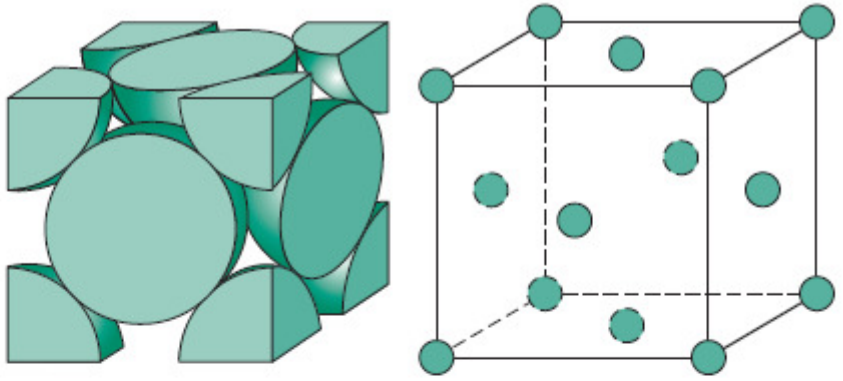
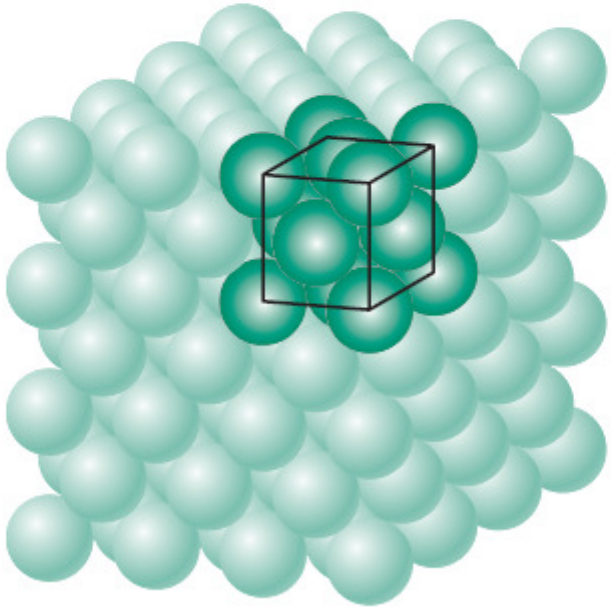
01

MATERIAIS DE CONSTRUÇÃO MECÂNICA

Engenharia Mecânica
Prof. Luis Fernando Maffeis



(a) (b)



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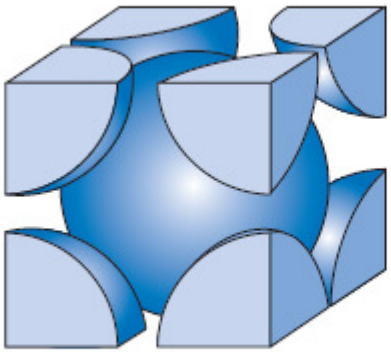

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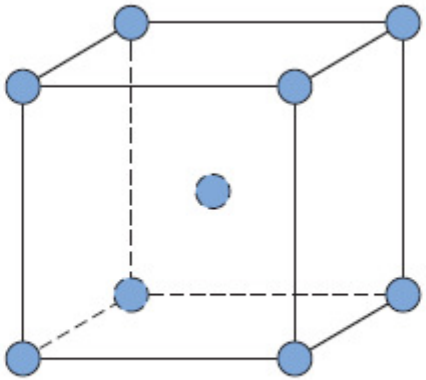

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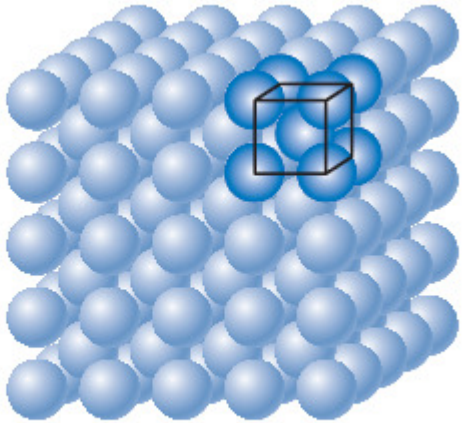

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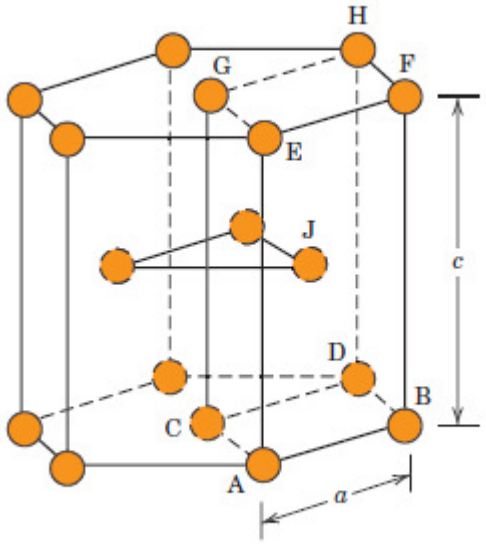

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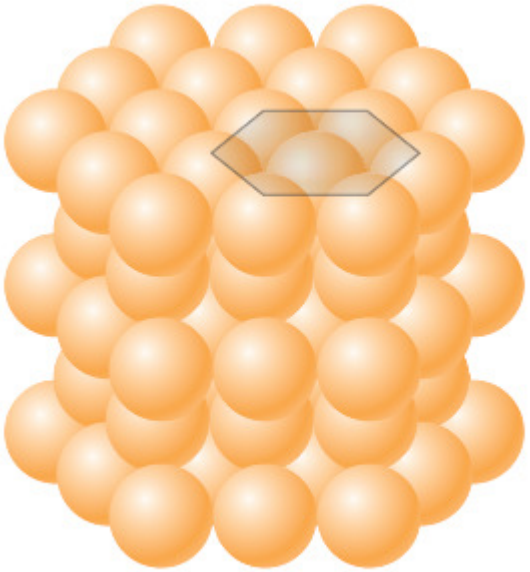

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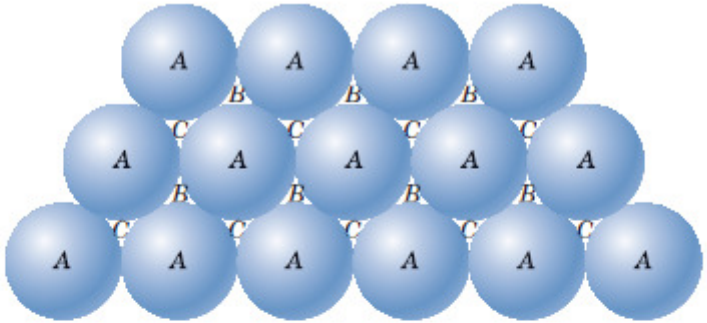
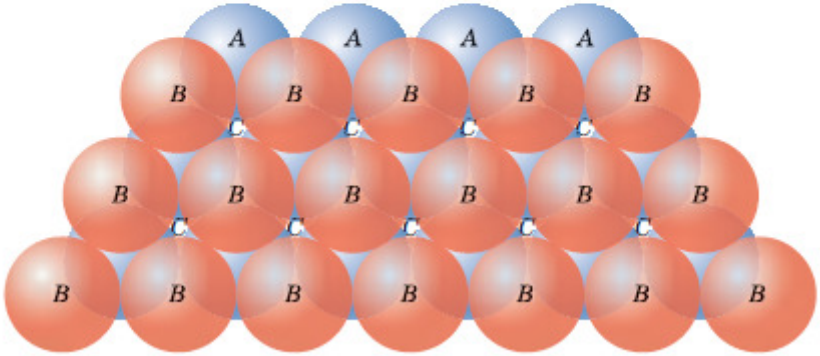
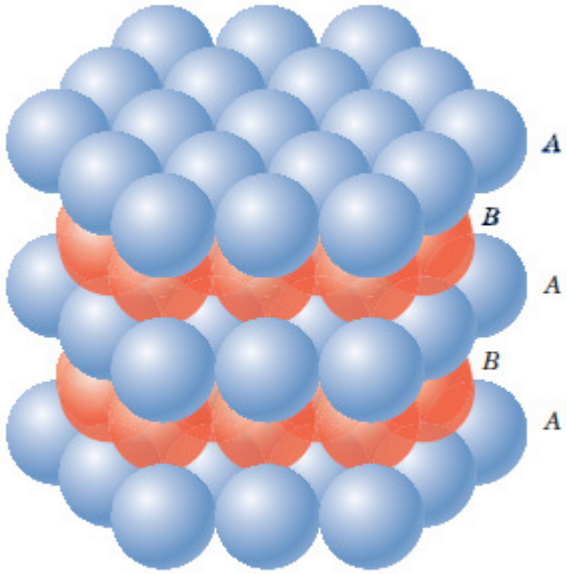
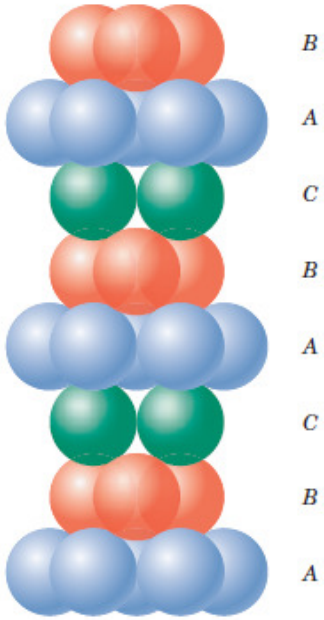

