ME 330: Engineering Materials

Lab - 2

Uniaxial Tension Tests

Overview

Tensile Test

1. Cast Iron (demo)
2. Steel 1045

    Cold Rolled,

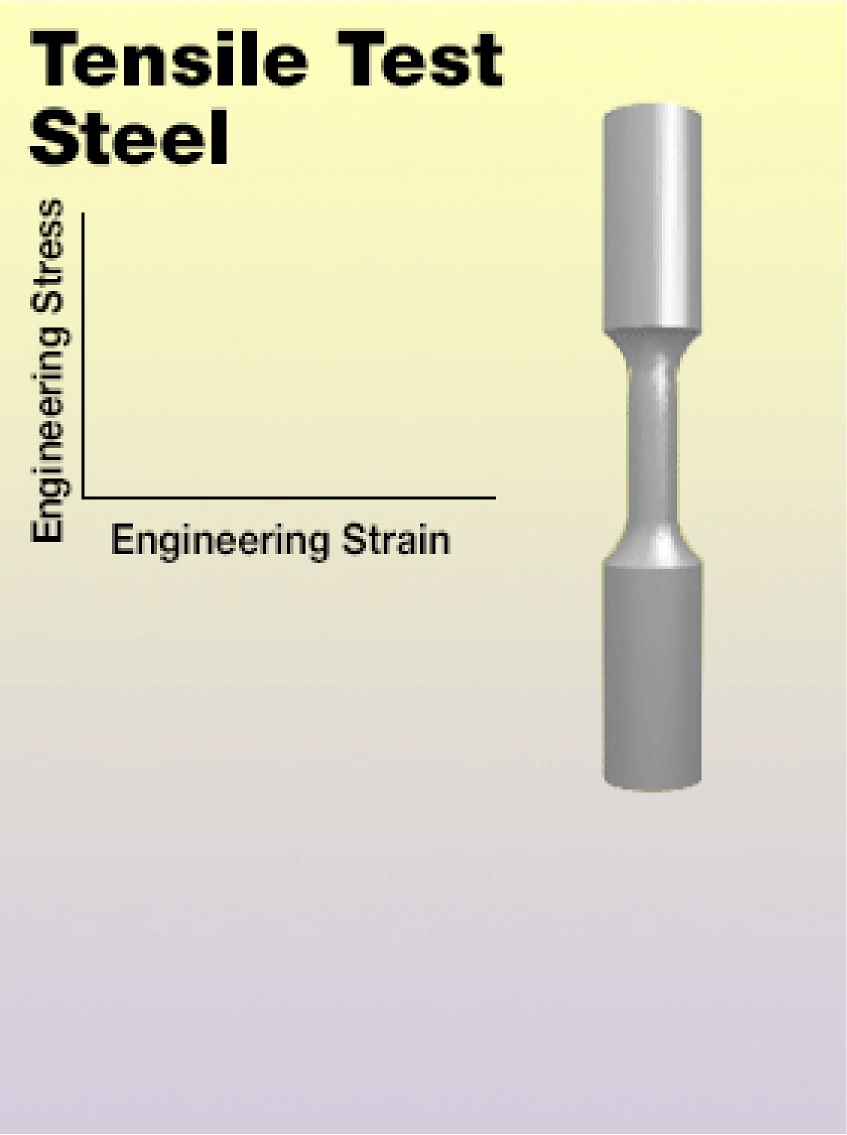
