

ENG1050 – Engineering Materials Notes

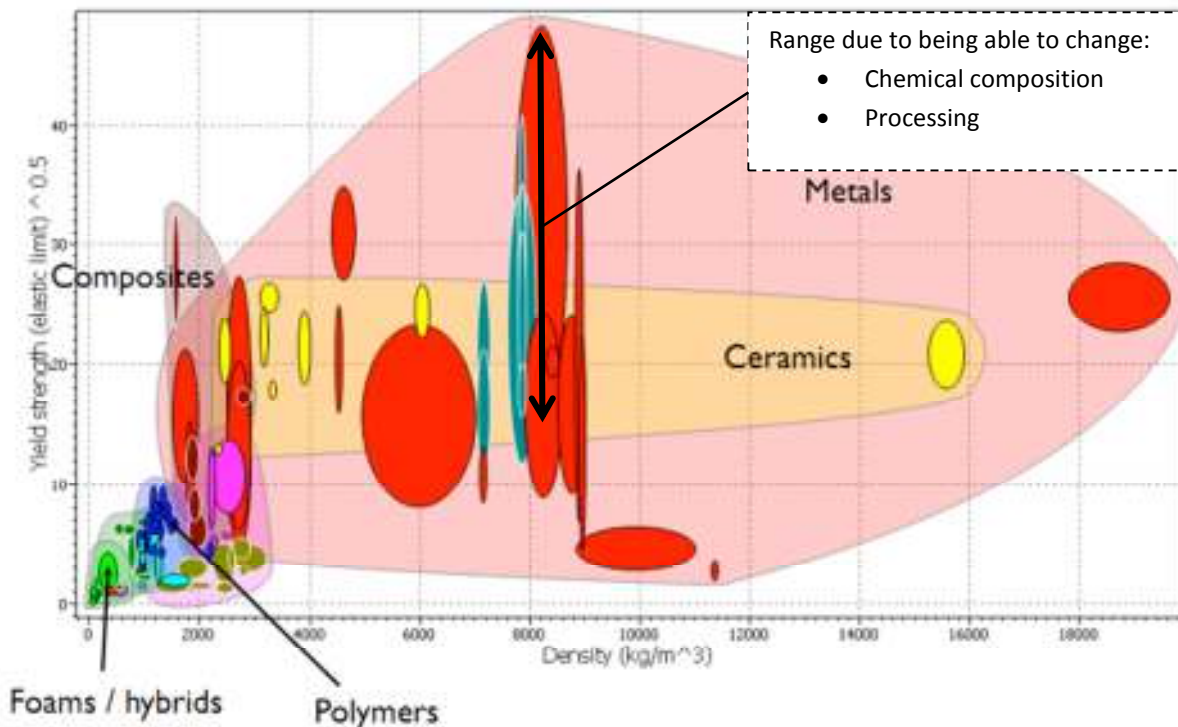
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Selecting appropriate Materials

Engineers choose materials for construction based on factors such as physical properties:



Other factors to consider include:

- Ease of manufacture
- Price
- Safety (toxicity)
- Availability

Force

$t = \left(\frac{Fl}{Cb\sigma_y} \right)^{1/2}$

$$F = \left(\frac{Cbt^2}{l} \right) \sigma_y$$

Mass = ρbtl

$$M = \left(\frac{Fl^3b}{C} \right)^{1/2} \left(\frac{\rho}{\sigma_y^{1/2}} \right)$$

Geometry (design) factors Material properties factors

- For something like a car panel, $\left(\frac{\rho}{\sigma_y^{1/2}} \right)$ should be minimized (low density, high yield stress)

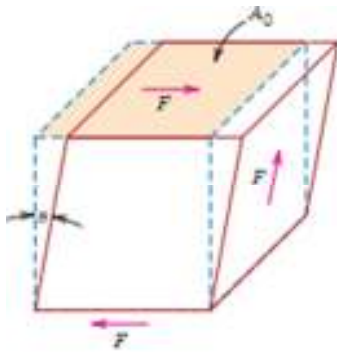
Ultimate Tensile Strength - The maximum stress measured on the **nominal** stress-strain curve. Necking occurs at this point. If maintained, fracture will occur.