A A A A
B B B B
C C C C
A A A A A
B B B B
C C C C
A A A A A A

(a)

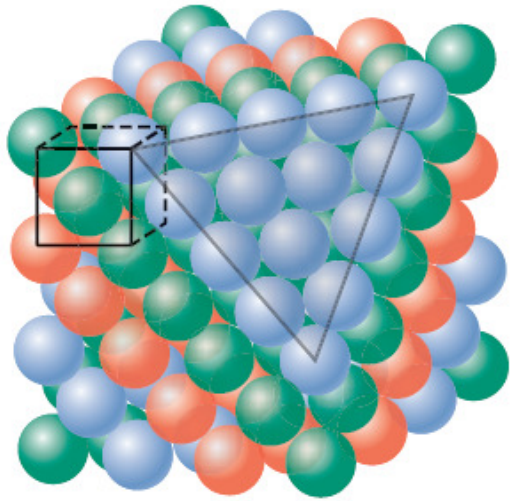

A A A A
B B B B B
C C C C
B B B B B B
C C C C
B B B B B B B

(b)





(a)



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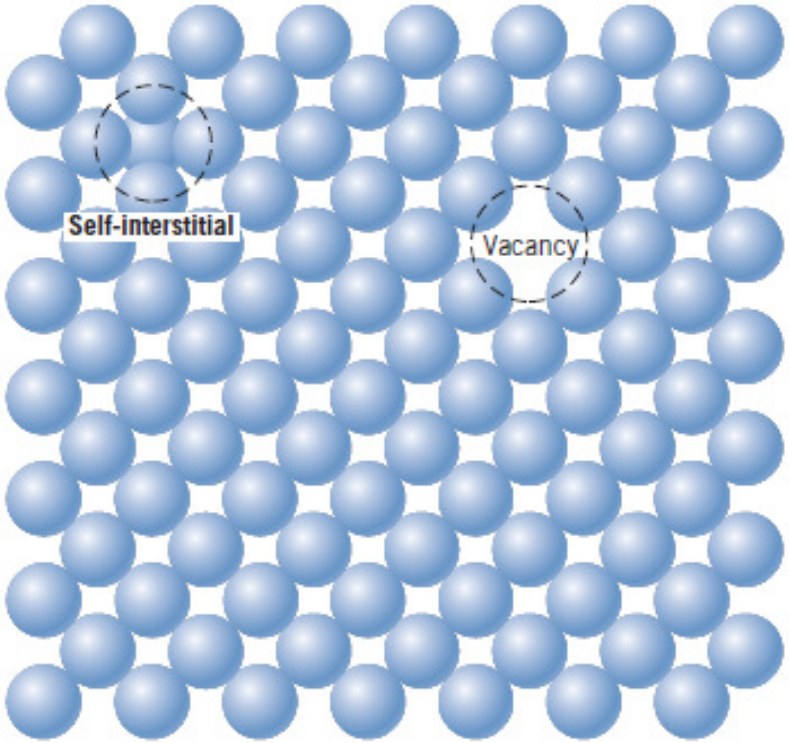
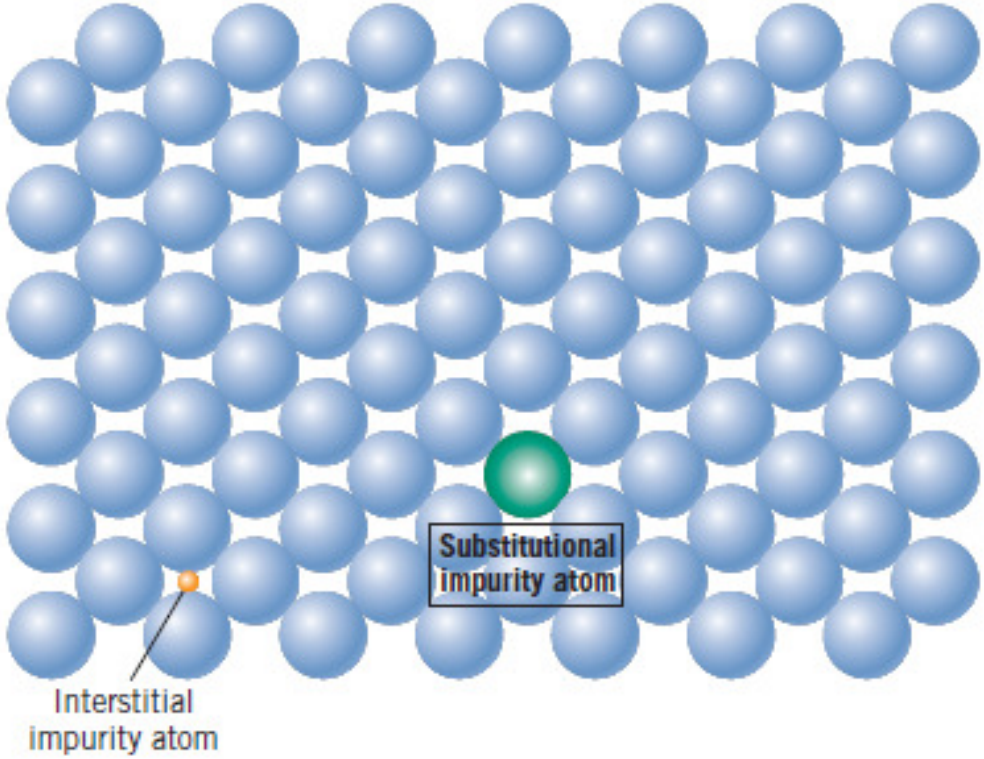
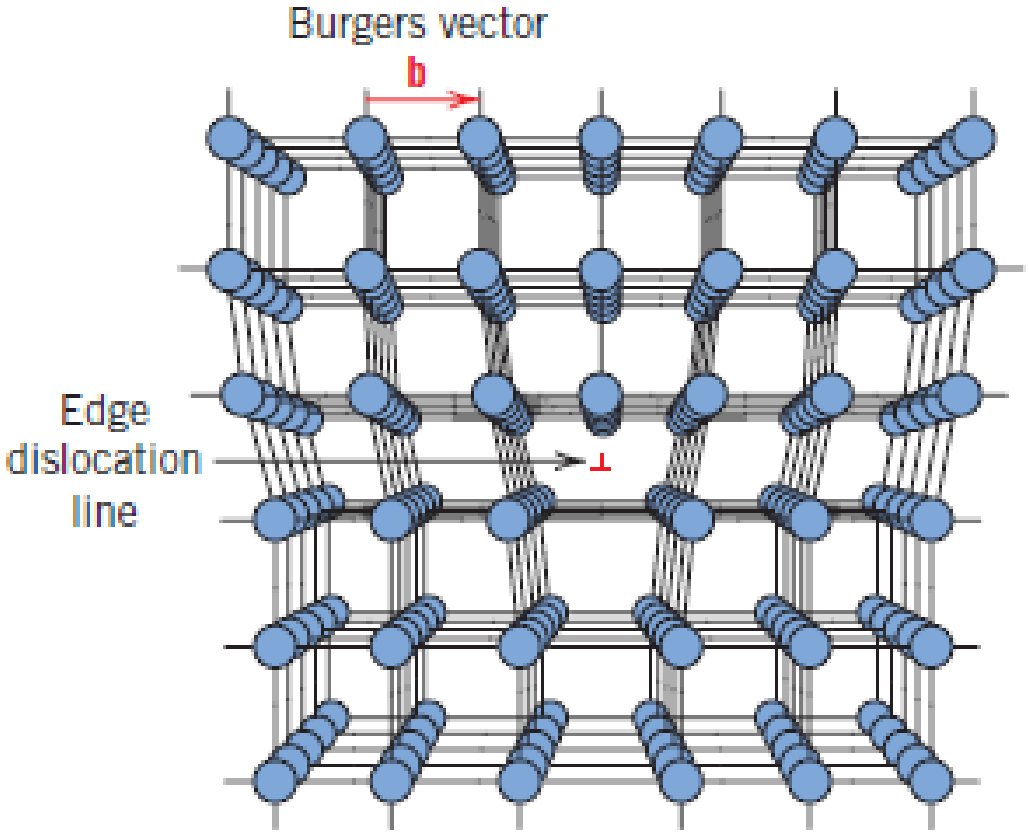
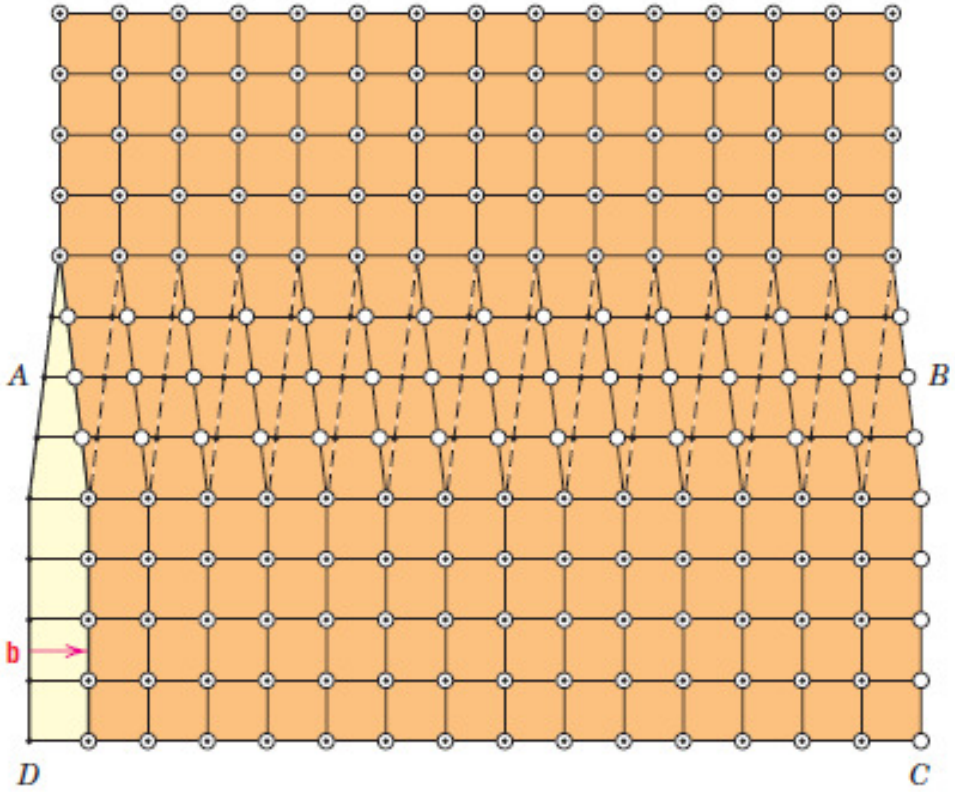

