CHAPTER 16
Optical Behavior

Optical behavior is often a critical factor in materials selection. An example is this automobile headlamp bezel constructed of a metal-coated polybutylene terephthalate (PBT) polymer. The bezel is placed between the reflector and the lens to enhance the aesthetics of the headlamp. The PBT polymer was chosen due to its combination of good optical reflectivity (after metal-coating), processing ability, and low warpage. (Courtesy of DuPont Automotive.)

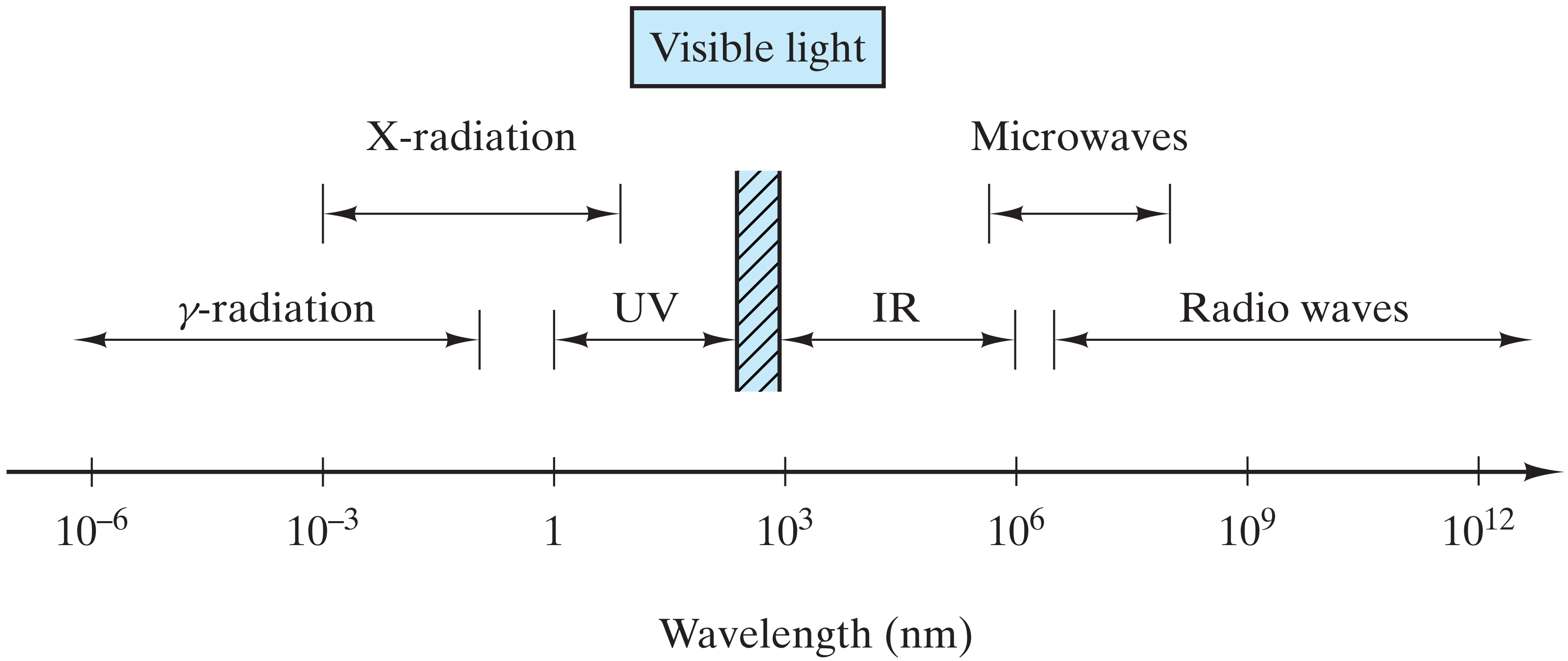


Figure 16-1 *Electromagnetic radiation spectrum,, with the visible light range (wavelengths between 400 and 700 nm) highlighted.*

