

# متالورژی فیزیکی

جلسه ششم: عیوب شبکه های بلوری

علی اشرفی

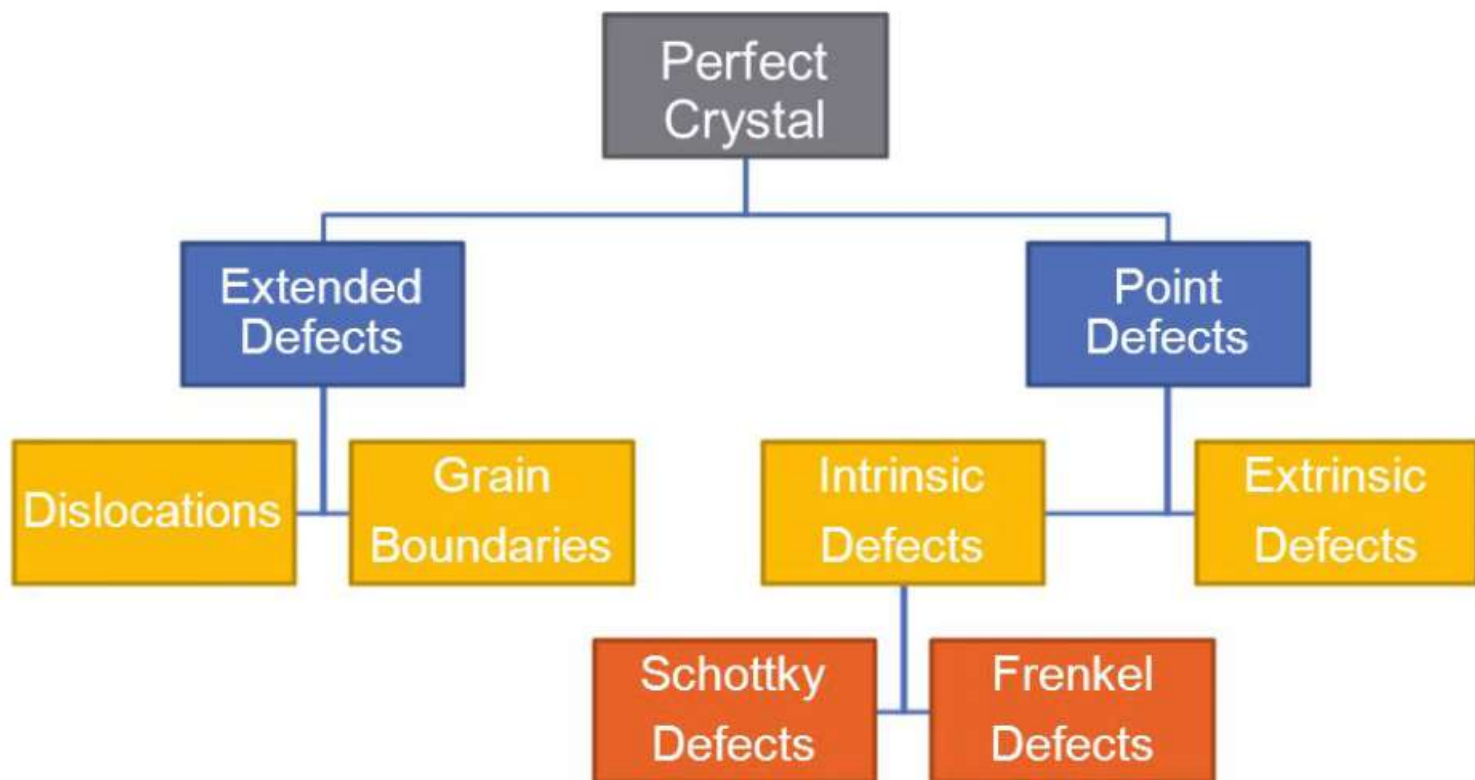
دانشکده مهندسی مواد

دانشگاه صنعتی اصفهان



دانشگاه صنعتی اصفهان  
Isfahan University  
of Technology

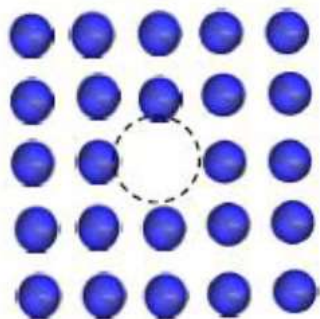
# عیوب شبکه های بلوری



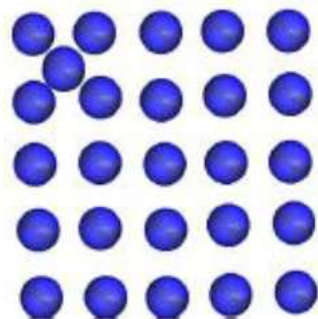
# عیوب نقطه ای



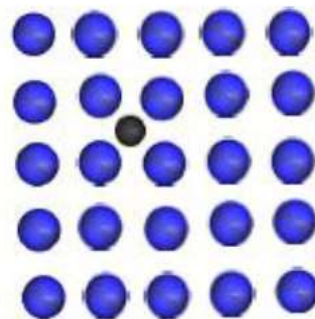
- جای خالی
- اتم بین نشین
- ناخالصی



Vacancy



Interstitialcy

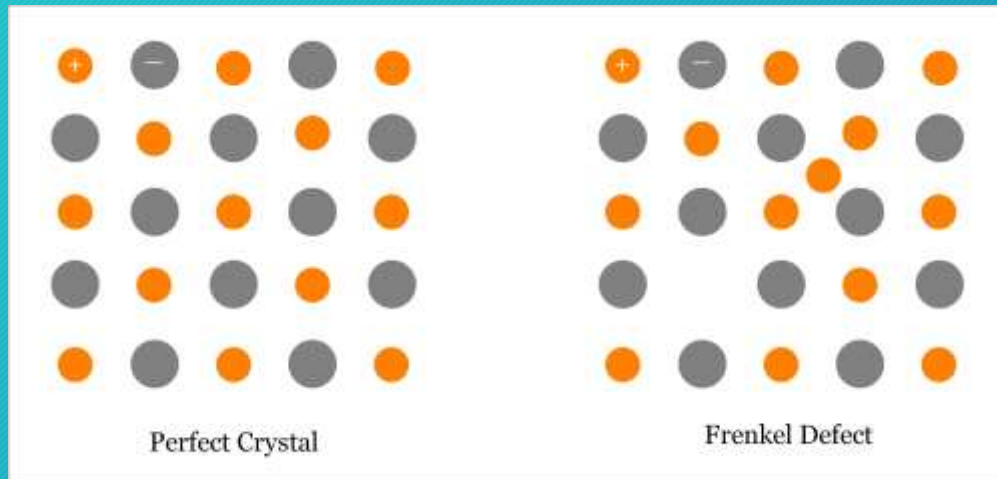


Impurity



## عیب فرانکل

- اتم های کوچکتر (کاتیون) از جایگاه معمول خود جدا شده و موقعیت های بین نشین را اشغال می کنند.
- هیچ تغییری در چگالی ایجاد نمی شود.
- معمولا در شرایطی که ابعاد کاتیون ها و آنیون ها متفاوت است دیده می شود.
- معمولا در جامدات یونی با عدد همسایگی کم مشاهده می شود.
- مثال ها  $NaCl$  ،  $ZnS$  ،  $AgCl$