Self-interstitial
Vacancy


Substitutional
impurity atom
Interstitial
impurity atom


Burgers vector
b
Edge
dislocation
line
⊥



(b)

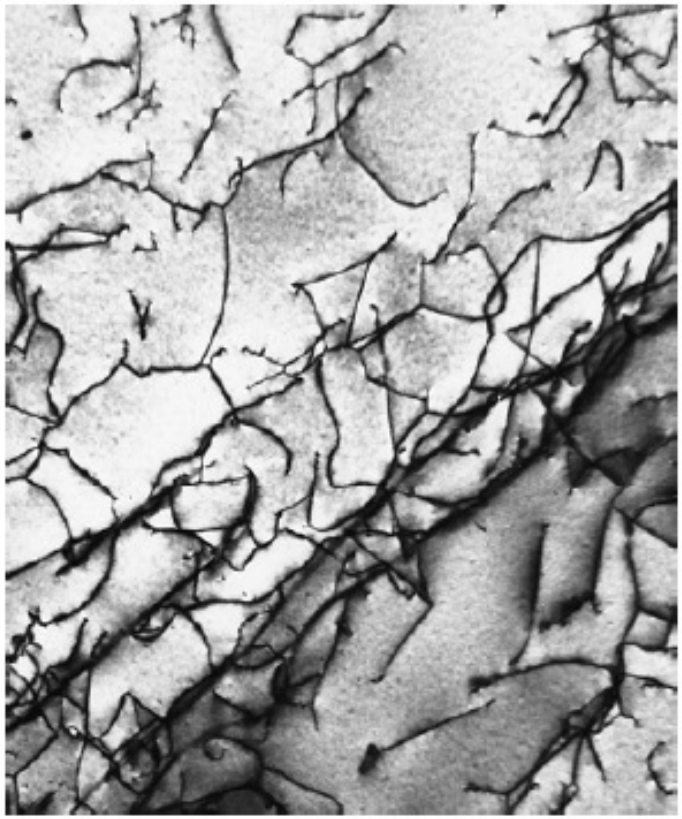
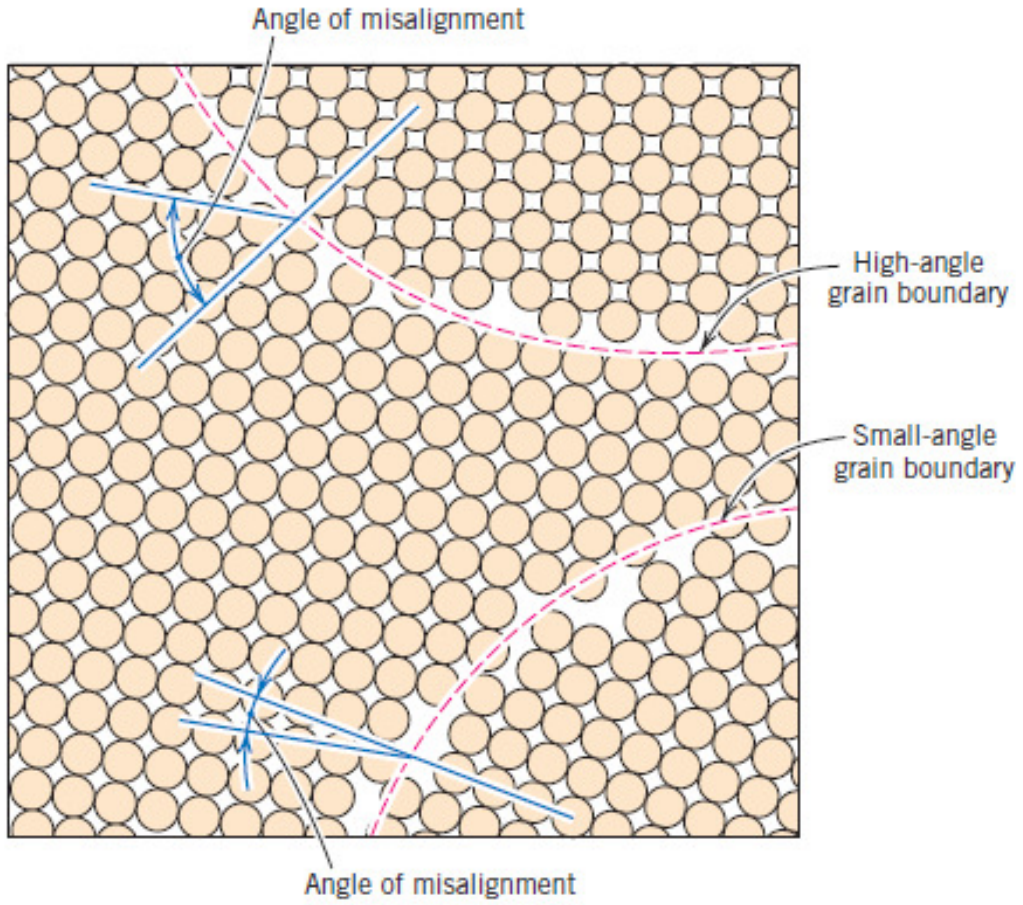
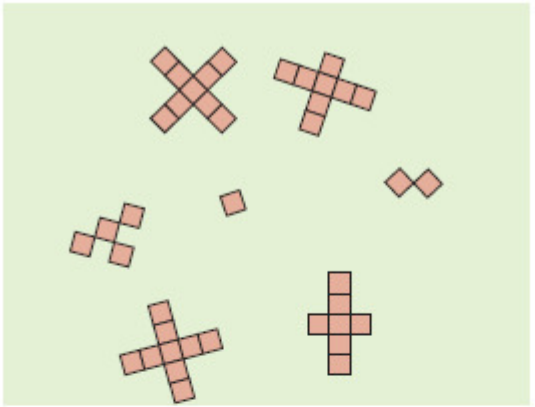
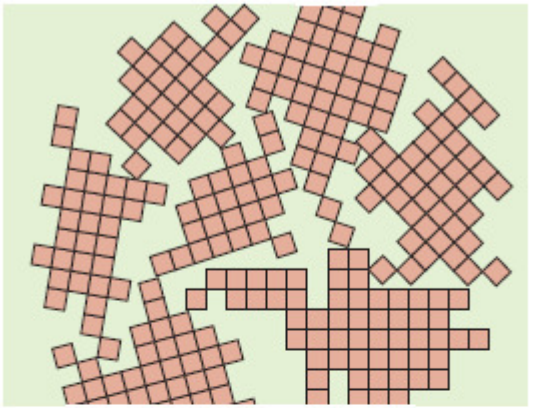


Figure 4.6 A transmission electron micrograph of a titanium alloy in which the dark lines are dislocations. 51,450×. (Courtesy of M. R. Plichta, Michigan Technological University.)