Stress	Strain
The load/force applied to the material. Measured as force/area or pressure so independent of material cross section size. $\sigma = \frac{F}{A_0} \text{ (nominal) or } \sigma = \frac{F}{A} \text{ (true)}$	The resulting effect of the stress on the material - the percentage increase in length. $\epsilon = \frac{\Delta l}{l_0}$
	

Neck formation – Struggle between Micro and Macro

Micro	Macro
Strain increases → work hardening occurs Work hardening → able to support higher stress	Specimen has constant volume Length increases → Cross sectional area decreases Area decreases → True stress increases Stress increases → extends more readily
There is a feedback loop between the micro and macro. Eventually the cross-sectional area decreases so much and the stress increases enough to overcome the strengthening effects of work hardening.	
Maths: $dP = 0 \quad \text{Constant force}$ $P = \sigma A$ $dP = \sigma dA + A d\sigma = 0 \quad 1$ $\frac{dL}{L} = -\frac{dA}{A} = d\epsilon \quad \text{Length increases, cross sectional area decreases}$ $-\frac{dA}{A} = \frac{d\sigma}{\sigma} \quad \text{From (1)}$ $\frac{d\sigma}{d\epsilon} = \sigma$ In the plastic region: $\sigma = A\epsilon^n$ n = work hardening exponent	

Shear Stress and Strain



Shear Stress:

$$\tau = \frac{F}{A_0}$$

Shear Strain:

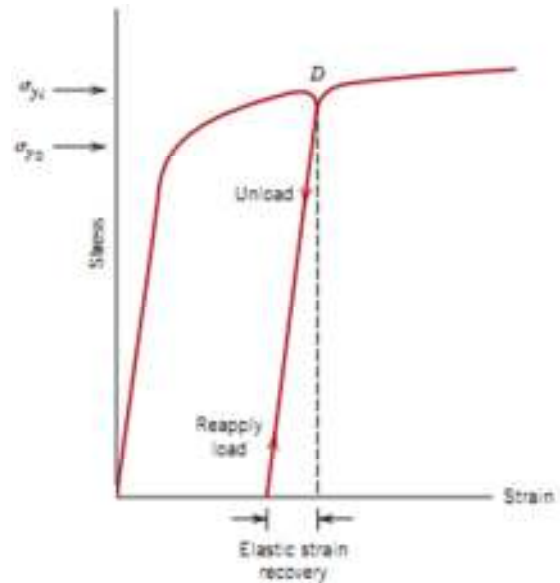
$$\gamma = \tan \theta$$

Relationship:

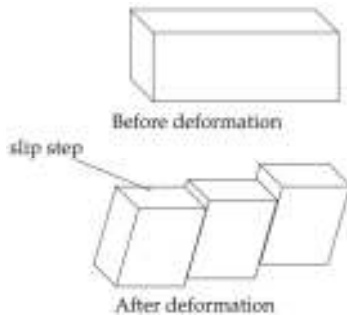
$$\tau = G\gamma$$

G = Shear modulus

When stress is released (at point D):



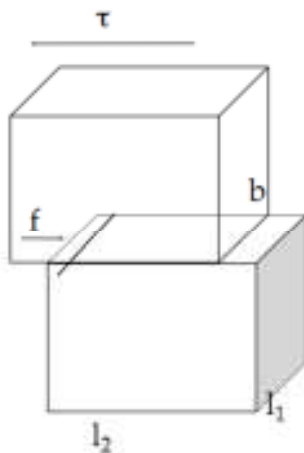
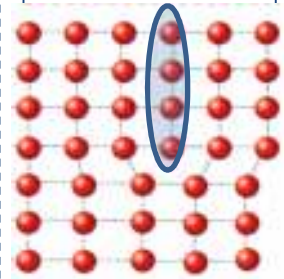
Plastic Deformation



Permanent deformation is the result of **slip** of planes of atoms.

- Stress required to break bonds and slip planes is very high
- There are line defects in real-world materials called **dislocations**
- Requires much less energy to move the dislocations than the entire atom plane

Dislocation
(extra half-plane)



In order to slip,

$$\text{Force from shear stress} > \text{resistance to motion}$$

Work to move upper block is:

$$\tau l_1 l_2 b$$

Work of dislocation motion:

$$f l_1 l_2$$

$\therefore \tau b = f$ $b = \text{Burger's Vector}$ $\tau = \text{shear yield stress}$
The amount of slip produced by the motion of one dislocation

Dislocation - A line defect or imperfection in the crystal lattice comprising an extra half plane of atoms

Dislocation density - The length of dislocation line per unit volume (m/m^3)

Slip - Process by which plastic deformation is produced by dislocation motion