Impacto de diferentes parámetros sobre los defectos

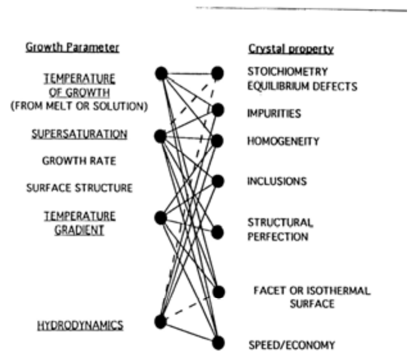

Fig. 4. Impact of the four major growth parameters on the properties of the crystal and on the economy of crystal fabrication. The multiple inter-relations normally are nonlinear.

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Single Crystals

Single crystal: lattice extends the edges of the material, e.g. a diamond

Single crystals are possible

Above their melting points, metals are liquids. The atoms are randomly arranged and relatively free to move

On cooling to below the melting point, the atoms rearrange forming the ordered, crystalline solid structure

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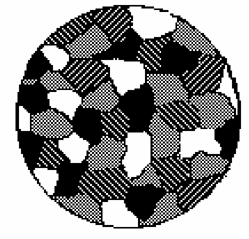
Polycrystalline

In most cases, solidification begins from multiple sites, each of which can produce a different orientation

The result is a "polycrystalline" material consisting of many small crystals of "grains"



Each grain has the same crystal lattice, but the lattices are misoriented from grain to grain

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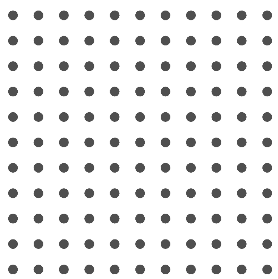
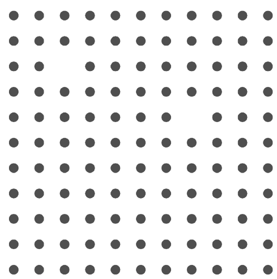
Crystal Defects

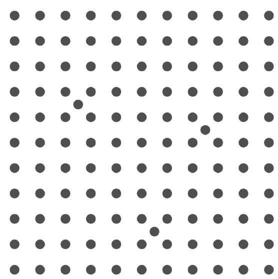
Crystals are not perfect



Perfect



Vacancies



Interstitials

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Why are defects important?

-They can speed up the process of crystal growth by orders of magnitude

-The distorted crystal lattice around defects provides rapid diffusion pathways within crystals (geometry)

- They are intimately involved in several deformation mechanisms (kinematics)

- Provide a driving force for many deformation processes (dynamics)

- Can weaken the strength of a crystal by several orders of magnitude

-The movement of dislocations can lead to the formation of crystallographic

- preferred orientations

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Crystals contain defects.

They can be classified into three types:

- –Point defects
- –Line defects
- –Planar defects

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Imperfections in Solids

An idealized solid with perfect crystal structure does not exist; all contain large numbers of various defects or imperfections

