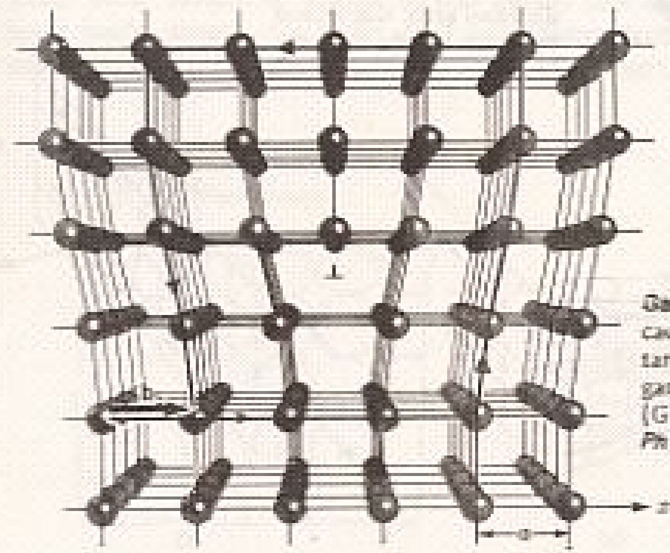
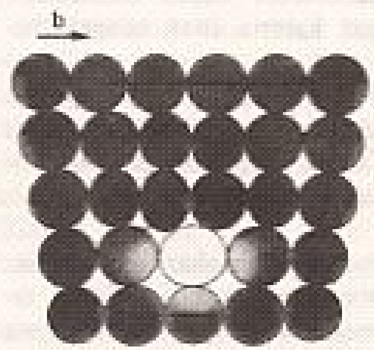
Line Defects

Dislocations

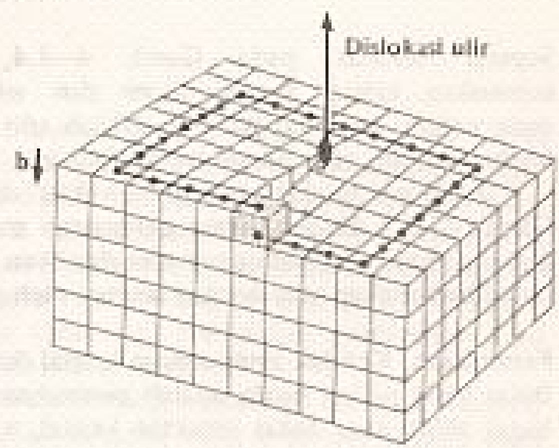
Cacat Garis (Dislokasi)



Gamb 4—4.2 Dislokasi garis ⊥. Terjadi cacat linier pada sisi bidang-atom tambahan. Vektor geser **b** menggambarkan hasil pergeseran. [Guy and Hren, *Elements of Physical Metallurgy*].



Gamb 4—4.3. Energi dislokasi. Atom yang berdekatan dengan dislokasi mengalami tekanan (warna gelap) dan tegangan (warna putih).



Gamb 4—4.4. Dislokasi ulir (tampak sel-sel satuan) Vektor geser **b** sejajar dengan cacat garis.

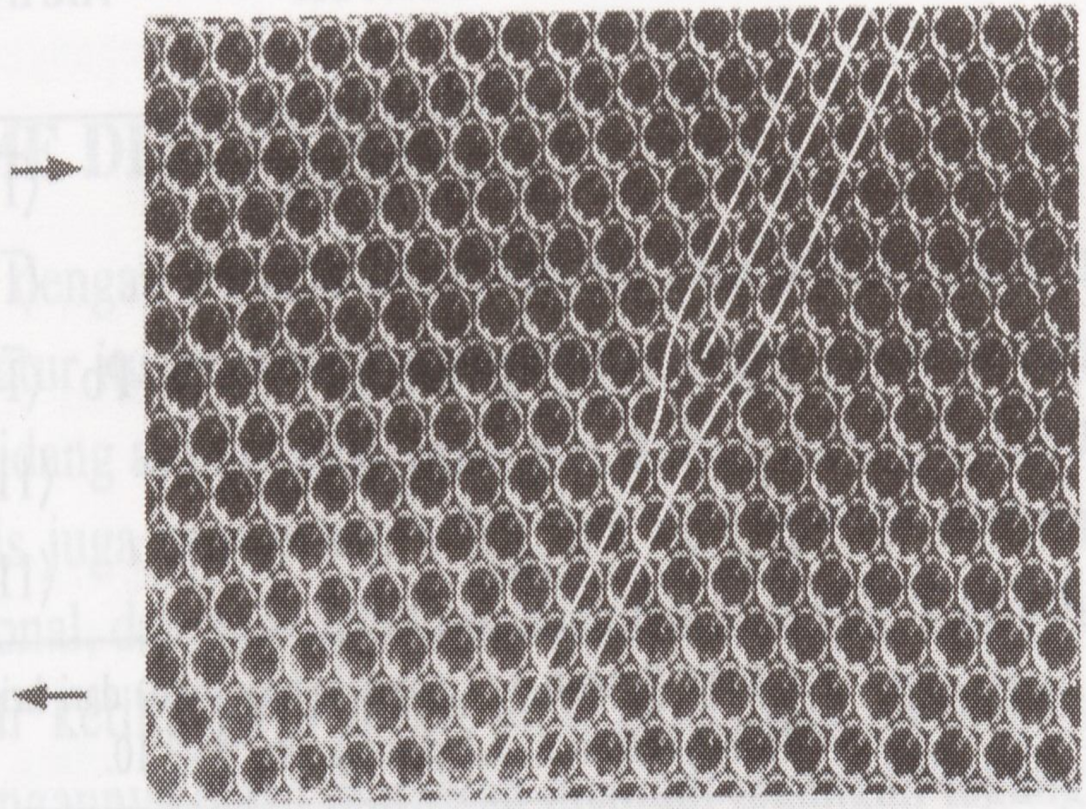
Cacat Garis / Dislokasi :

Cacat titik yang melibatkan banyak atom dalam bentuk deret (sisipan satu bidang atom tambahan dalam struktur kristal) yang timbul karena deformasi akibat pengaruh gaya luar atau selama proses pertumbuhan kristal

1. Bila bagian atas bidang slip yg mendapat tambahan baris atom disebut dislokasi sisi positif (+), bila bagian bawah bidang slip disebut dislokasi sisi negatif (-)
2. Vektor Burger (VB); jarak geser atom di sekitar dislokasi. Pada dislokasi garis VB tegak lurus garis dislokasi, sedangkan pada dislokasi ulir VB sejajar dengan garis dislokasinya.

Dislokasi Ulir/Dislokasi Burgers :

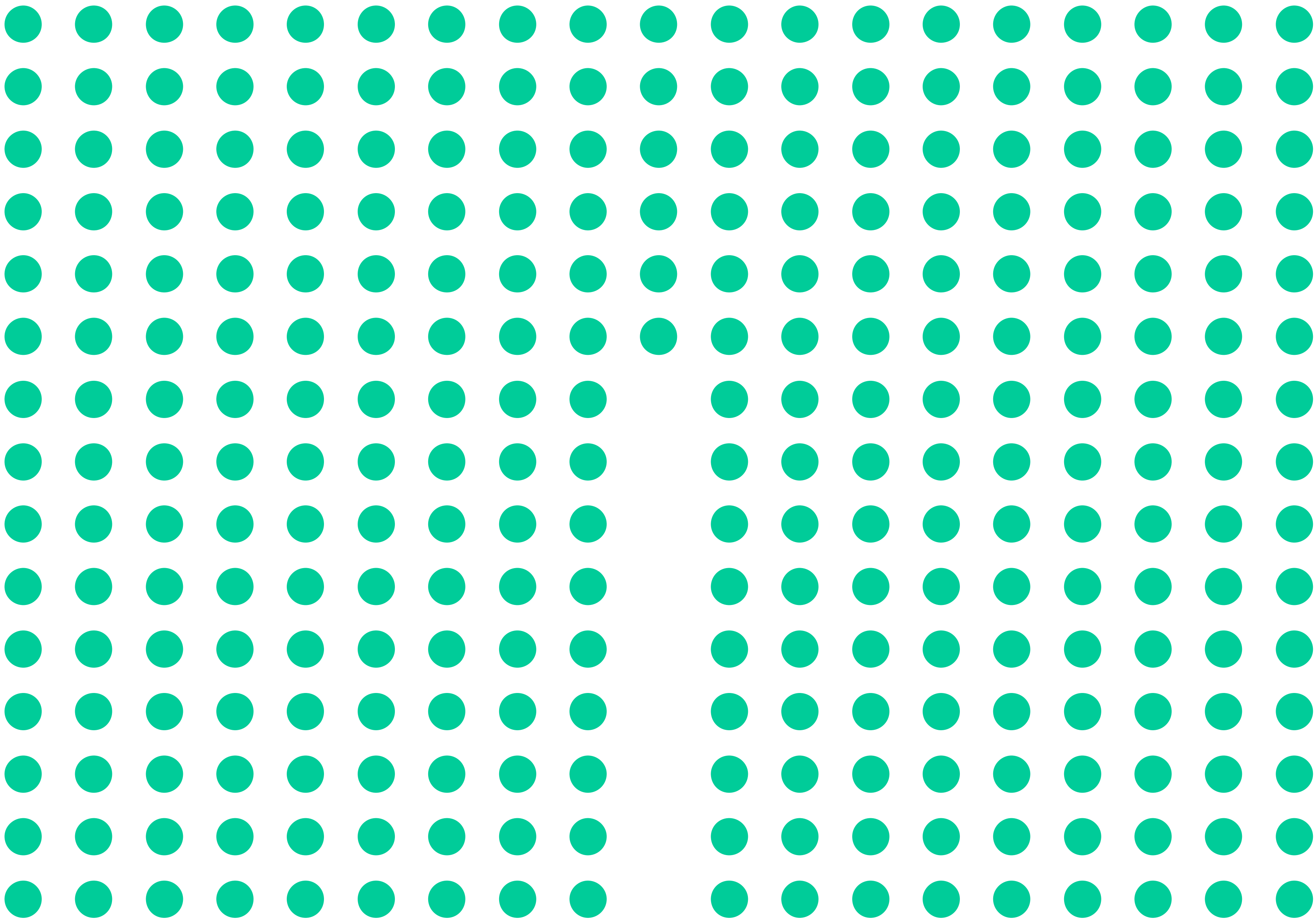
cacat menyerupai spiral dengan garis cacat sepanjang sumbu ulir, dimana vektor gesernya sejajar dengan garis cacat.



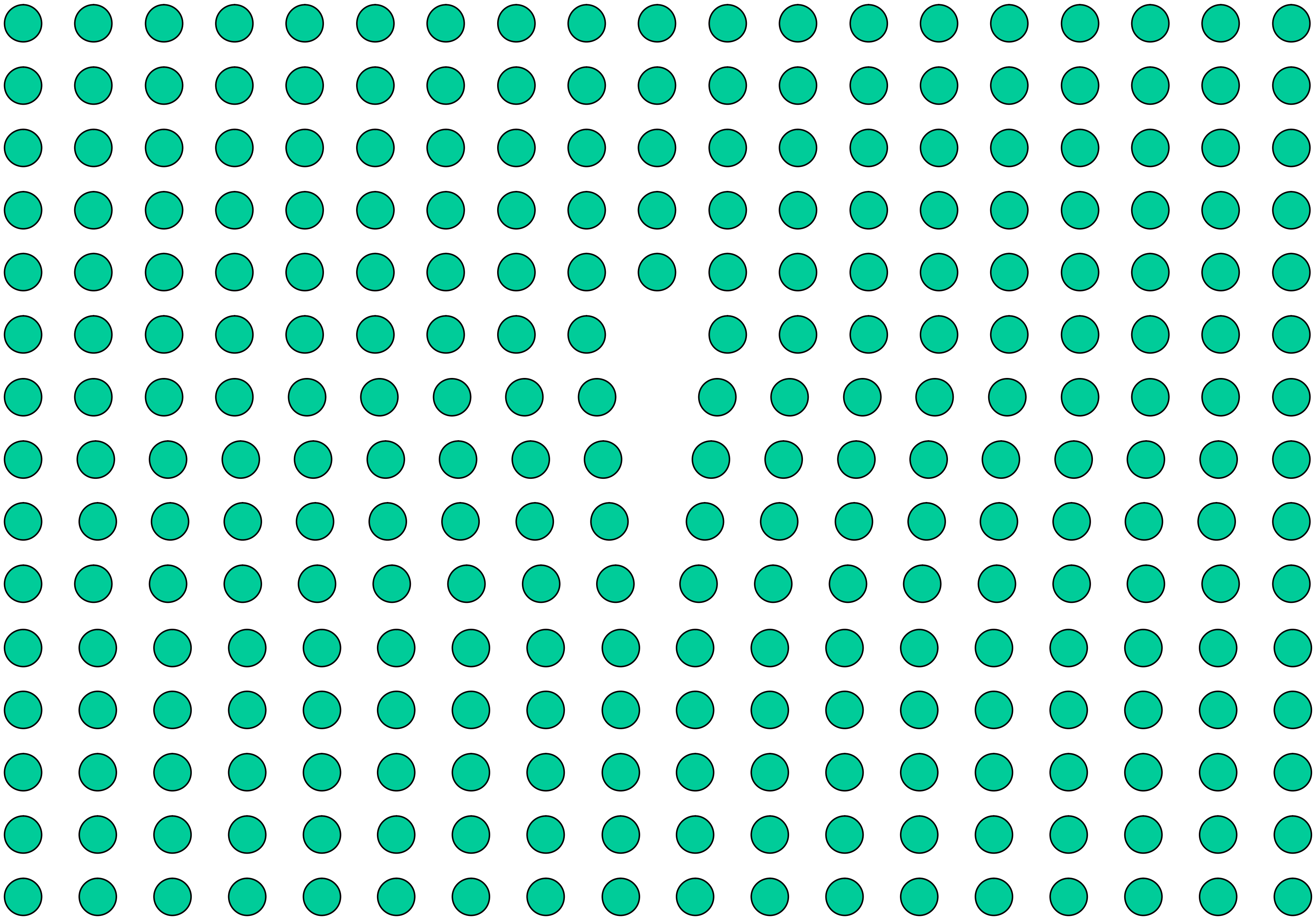
GAMBAR 8–3.3

Dislokasi tepi. Model "gelembung" dari struktur kristal yang cacat. Perhatikan barisan atom-atom ekstra (Bragg dan Nye, *Proc. Roy. Soc* (*London*))

