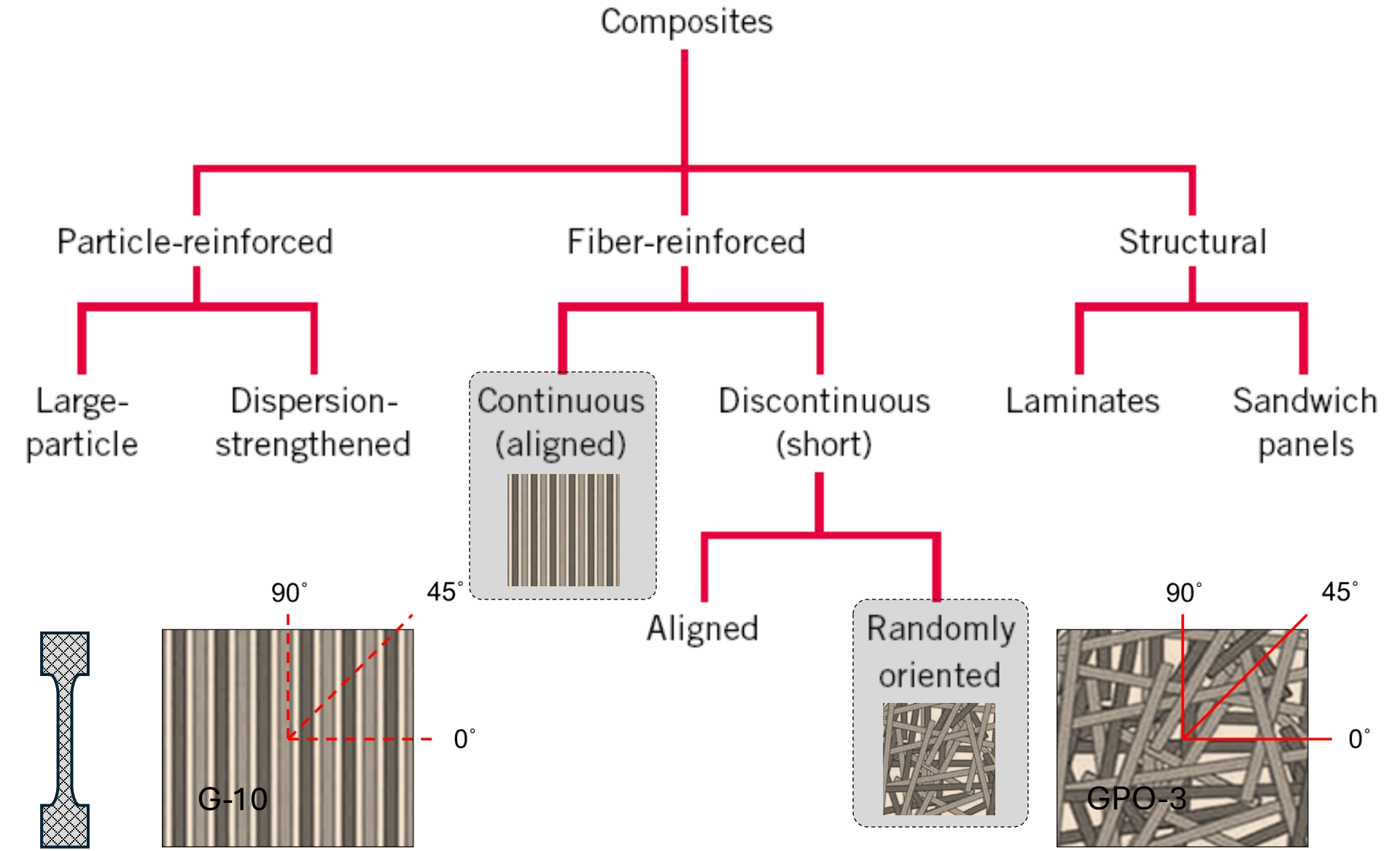






© 2024 University of Illinois Urbana-Champaign, All Rights Reserved.