Angle of misalignment
High-angle grain boundary
Small-angle grain boundary
Angle of misalignment



(a)



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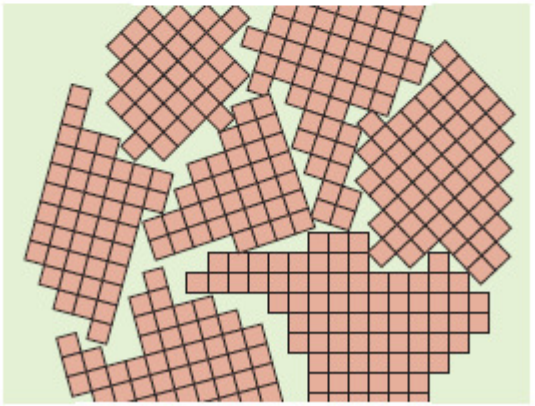
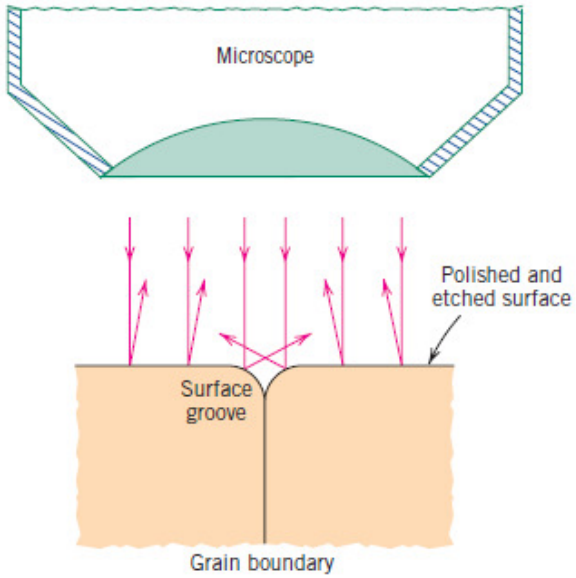
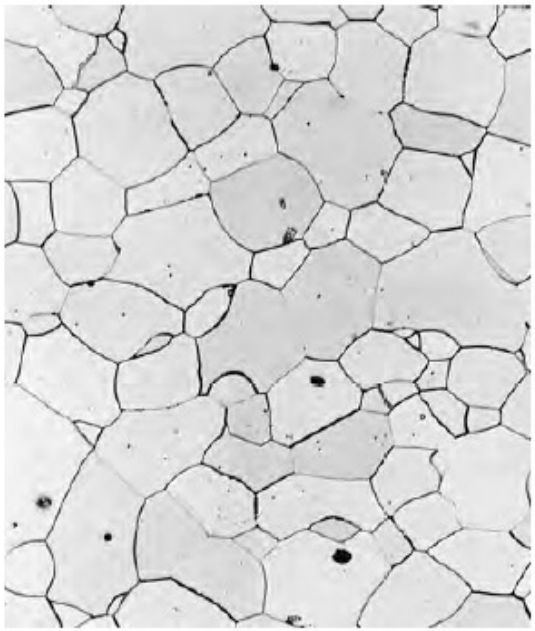


(c)

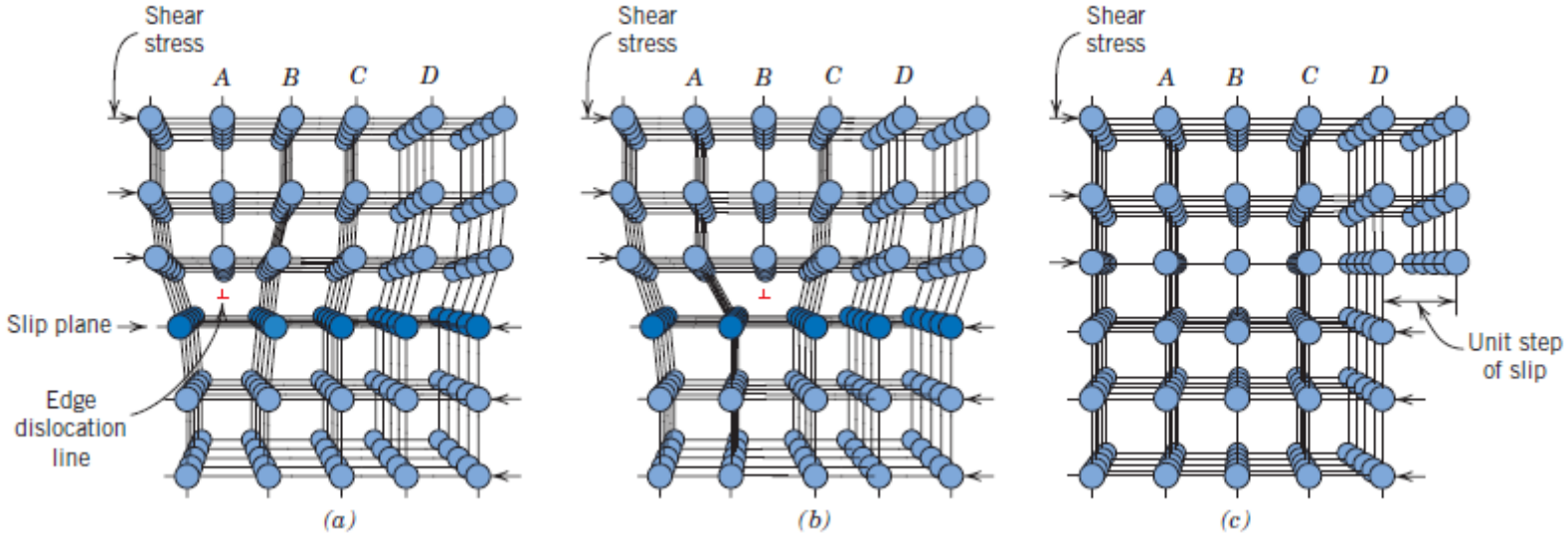
(d)

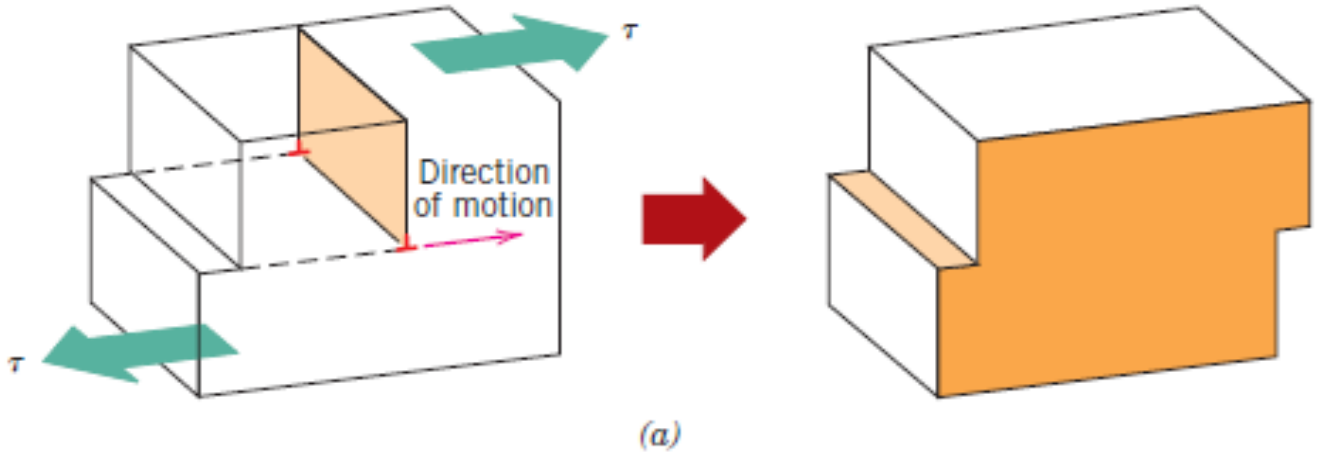

Microscope
Polished and
etched surface
Surface
groove
Grain boundary

(a)