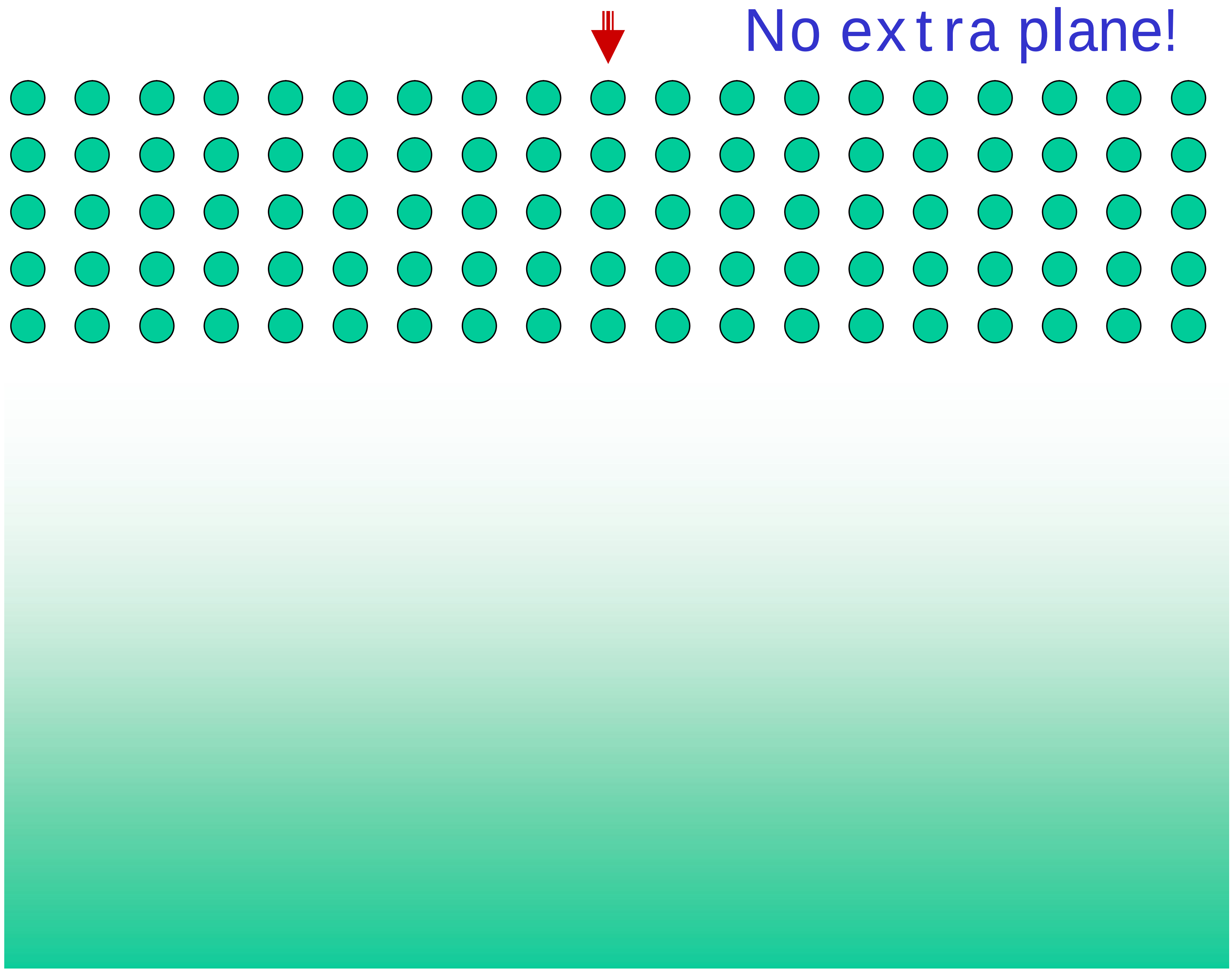
Missing half plane→ A Defect

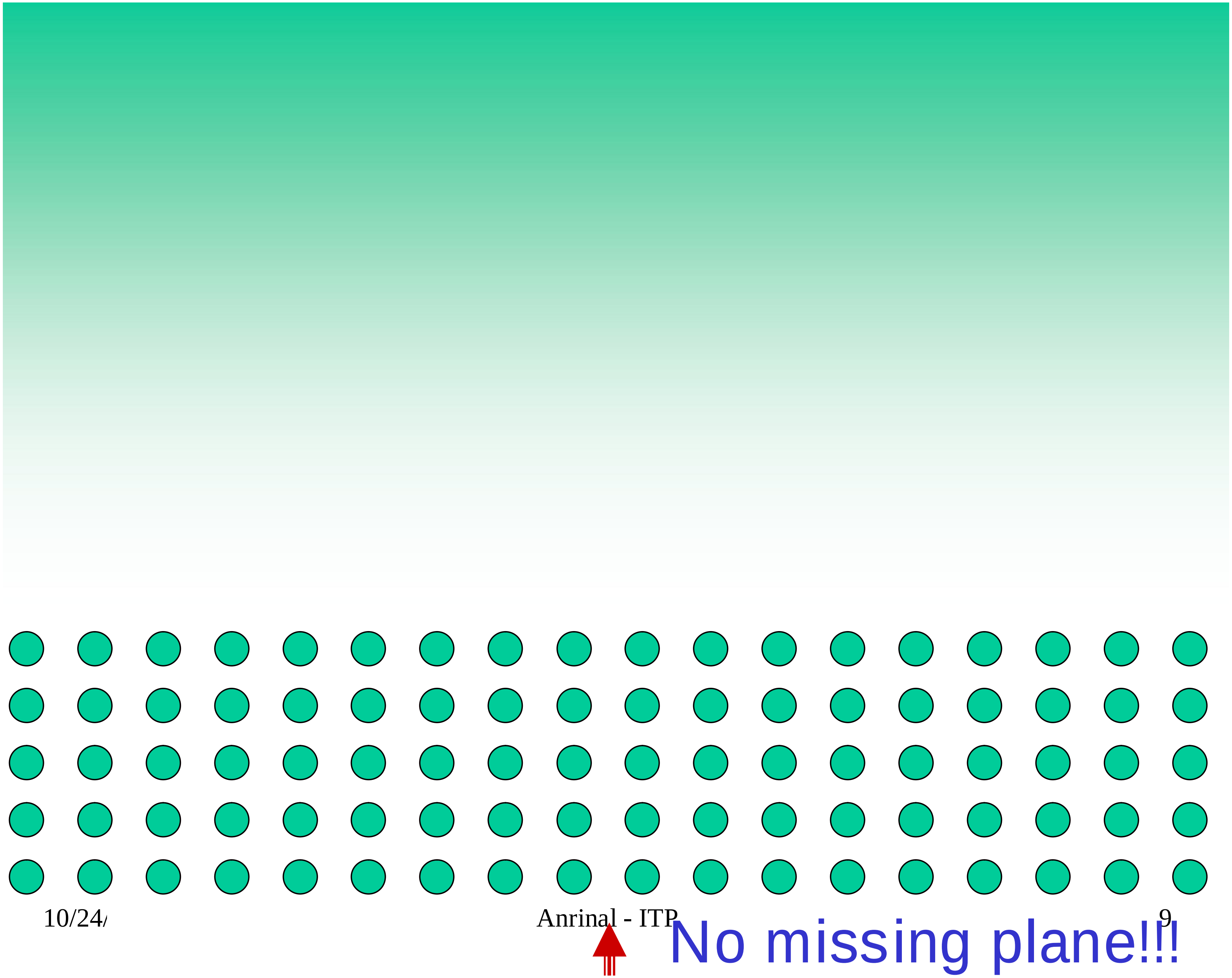


An extra half plane...

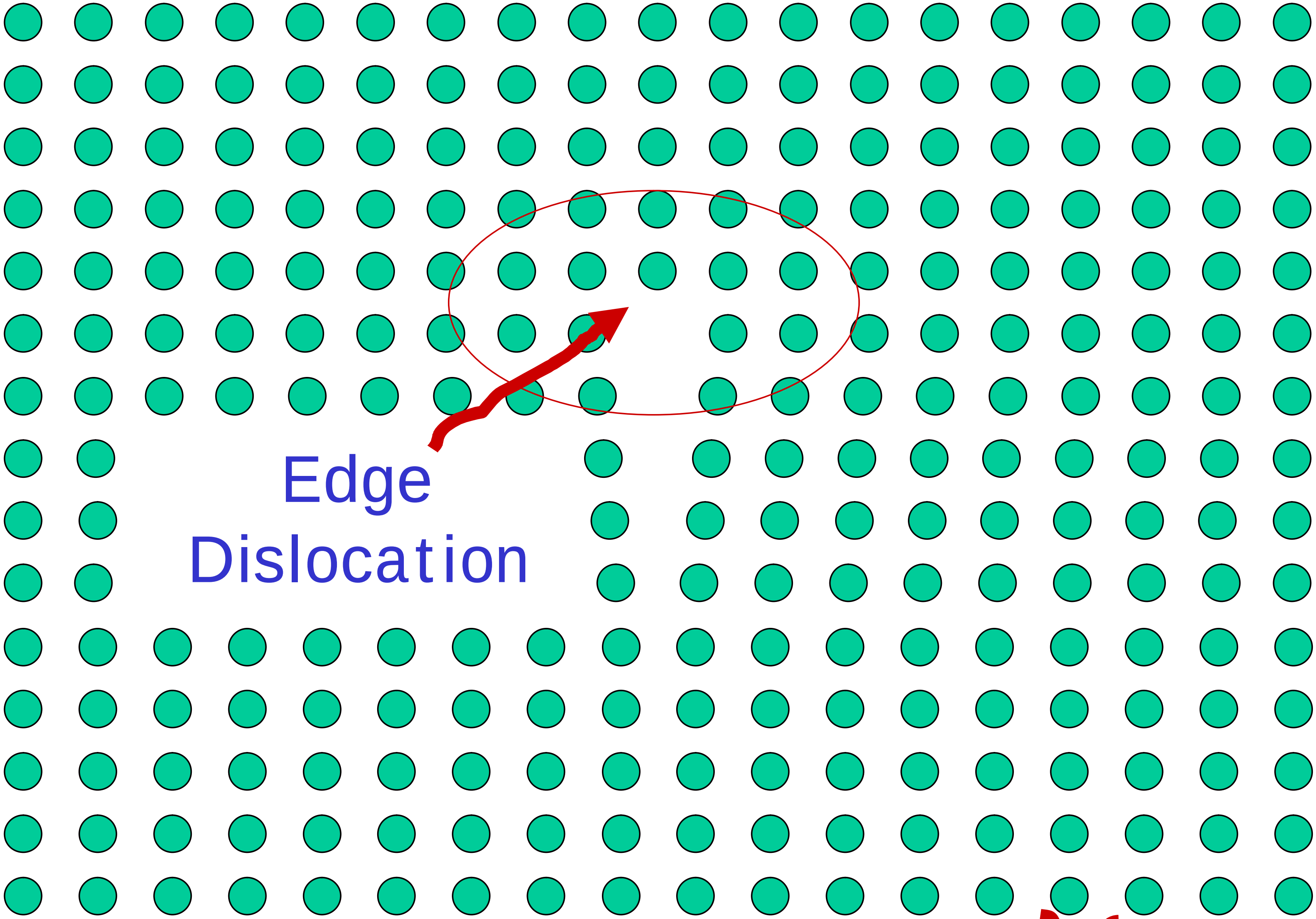


...or a missing half plane

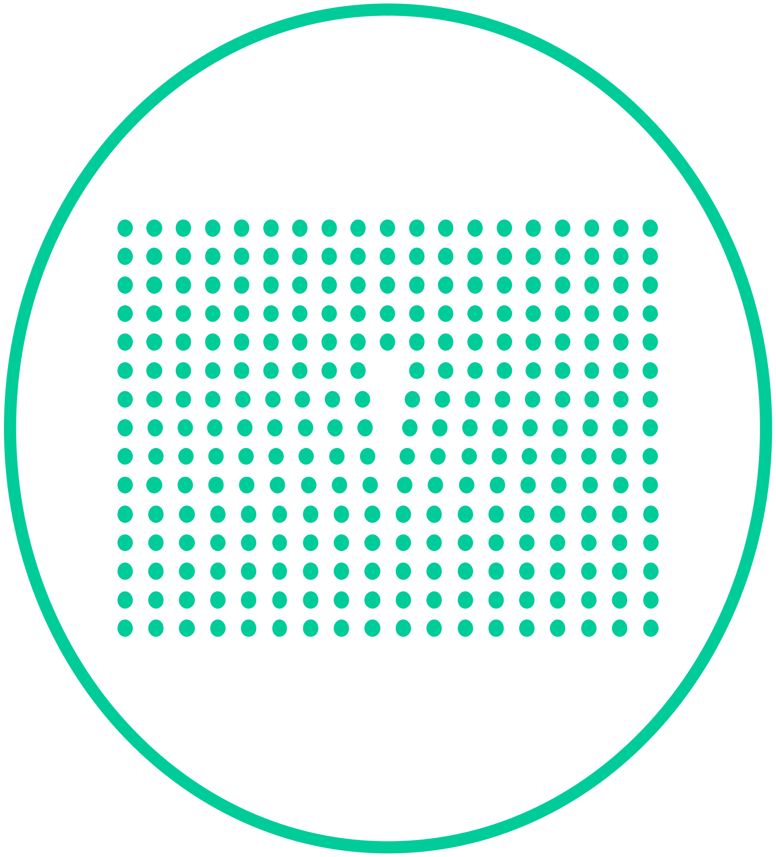

No extra plane!


No missing plane!!!

An extra half plane...