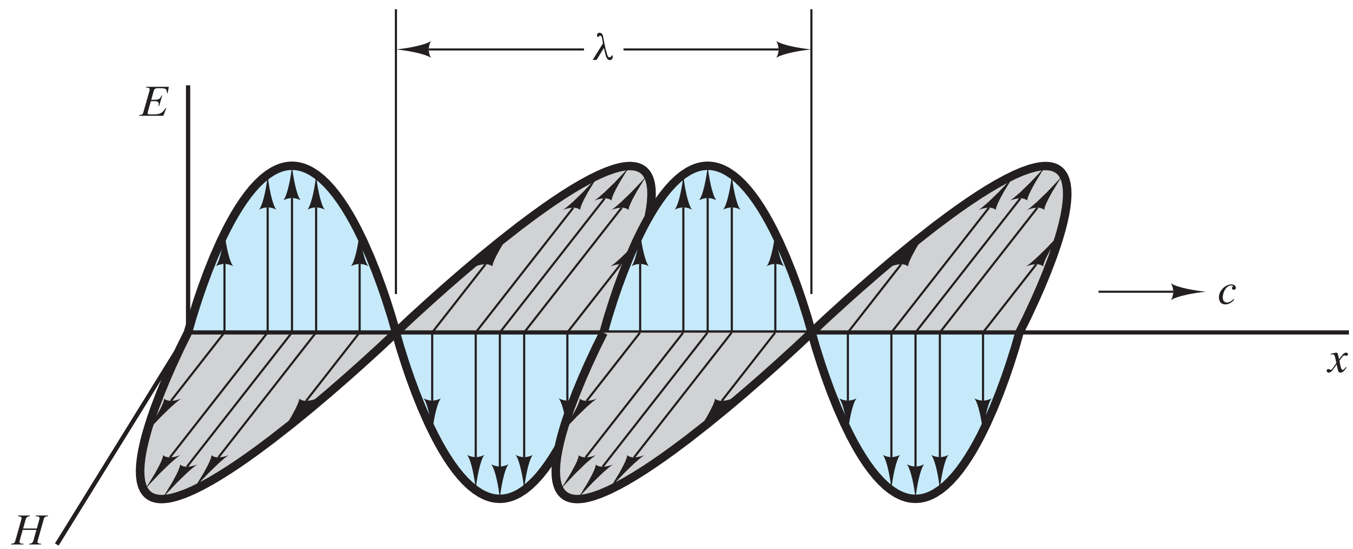
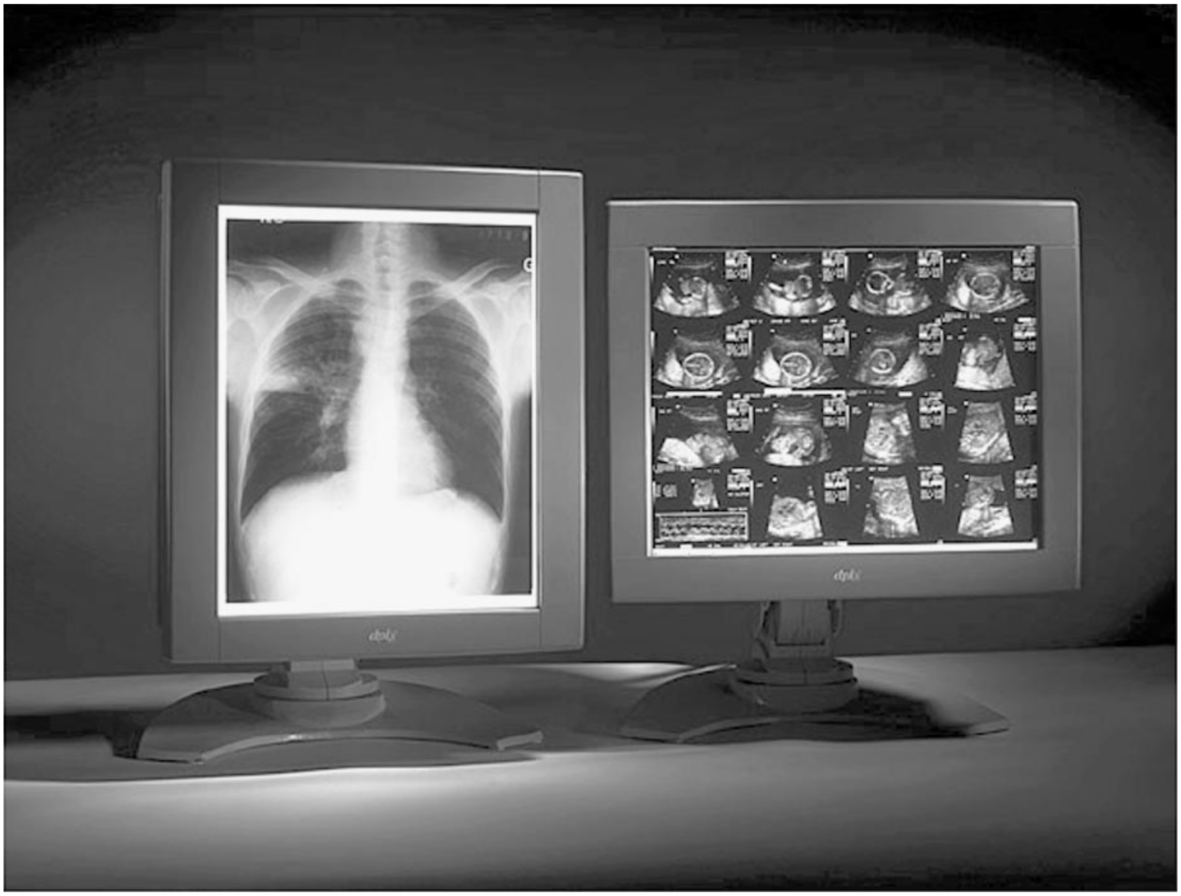