    Normalized

3. Aluminum

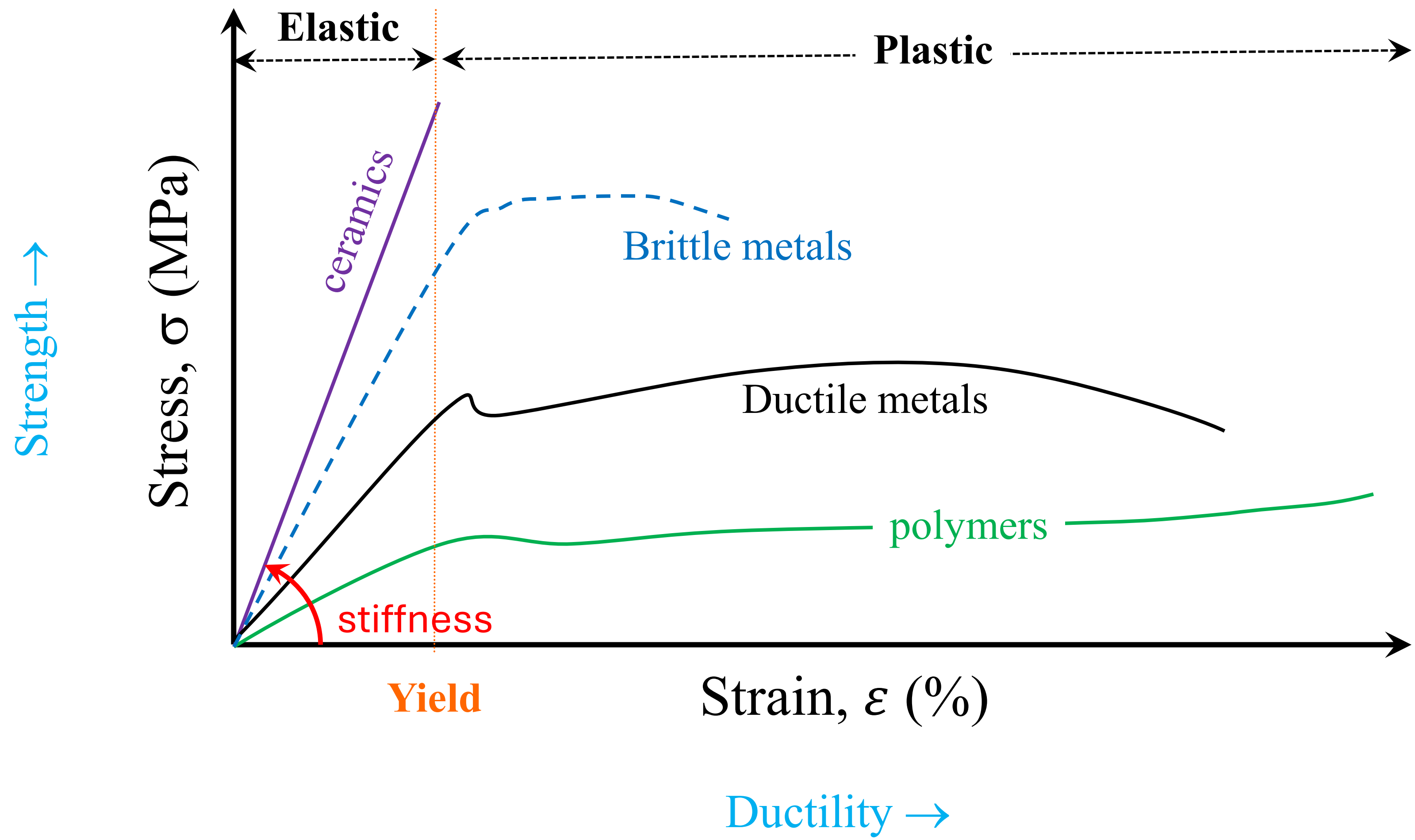
    2024-T4,

    7075-T6

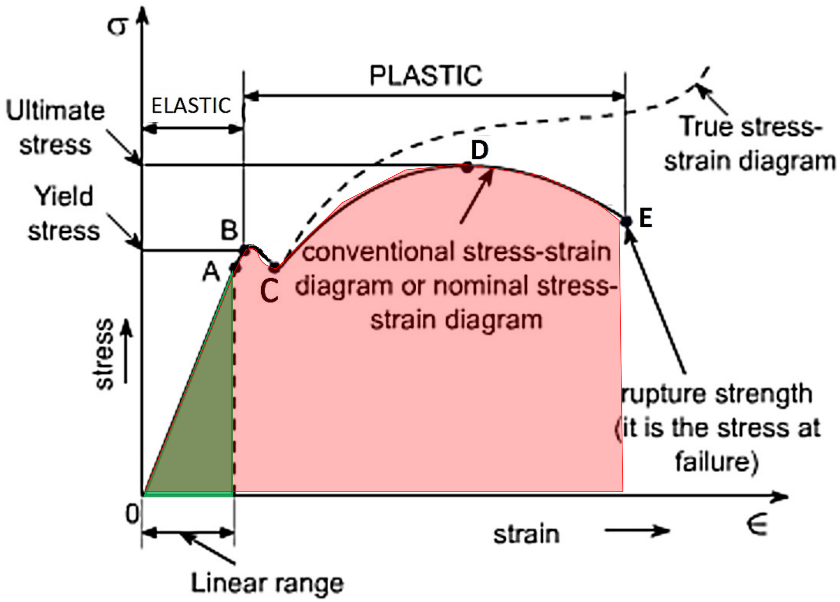
4. Stainless Steel
5. PMMA
6. Brass(demo)