...or a missing half plane

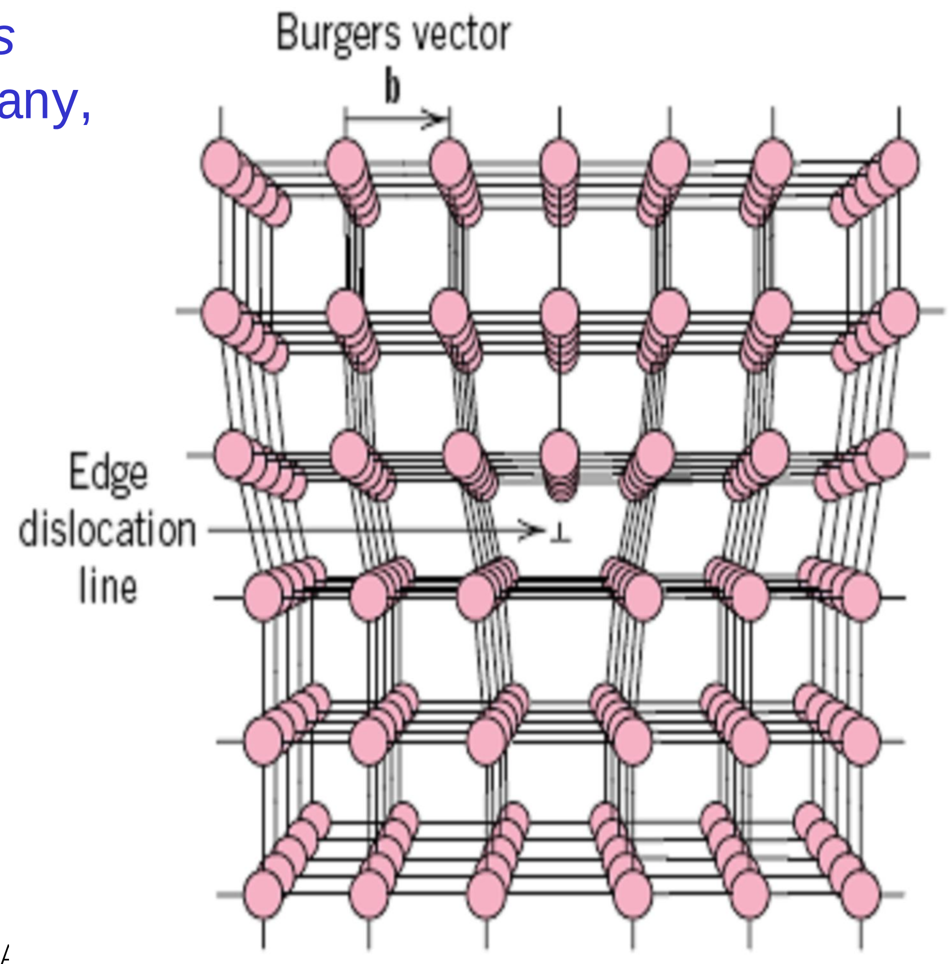


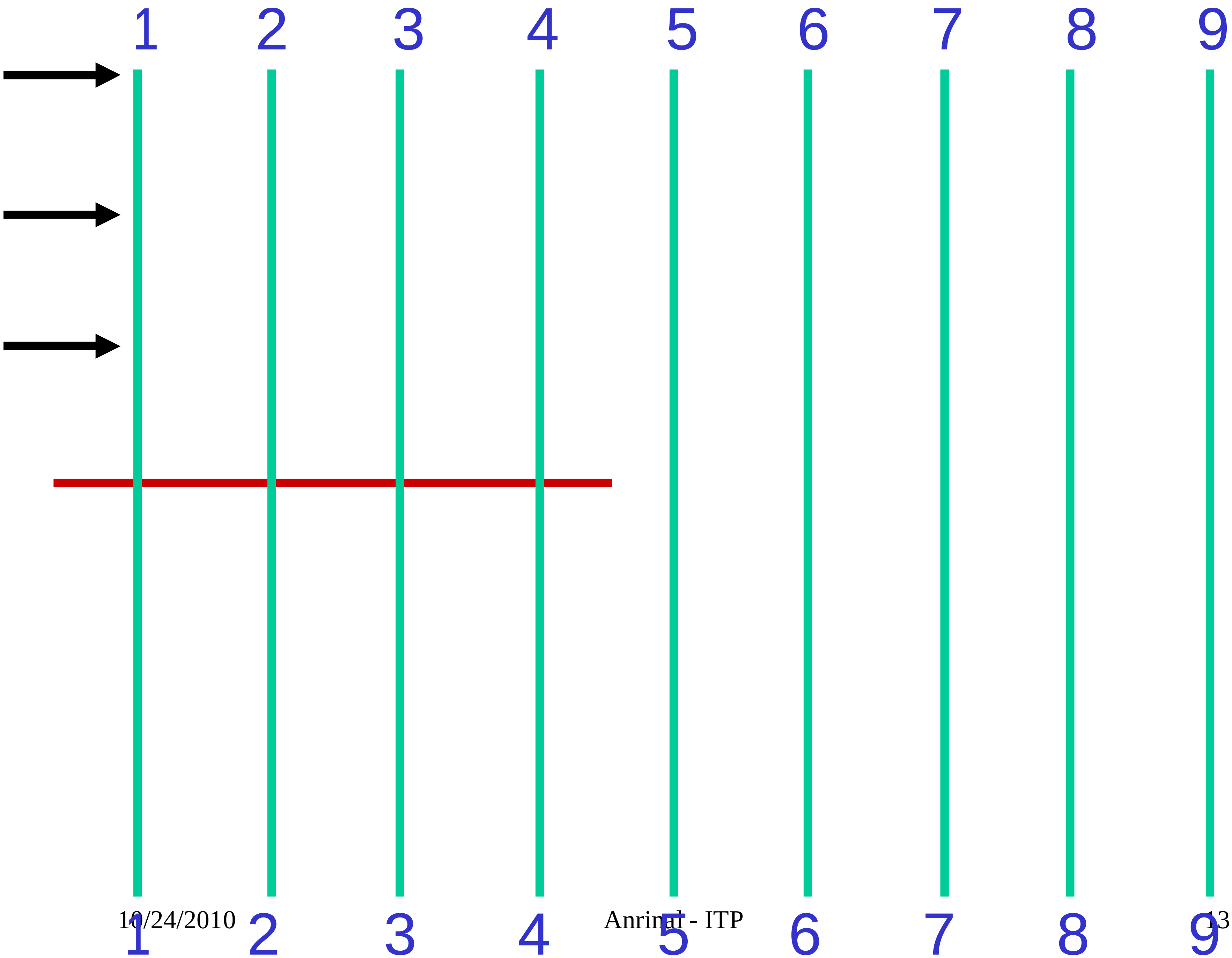
This is a line defect called an

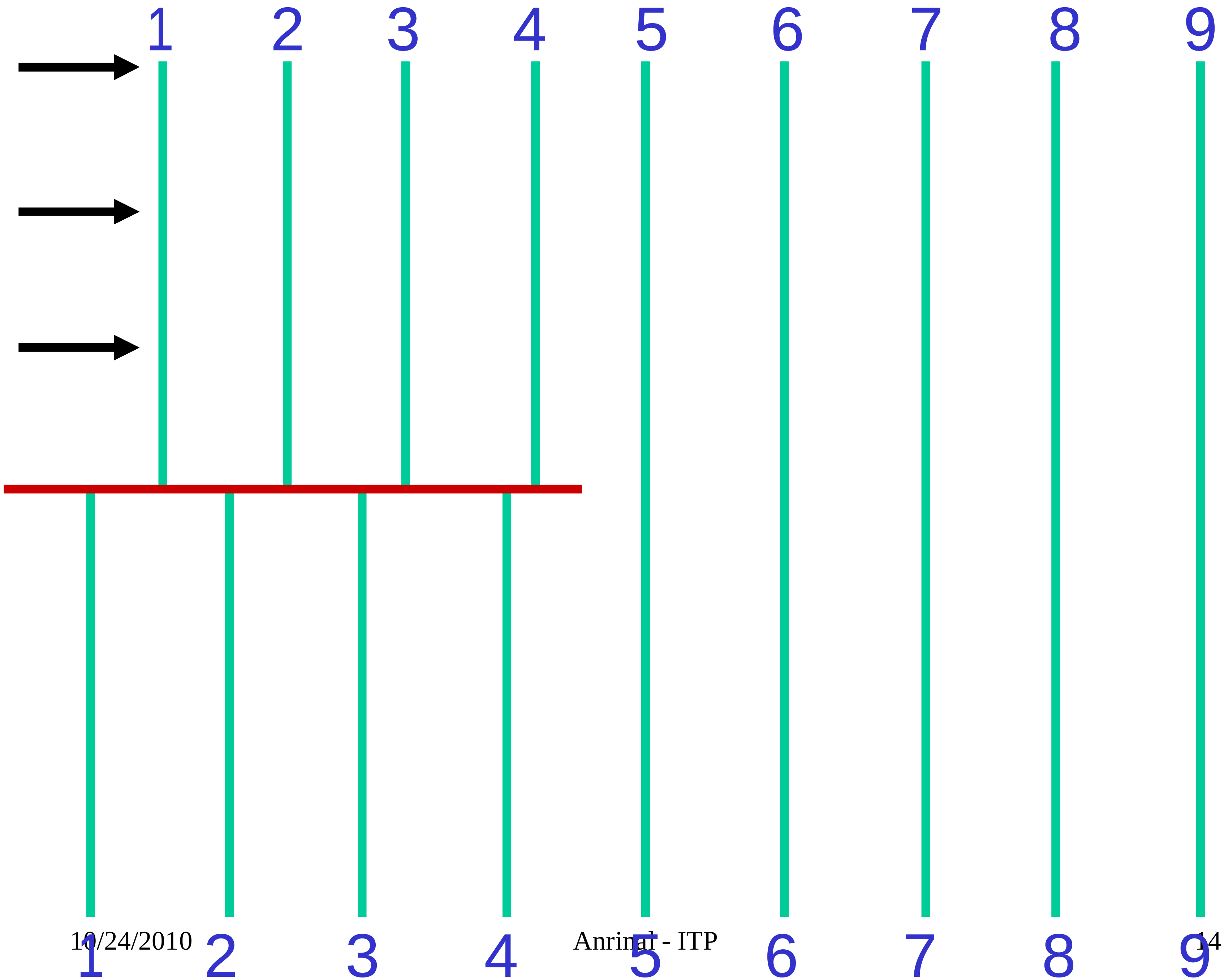
EDGE DISLOCATION

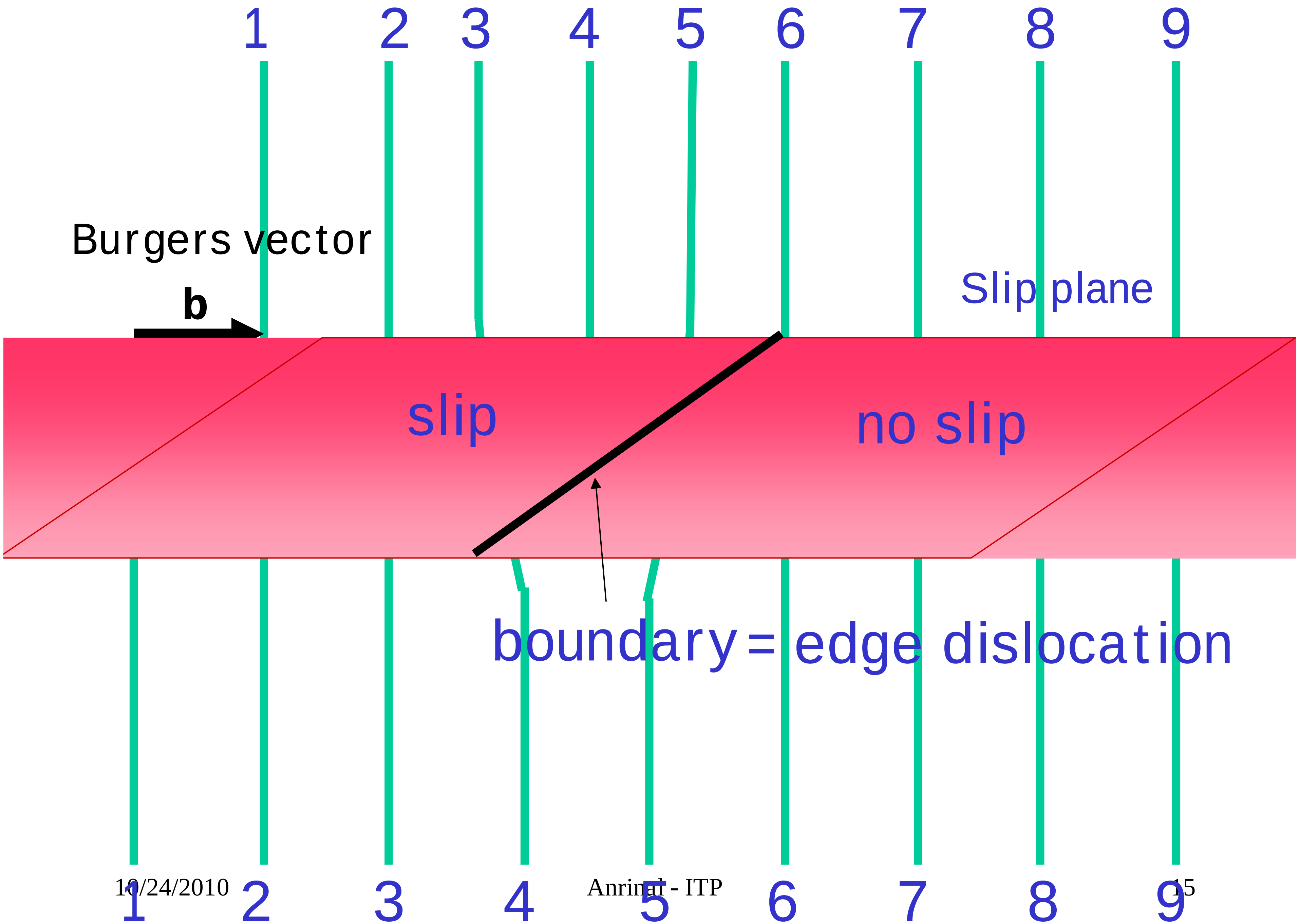
Callister FIGURE 4.3

The atom positions around an edge dislocation; extra half-plane of atoms shown in perspective. (Adapted from A. G. Guy, *Essentials of Materials Science,* McGraw-Hill Book Company, New York, 1976, p. 153.)

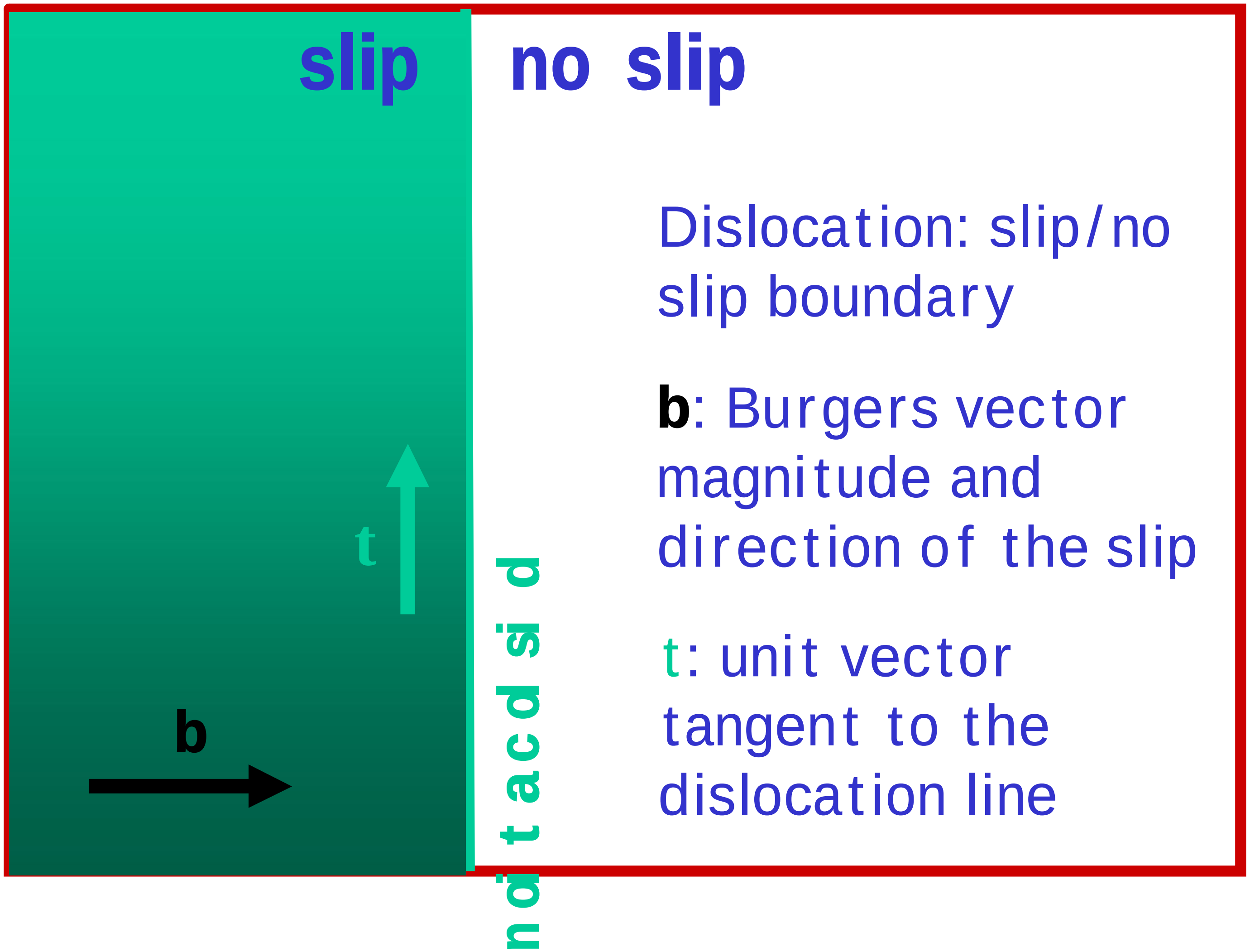



1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9


1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9


1 2 3 4 5 6 7 8 9
Burgers vector
b
Slip plane
slip
no slip
boundary = edge dislocation
1 2 3 4 5 6 7 8 9

Slip plane


slip
no slip
t
b
dislocation
Dislocation: slip/no slip boundary
b: Burgers vector magnitude and direction of the slip
t: unit vector tangent to the dislocation line

Dislocation Line:

A dislocation line is the boundary between slip and no slip regions of a crystal

Burgers vector:

The magnitude and the direction of the slip is represented by a vector **b** called the Burgers vector,

Line vector

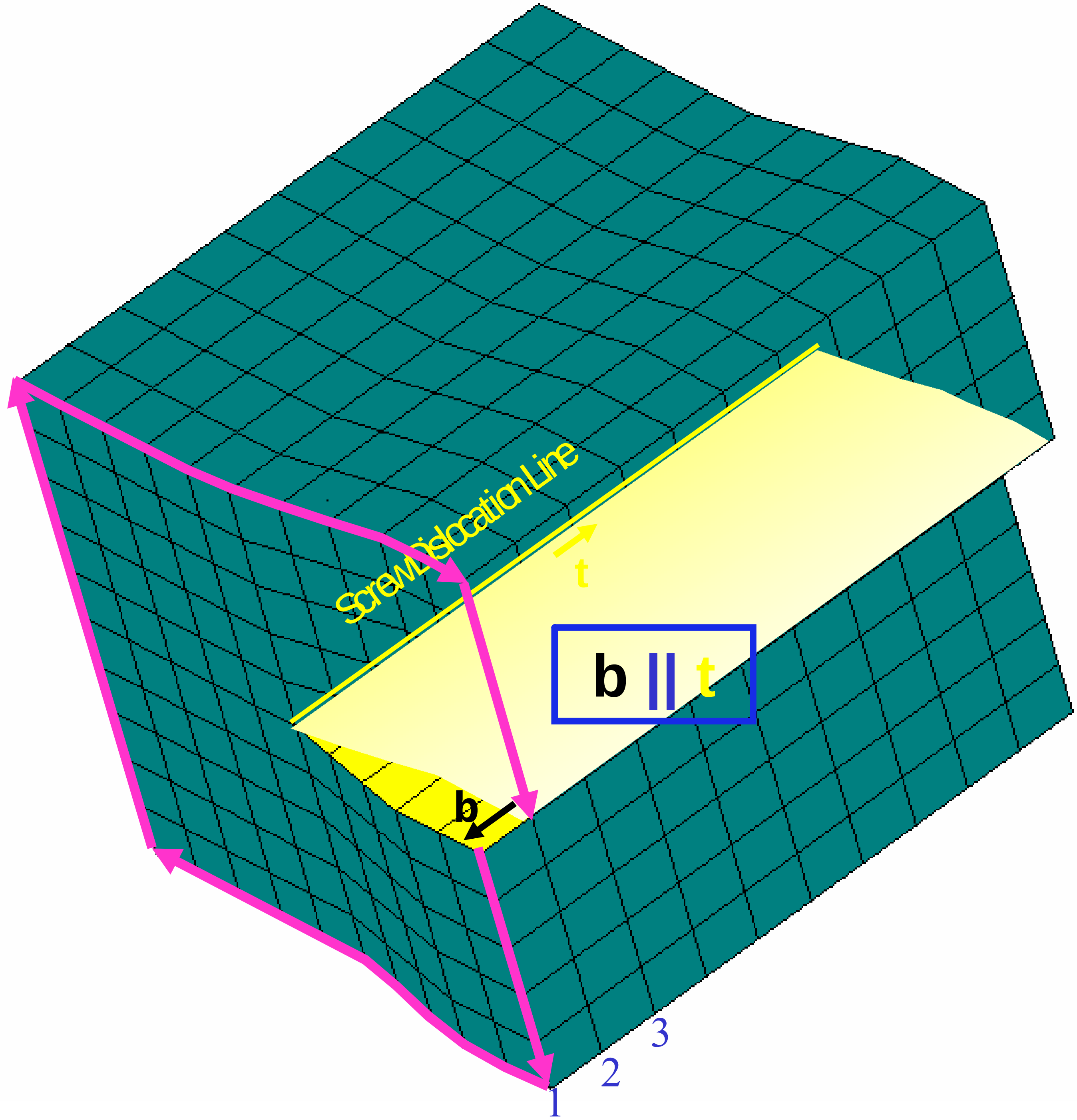
A unit vector **t** tangent to the dislocation line is called a tangent vector or the line vector.