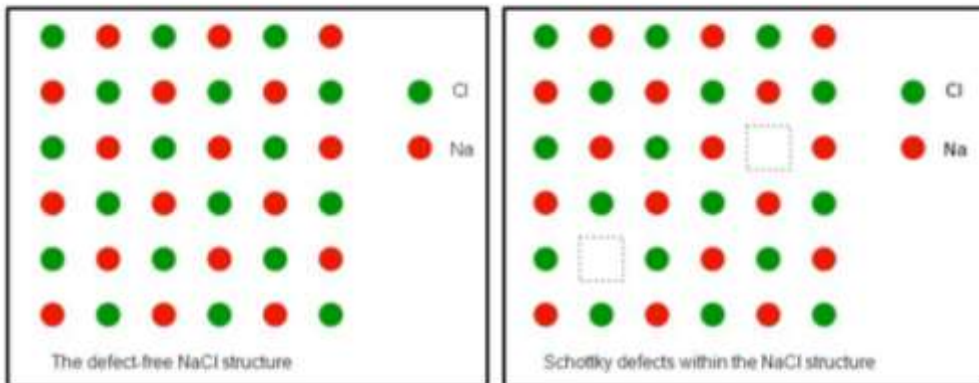


# عیب شاتکی



- تعداد یکسان کاتیون و آنیون در موقعیت معمول خود قرار ندارند.
- چگالی کاهش می یابد.
- معمولاً در شرایطی رخ می دهد که ابعاد کاتیون و آنیون یکسان باشد.
- معمولاً در جامدات یونی با عدد همسایگی بالا مشاهده می شود.
- مثال ها  $KCl$  ،  $KBr$  ،  $CsCl$

## Schottky Defects

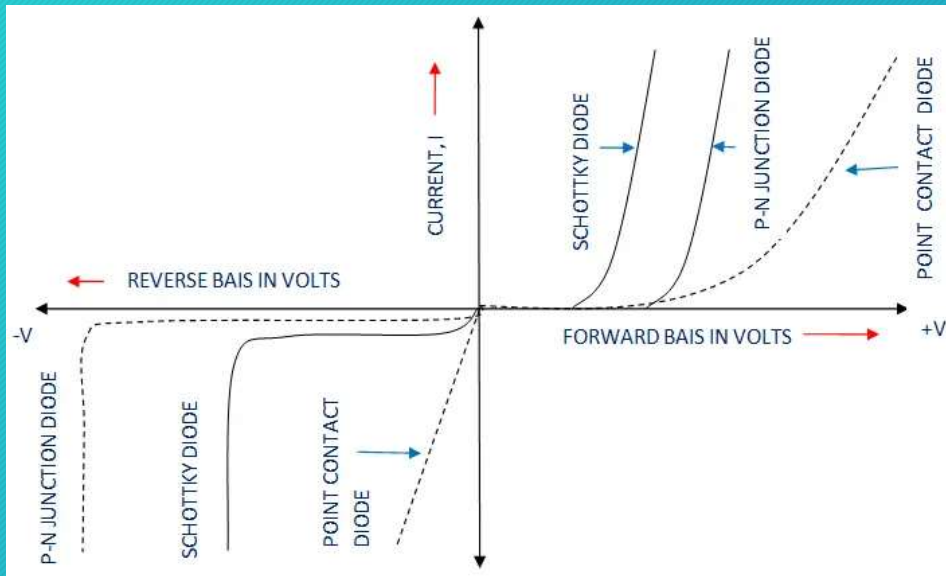


# کاربردهای عیب شاتکی



- دیودها: به عنوان کانال بین دو اتصال در دیود
- سلول های خورشیدی:

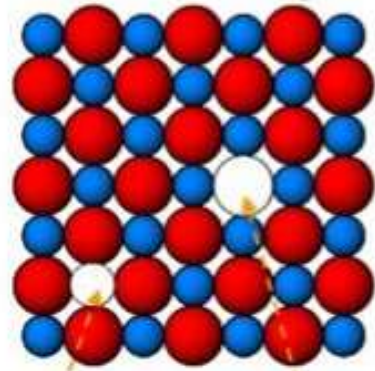
- ترانزیستورها: کنترل هدایت الکتریکی بین نیمه رسانای نوع  $P$  و نوع  $n$
- کاتالیزورها: افزایش مبادله یونی و بهبود واکنش های سطحی





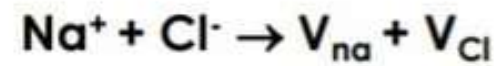
### Point Defect - Intrinsic

#### Schottky

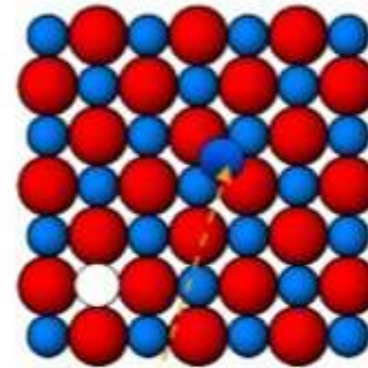


cation vacancy

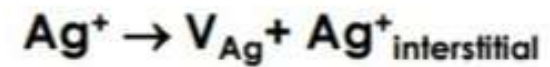
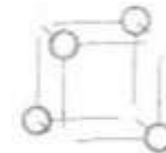
anion vacancy



#### Frenkel



interstitial cation



## تعداد عیوب



معمولا تشکیل عیب یک فرایند گرماگیر است.

تعداد تعادلی عیوب در هر دما

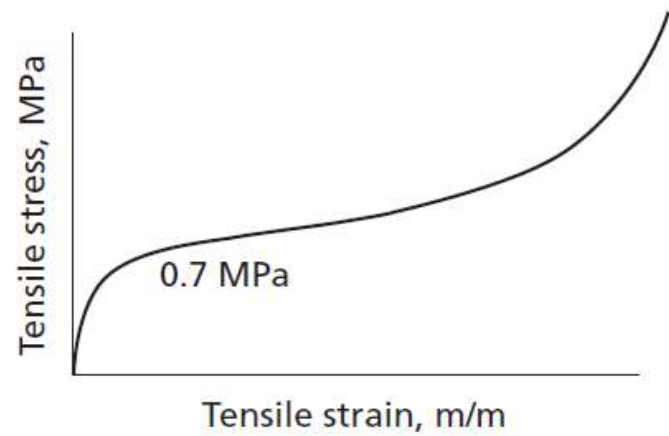
$$n_s \approx N \exp\left(\frac{-\Delta H_s}{2kT}\right)$$



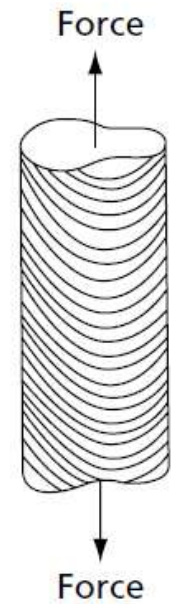


	Compound	$\Delta H/10^{19} J$	$\Delta H/eV^*$
Schottky defects	MgO	10.57	6.60
	CaO	9.77	6.10
	LiF	3.75	2.34
	LiCl	3.40	2.12
	LiBr	2.88	1.80
	LiI	2.08	1.30
	NaCl	3.69	2.30
	KCl	3.62	2.26
Frenkel defects	UO <sub>2</sub>	5.45	3.40
	ZrO <sub>2</sub>	6.57	4.10
	CaF <sub>2</sub>	4.49	2.80
	SrF <sub>2</sub>	1.12	0.70
	AgCl	2.56	1.60
	AgBr	1.92	1.20
	$\beta$ -AgI	1.12	0.70