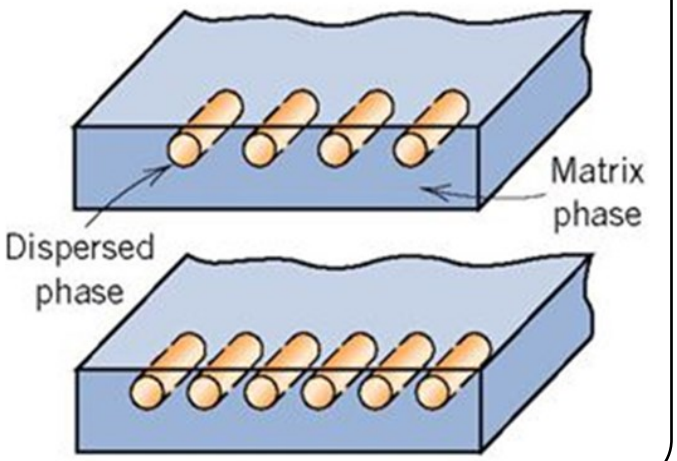
Map of Composite Materials



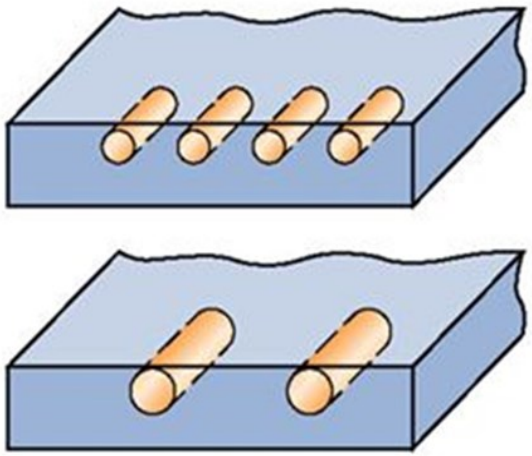
© 2024 University of Illinois Urbana-Champaign, All Rights Reserved.