In general, there can be any angle between the Burgers vector **b** (magnitude and the direction of slip) and the line vector **t** (unit vector tangent to the dislocation line)

$\mathbf{b} \perp \mathbf{t} \Rightarrow$ Edge dislocation

$\mathbf{b} \parallel \mathbf{t} \Rightarrow$ Screw dislocation

$\mathbf{b} \not\perp \mathbf{t},\ \mathbf{b} \nparallel \mathbf{t} \Rightarrow$ Mixed dislocation

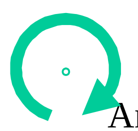


Screw Dislocation Line
t
b || t
b
1
2
3

If b || t

Then parallel planes ⊥ to the dislocation line lose their distinct identity and become one continuous spiral ramp

Hence the name SCREW DISLOCATION

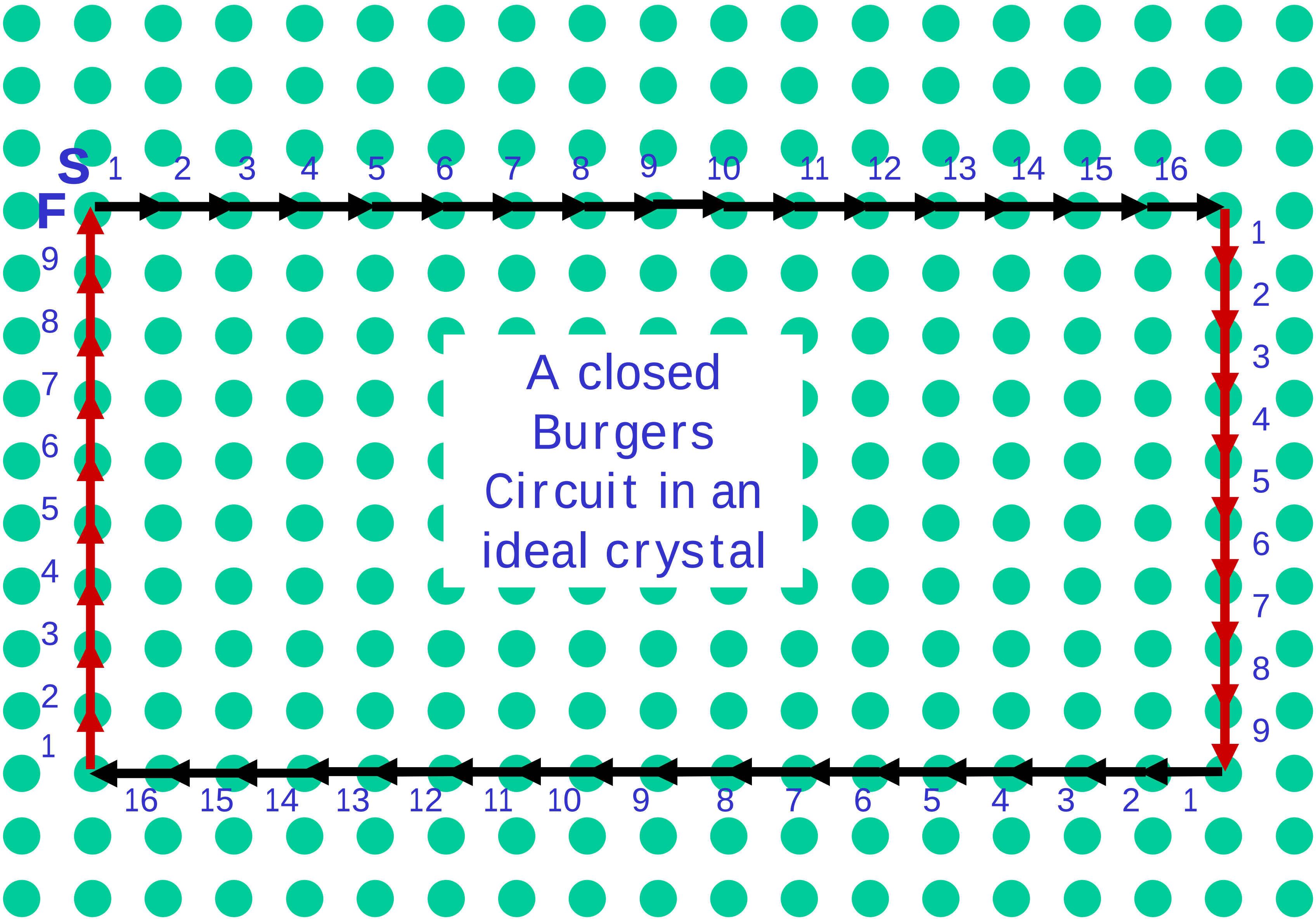
	Positive	Negative
Edge Dislocation	Extra half plane ***above*** the slip plane ⊥	Extra half plane ***below*** the slip plane ⊤
Screw Dislocation	Left-handed spiral ramp b **parallel** to t 	Right-handed spiral ramp b **antiparallel** to t 

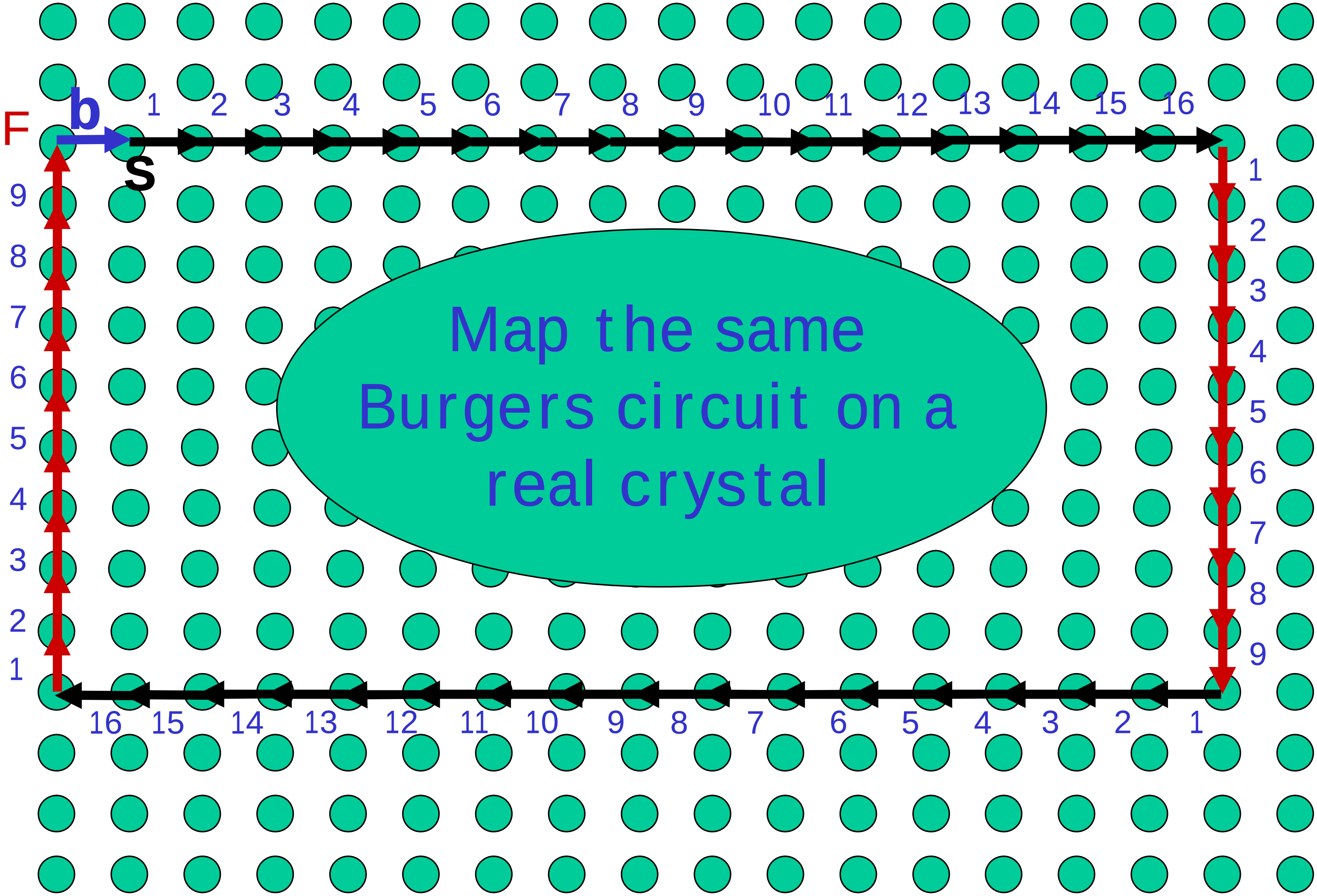
Burgers vector

Johannes Martinus BURGERS

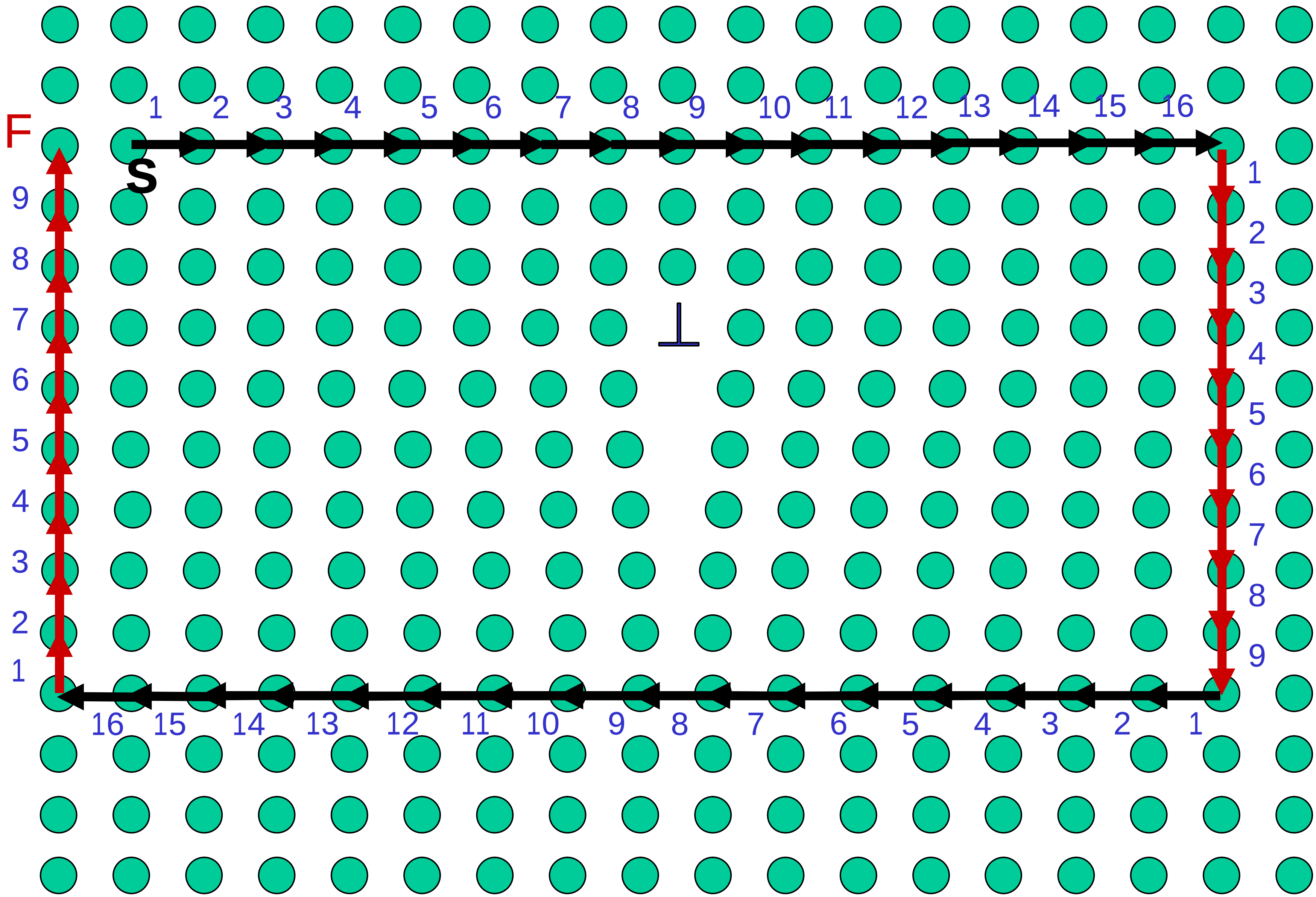
Burger's vector

Burgers vector

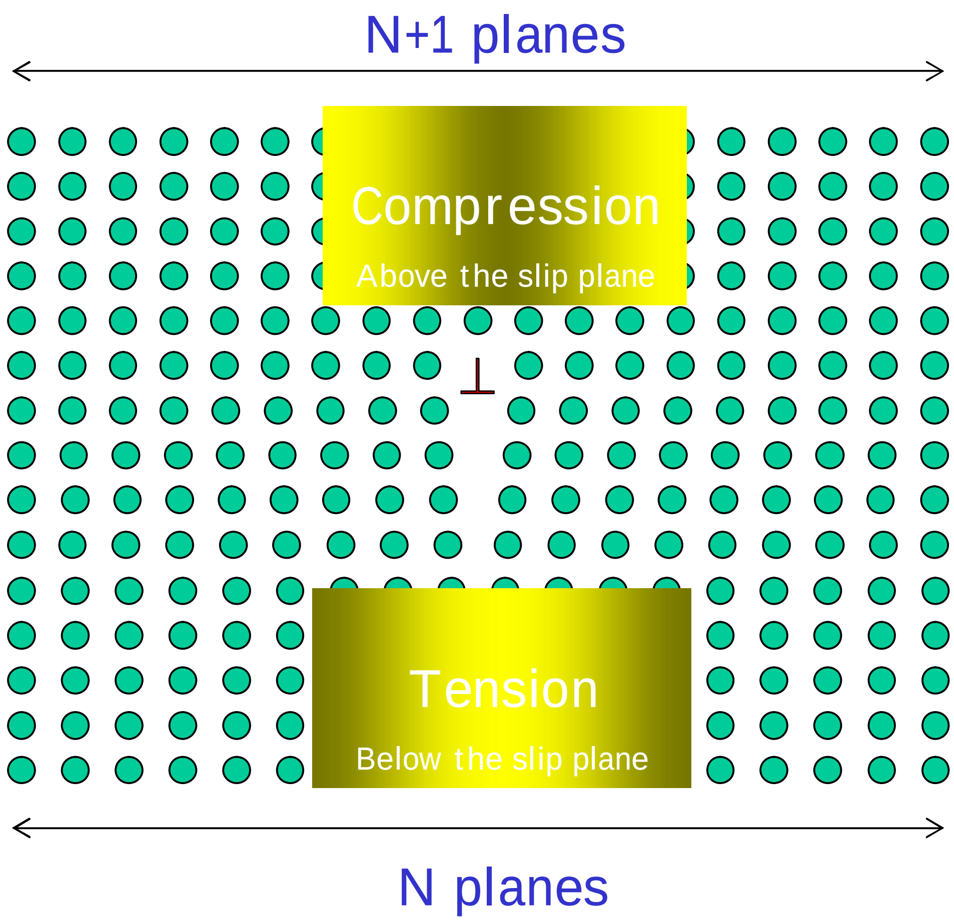

S
F
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
1 2 3 4 5 6 7 8 9
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
9 8 7 6 5 4 3 2 1
A closed Burgers Circuit in an ideal crystal



RHFS convention


F
S
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
1
2
3
4
5
6
7
8
9
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
9
8
7
6
5
4
3
2
1