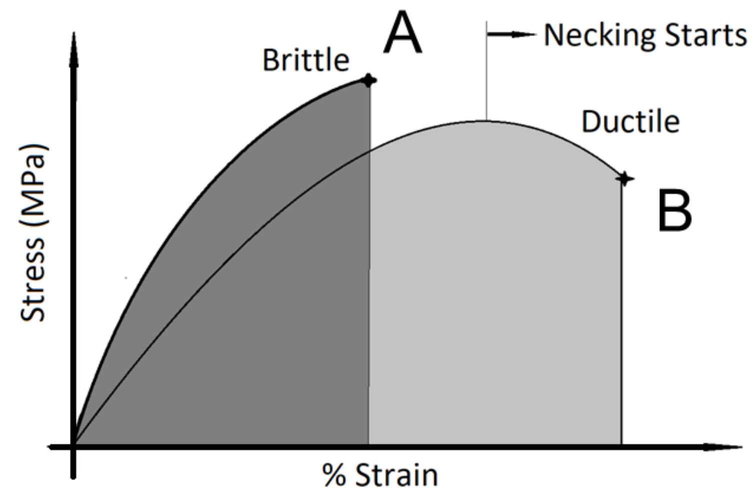


Typical Stress-Strain Curves



Stress-Strain Curves





Engineering stress : $\sigma = F/A_0$

Engineering strain : $\varepsilon = (Li - Lo)/Lo$

True stress : $\sigma_T = F/Ai$

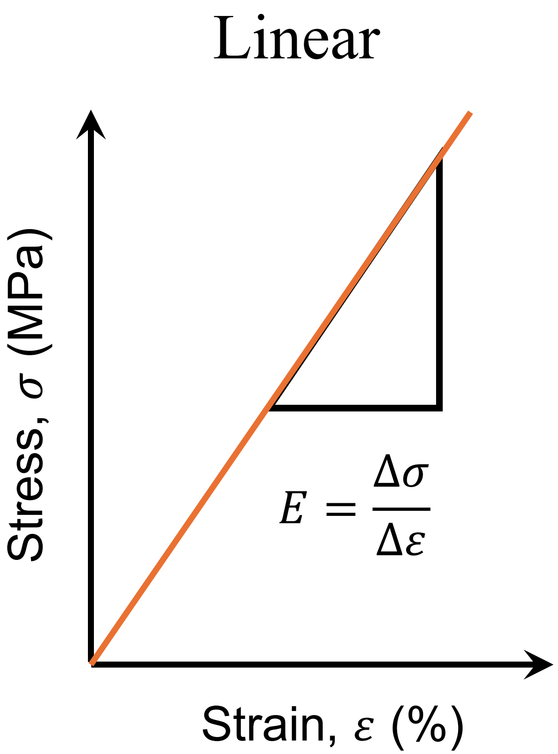
True strain : $\varepsilon_T = ln(Li/Lo)$

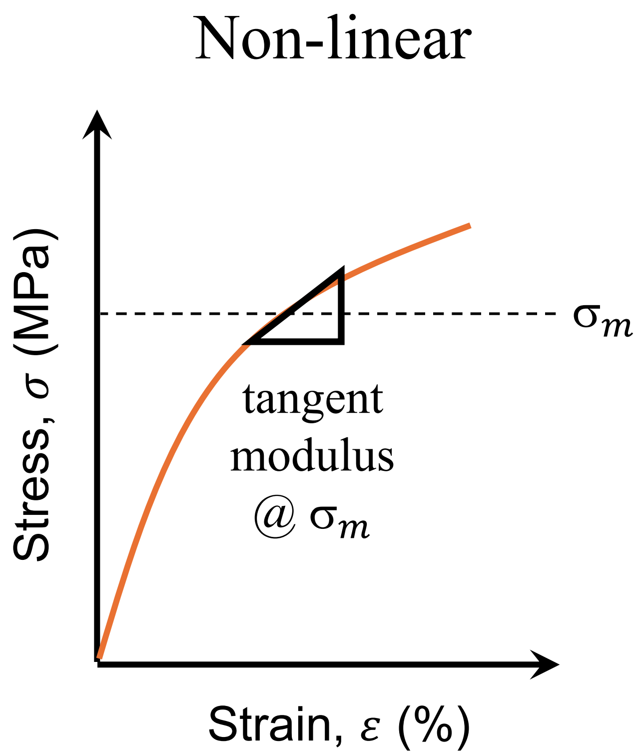
$$\sigma_T = \sigma(\varepsilon + 1)$$
$$\varepsilon_T = \ln(\varepsilon + 1)$$

- Value on curve:
  - What material is stronger?
  - What material is ductile?
- Initial slope of curve:
  - What material is stiffer?
- Area under curve:
  - What material is more resilient?
  - What material is tougher?
  - What material is better for shock absorption?
- Hardness ????????