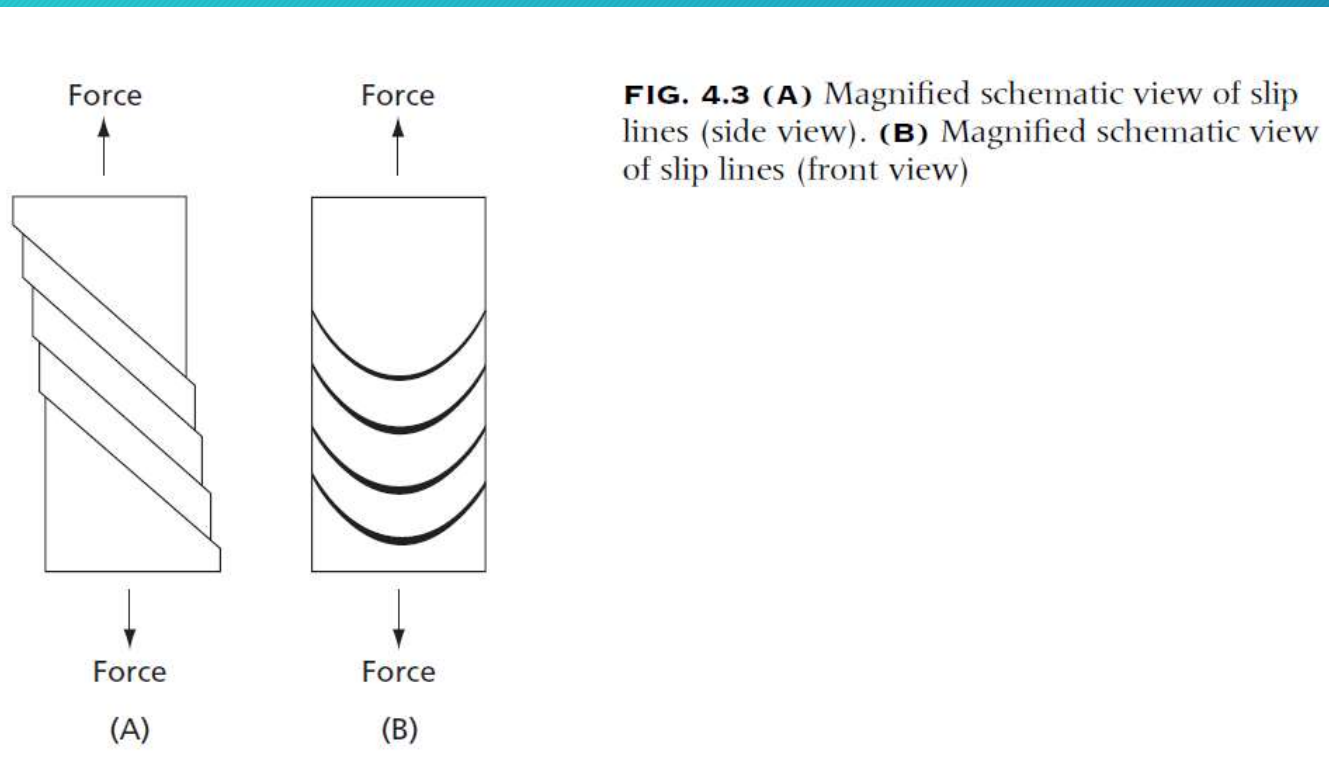
\*The literature often quotes values in eV, so these are included for comparison.  $1 eV = 1.60219 \times 10^{19} J$