Elastic strain field associated with an edge dislocation



Line energy of a dislocation

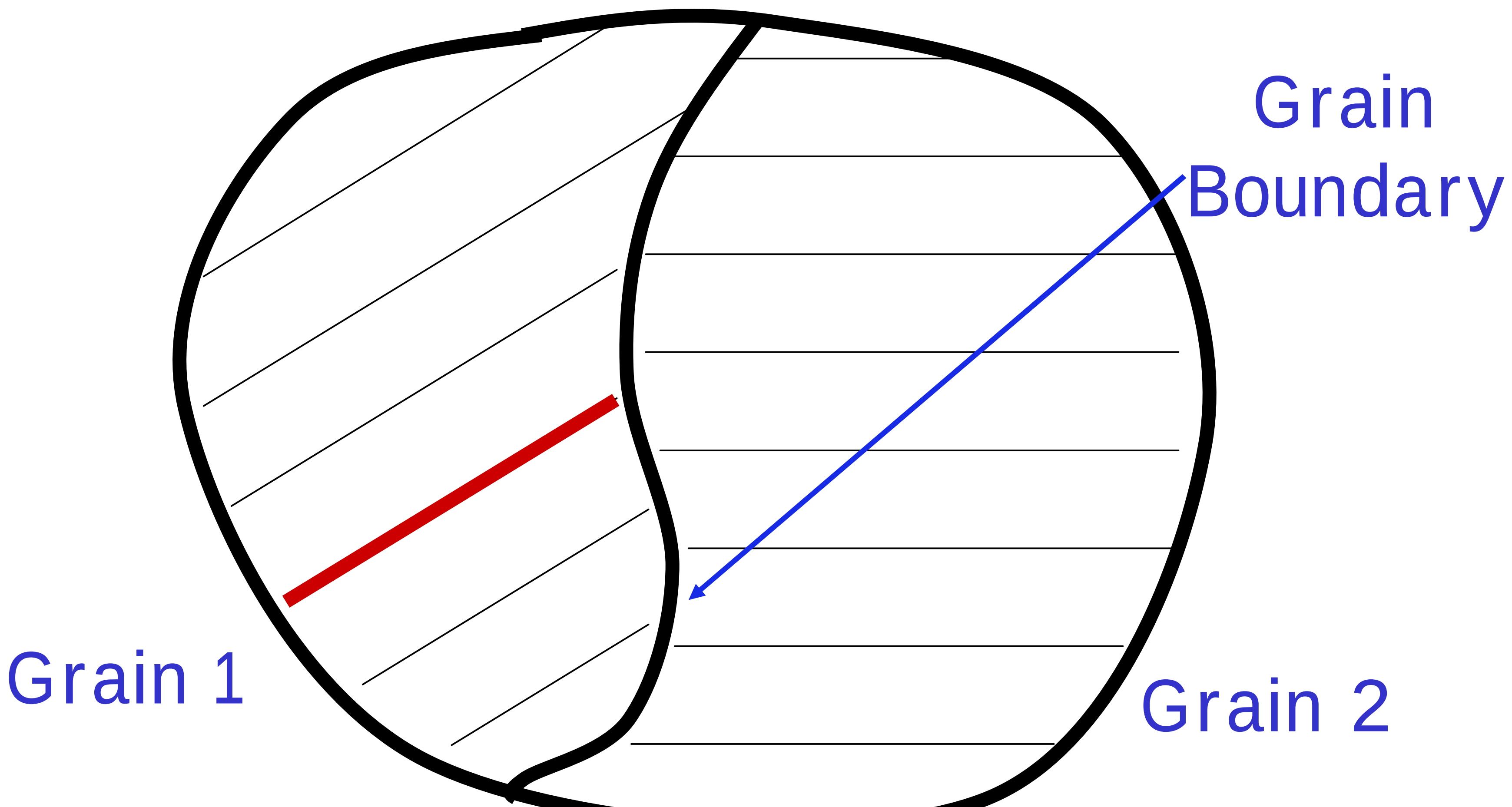
Elastic energy per unit length of a dislocation line

$$E = \frac{1}{2}\mu b^2$$

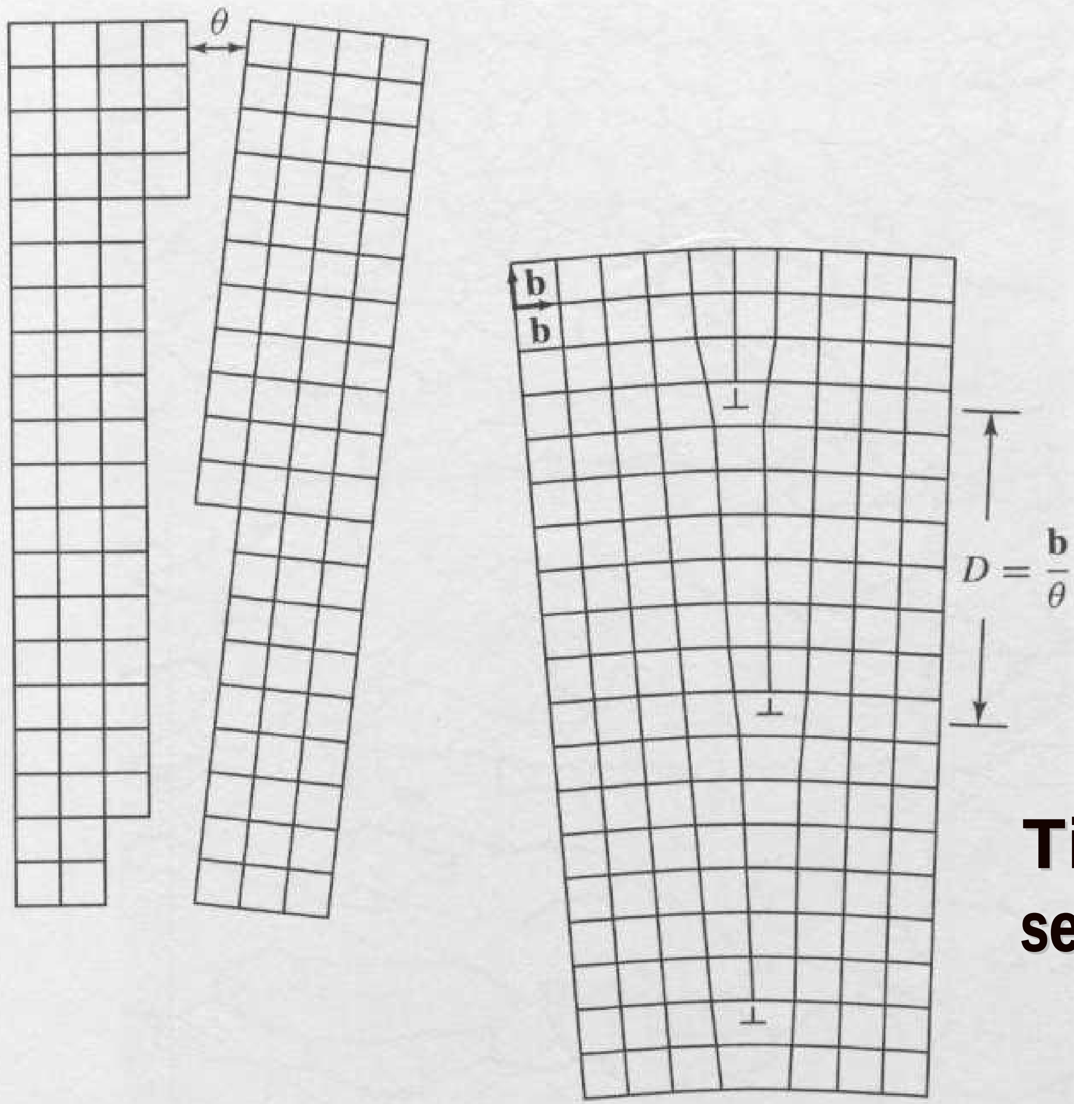
μ	Shear modulus of the crystal
b	Length of the Burgers vector

Unit: J m^{-1}

Dislocation can end on a grain boundary



Grain Boundaries

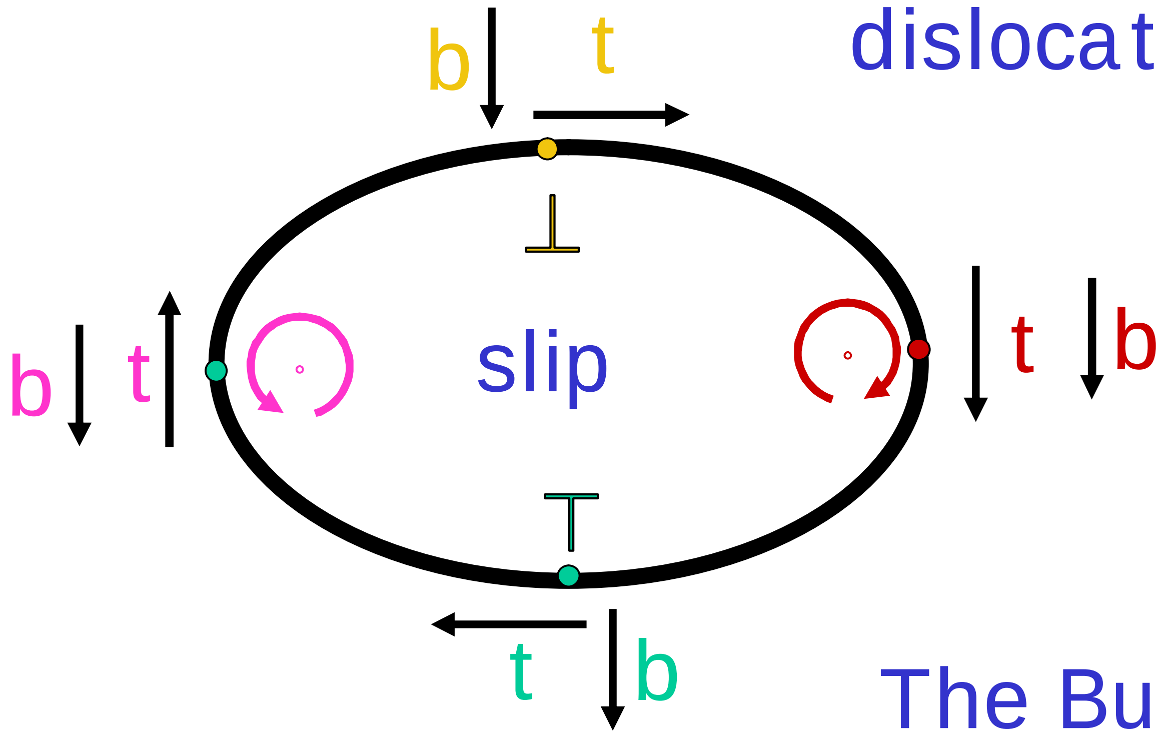


Simple grain boundary structure. This is termed a tilt boundary because it is formed when two adjacent crystalline grains are tilted relative to each other by a few degrees (θ). The resulting structure is equivalent to isolated edge dislocations separated by the distance b/θ, where b is the length of the Burgers vector, **b**. *(From W. T. Read,* Dislocations in Crystals, *McGraw-Hill Book Company, New York, 1953. Reprinted with permission of the McGraw-Hill Book Company.)*

Tilt boundary: Result of a set of edge dislocations.

A dislocation loop

The line vector **t** is always tangent to the dislocation line

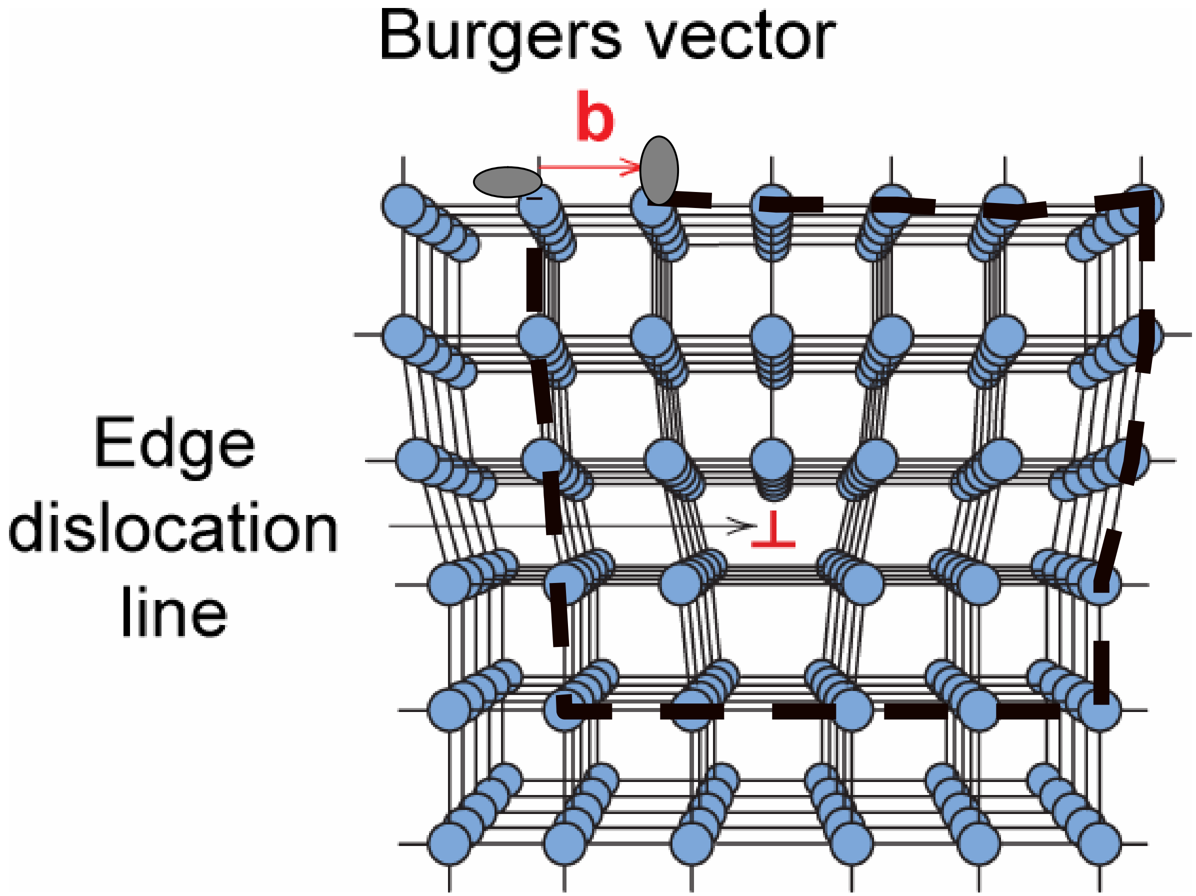


No slip

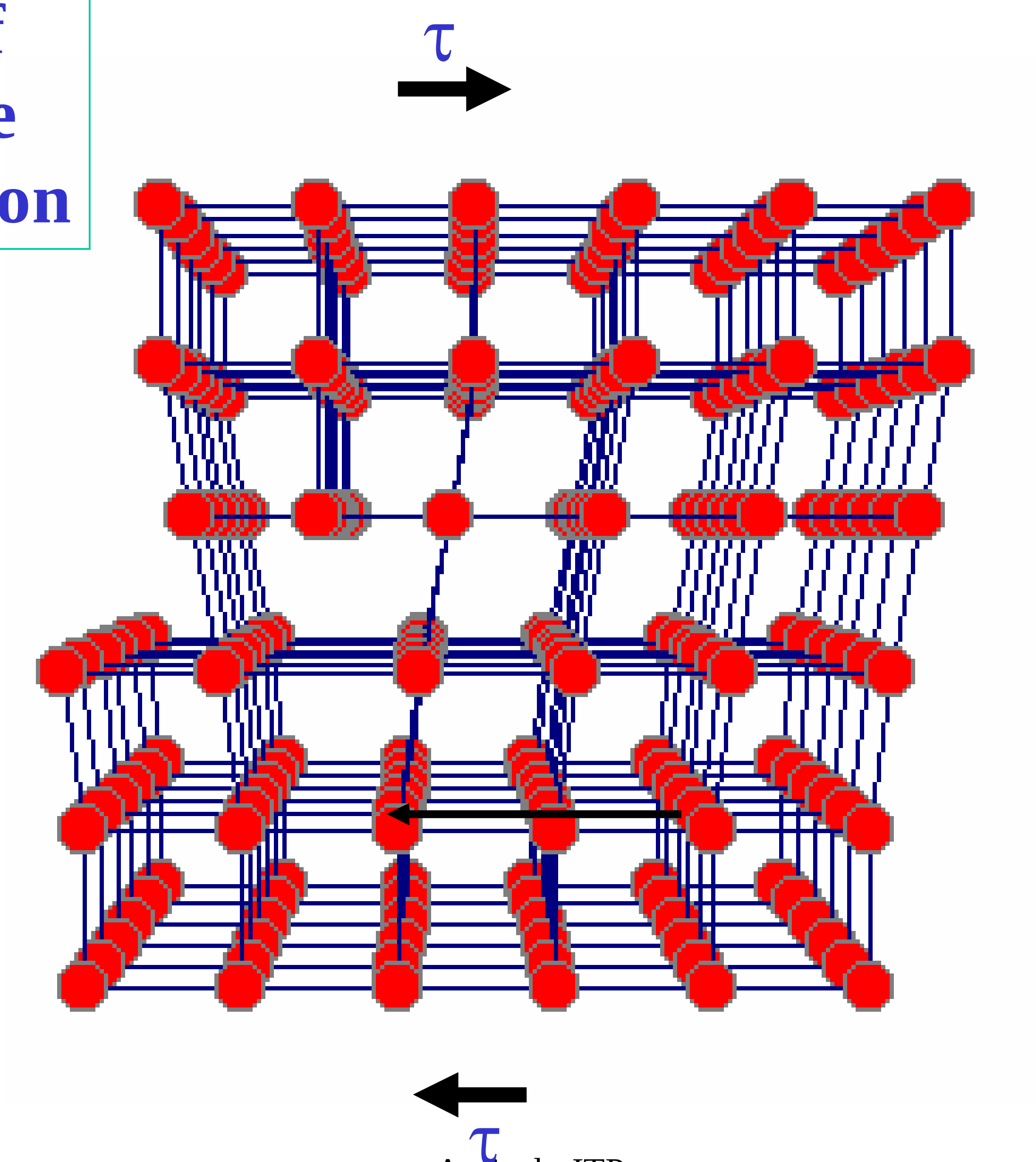
The Burgers vector **b** is constant along a dislocation line