Fiber Reinforcement Influences

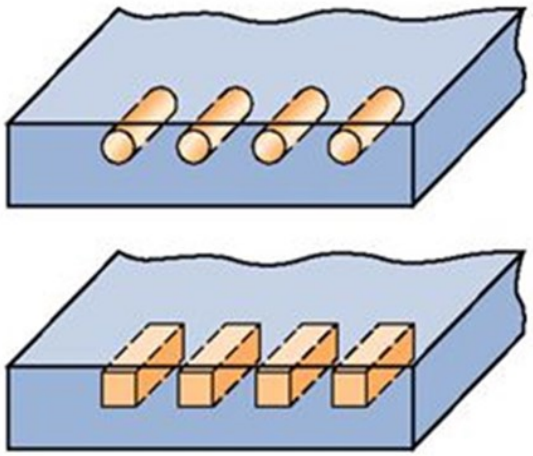
Concentration



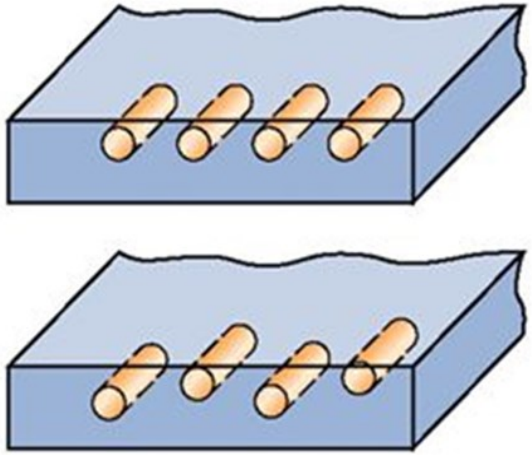
Size



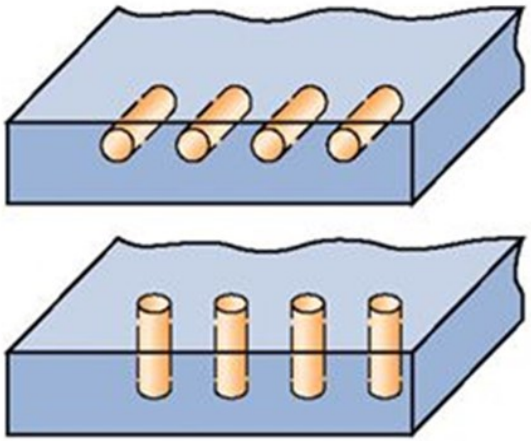
Shape



Distribution



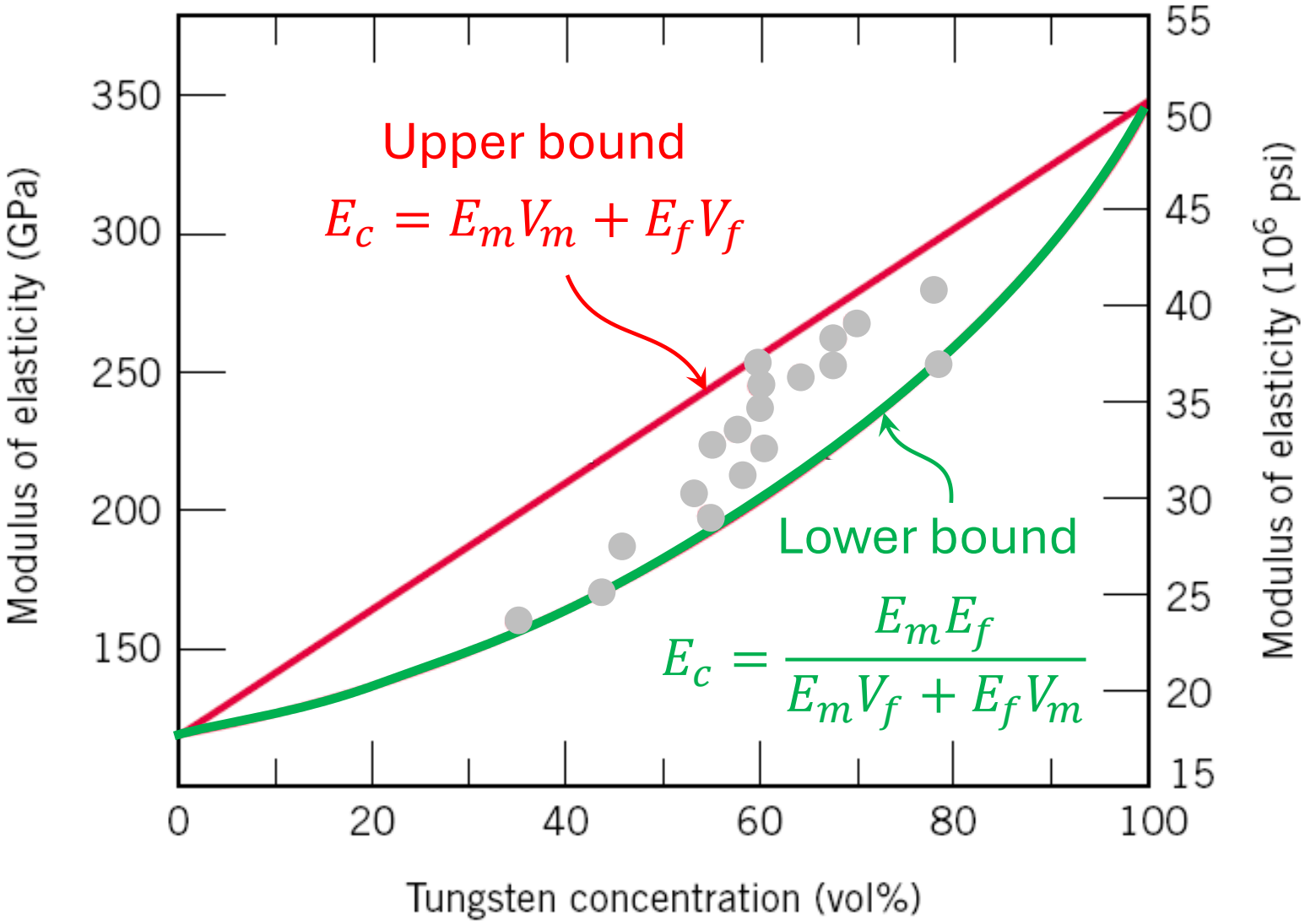
Orientation



© 2024 University of Illinois Urbana-Champaign, All Rights Reserved.