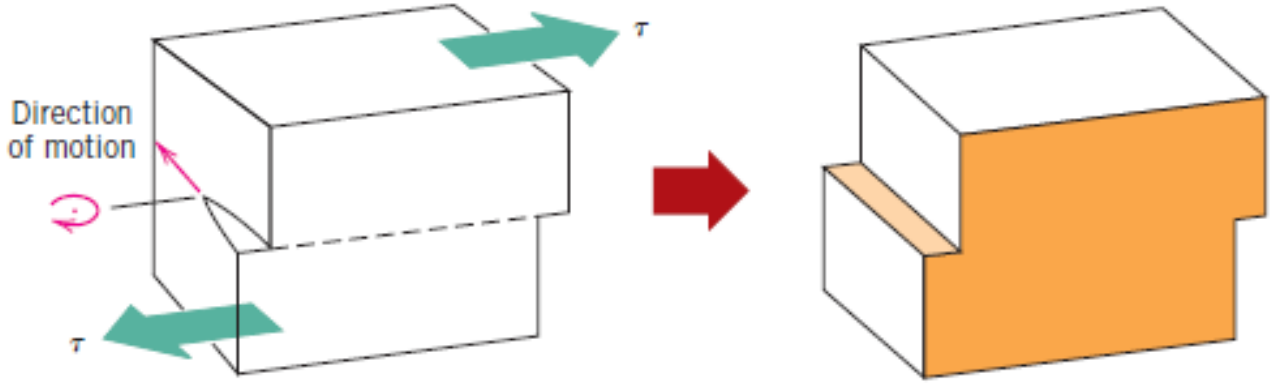


(b)


Shear stress
A
B
C
D
Slip plane
Edge dislocation line
(a)
Shear stress
A
B
C
D
(b)
Shear stress
A
B
C
D
Unit step of slip
(c)



(a)



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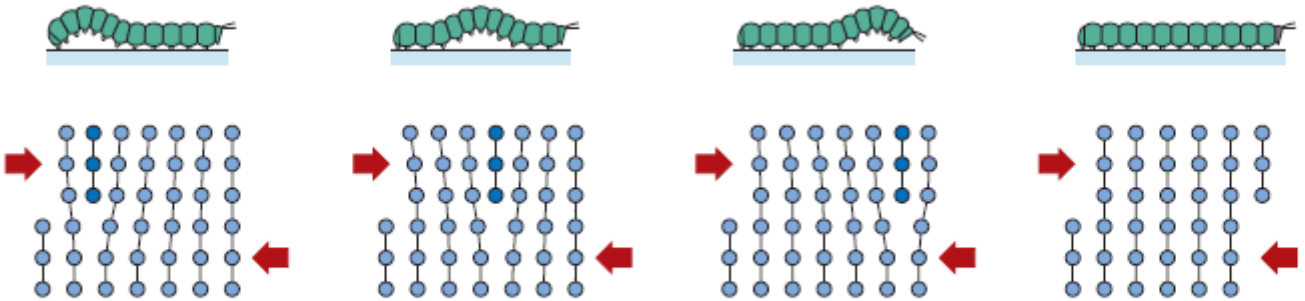
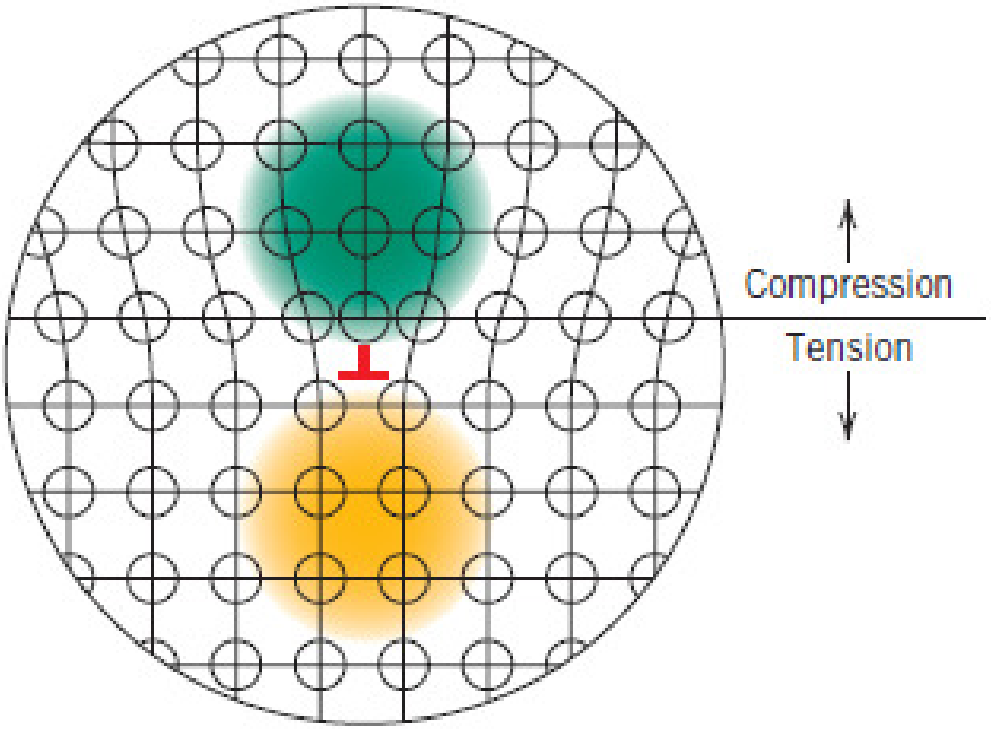
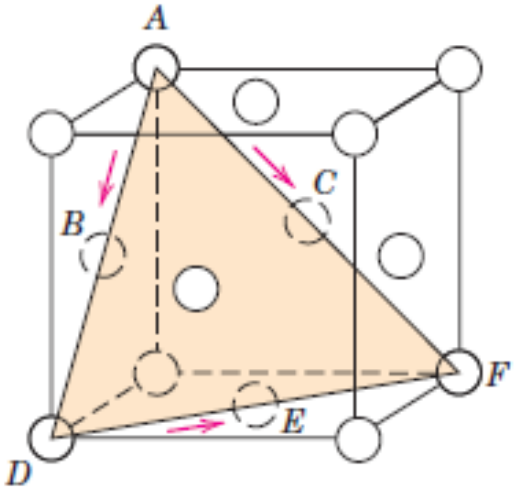
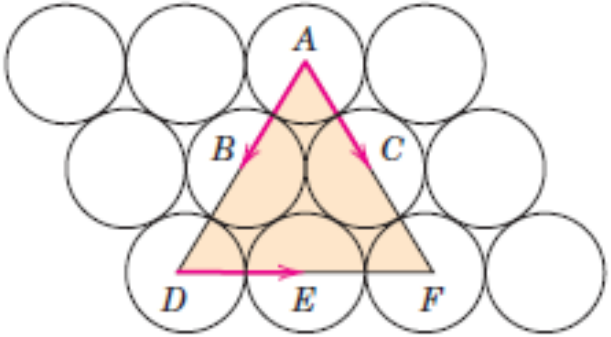


Figure 7.3 Representation of the analogy between caterpillar and dislocation motion.


Compression
Tension



(a)



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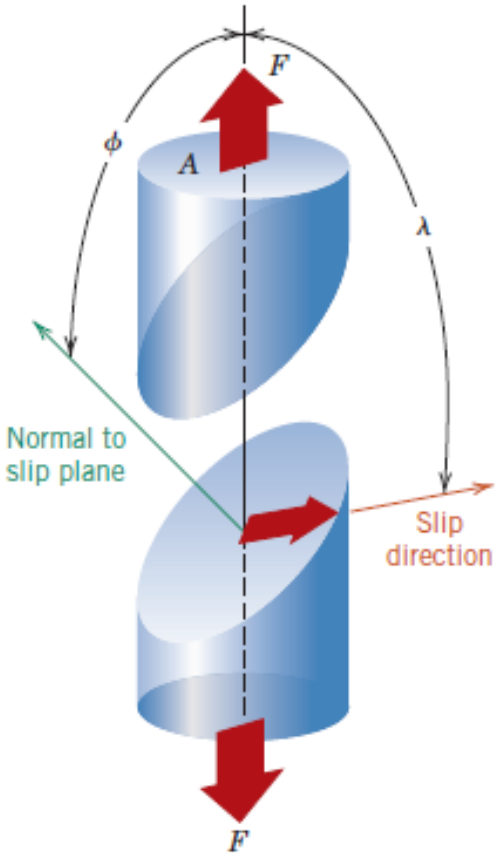
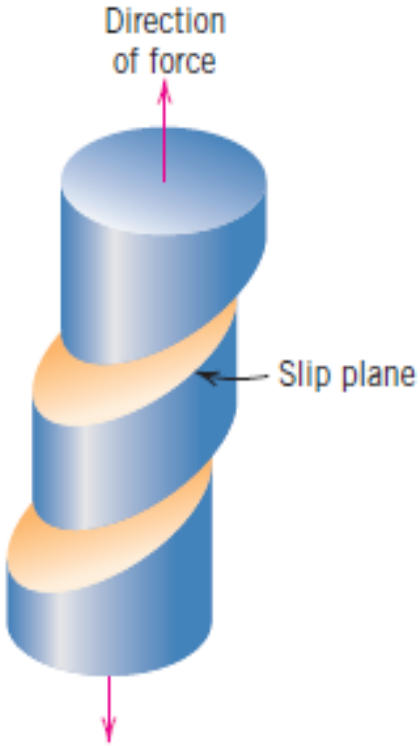