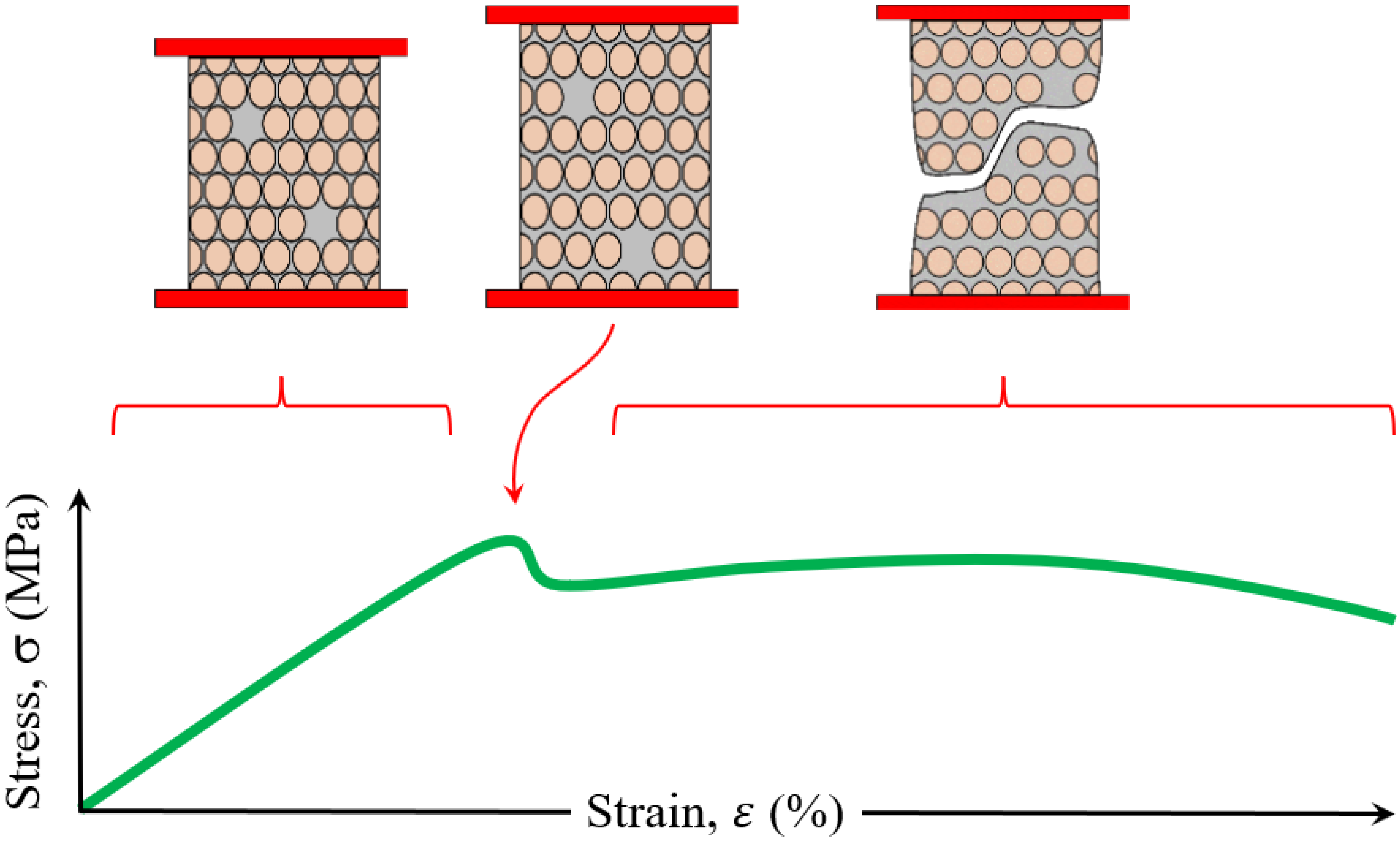
Elastic Behavior

- Elastic region: strain returns to zero when stress removed (100 % reversible)
- Elastic Modulus (E) - measure of stiffness