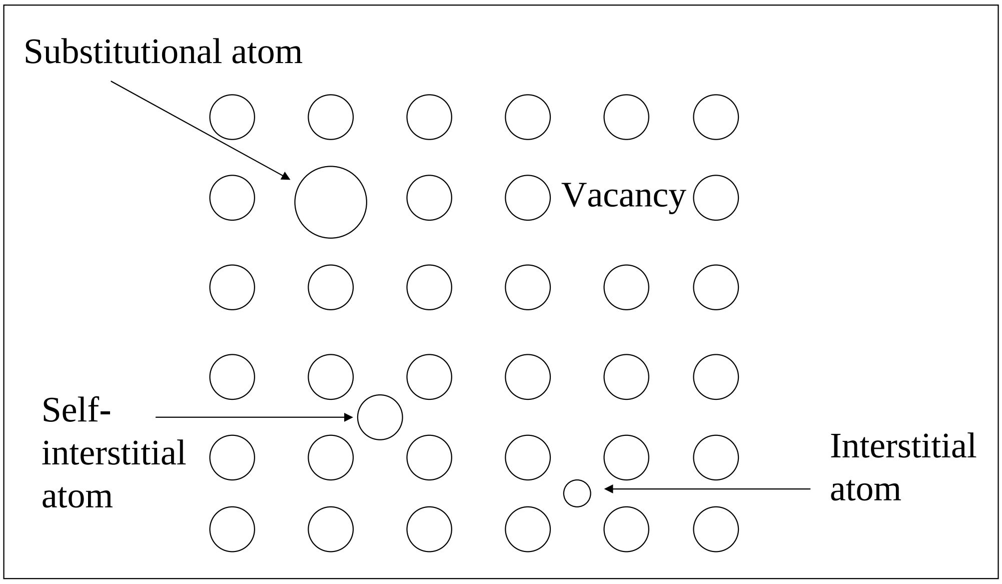
Crystal defect:

- –A lattice irregularity having one or more of its dimensions on the order of an atomic diameter

Classification of crystalline imperfection:

- –Point defect (0 – D)
- –Dislocation (1 – D)
- –Interfacial defect or boundaries (2 – D)
- –Bulk/volume defect (3 – D)

Point defects



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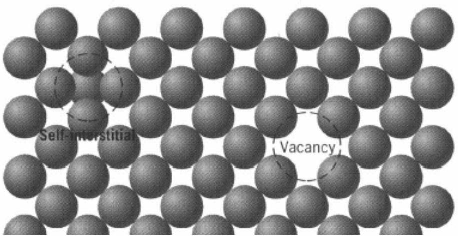
Point Defects:
Vacancies and Self-interstitials

Vacancy
- Vacant lattice site
- Atom missing

Self-interstitial
- An atom from the crystal occupies an interstitial site that under ordinary condition is not occupied
- Extra atom of the same kind wedged in lattice



$$N_v = N \exp\left(-\frac{Q_v}{kT}\right)$$

Point Defects: Impurities in Solids

A doped material is not possible as an idealized solid without defects.

Alloy:

- Impurity atoms have been added intentionally to impart specific characteristics to the materials

Addition of impurity atoms → solid solution
→ new 2nd phase

Solid solution: crystal structure does not change

- Solvent
- Solute

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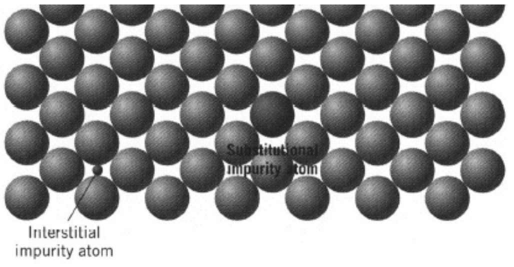
Impurity Point Defects

Substitutional and Interstitial impurity point defects

Rules
1. Atomic size factor
2. Crystal structure
3. Electronegativity
4. Valences



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Lineal defects

Long in one direction but only a few atomic diameters at right angles to their length

Also known as dislocations

Enables us to account for discrepancies between theoretical and actual stress required to deform a ‘perfect’ crystal.

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Dislocations: Linear Defects

–Edge dislocation

–Screw dislocation

–Mixed mode

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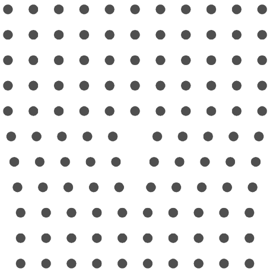
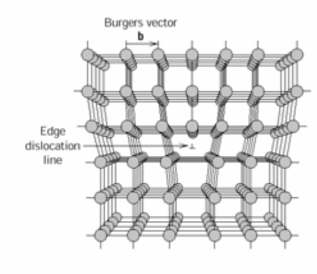


