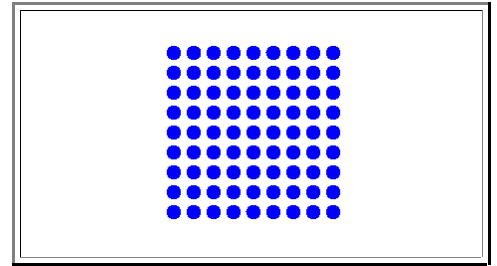


### 5.1.3 Essentials to Chapter 5.1: Dislocations - Basics

#### 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 $\underline{b}$ =

- 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.

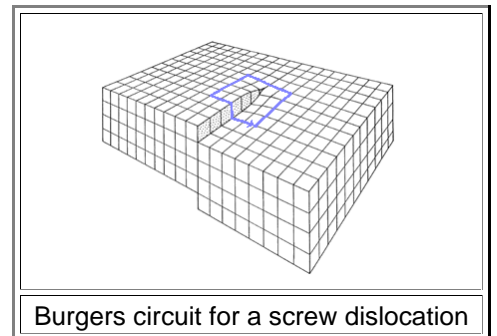
- All definitions of  $\underline{b}$  give identical results for a given dislocations; but watch out for sign conventions!
- By definition,  $\underline{b}$  is always a translation vector  $\underline{T}$  of the lattice.
- For energetic reasons  $\underline{b}$  is usually the shortest translation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

#### 2. Their line vector $\underline{l}(x,y,z)$ describing the direction of the dislocation line in the lattice

- $\underline{l}(x,y,z)$  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  $\underline{l}(x,y,z)$  and  $\underline{b}$  and is thus defined by the two vectors

- The angle  $\alpha$  between  $\underline{l}(x,y,z)$  and  $\underline{b}$  determines the character or kind of dislocation:
- Note that any plane containing  $\underline{l}$  is a glide plane for a screw dislocation.



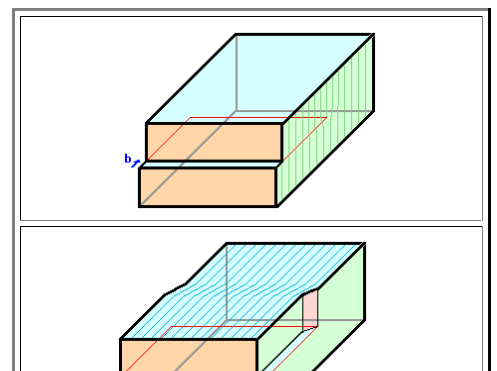
- $\alpha=90^\circ$ : Edge dislocation.
- $\alpha=0^\circ$ : Screw dislocation.
- $\alpha=60^\circ$ : "Sixty degree" dislocation.
- $\alpha$ =arbitrary : "Mixed" dislocation.

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

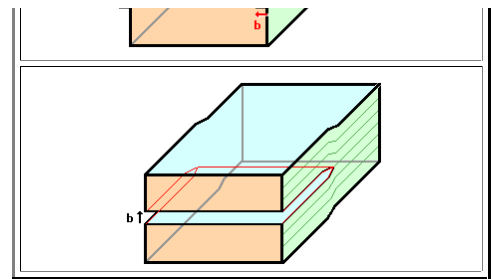
$$E_{dis} \approx 5 \text{ eV}/|\underline{b}|$$

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).

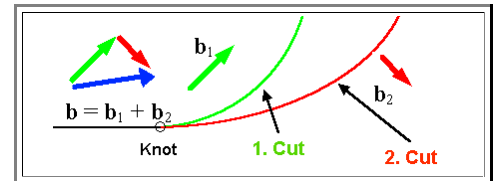


- Mend the *lattice* (or *crystal*) by "welding the upper part to the lower one. There will be a perfect fit by definition everywhere except along the dislocation line.
- Make the best arrangement of the atoms along the dislocation line by minimizing their energy (make best possible bonds).
- ▶ You now 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:  
 $\mathbf{Sb} = 0$   
 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