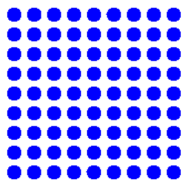
5.1.3 Essentials to Chapter 5.1: Dislocations - Basics

Plastic deformation of crystals=movement of dislocations through the crystal.

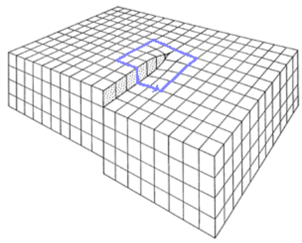
- The distortion necessary to deform a crystal is localized in a **1-**dimensional defect=dislocation that moves through the crystal under the influence of (external shear) forces.
- "Discovery" of dislocations as source of plastic deformation=answer to one of the biggest and oldest scientific puzzles in **1934** (Taylor, Orowan and Polyani). No Noble prize!
- Movement of dislocations produce steps of atomic size characterized by a vector called "Burgers vector".
- Movement of dislocations occurs in a plane (=glide plane) and shifts the upper part of the crystal with respect to the lower part.



Dislocations are characterized by

1. Their Burgers vector ***b***=

- vector describing the step obtained after a dislocation passed through the crystal.
- Vector obtained by a Burgers circuit around a dislocation.
- Translation vector in the Volterra procedure.



Burgers circuit for a screw dislocation

- All definitions of ***b*** give identical results for a given dislocations; but watch out for sign conventions!
- By definition, ***b*** is always a translation vector ***T*** of the lattice.
- For energetic reasons ***b*** is usually the shortest translation vector of the lattice; e.g. ***b*=a/2** <**110**> for the **fcc** lattice.

2. Their line vector ***t*(*x*,*y*,*z*)** describing the direction of the dislocation line in the lattice

- ***t*(*x*,*y*,*z*)** is an arbitrary (unit) vector in principle but often a prominent lattice direction in reality
- While the dislocation can be curved in any way, it tends to be straight (=shortest possible distance) for energetic reasons.

The glide plane by necessity must contain ***t*(*x*,*y*,*z*)** and ***b*** and is thus defined by the two vectors

- The angle α between ***t*(*x*,*y*,*z*)** and ***b*** determines the character or kind of dislocation:
- Note that any plane containing ***t*** is a glide plane for a screw dislocation.

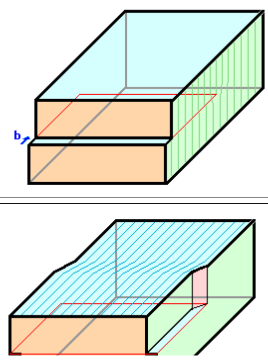
- **α=90 º**: Edge dislocation.
- **α=0 º**: Screw dislocation.
- **α=60 º**: "Sixty degree" dislocation.
- α=arbitrary : "Mixed" dislocation.

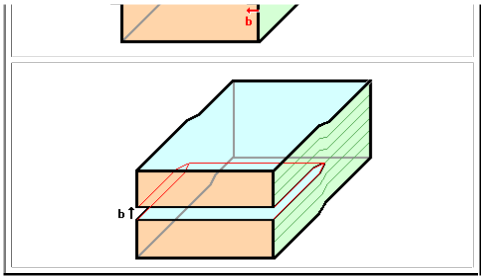
Dislocations have a large line energy E_{dis} per length and therefore are never thermal equilibrium defects

$E_{dis} \approx$ **5 eV/|*b*|**

The formal Volterra definition of dislocations is very useful and extendable to more complex kinds of dislocations

- Cut into the *lattice* with a fictitious "Volterra" knife (make a plane cut to keep it easy), The cut line is a closed loop by necessity. The part of the cut line inside the crystal identifies the dislocation line.
- Move the part of the *lattice* above (or below - attention, signs change!!) the cut plane by an arbitrary lattice translation vector=Burgers vector of the dislocation. Add or remove *lattice* points as necessary (=remove or fill in atoms in the *crystal* going with the lattice).

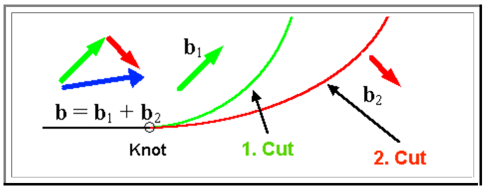




- Mend the *lattice* (or *crystal)* by "welding the upper part to the lower one. There will be a perfect fit by definition everywhere except along the dislocation line.
- Make the best arrangement of the atoms along the dislocation line by minimizing their energy (make best possible bonds).

You now have formed a dislocation.

- The procedure is "easily" extended to dislocations in ***n***-dim. lattices, to (special) dislocations with a Burgers vector not defined as translation vector of the lattice and to lattices more complex than a simple crystal lattice.



Direct consequences are:

- A dislocation cannot just end in the interior of a crystal
- There is a "knot rule" for dislocation knots:
  S*b*=0
  provided the signs of the line vectors follow a convention (all pointing to or away from the knot)
- There can be all kinds of *dislocation loops* (just confine your fictitious cut to the lattice interior!)

Note: "Simple" geometric considerations allow to deduce a lot about properties of dislocations