Dislocations



Definition:One-dimensional defect around which some of the atoms are misaligned. Dislocations are a localised imperfection in the alignment of the layers of atoms in the lattice

Classification

1. Edge dislocation: a missing half plane of atoms
2. Screw dislocation: layers twisted with respect to each other
3. A combination of the two: Mixed

Imperfections, grains and grain boundaries, determine many of the mechanical properties of metals

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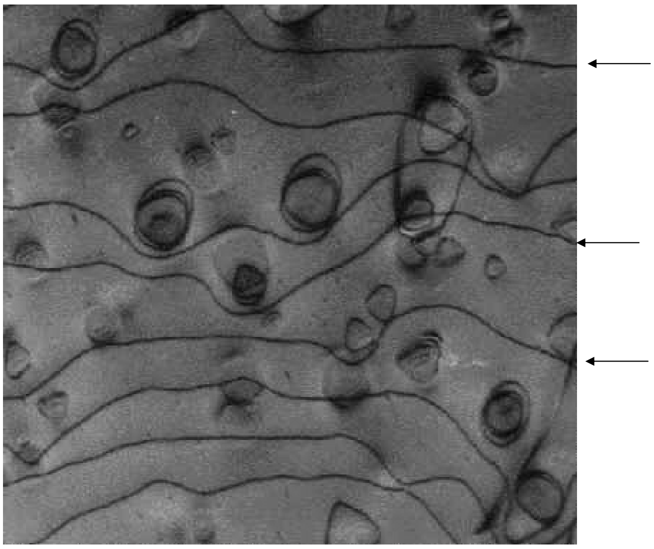
Dislocations in Nickel



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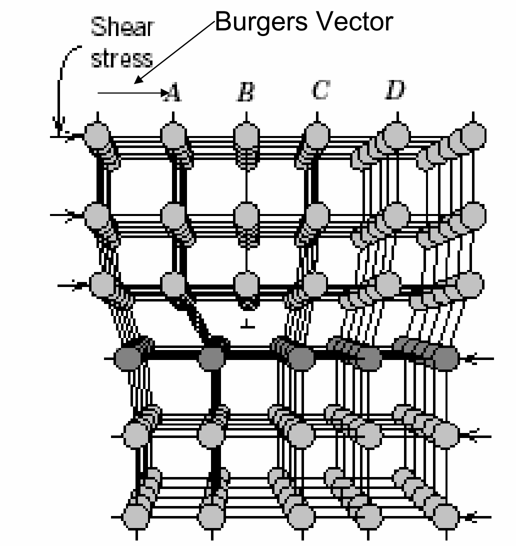
Edge Dislocation



- Dislocation line
- Burgers vector

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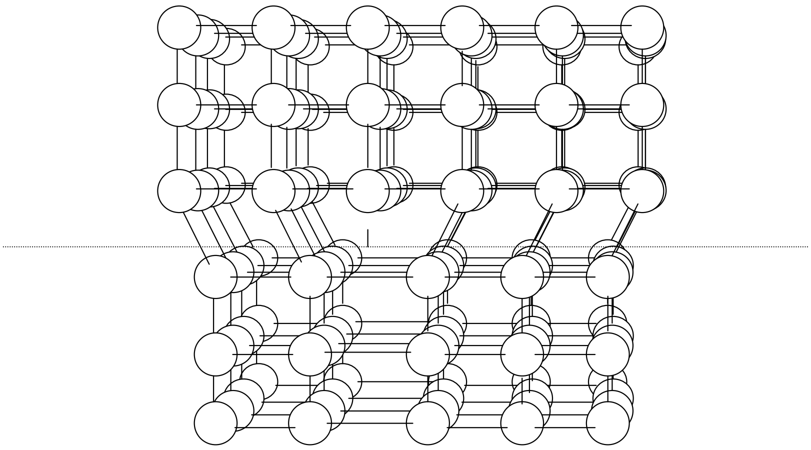
An edge dislocation