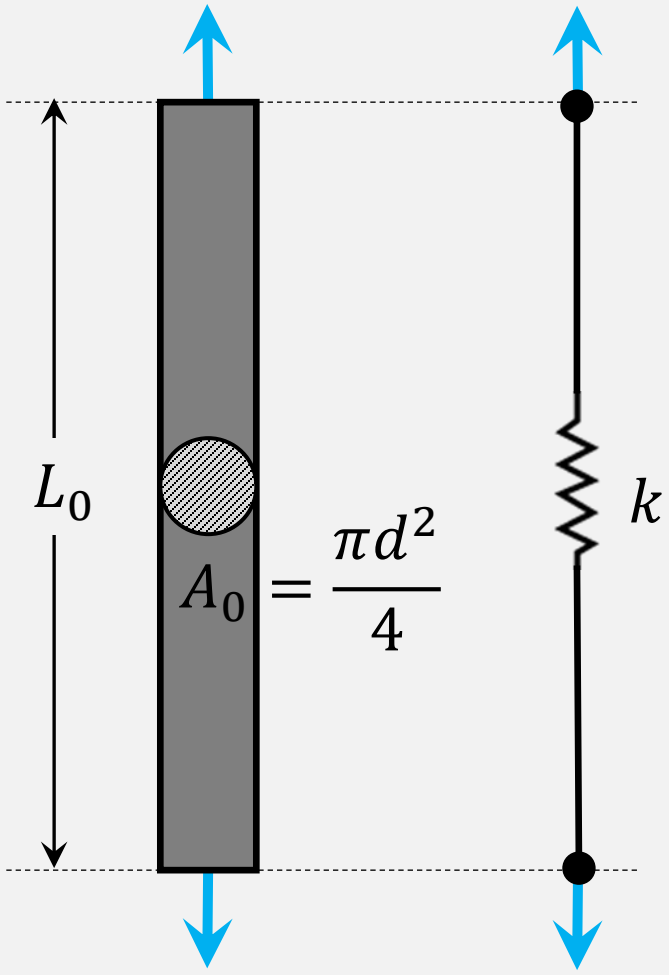
Rule of Mixtures

Tungsten (fiber) in Copper(matrix)

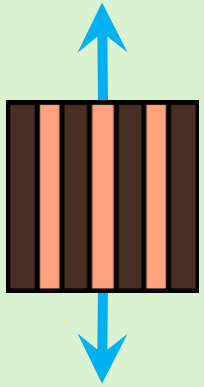


© 2024 University of Illinois Urbana-Champaign, All Rights Reserved.

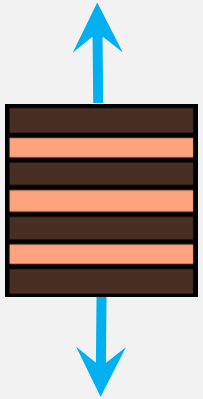
Rule of Mixtures



$$k = \frac{F}{\delta} = \frac{\sigma A_0}{\varepsilon L_0} = E\left(\frac{A_0}{L_0}\right)$$