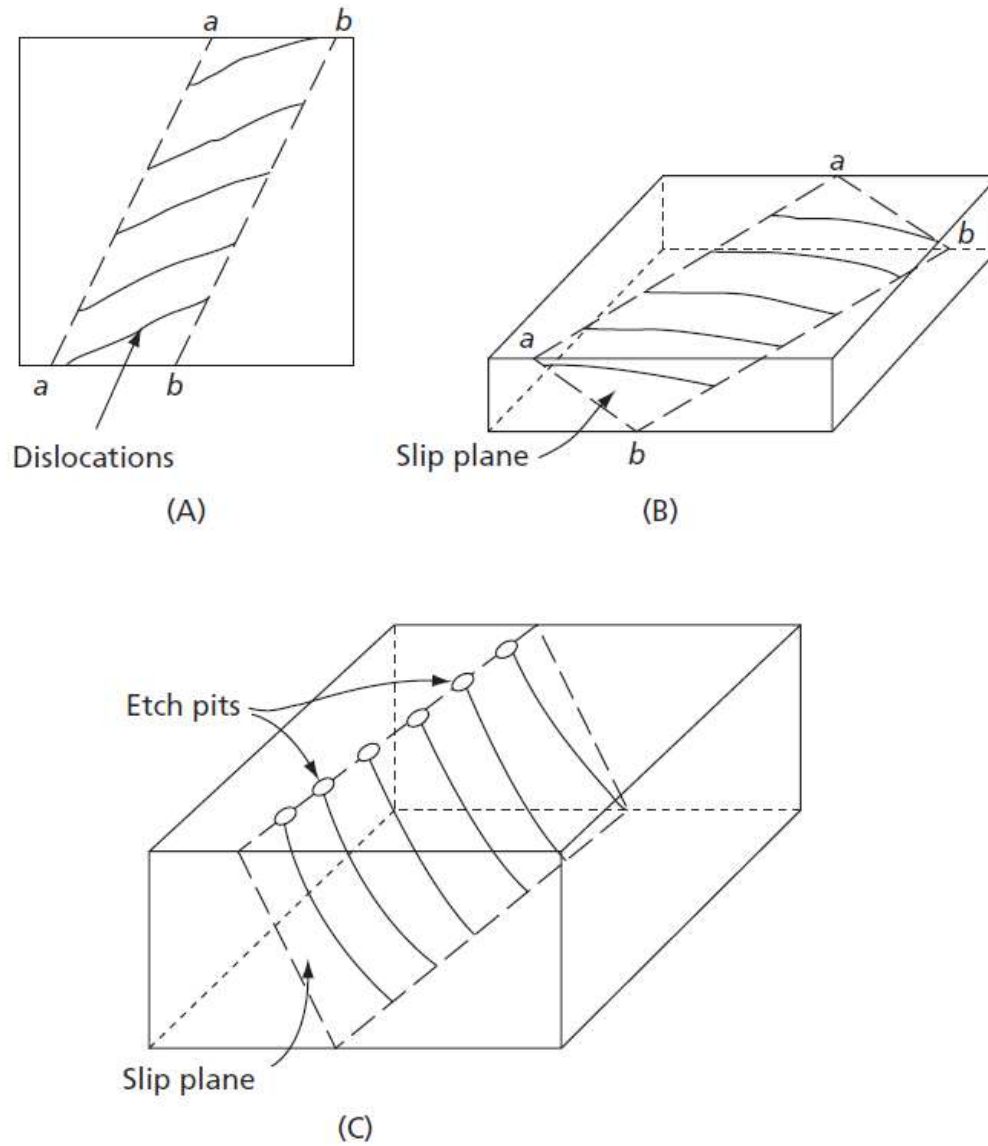


**FIG. 4.1** Tensile stress-strain curve for a magnesium single crystal

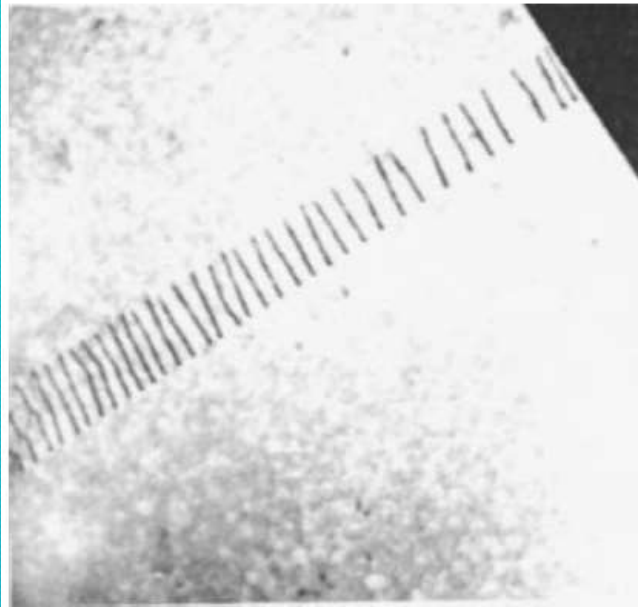


**FIG. 4.2** Slip lines on magnesium crystal



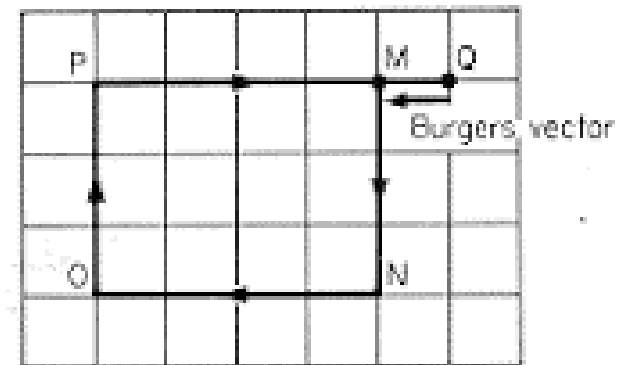
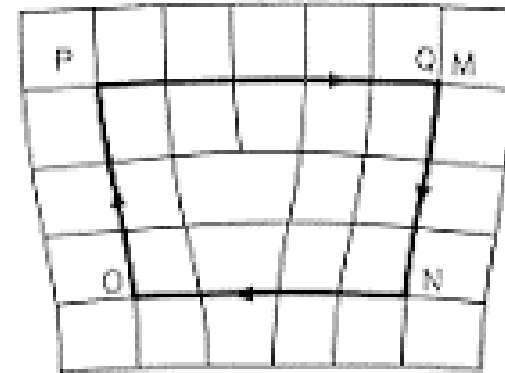
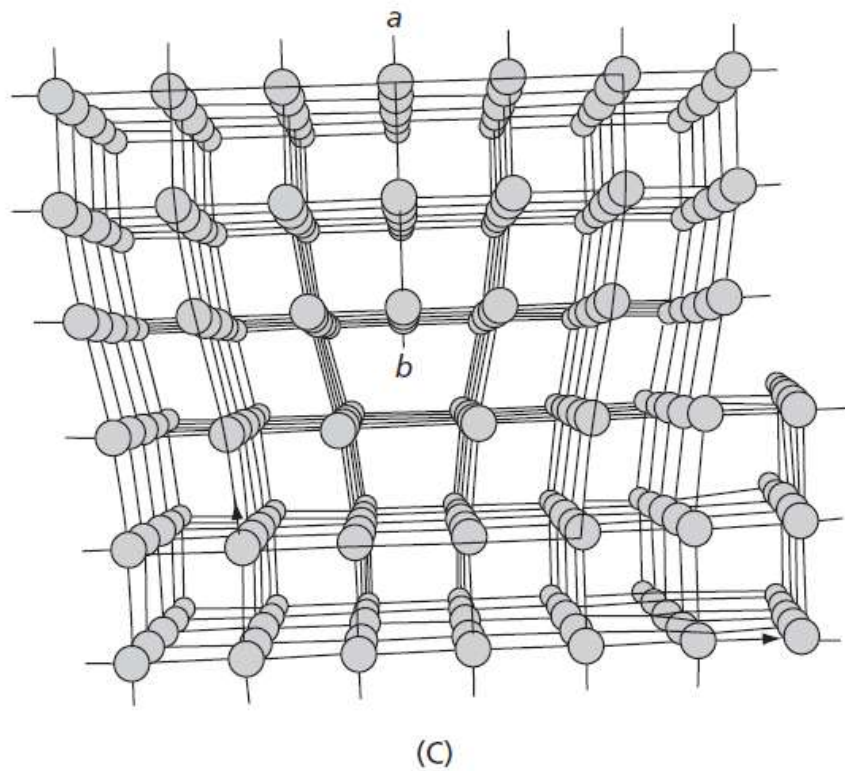
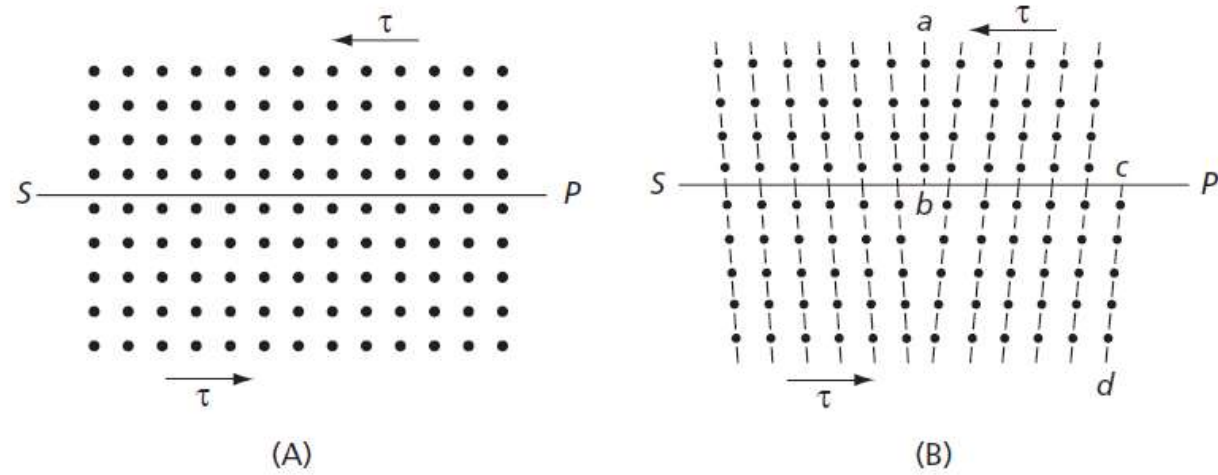


**FIG. 4.5 (A)** Schematic representation of an electron microscope photograph showing a section of a slip plane. **(B)** A three-dimensional view of the same slip plane section. **(C)** Termination of dislocations can also be revealed by etch pits