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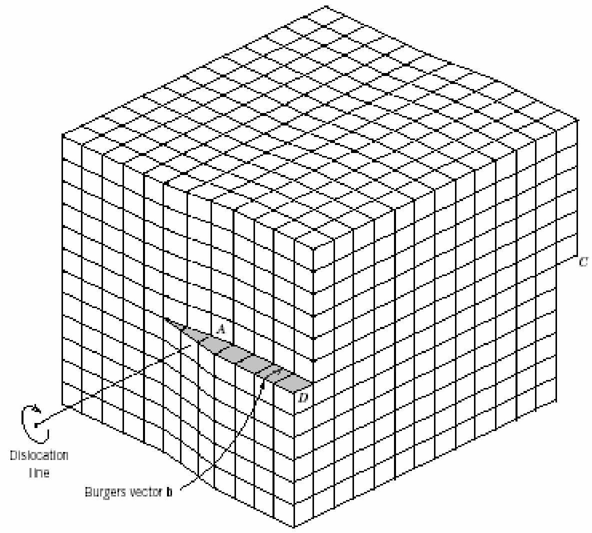
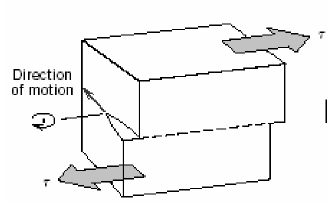
Screw Dislocation





• Dislocation line
• Burgers vector

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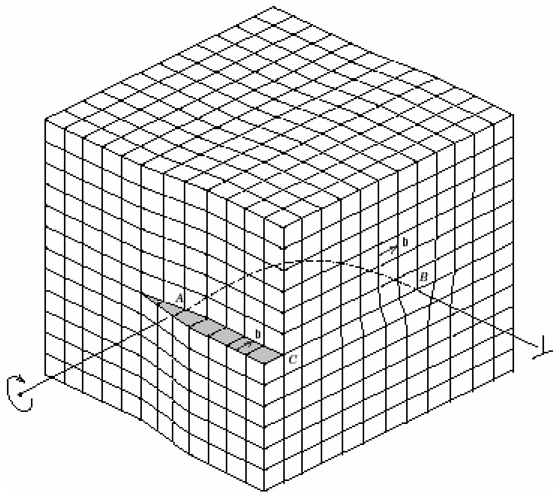
Mixed Dislocation



- Dislocation line
- Burgers vector

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Planar defects

Atomic in distance in one direction and large in the others

May be classified as external or external

External are solid-gas, solid-liquid, and liquid-gas interfaces

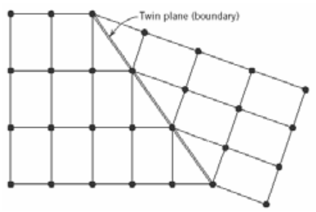
Common internal defects are grain boundaries and twinning.

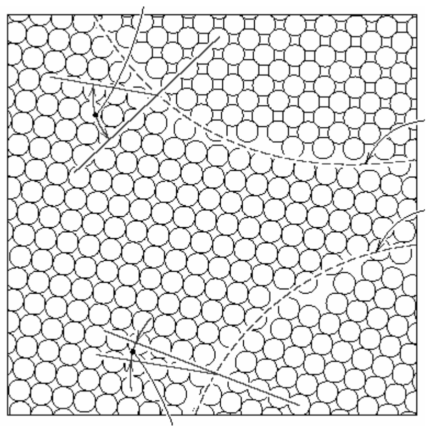
Interfacial Defects

Definition

Classification

- External surfaces
- Grain boundaries
- Twin boundaries
- Stacking faults
- Phase boundaries