Iso-strain



Iso-stress

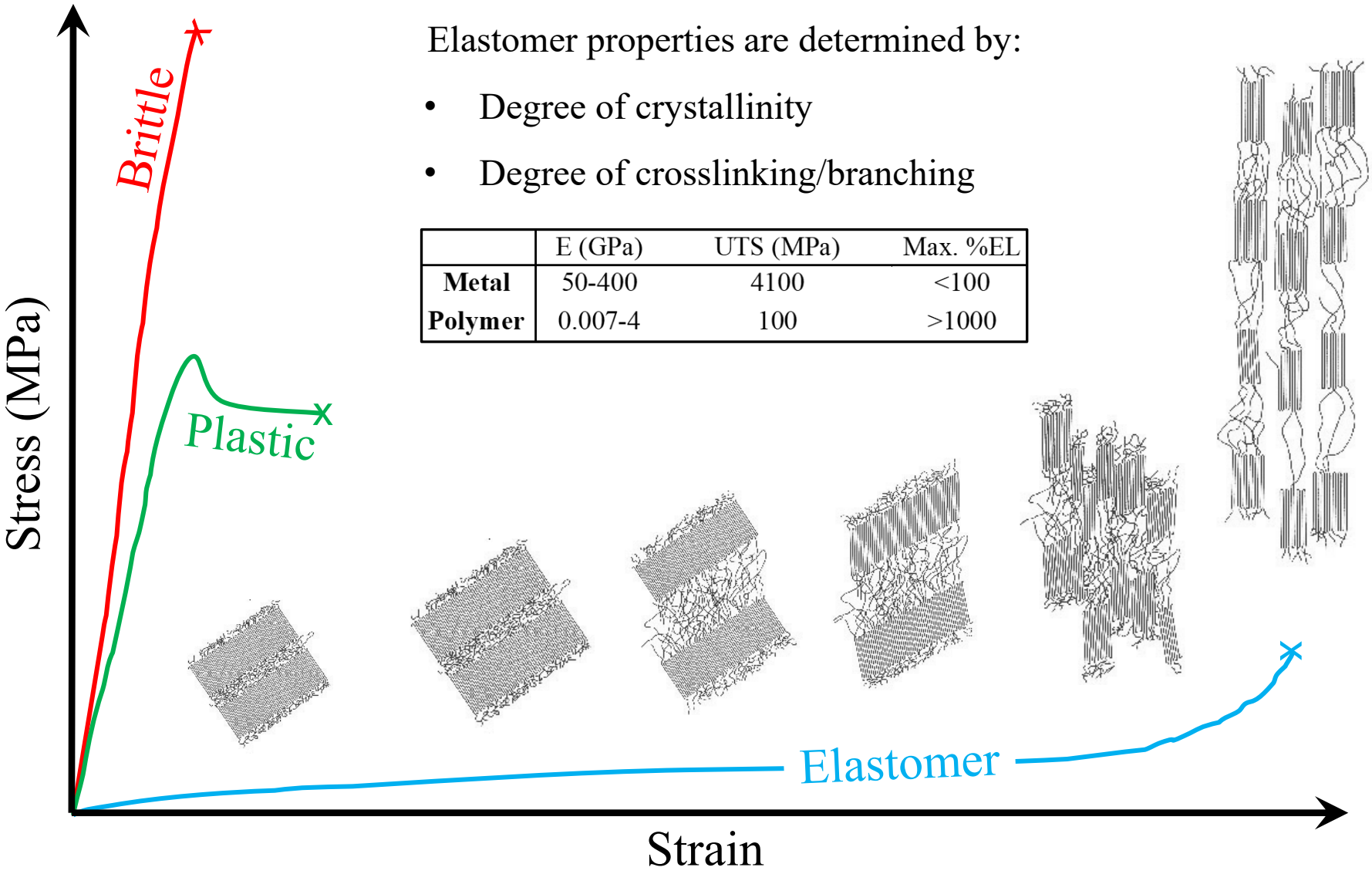
© 2024 University of Illinois Urbana-Champaign, All Rights Reserved.

Deforming Semi-Crystalline Polymers

Elastomer properties are determined by:

- Degree of crystallinity
- Degree of crosslinking/branching

	E (GPa)	UTS (MPa)	Max. %EL
Metal	50-400	4100	<100
Polymer	0.007-4	100	>1000

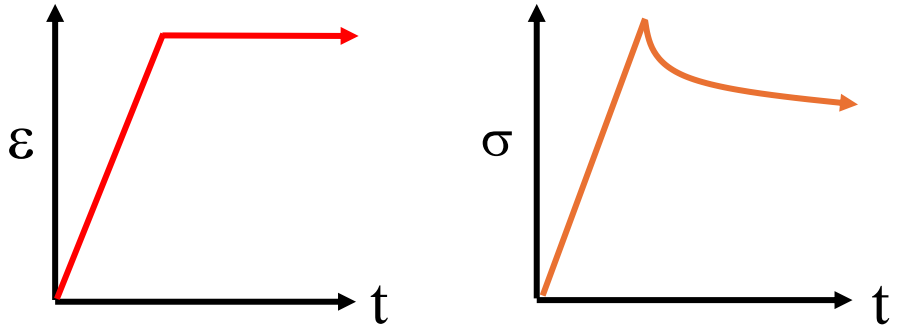


© 2024 University of Illinois Urbana-Champaign, All Rights Reserved.