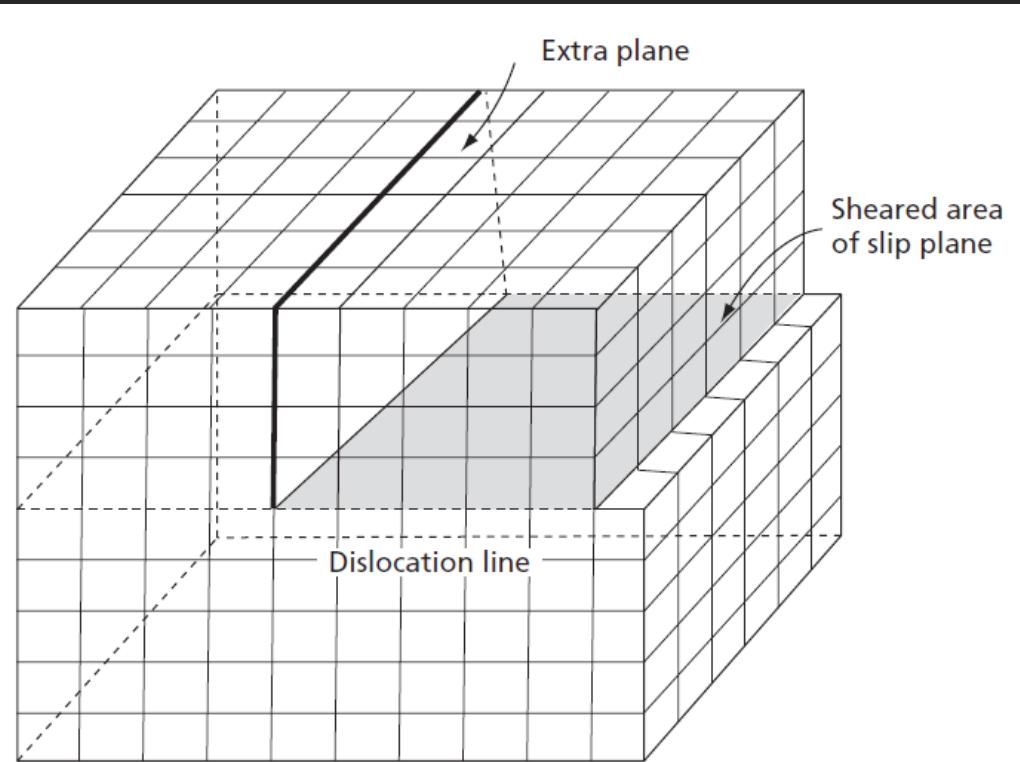


**FIG. 4.6** An electron micrograph of a foil removed from an aluminum specimen. Note the dislocations lying along a slip plane, in agreement with Fig. 4.5. (Photograph courtesy of E.J. Jenkins and J. Hren.)

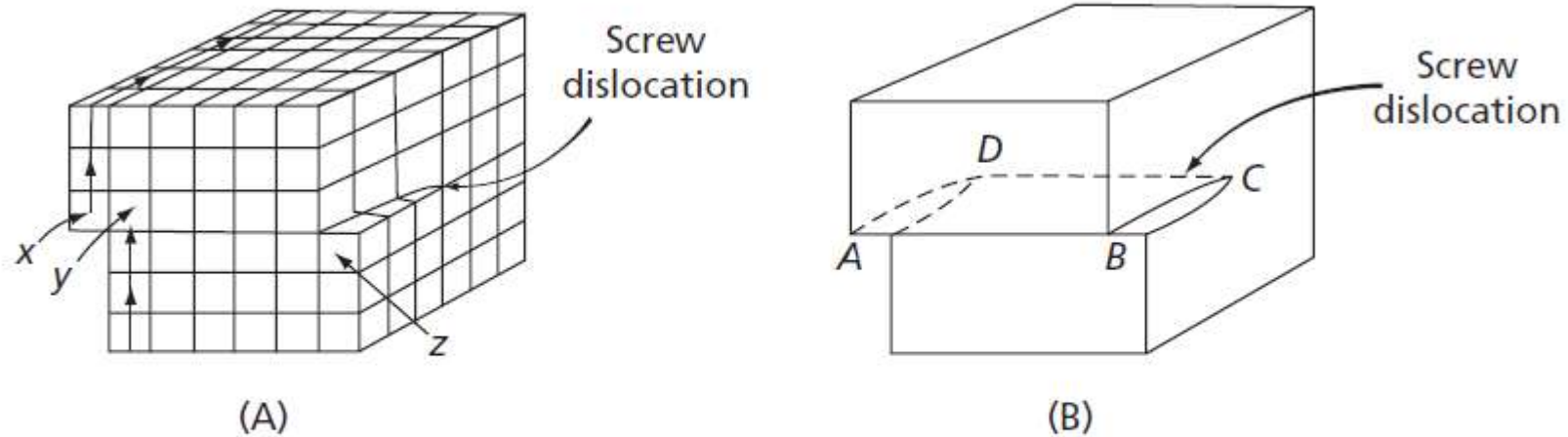
# جابجایی لبه ای



# خط نابجایی: مرز بین ناحیه لغزش یافته و بدون لغزش

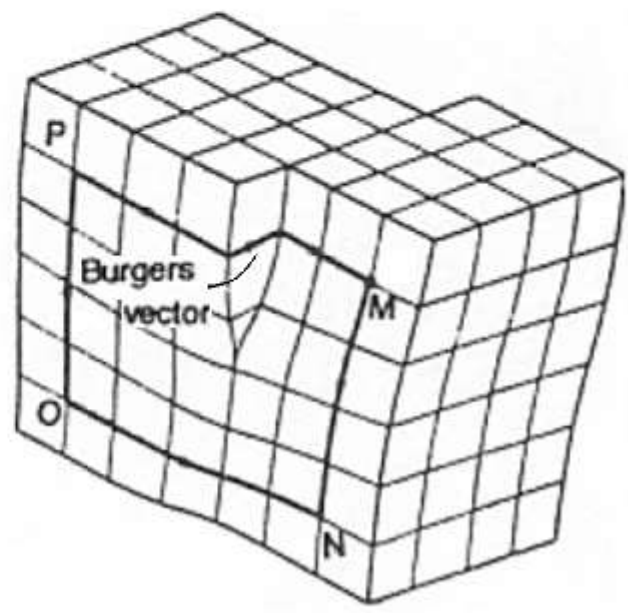
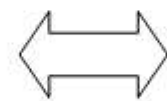
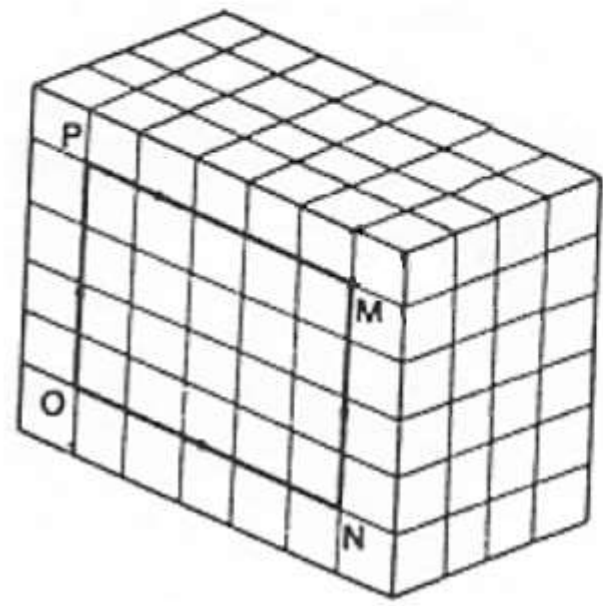
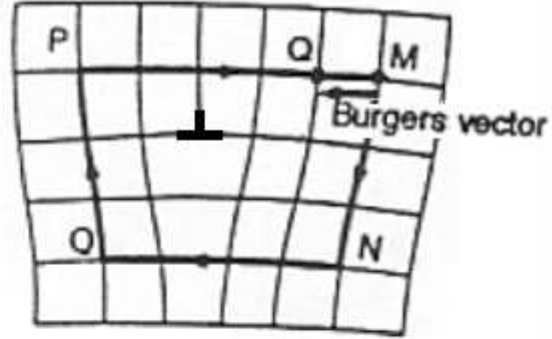
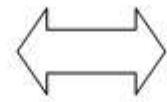
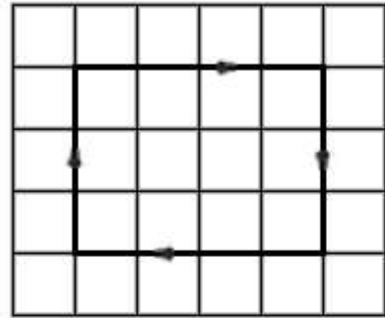