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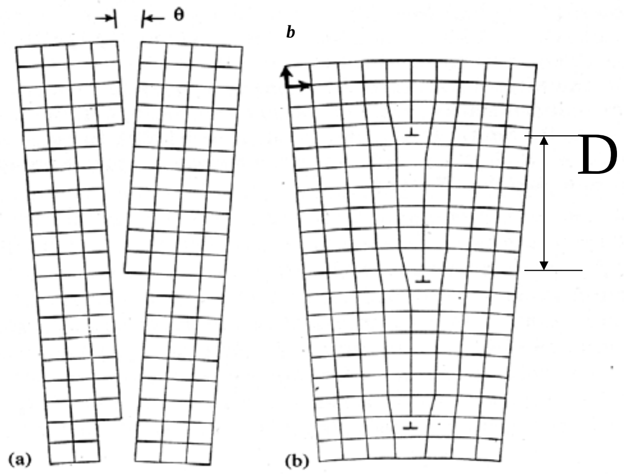
Tilt boundary



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Volume Defects

Pores

Cracks

Foreign inclusions

...

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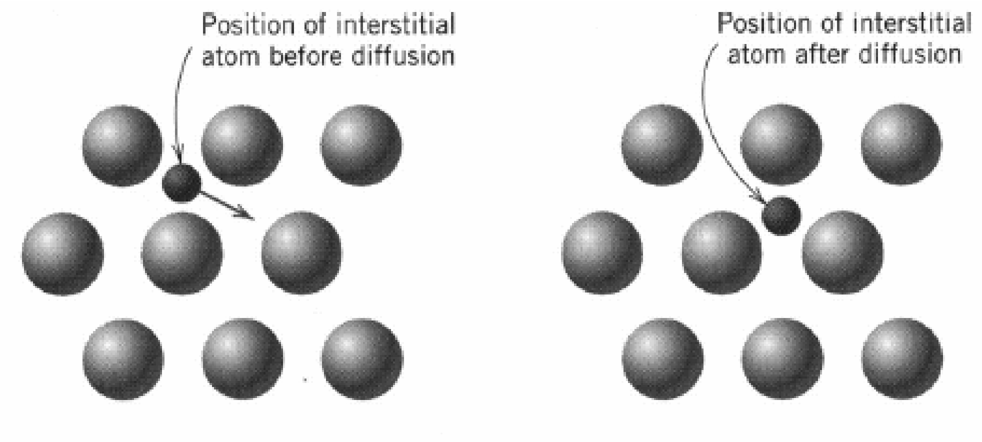
Interstitial Diffusion



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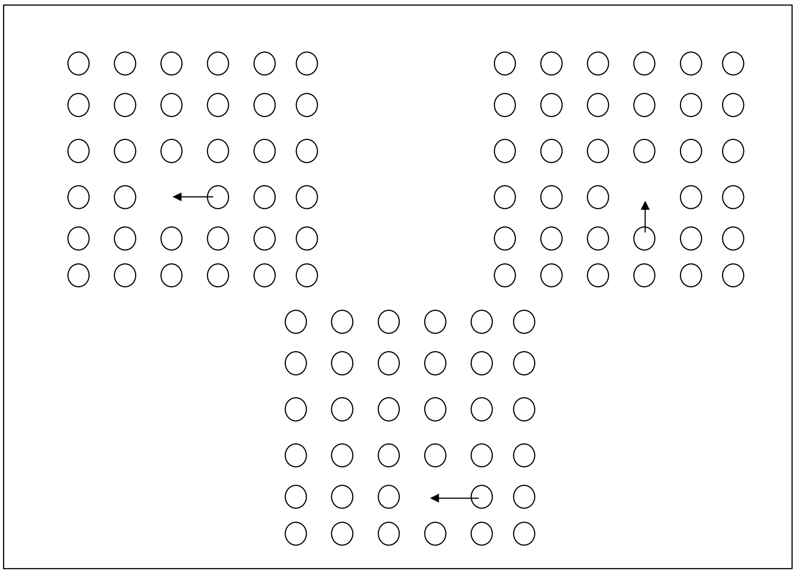
Self diffusion via vacancy mechanism