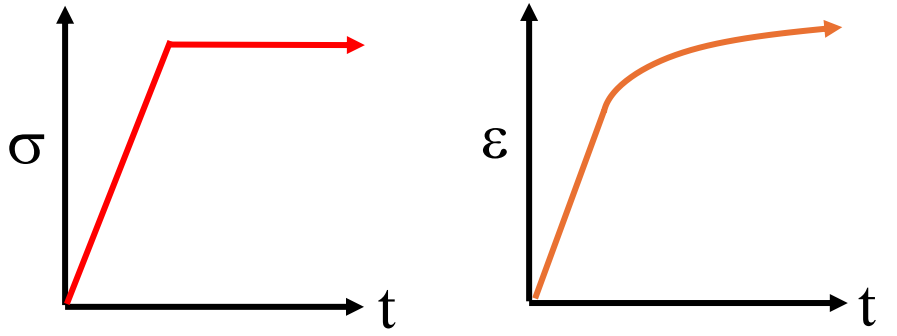
Creep Properties

Due to low melting temperatures, stress relaxation and creep are important at room temperatures.

Relaxation modulus:



Creep modulus:



$$E_r(t) = \frac{\sigma(t)}{\varepsilon}$$

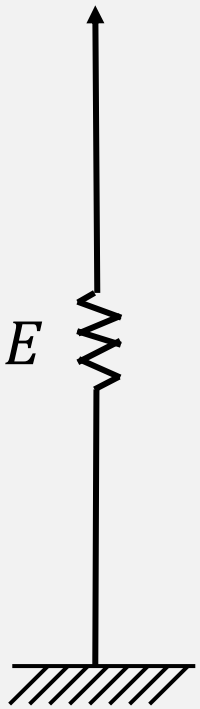
$$E_r(t) \neq E_c(t)$$

$$E_c(t) = \frac{\sigma}{\varepsilon(t)}$$

© 2024 University of Illinois Urbana-Champaign, All Rights Reserved.

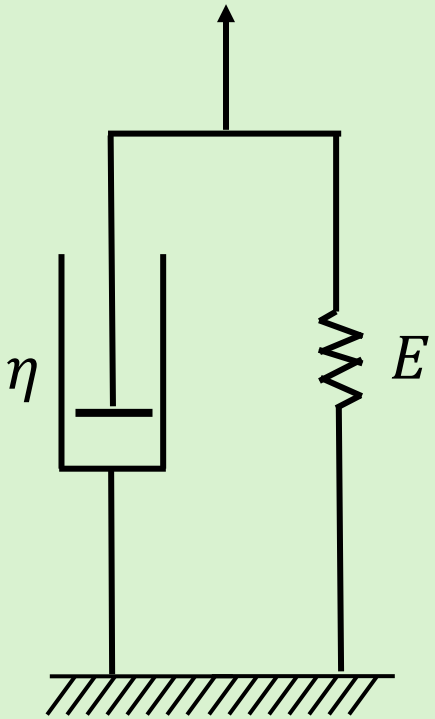
Material Models

Solids



$$\sigma = E\varepsilon$$

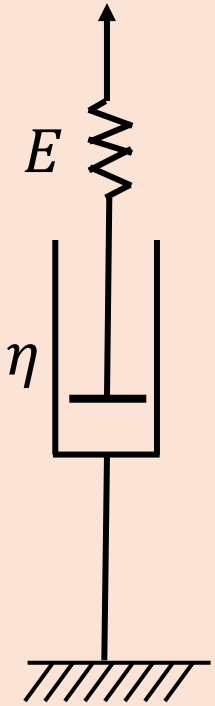
Viscoelastic solids



Kelvin - Voigt

$$\sigma = E\varepsilon + \eta\dot{\varepsilon}$$

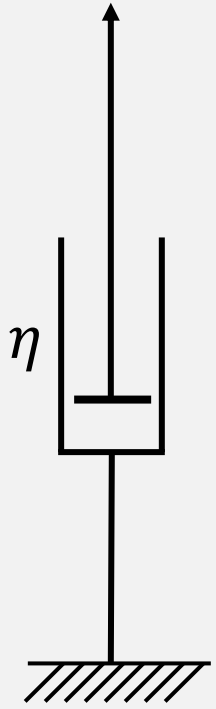
Viscoelastic liquids



Maxwell

$$\dot{\varepsilon} = \frac{\sigma}{\eta} - \frac{\dot{\sigma}}{E}$$

Liquids



$$\sigma = \eta\dot{\varepsilon}$$

© 2024 University of Illinois Urbana-Champaign, All Rights Reserved.

© 2024 University of Illinois Urbana-Champaign, All Rights Reserved.