C5.2 Elasticity and Plasticity

Introduction to metal plasticity

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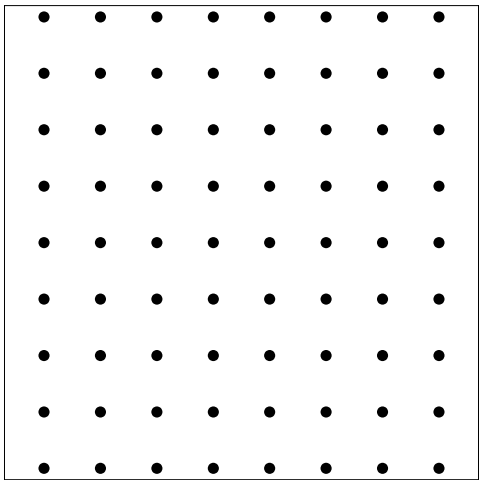
Michaelmas Term

Microstructure of metals

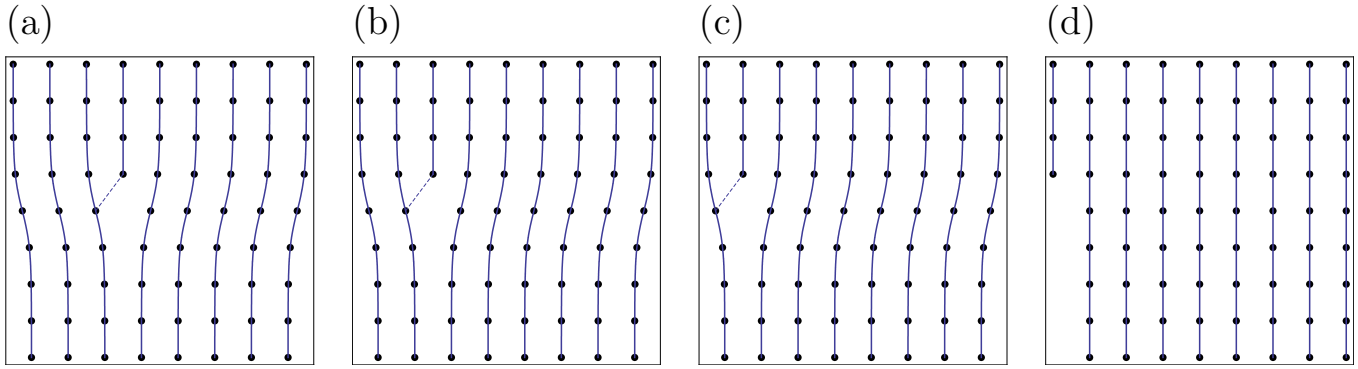
- Microstructure of metals is a periodic lattice of atoms.
- In a pristine lattice $\mathrm{O}(1)$ strain and hence $\mathrm{O}(\mu)$ stress required for irreversible deformation.
- But measured yield stresses are much smaller by factor of $\approx 10^{-5}$!



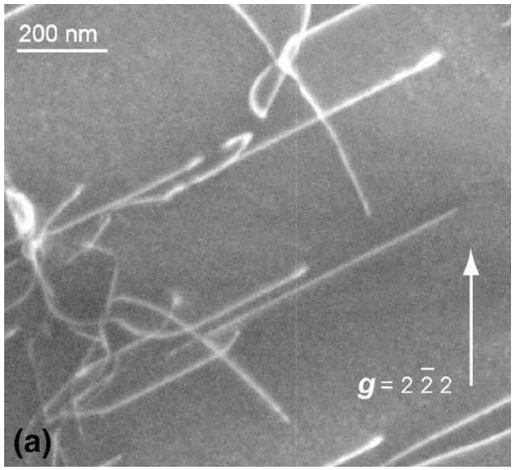
- Hypothesis (1930s): plastic deformation arises from motion of dislocations, *i.e.* crystallographic defects.

Dislocations

- Only small reorganisation of lattice is needed to shift dislocation and cause irreversible deformation of the lattice.
- For example, a moving edge dislocation:



- Requires yield stress τ_Y much smaller than μ.
- Hypothesis was confirmed much later by electron microscopy: metals contain trillions of dislocations which are generated and propagated by plastic deformation of the sample.



Perfect plasticity in metals

Study of behaviour of dislocations leads to the following...

Hypothesis: plastic deformation in metals is driven by shear stress — normal stress does not (usually) cause irreversible deformation

Based on this hypothesis, build a perfect plasticity model whereby...

- $|\text{shear stress}| < \tau_Y \quad \Rightarrow \quad$ elastic
- $|\text{shear stress}| = \tau_Y \quad \Rightarrow \quad$ plastic