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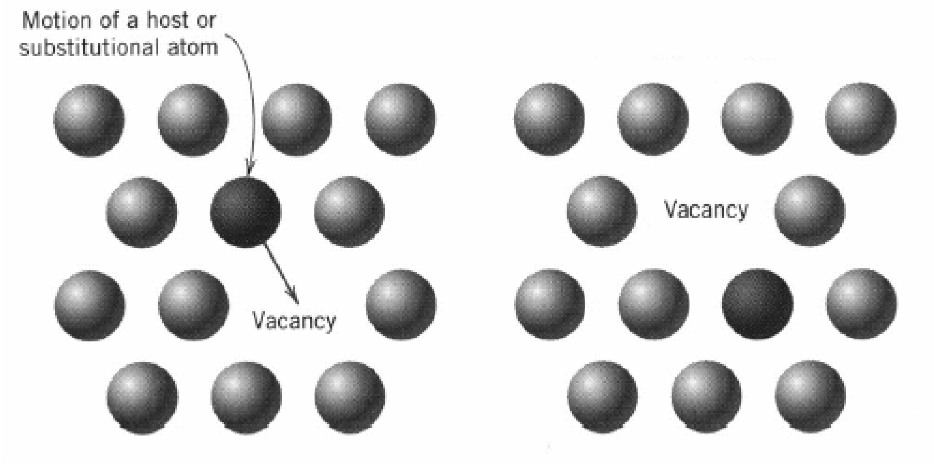
Vacancy Diffusion



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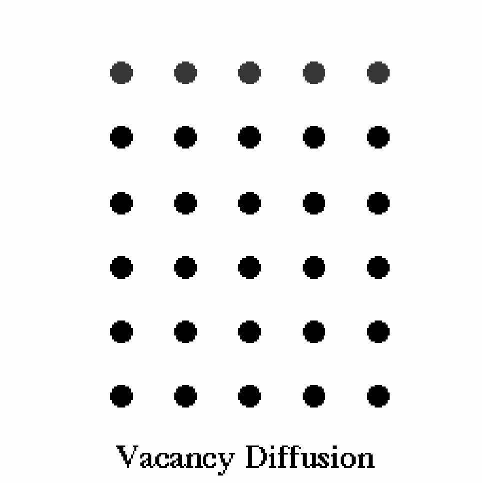

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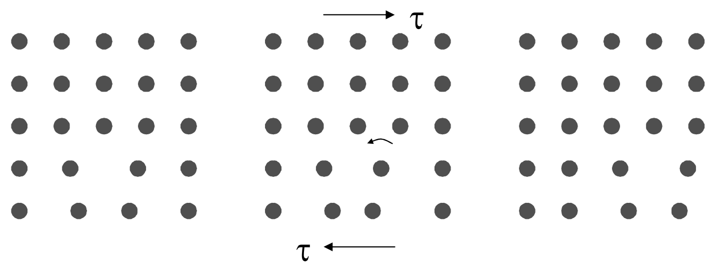
Plastic Deformation and Dislocations

Dislocations can serve as a means of producing the shearing involved in plastic deformation

When a shear stress is applied, bonds are made and broken *locally*, reducing the yield stress



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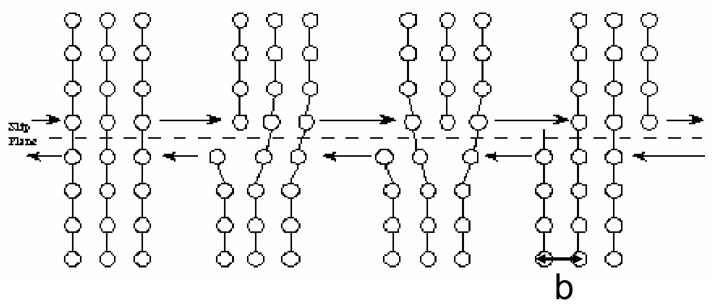
Motion of Dislocations

Dislocations move easily in metals, due to delocalised bonding

Dislocations exist in ceramics, but do not move easily because of the very strong *localised* bonding