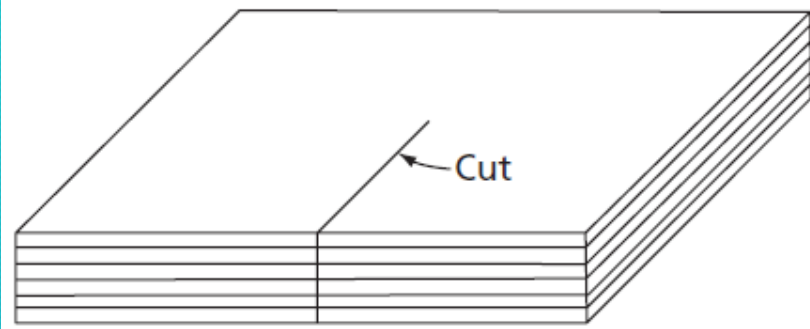
**FIG. 4.8** This three-dimensional view of a crystal containing an edge dislocation shows that the dislocation forms the boundary on the slip plane between a region that has been sheared and a region that has not been sheared



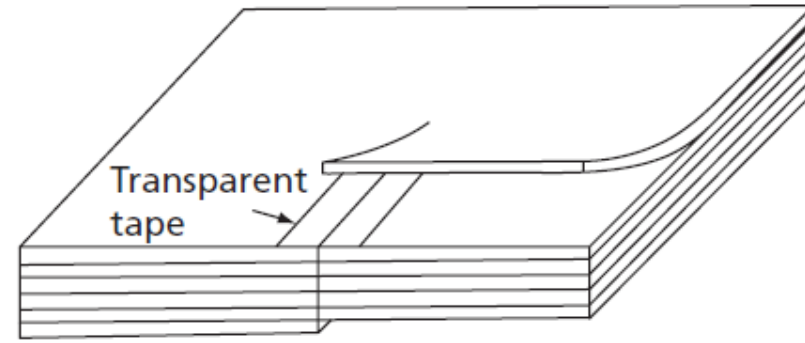
**FIG. 4.10** Two representations of a screw dislocation. Notice that the planes in this dislocation spiral around the dislocation like a left-hand screw







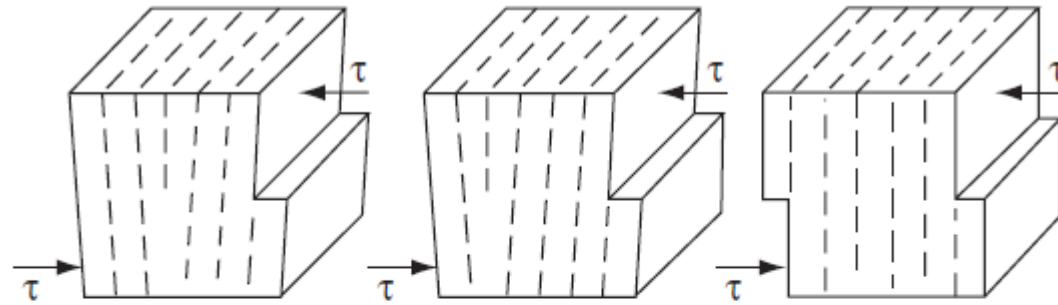
(A)



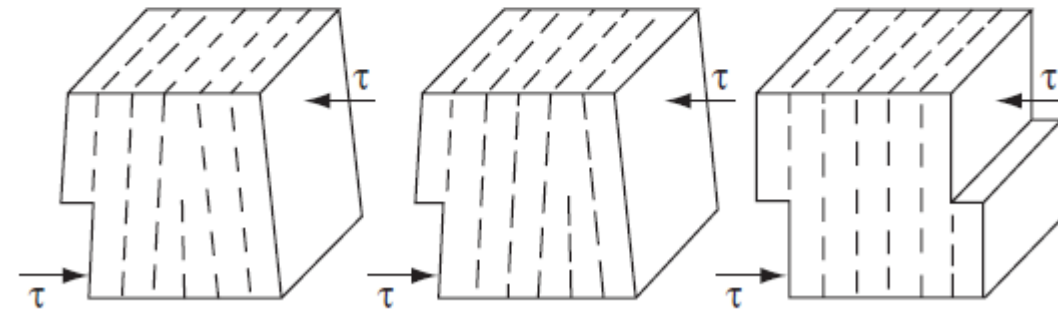
(B)