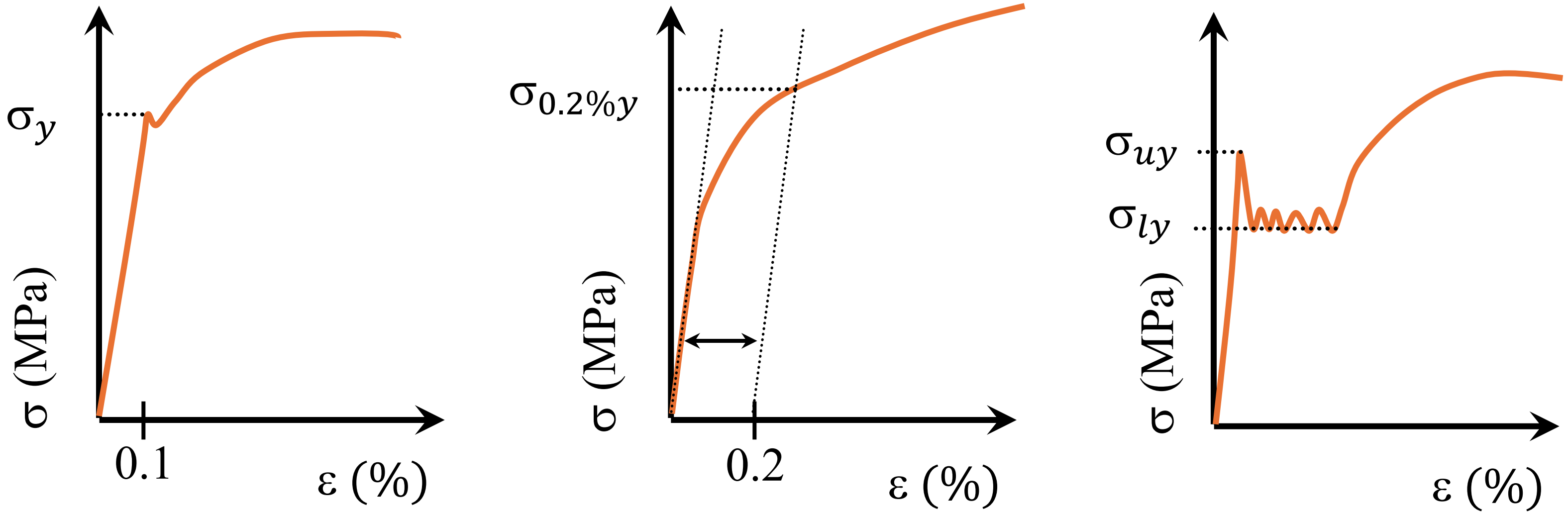




Yielding

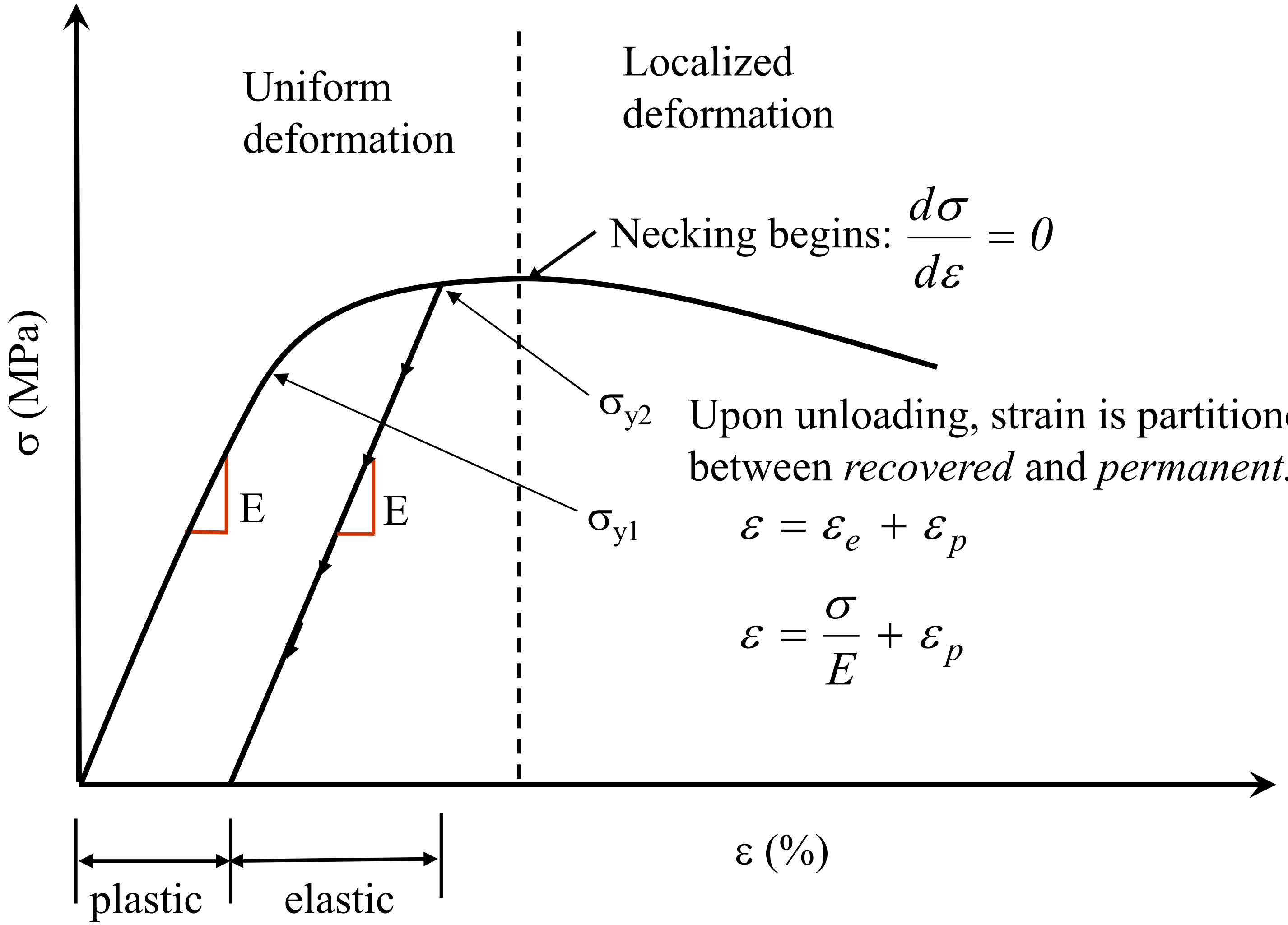


Types of Yielding



- ***Proportional limit*** marks the end of linearity
- ***Yield point*** marks the beginning of plastic deformation
  - Some materials show an obvious transition, σ_y
  - Often need to define 0.2% offset yield, $\sigma_{0.2\%y}$
  - Sometime see an upper (σ_{uy}) and lower (σ_{ly}) yield stresses occur
    - Caused by significant dislocation-solute interaction
    - Common in BCC iron-based alloys

Plastic Phenomena



Upon unloading, strain is partitioned between *recovered* and *permanent*.

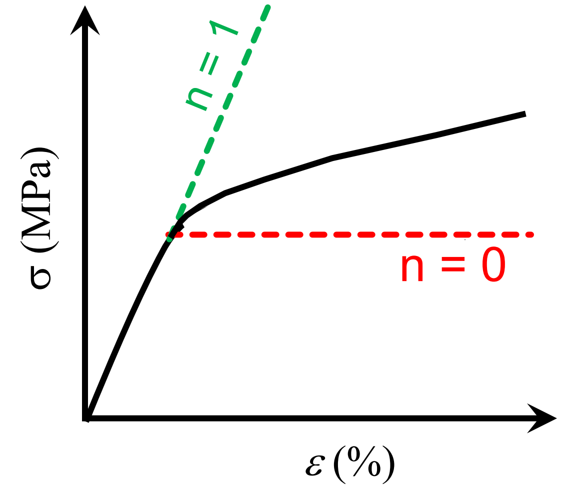
$$\varepsilon = \varepsilon_e + \varepsilon_p$$

$$\varepsilon = \frac{\sigma}{E} + \varepsilon_p$$

Plastic Constitutive Response

- Can approximate relation between true stress-strain curve in *constant plastic deformation* region by:

$$\sigma_t = K\varepsilon_t^n$$



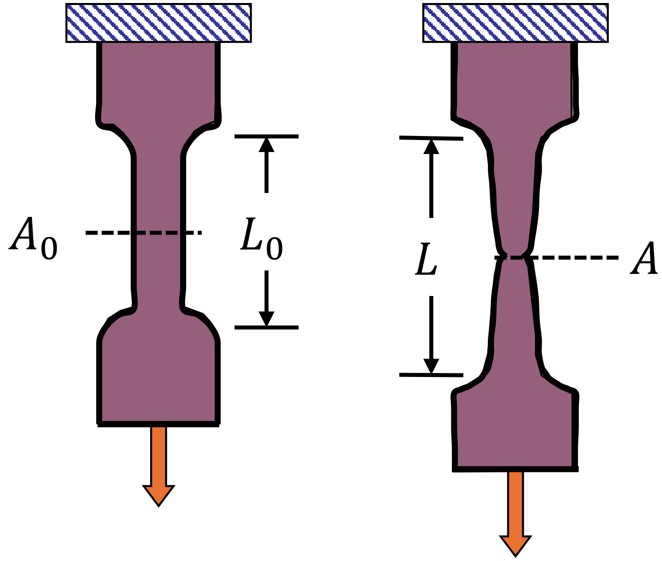
  - K is the strength parameter
  - n is the strain-hardening exponent $(0 \leq n \quad 1)$
    if $n = 0$, elastic-perfectly plastic response
    if $n = 1$, ideally elastic material
    as n increases, achieve more strain hardening
  - Typically, valid only for some metals and alloys
  - Termed "power law hardening"

Measures of Ductility

Percent Elongation:

$$\%EL = \left(\frac{L - L_0}{L_0}\right) \times 100\%$$

Sensitive to gage length
Does not account for necking



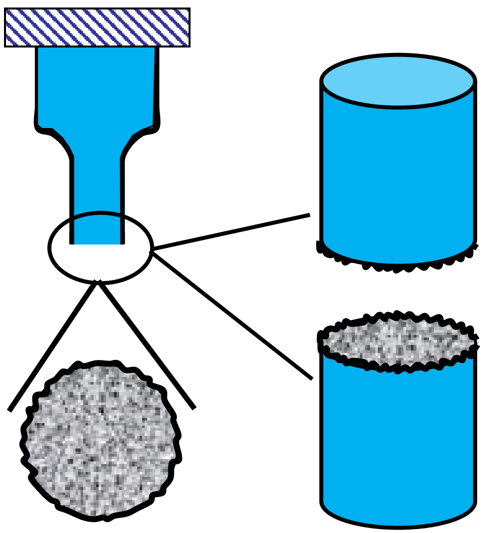
Area reduction:

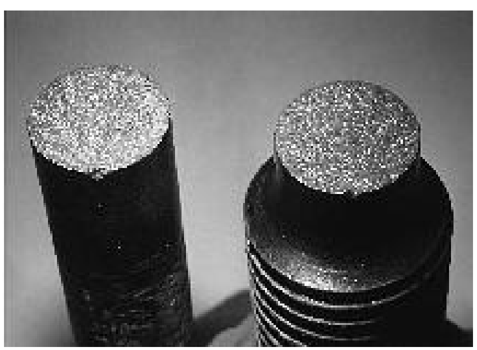
$$\%AR = \left(\frac{A_0 - A}{A_0}\right) \times 100\%$$

Insensitive to gage length
Does account for necking
Sensitive to cross-section

Fracture Surfaces

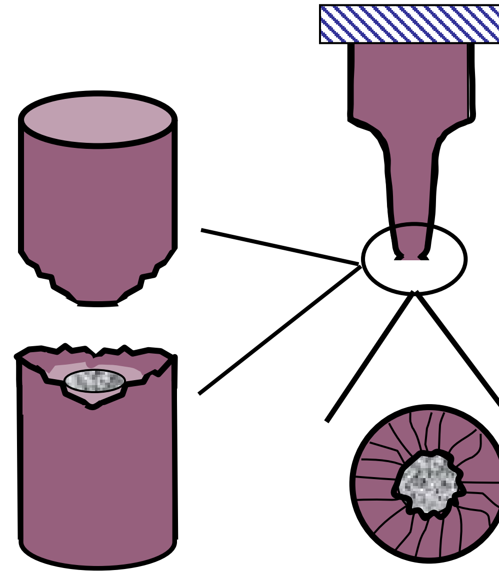
Brittle

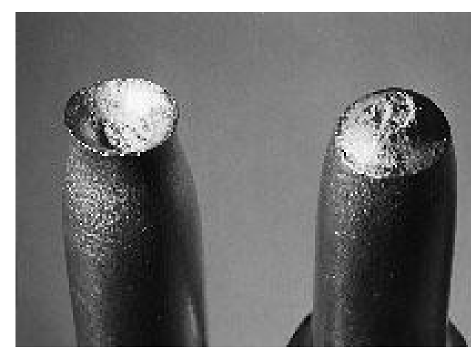




- Cleavage failure
- Flat, rough fracture surface
- No necking
- Failure in tension