Edge Dislocations

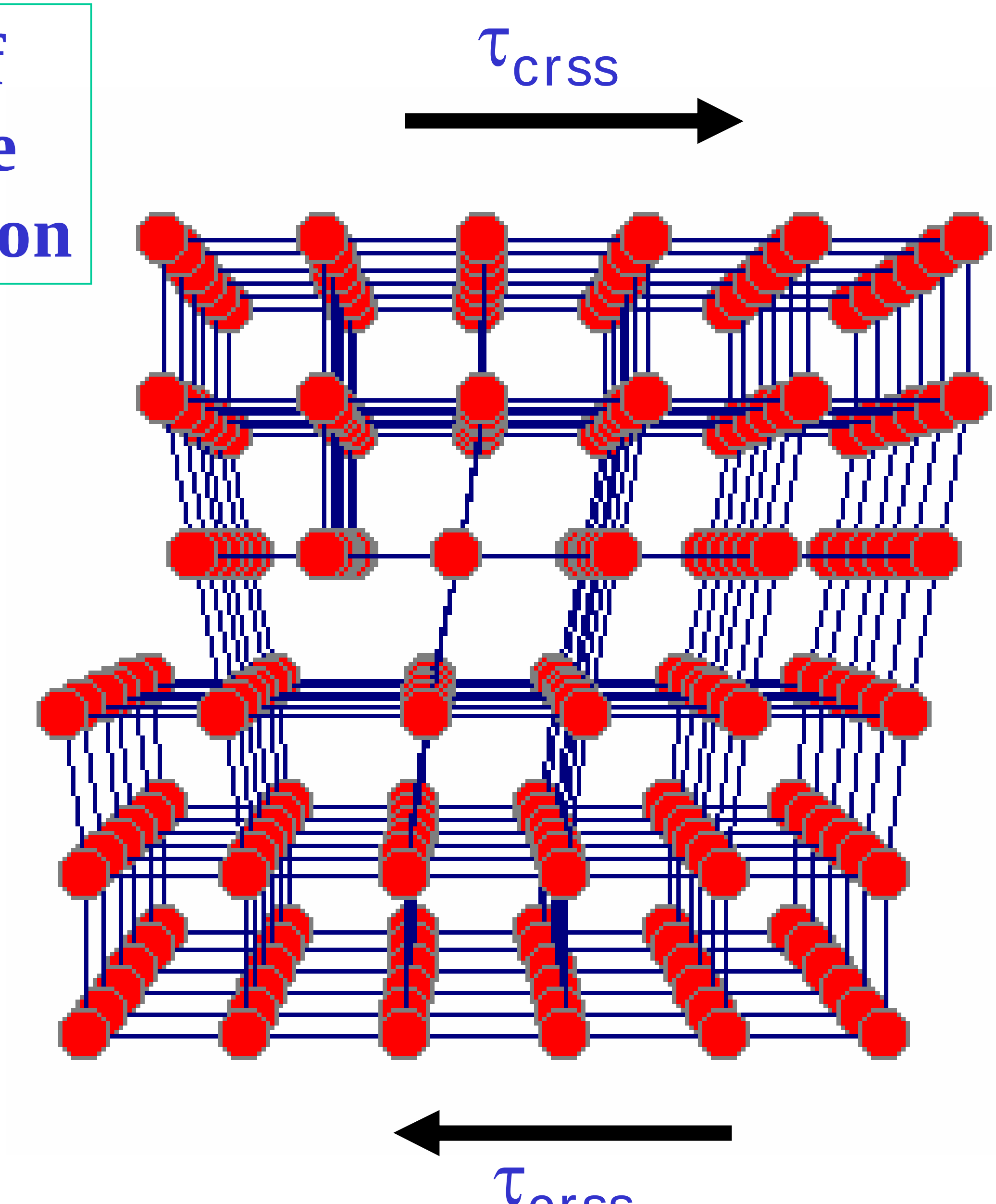
Burger's vector is perpendicular to dislocation in edge dislocations.



Glide of an Edge Dislocation

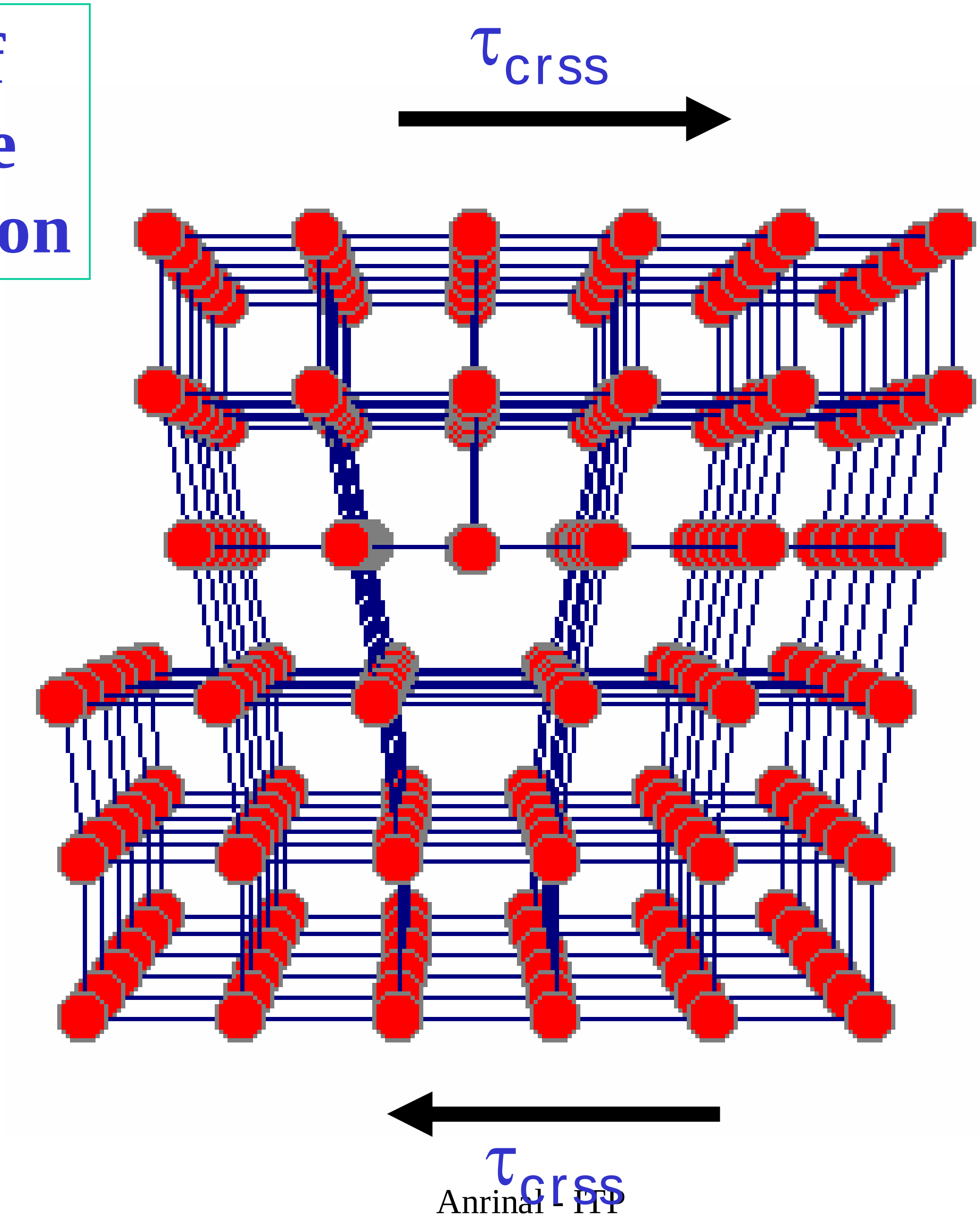


Glide of an Edge Dislocation



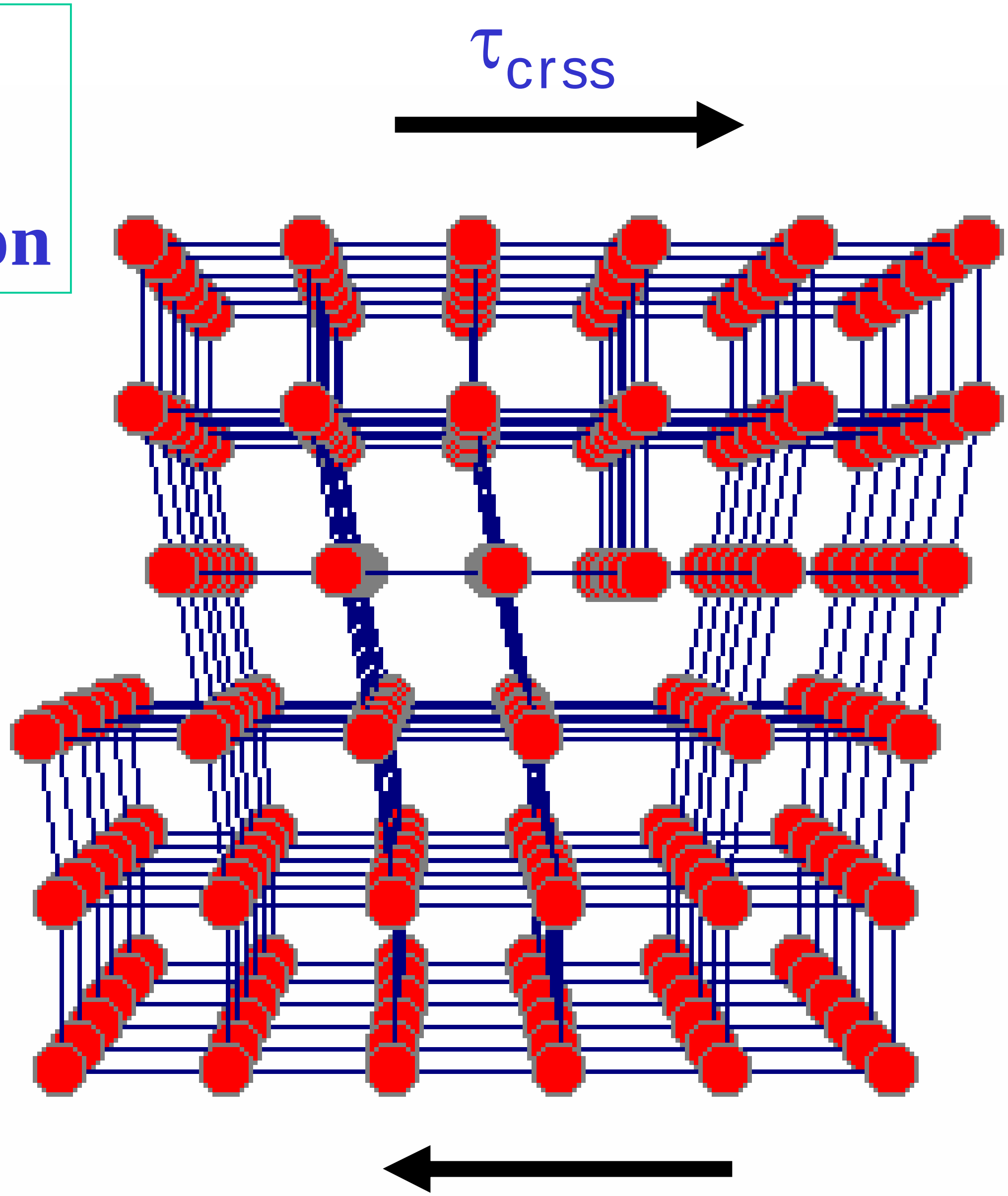
τ_{crss} is critical resolved shear stress on the slip plane in the direction of b.

Glide of an Edge Dislocation



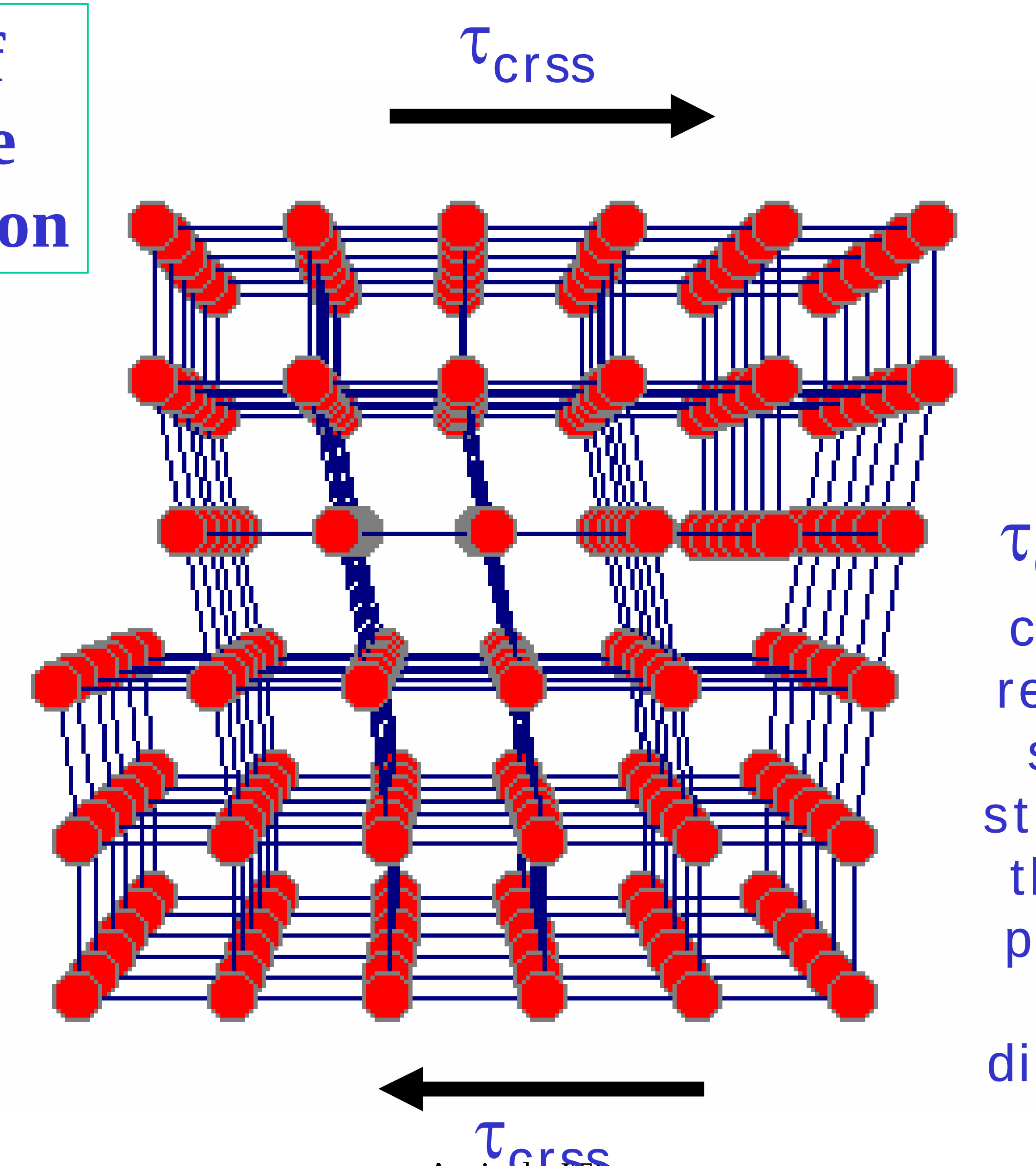
τ_{crss} is critical resolved shear stress on the slip plane in the direction of b.

Glide of an Edge Dislocation



τ_{crss} is critical resolved shear stress on the slip plane in the direction of b.