**FIG. 4.11** Illustration of the construction of a model of a screw dislocation

# نابجایی لبه ای مثبت و منفی

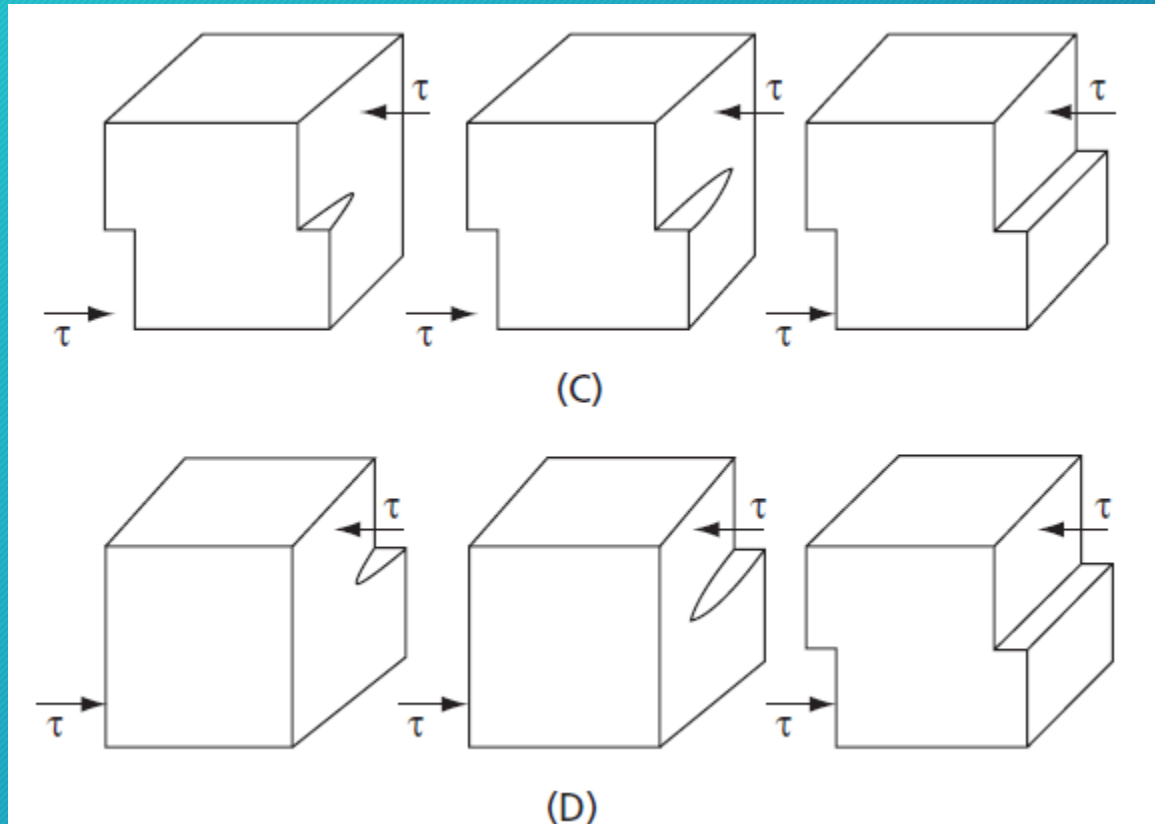


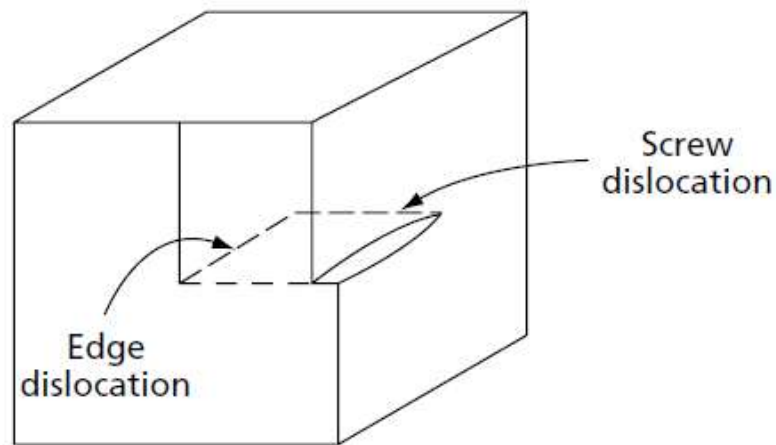
(A)



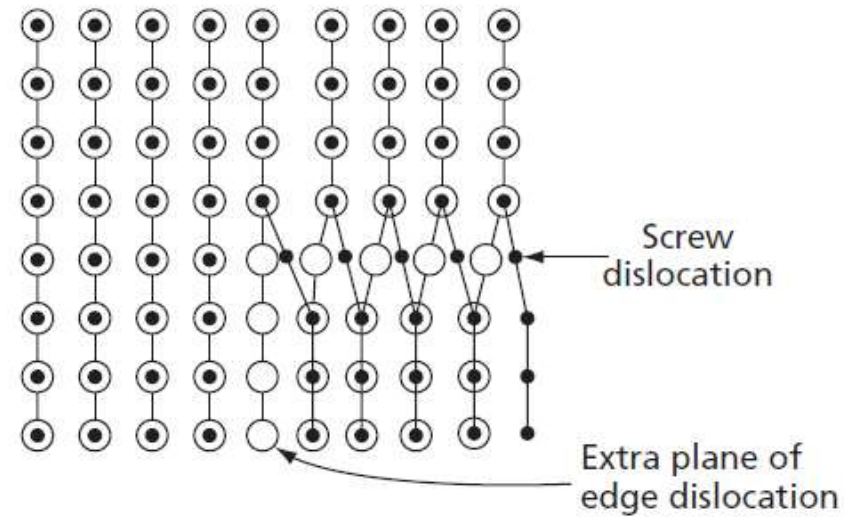
(B)

# نابجایی پیچی راستگرد و چپگرد



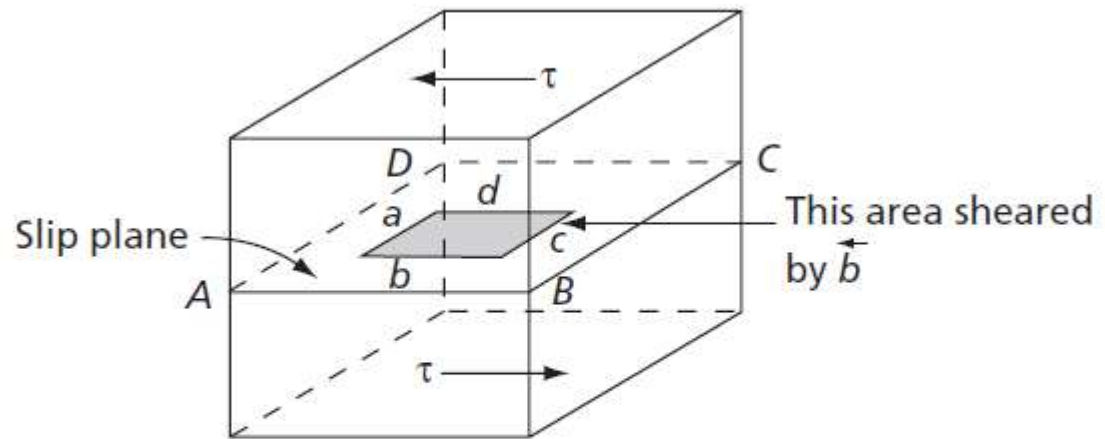


**FIG. 4.14** A two-component dislocation composed of an edge and a screw component

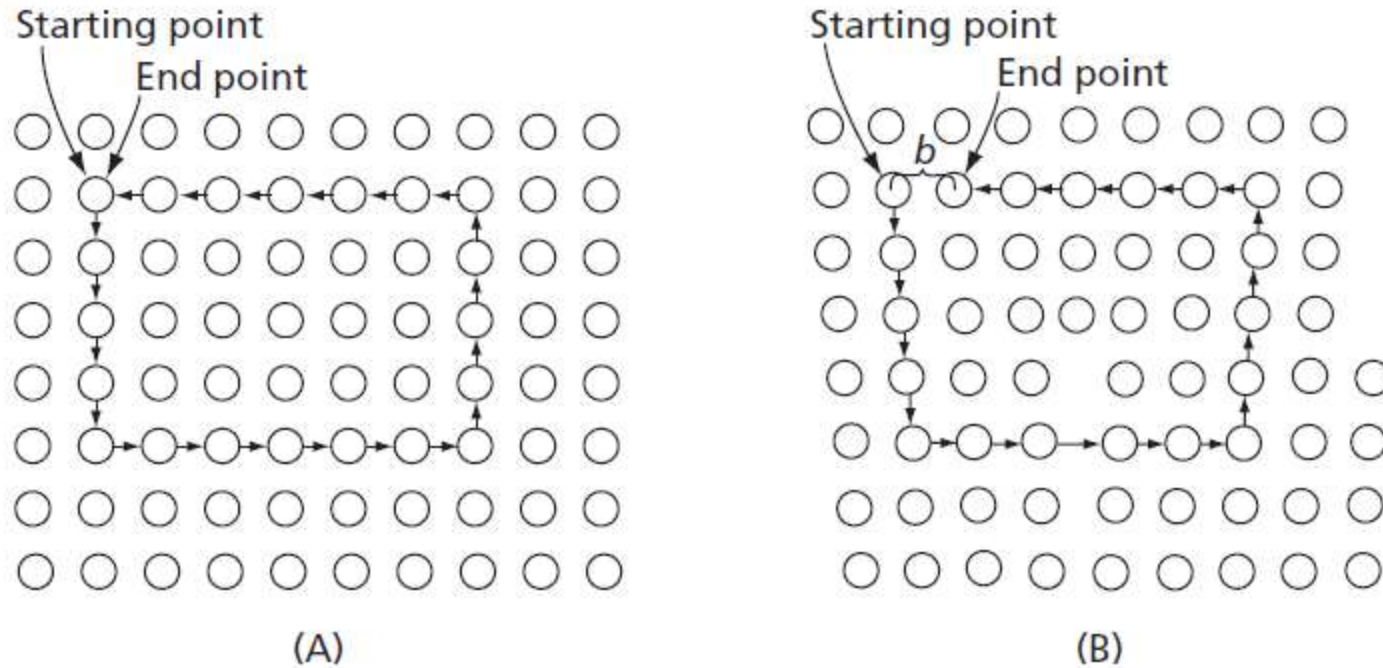


**FIG. 4.15** Atomic configuration corresponding to the dislocation of Fig. 4.14 viewed from above. Open-circle atoms are above the slip plane, dot atoms are below the slip plane