This explains why metals are ductile, while ceramics are brittle



b is the unit of slip (the Burger's vector)

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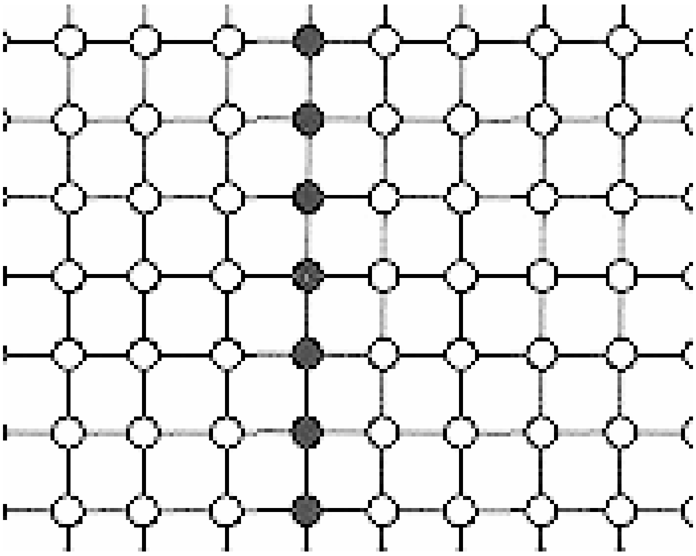

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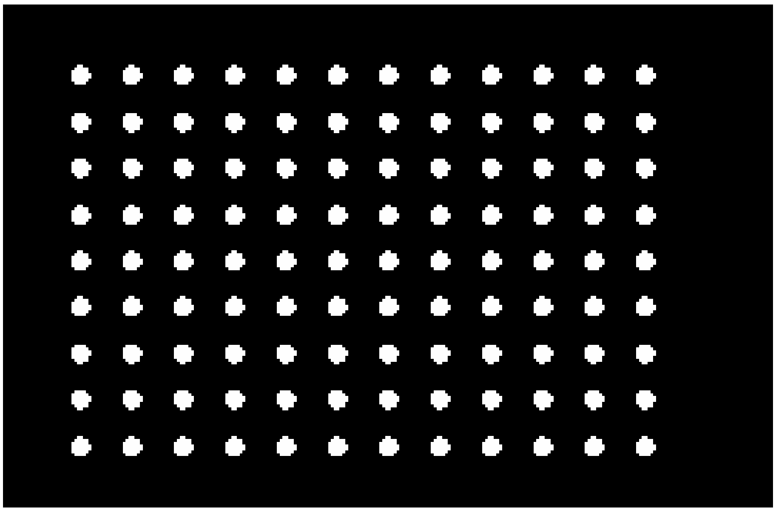

Dislocation glide (edge dislocation)

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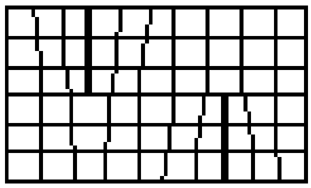
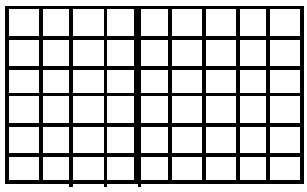
Motion of Dislocations

Mutual annihilation when dislocations of opposite sign meet up exactly.
The two half planes of each dislocation become a full plane, and the two dislocations disappear.

In the following example cross-slip occurs to allow this totake place.