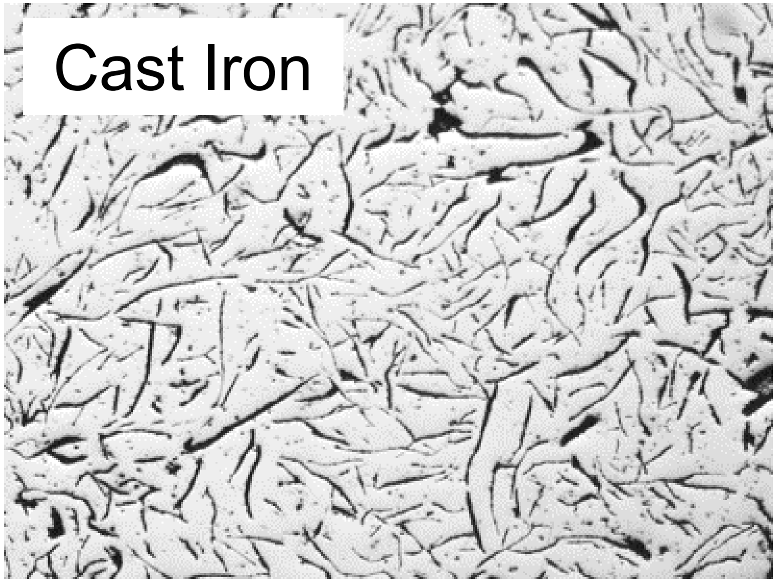
Ductile

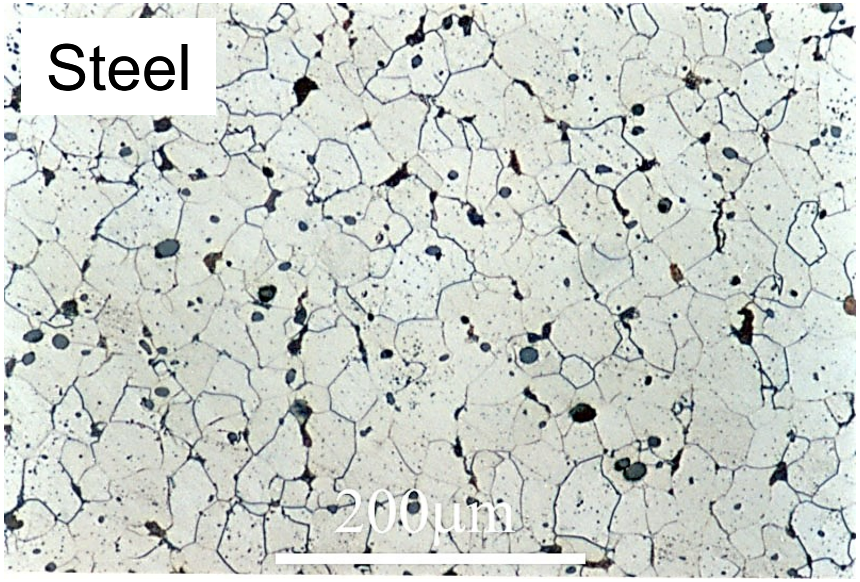


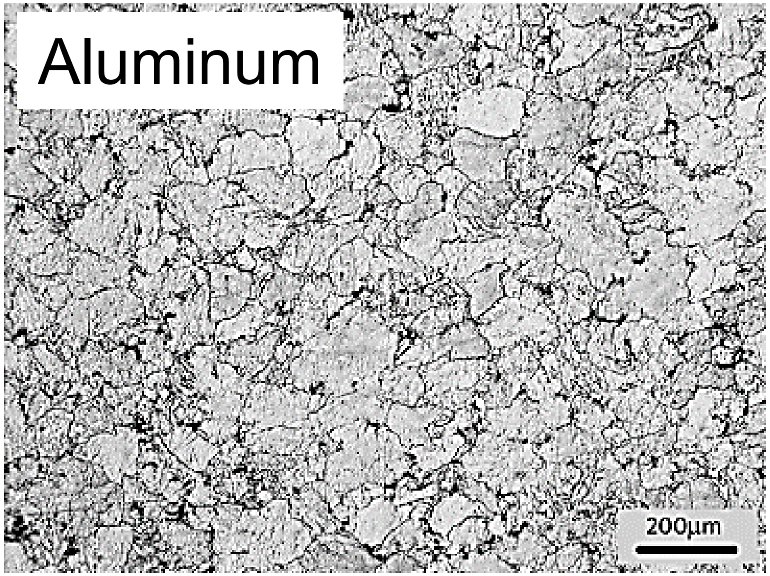


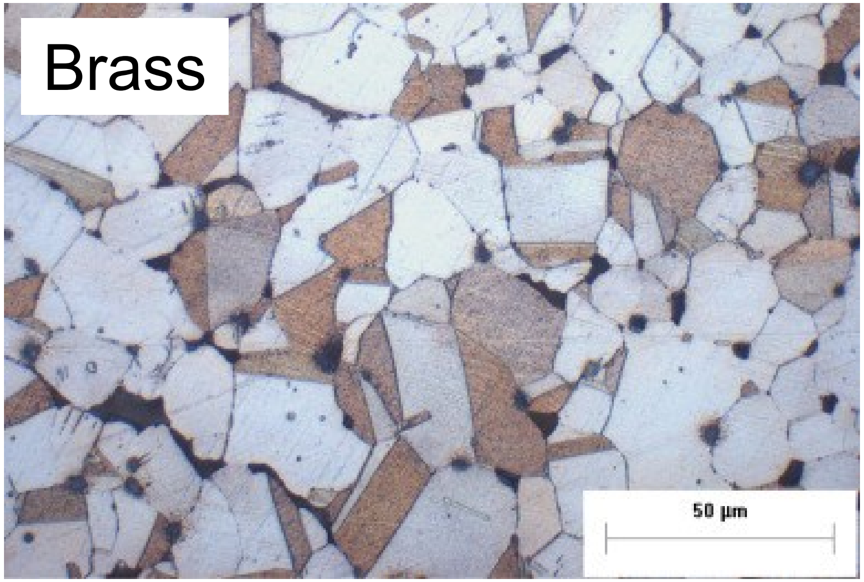
- Completely ductile failure necks to a point
- Cup-cone fracture surface
  - Necking prior fracture
  - Cavities initiate in neck
  - Voids coalesce to form crack