F
ϕ
A
λ
Normal to
slip plane
Slip
direction
F


Direction
of force
Slip plane

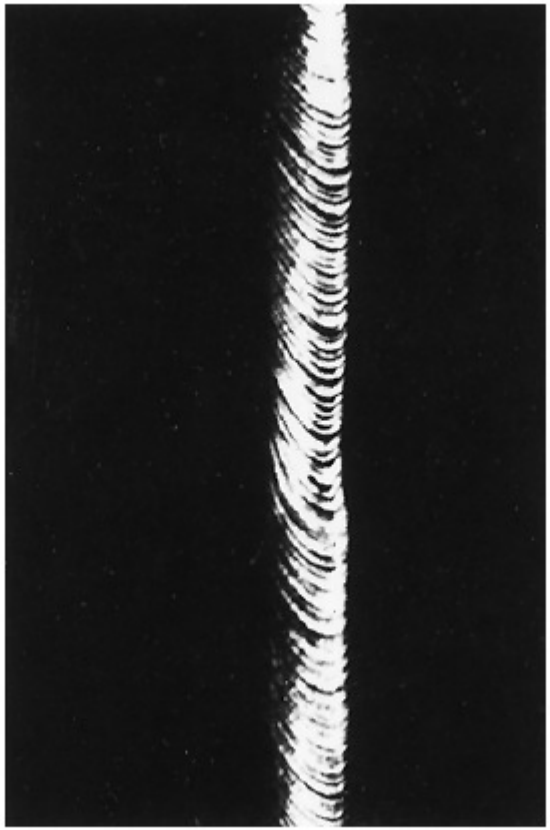


Figure 7.9 Slip in a zinc single crystal. (From C. F. Elam, *The Distortion of Metal Crystals*, Oxford University Press, London, 1935.)

Figure 7.10 Slip lines on the surface of a polycrystalline specimen of copper that was polished and subsequently deformed. 173×. [Photomicrograph courtesy of C. Brady, National Bureau of Standards (now the National Institute of Standards and Technology, Gaithersburg, MD).]

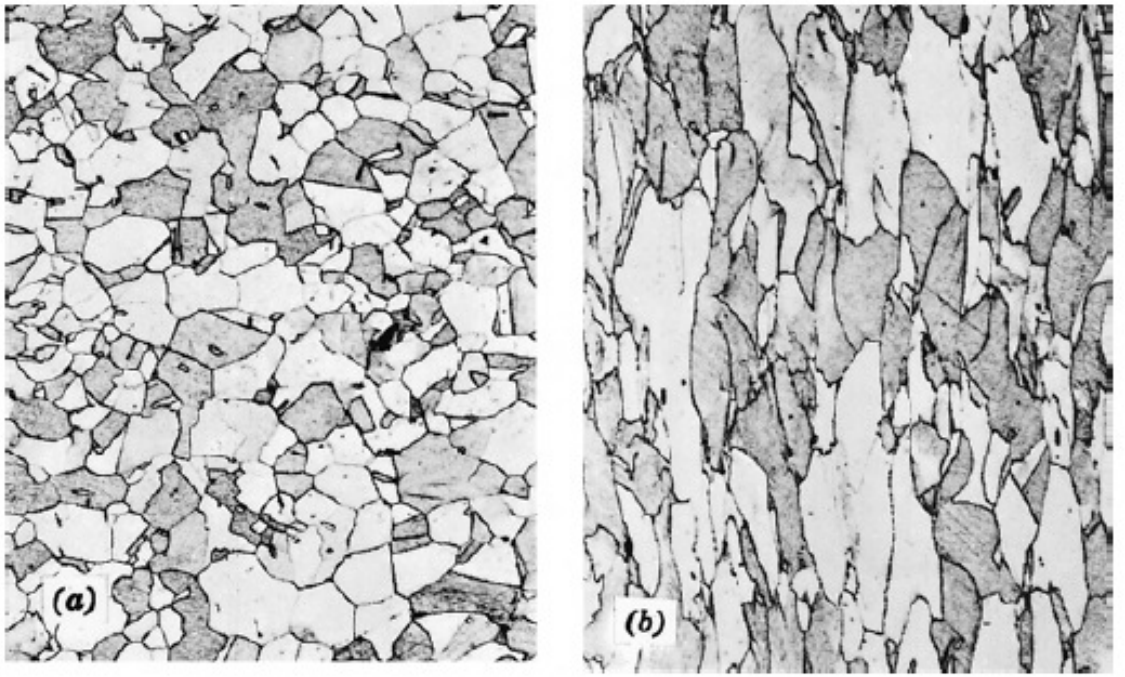
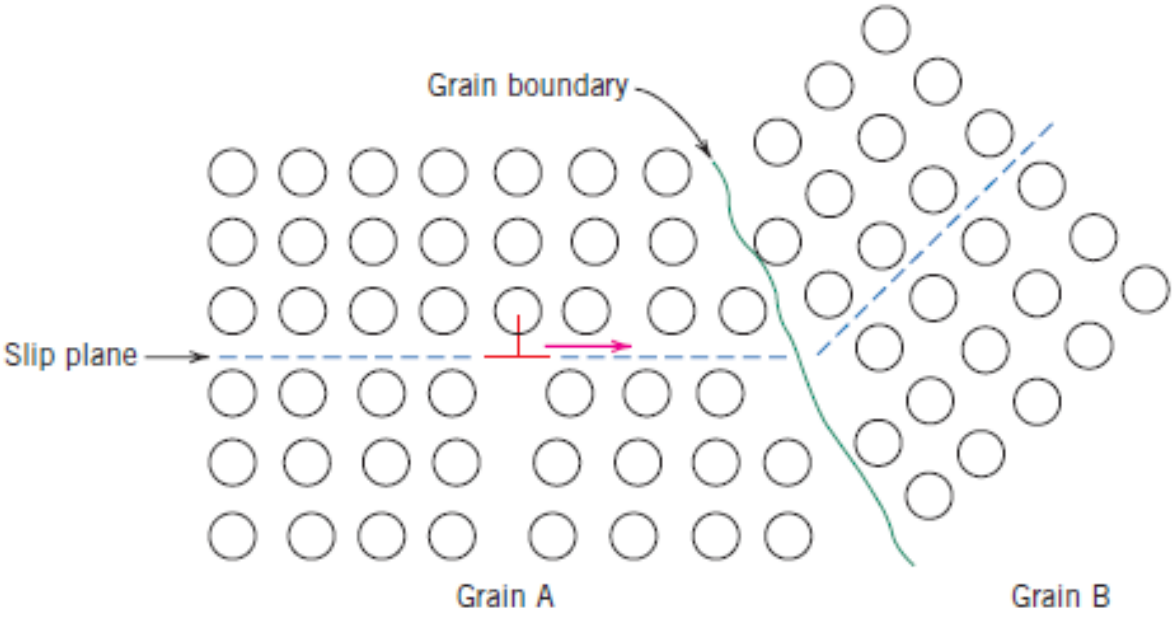


Figure 7.11 Alteration of the grain structure of a polycrystalline metal as a result of plastic deformation. (*a*) Before deformation the grains are equiaxed. (*b*) The deformation has produced elongated grains. 170×. (From W. G. Moffatt, G. W. Pearsall, and J. Wulff, *The Structure and Properties of Materials,* Vol. I, *Structure,* p. 140. Copyright © 1964 by John Wiley & Sons, New York. Reprinted by permission of John Wiley & Sons, Inc.)