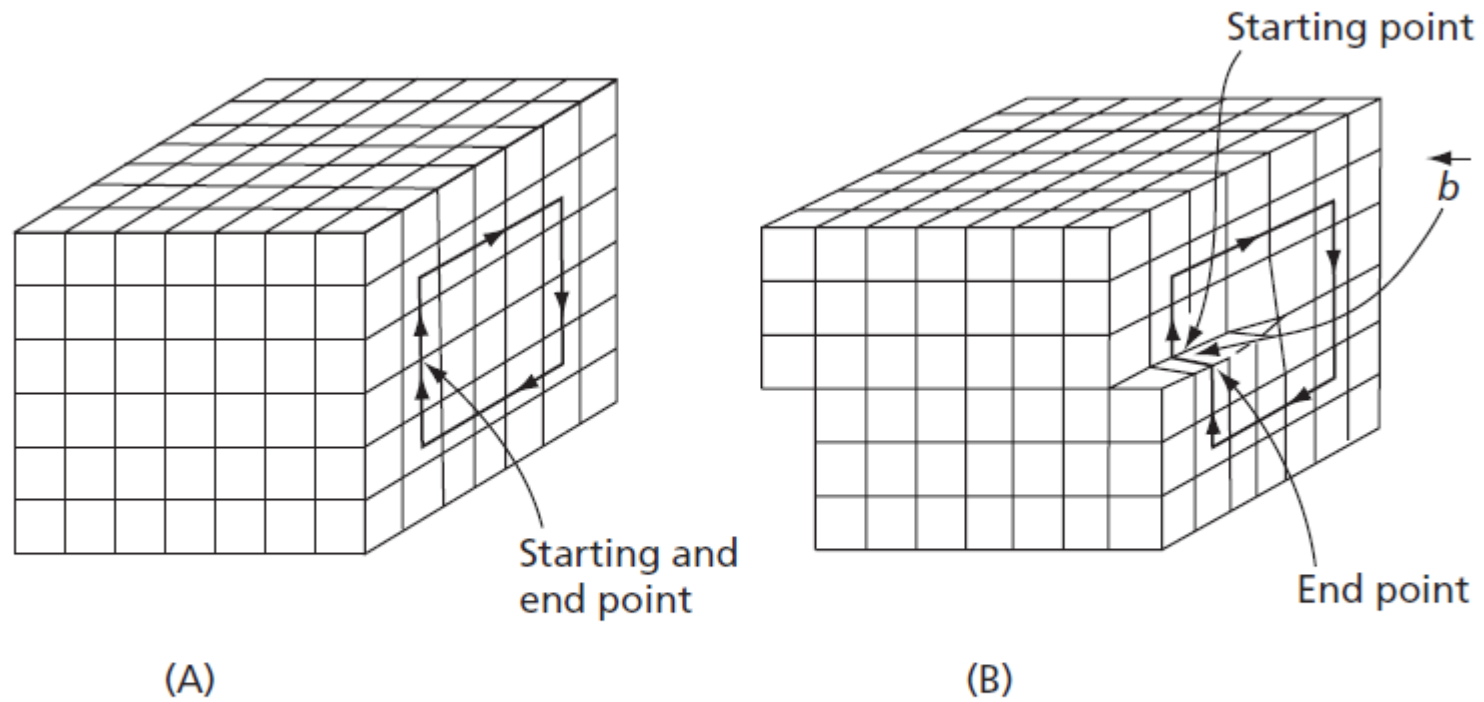
# لوپ (حلقه) بسته نابجایی



**FIG. 4.17** A closed dislocation loop consisting of (a) positive edge, (b) right-hand screw, (c) negative edge, and (d) left-hand screw



**FIG. 4.19** The Burgers circuit for an edge dislocation: **(A)** Perfect crystal and **(B)** crystal with dislocation



**FIG. 4.20** The Burgers circuit for a dislocation in a screw orientation. **(A)** Perfect crystal and **(B)** crystal with dislocation



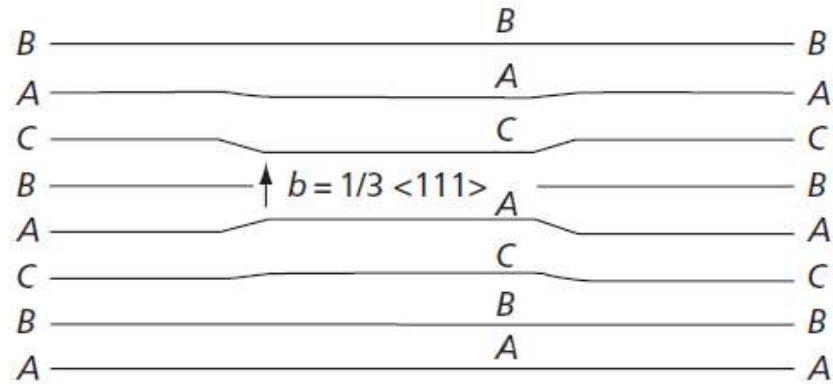
1. *Edge dislocations:*

- (a) An edge dislocation lies perpendicular to its Burgers vector.
- (b) An edge dislocation moves (in its slip plane) in the direction of the Burgers vector (slip direction). Under a shear-stress sense  $\rightleftharpoons$  a positive dislocation  $\perp$  moves to the right, a negative one  $\top$  to the left.

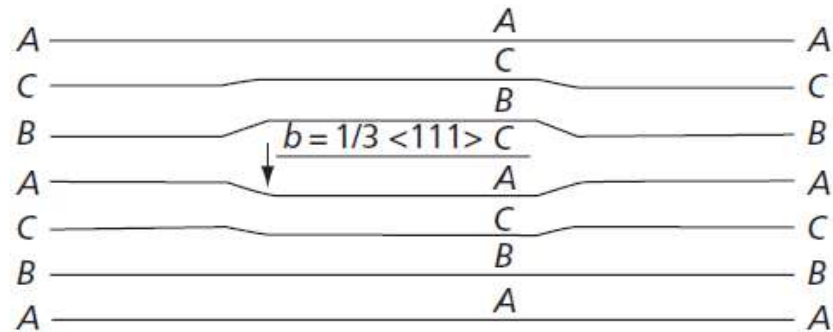
2. *Screw dislocations:*

- (a) A screw dislocation lies parallel to its Burgers vector.
- (b) A screw dislocation moves (in the slip plane) in a direction perpendicular to the Burgers vector (slip direction).

# نقص در چیدمان (*Stacking Fault*)



(A)



(B)

**FIG. 4.27A** An intrinsic stacking fault can also be formed in a face-centered cubic crystal by removing part of a close-packed plane

**FIG. 4.27B** The addition of a portion of an extra close-packed plane to a face-centered cubic crystal produces an extrinsic stacking fault

# انرژی نقص چیدمان

Material	Brass	Stainless Steel	Ag (Silver)	Au	Si (Silicon)	Ni (Nickel)	Cu (Copper)	Mg (Magnesium)	Al (Aluminum)
SFE ( $\text{mJ m}^{-2}$ )	$<10^{[2]}$	$<10^{[2]}$	$25^{[2]}$	$75^{[2]}$	$>42$	$90^{[2][3]}$	$70^{[4]} - 78^{[5]}$	$125^{[6]}$	$160-250^{[7][2]}$

# تشکیل دوقلوی