  - Final failure in shear
- Discuss more completely in fracture

Metallic microstructure

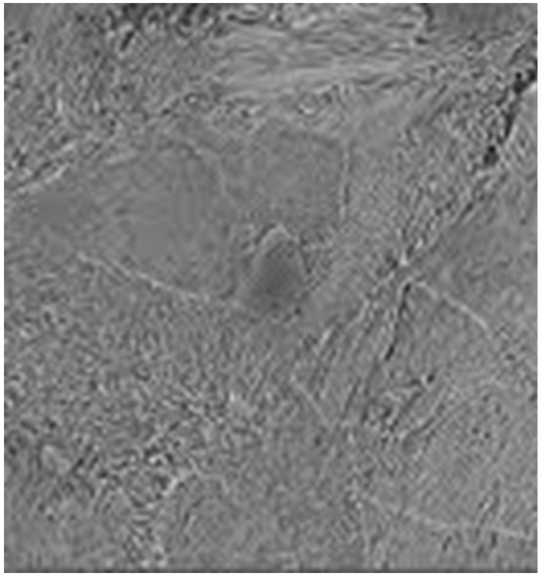


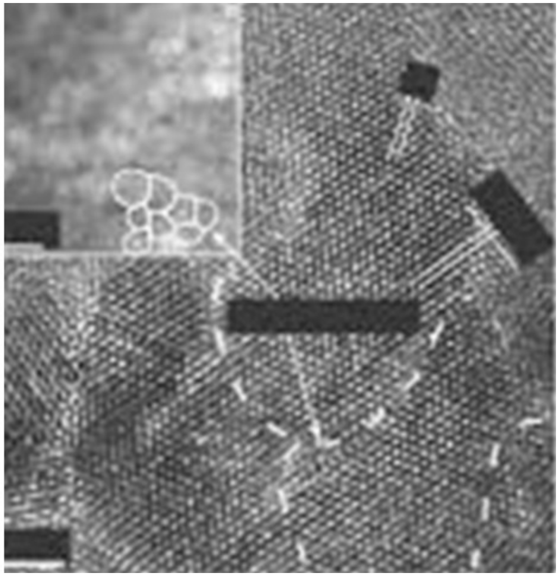


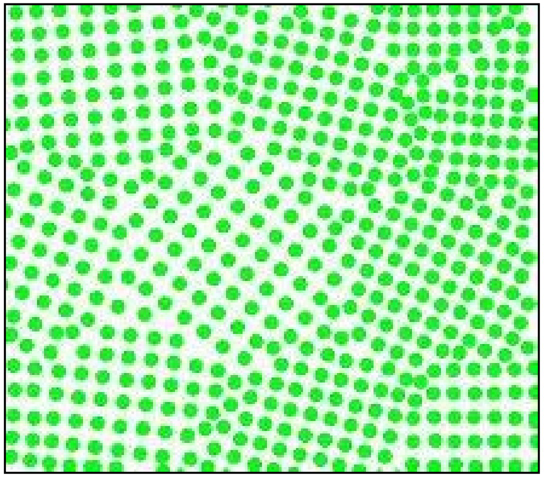


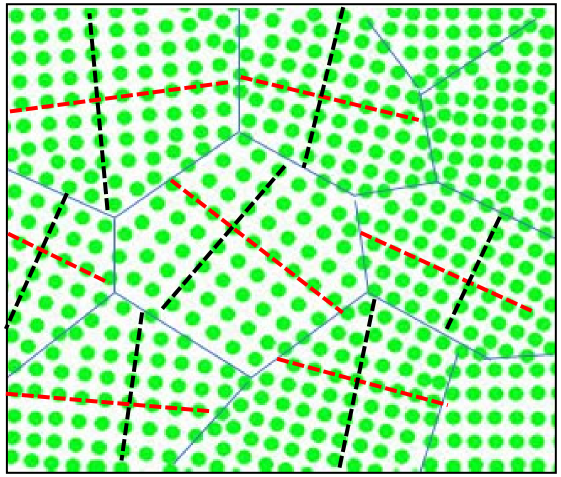


Grains









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