Grain boundary
Slip plane
Grain A
Grain B

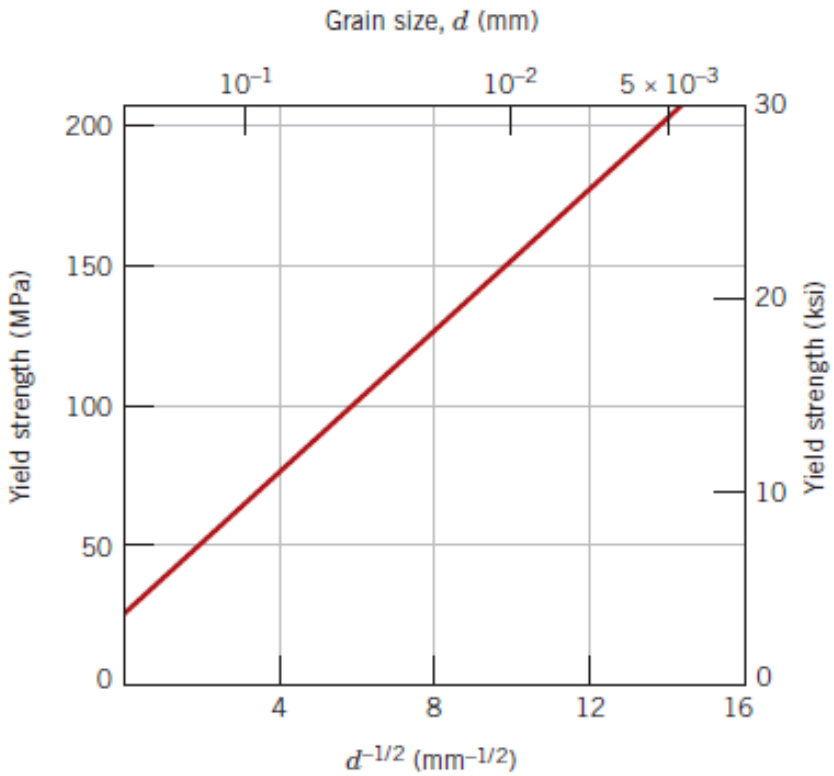
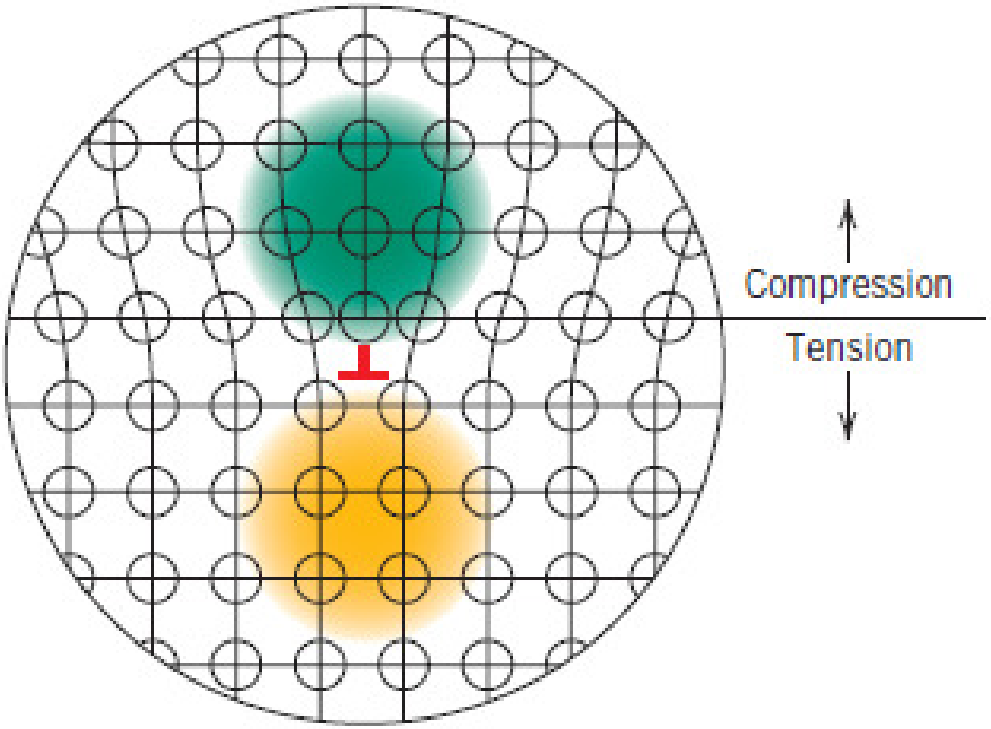
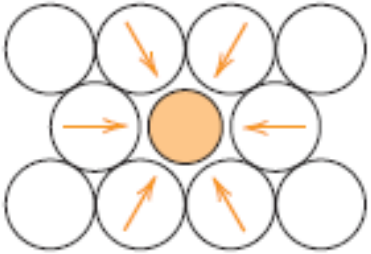


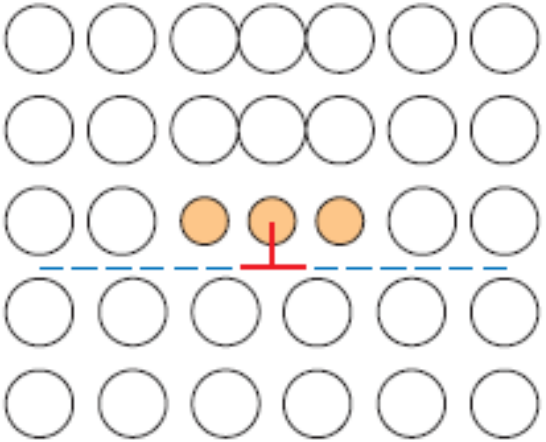
Figure 7.15 The influence of grain size on the yield strength of a 70 Cu–30 Zn brass alloy. Note that the grain diameter increases from right to left and is not linear. (Adapted from H. Suzuki, "The Relation Between the Structure and Mechanical Properties of Metals," Vol. II, *National Physical Laboratory, Symposium No. 15,* 1963, p. 524.)

$$\sigma_y = \sigma_0 + k_y d^{-1/2}$$


Compression
Tension



(a)



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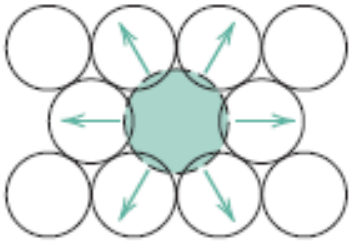

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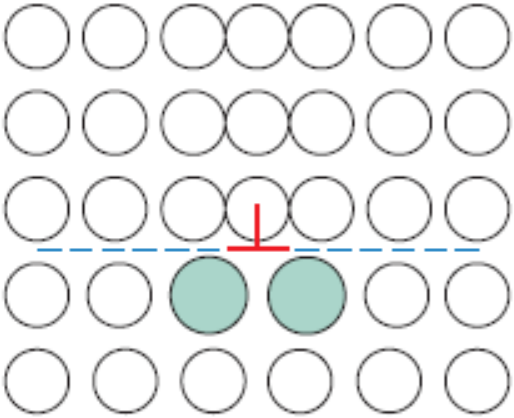


(b)