Opposite dislocation edges



Annihilation

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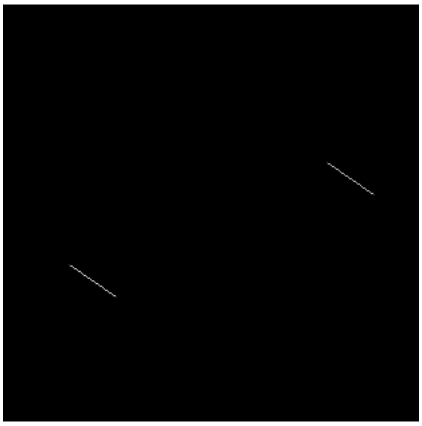

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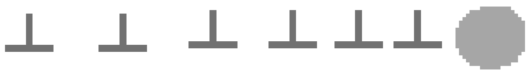
Pile-ups when dislocations are held up by, for example another type of dislocation or an impurity, it just sits there, because dislocations of like sign repel each other, the next dislocation will "wait" in the queue behind the first one, and so on. Each dislocation adds to the stress on the object blocking the way, until, sometimes that object may be overcome, and the dislocations may move freely again. The longer the pathway for the dislocations to build up the larger the obstacle that can be overcome, hence the Hall-Petch law which says the yield strength is proportional to 1/grain size.



Hardening

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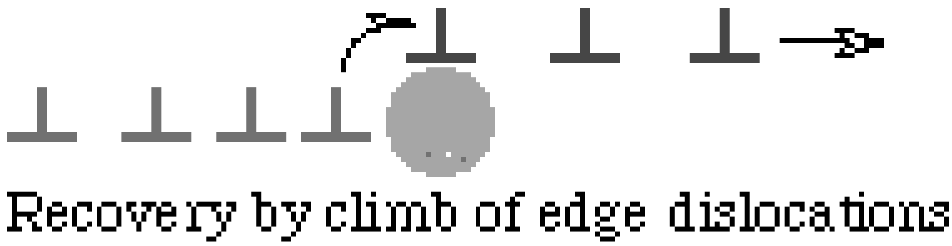
Climb another way of clearing an obstacle is to climb over it. Climb is easier at higher temperatures, as it is a diffusional process.



Polygonisation: The movement of free dislocations (those not bound up in dislocation arrays) will eventually bringthem into existing dislocation arrays, this reduces the energy state of the system, and is thus more stable, and the formation of these sub-grain boundaries is a typical microstructural response to recovery processes.

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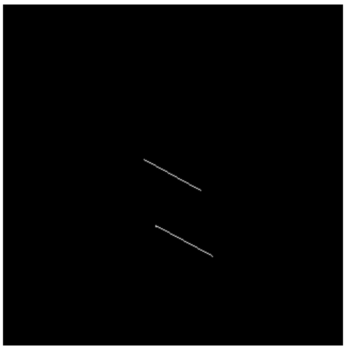
Cross-slip: Another form of dislocation motion can take place when the dislocation moves on a vector which is a combination of two or more existing slip systems. In this example double cross-slip occurs to avoid a fixed dislocation.



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Grain boundaries

May be defined as the interface between crystals that differ in orientation, composition or dimensions of the crystal lattice (or combinations).

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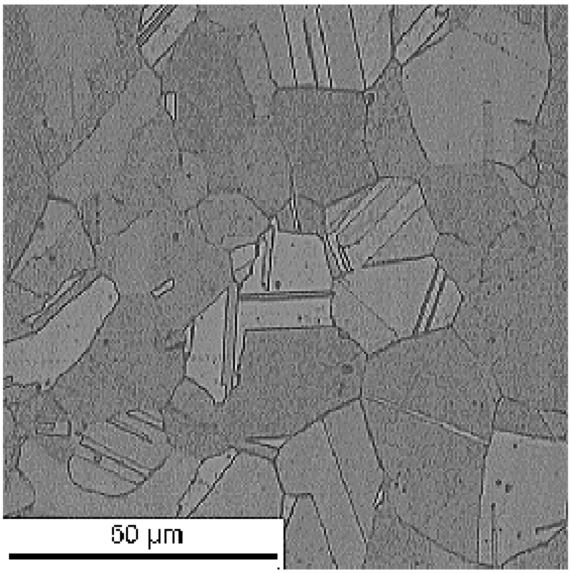
Microestructure of Brass



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