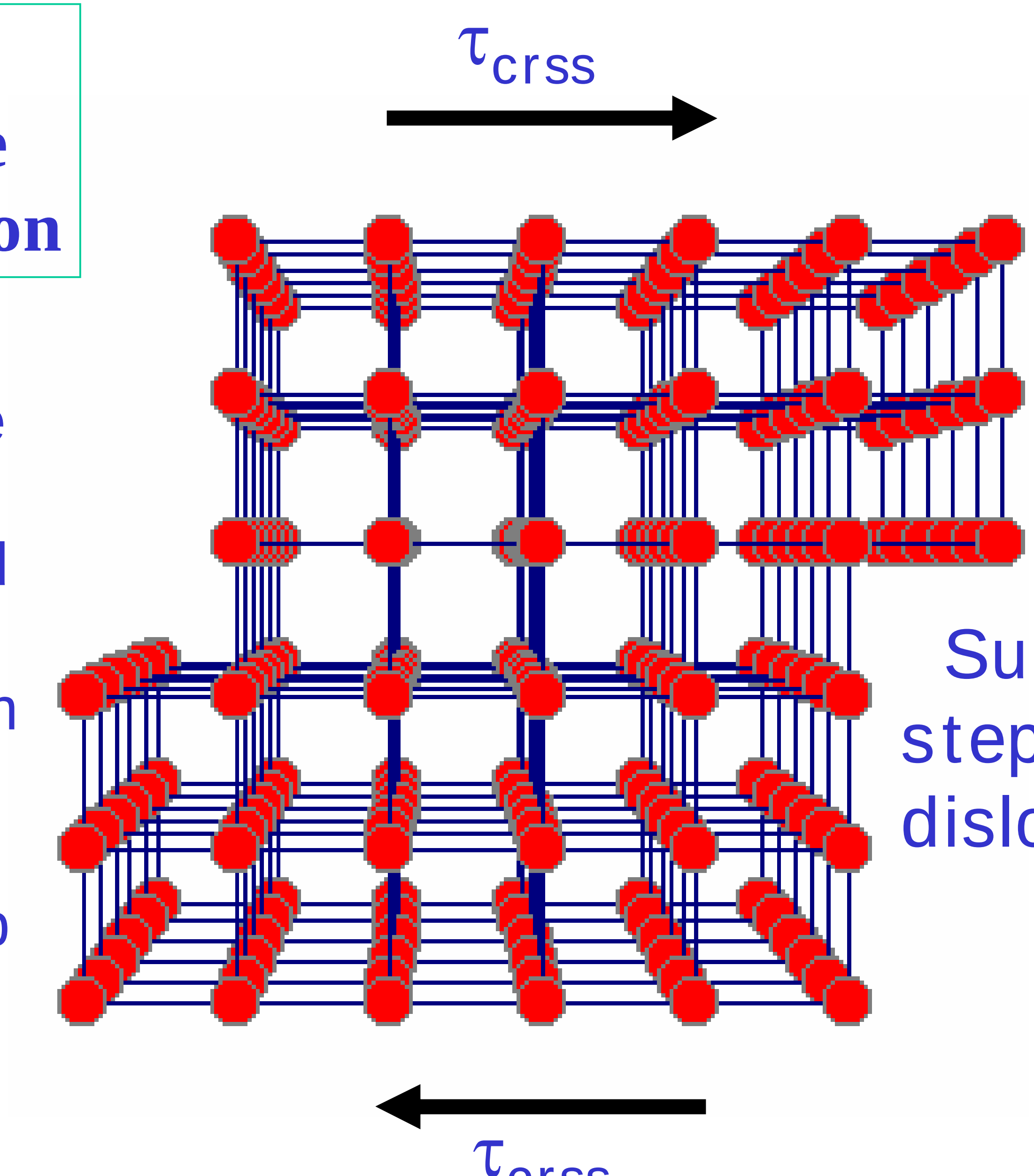
Glide of an Edge Dislocation



τ_{crss} is critical resolved shear stress on the slip plane in the direction of b.

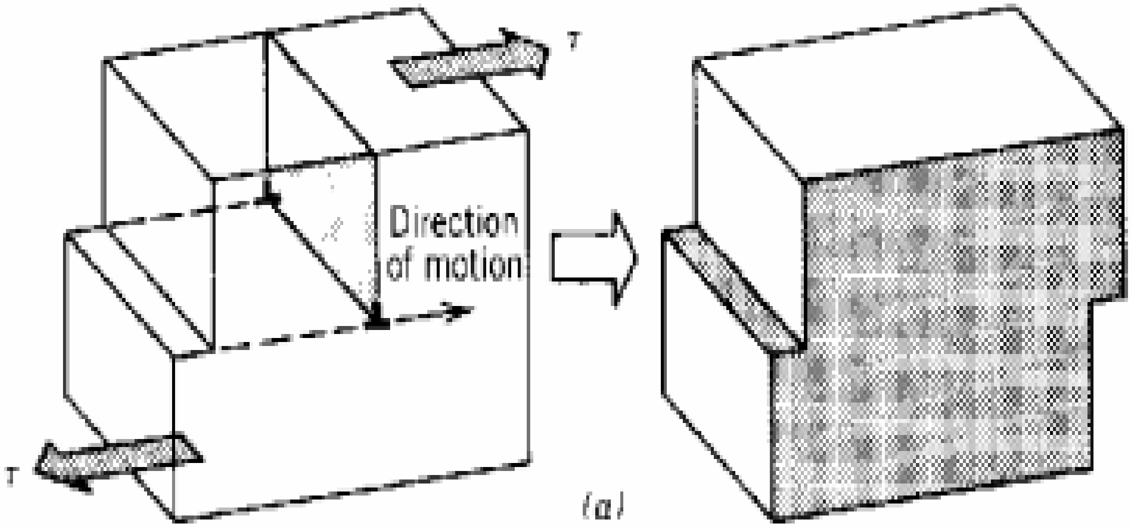
Glide of an Edge Dislocation

A surface step of b is created if a dislocation sweeps over the entire slip plane



Surface step, not a dislocation

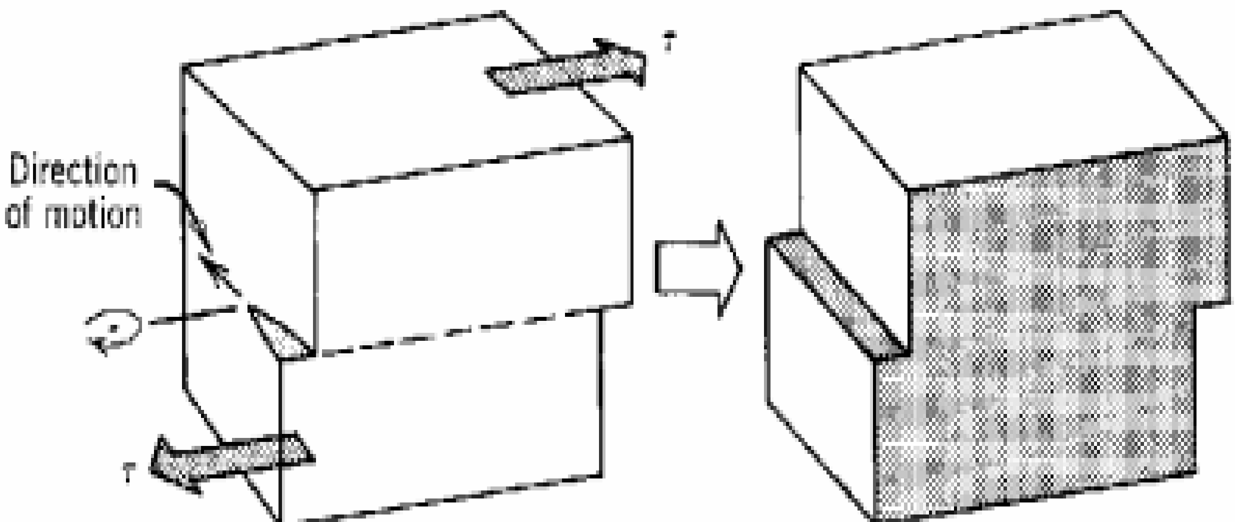
Formation of a step on the surface of a crystal due to:



(a)

Edge Dislocation:

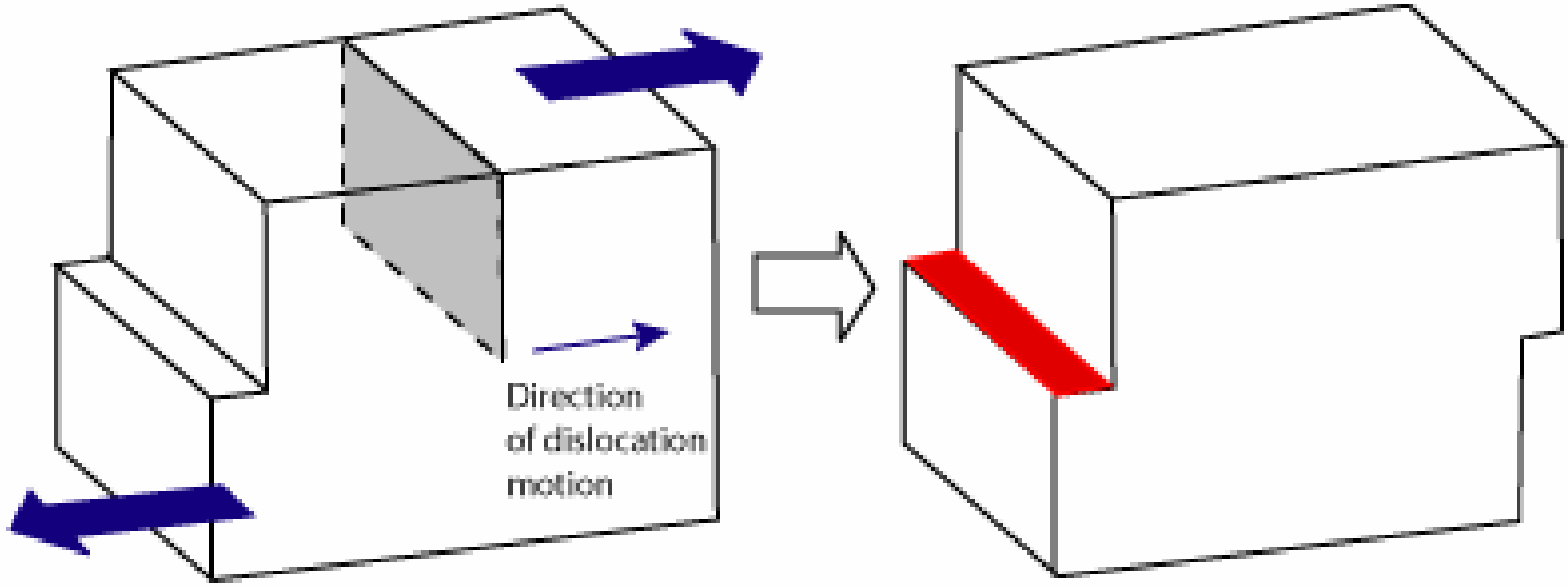
Dislocation moves in direction of applied shear stress



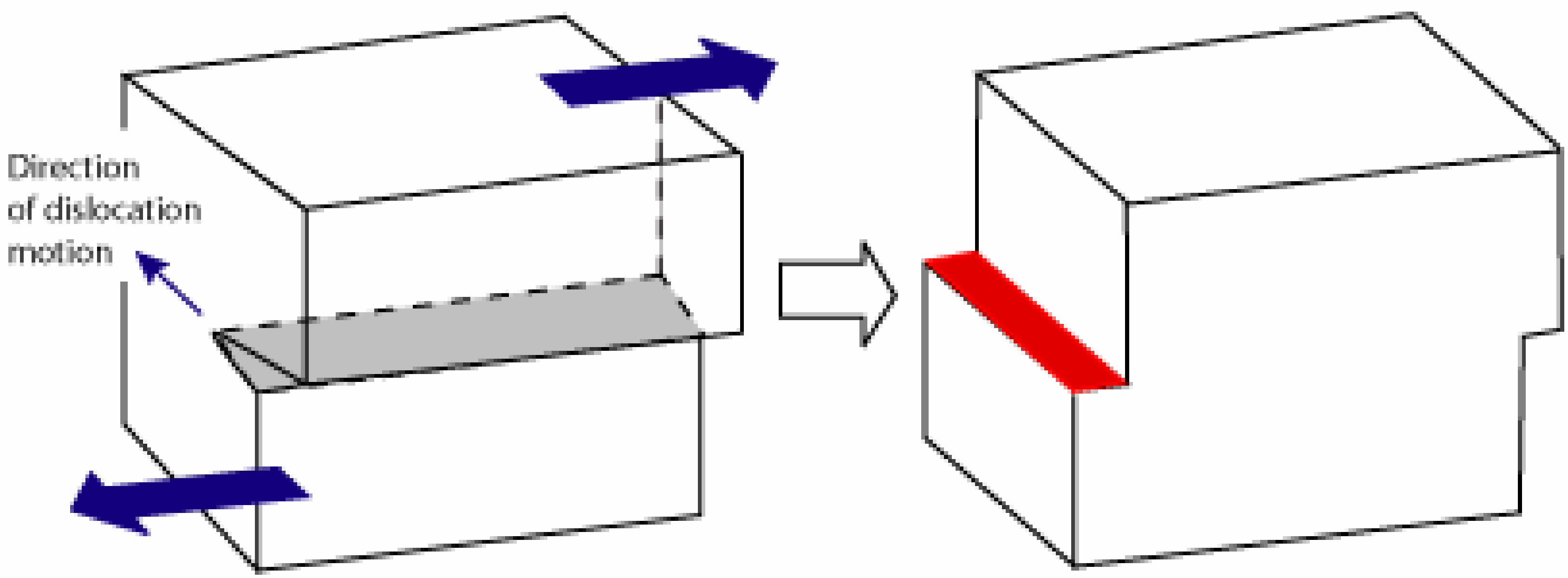
(b)

Screw Dislocation:

Dislocation motion is perpendicular to applied shear stress

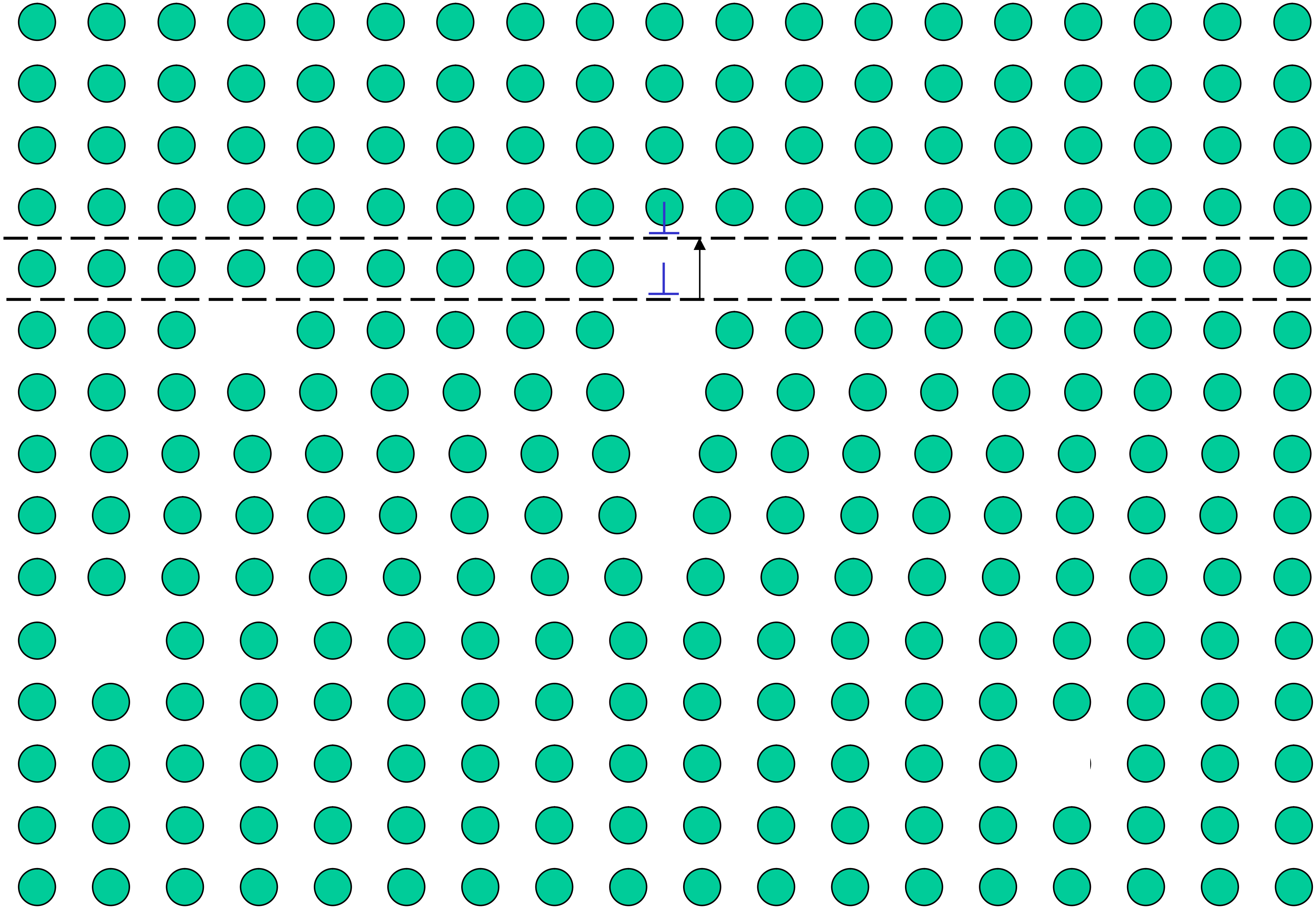


Edge Dislocation



Screw Dislocation

Atomistic mechanism of climb



Surface Defects

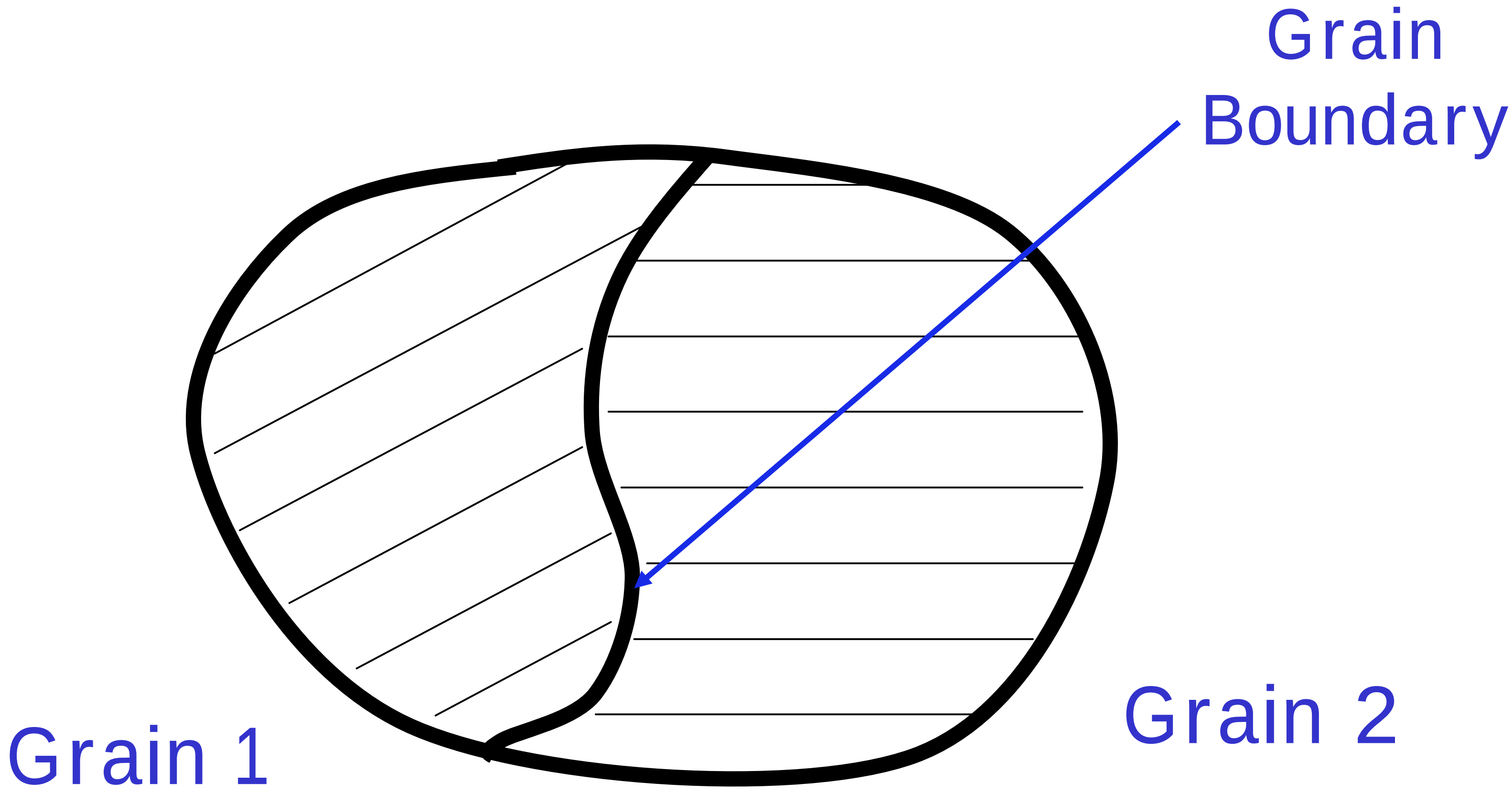
Surface Defects

External	Internal	
Free surface	Grain boundary	Same phase
	Stacking fault	
	Twin boundary	
	Interphase boundary	Different phases

Cacat Permukaan / cacat batas butir :

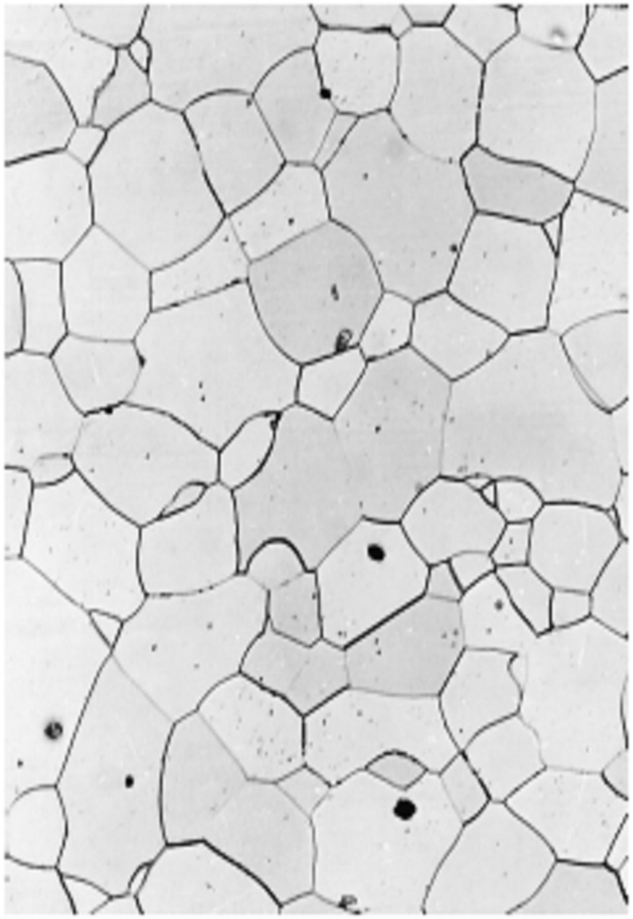
1. Cacat akibat atom pada batas butir (berenergi lebih besar) mudah meloncat ke batas butir tetangganya.
2. Perilaku ini menimbulkan distorsi pada batas butir sekitar 1 sampai 2 atom

Internal surface: grain boundary

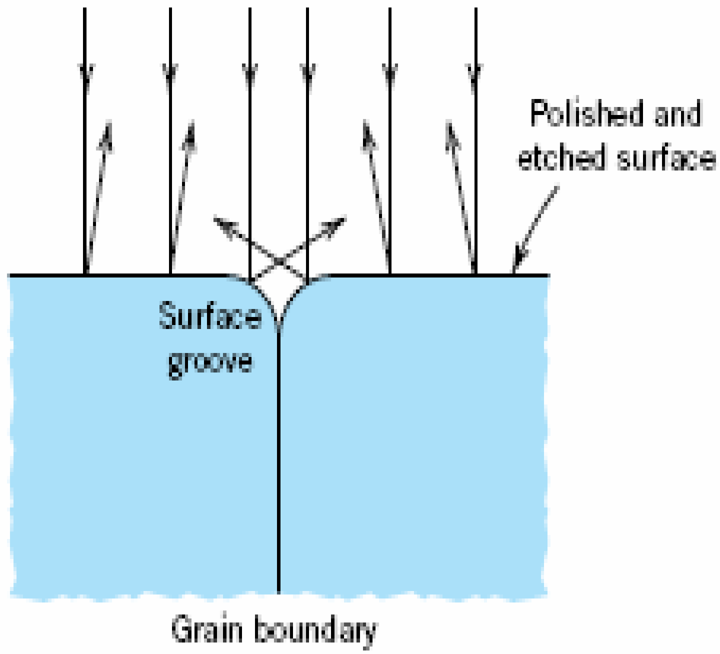


A grain boundary is a boundary between two regions of identical crystal structure but different orientation

Optical Microscopy, Experiment 4



Photomicrograph an iron chromium alloy. 100X.



Callister, Fig. 4.12

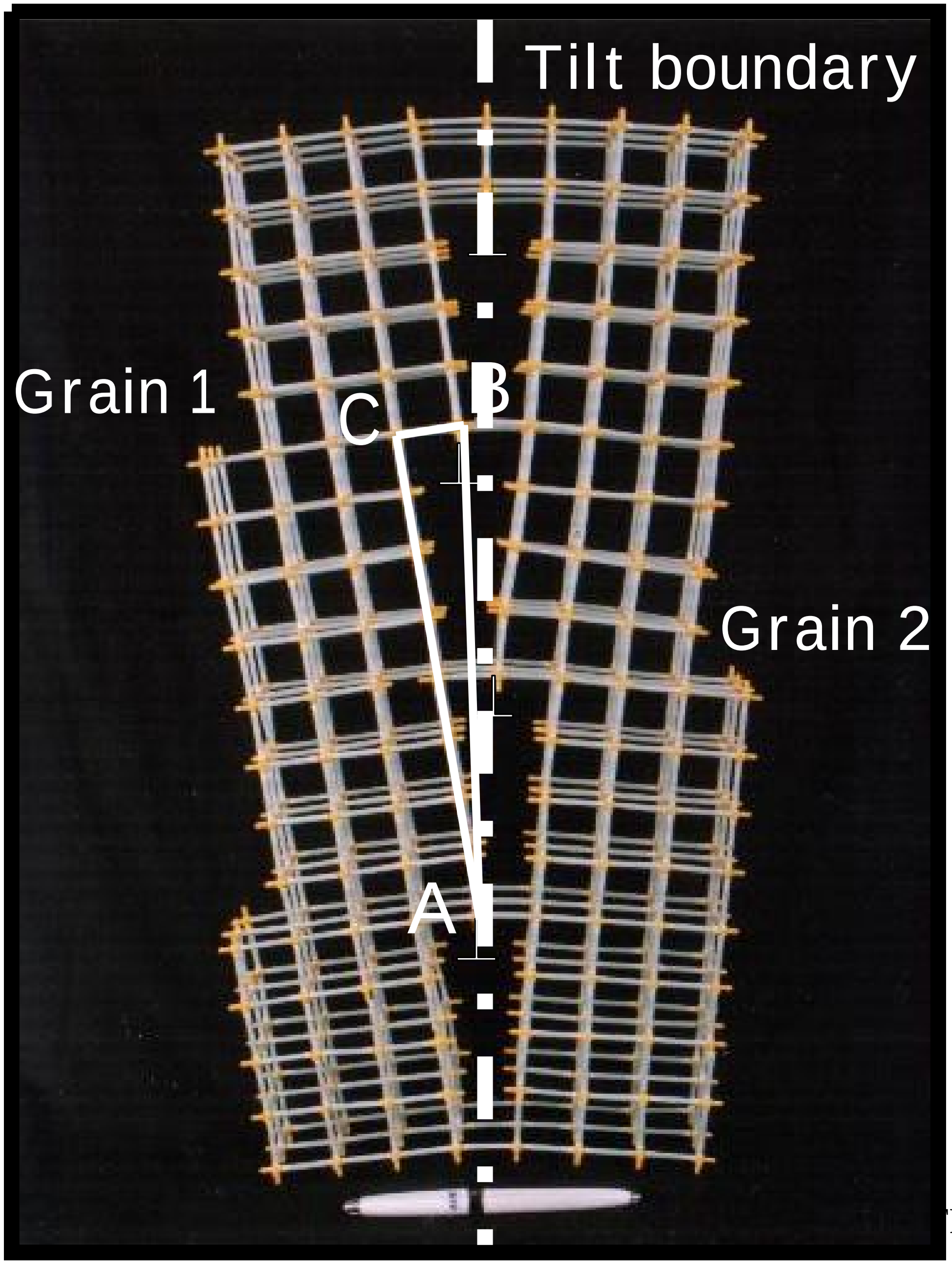
Grain Boundary: low and high angle

One grain orientation can be obtained by rotation of another grain across the grain boundary about an axis through an **angle**

If the angle of rotation is high, it is called a high angle grain boundary

If the angle of rotation is low it is called a low angle grain boundary

Edge dislocation model of a small angle tilt boundary

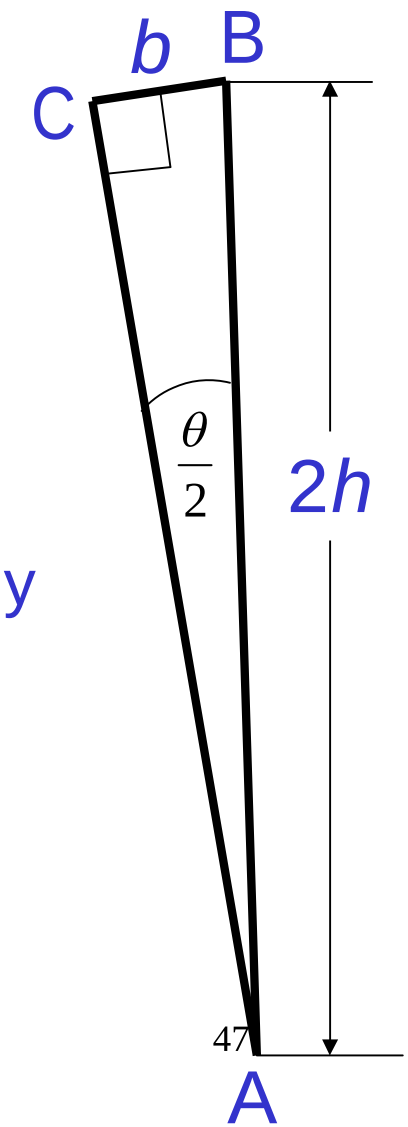


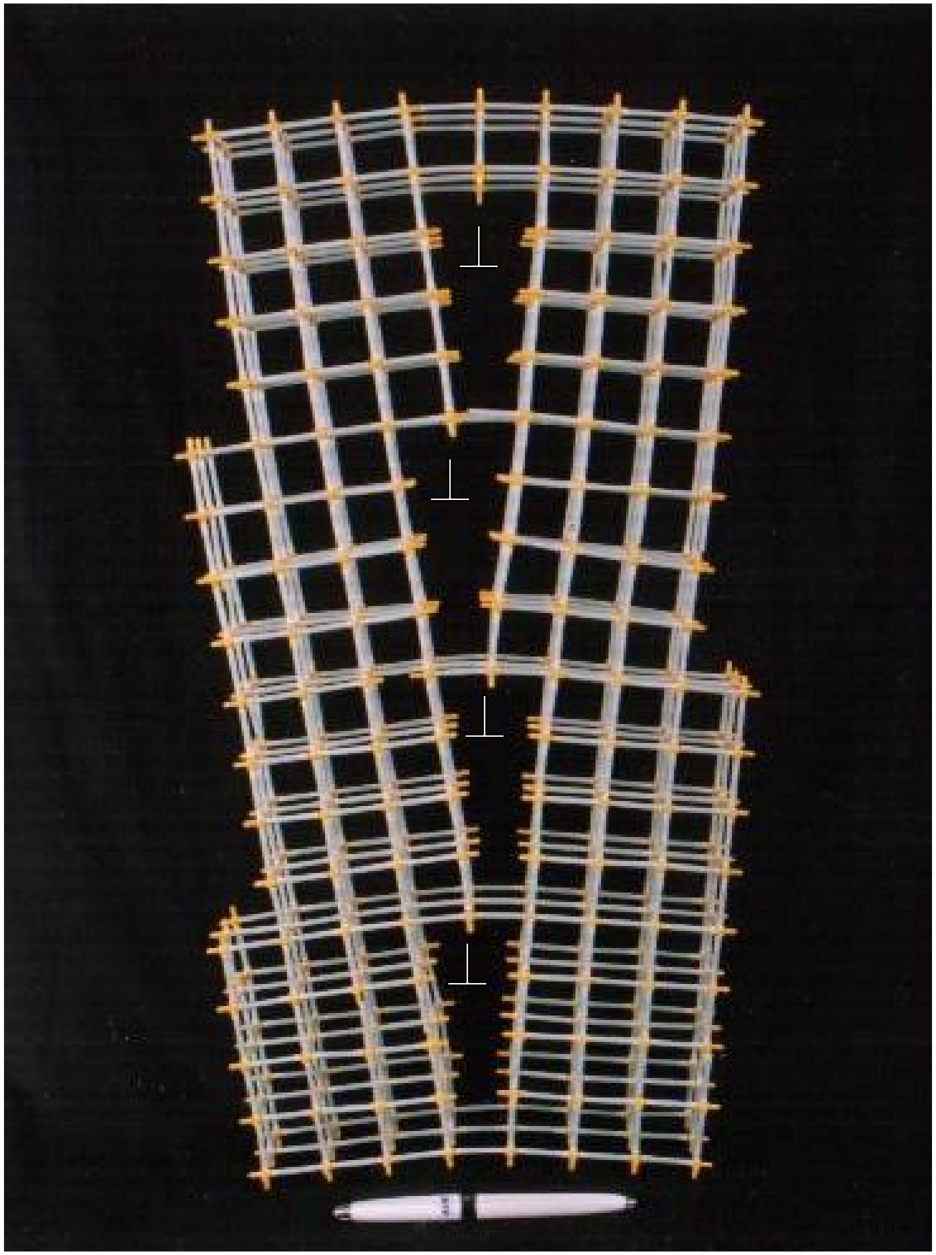
$$\frac{b}{2h} = \sin\frac{\theta}{2}$$

Or approximately

$$\frac{b}{h} = \tan\theta$$

Eqn. 6.7





A low-angle Symmetric Tilt Boundary

477 atoms

55 x 30 x 8 cm^3

4. BULK DEFECTS

- They are either introduced during the production of the material or during its fabrication.

- For example → inclusions (cracks, notches, air bubbles & etc.) added during production.

IMPORTANCE OF IMPERFECTIONS

Most of the properties of materials are affected by imperfections:

- Small amount of impurity atoms may increase the electrical conductivity of semi-conductors.
- Dislocations are responsible for ductility. Strength of materials can be increased to a large extent by the mechanism "strain-hardening" which produces line defects that act as a barrier to control the growth of other imperfections.
- Presence of bulk defects such as cracks, notches, holes causes brittle materials, which break at very low stresses without showing large deformations.