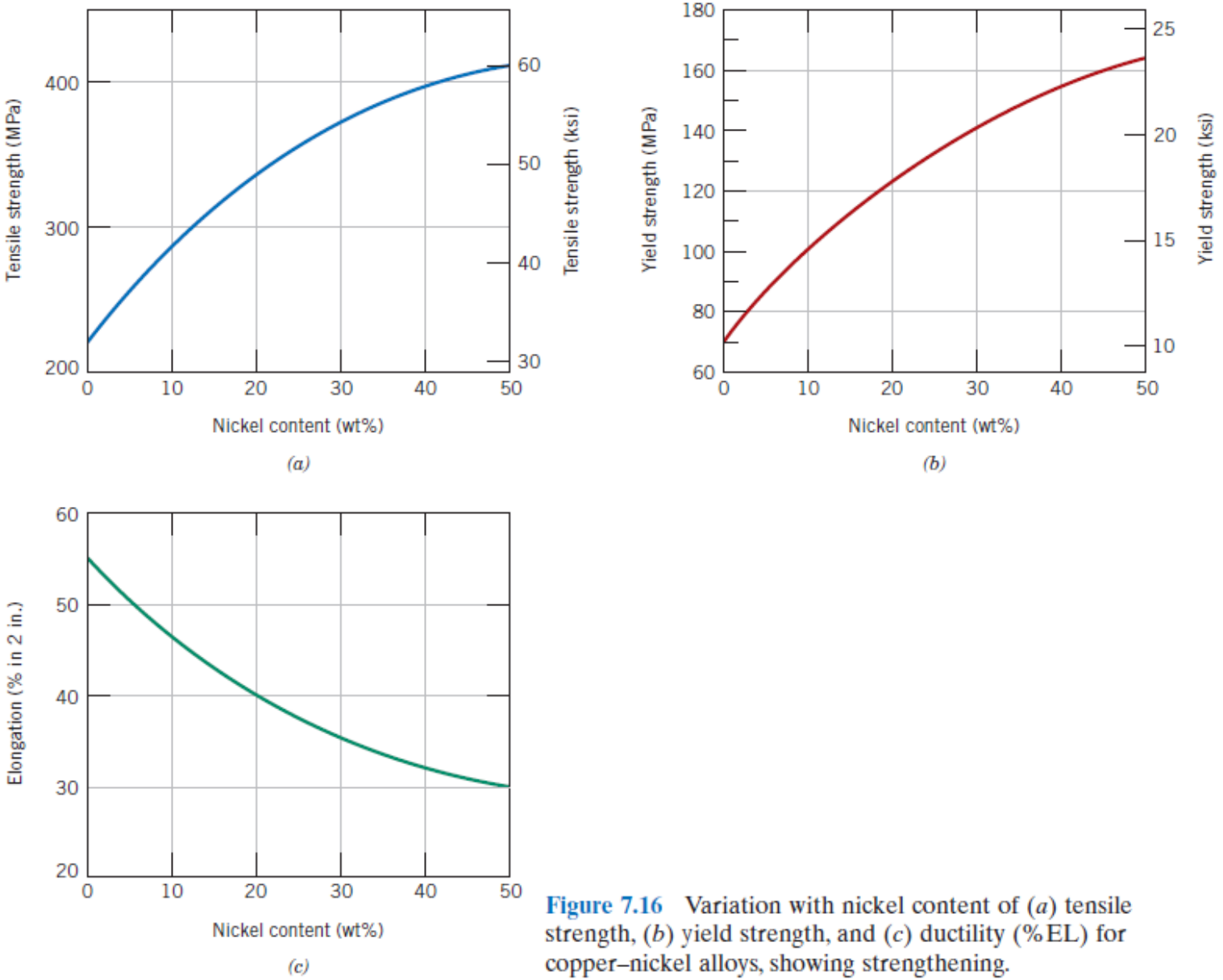
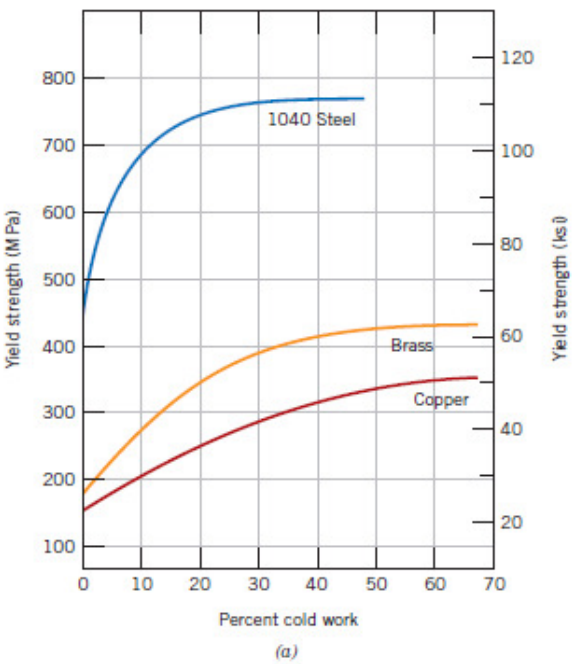
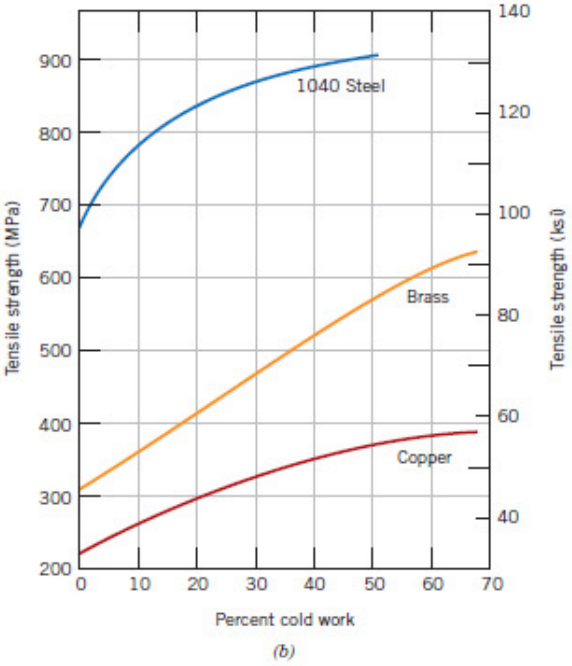


Figure 7.16 Variation with nickel content of (*a*) tensile strength, (*b*) yield strength, and (*c*) ductility (%EL) for copper–nickel alloys, showing strengthening.





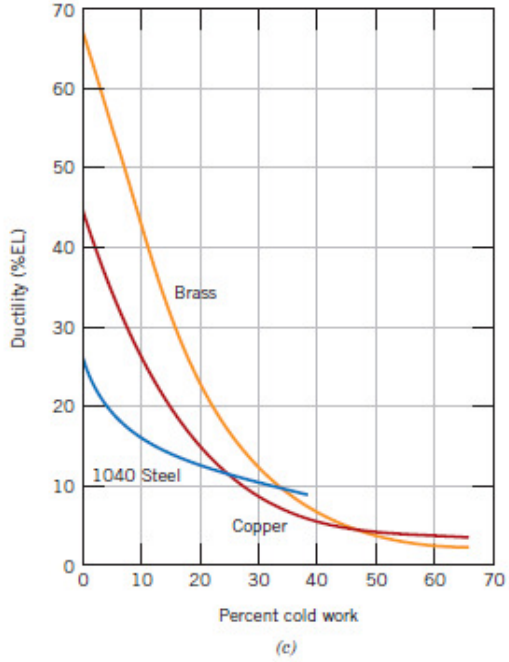


Figure 7.19 For 1040 steel, brass, and copper, (*a*) the increase in yield strength, (*b*) the increase in tensile strength, and (*c*) the decrease in ductility (%EL) with percent cold work. [Adapted from *Metals Handbook: Properties and Selection: Irons and Steels,* Vol. 1, 9th edition, B. Bardes (Editor), American Society for Metals, 1978, p. 226; and *Metals Handbook: Properties and Selection: Nonferrous Alloys and Pure Metals,* Vol. 2, 9th edition, H. Baker (Managing Editor), American Society for Metals, 1979, pp. 276 and 327.]

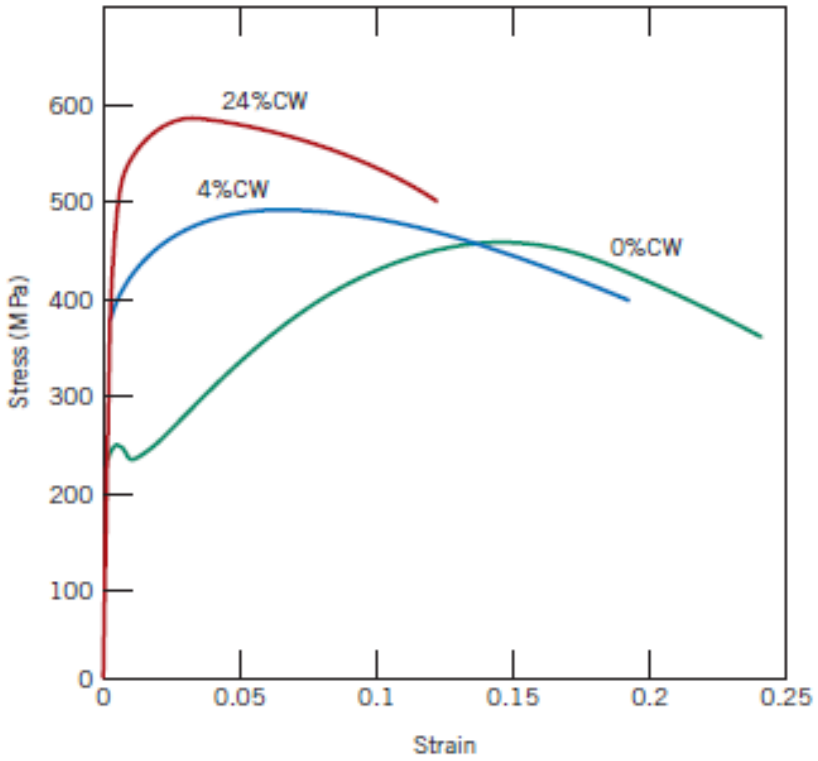


Figure 7.20 The influence of cold work on the stress–strain behavior of a low-carbon steel; curves are shown for 0% CW, 4% CW, and 24% CW.