Figure 16-2 *The wavelike nature of an electromagnetic wave, such as light. Both the electric field (E) and magnetic field (H) components are sinusoidal, and the oscillations of E and H occur in perpendicular planes. The wavelength, λ, and the speed of light, c, are noted.*



(Courtesy of dpiX, Incorporated)

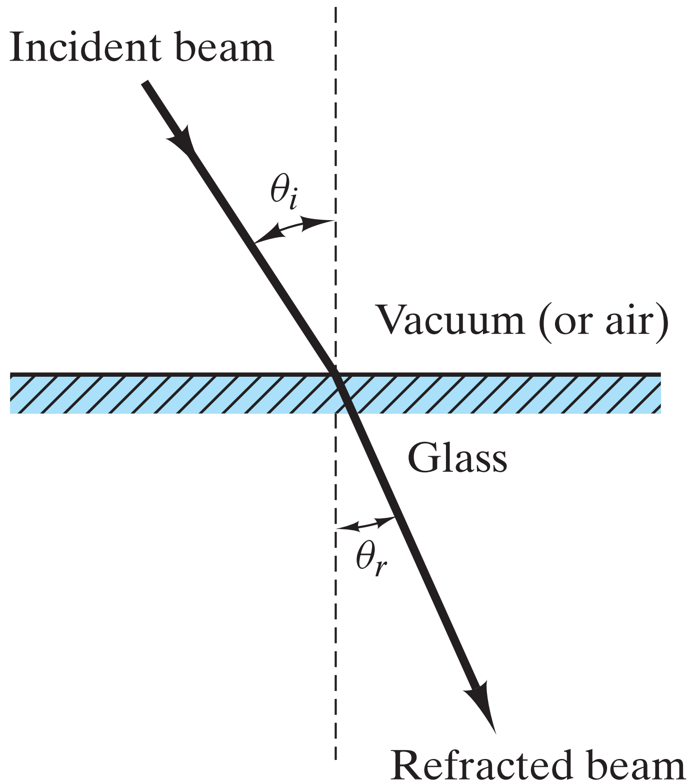


Figure 16-3 *Refraction of light as it passes from vacuum (or air) into a transparent material.*

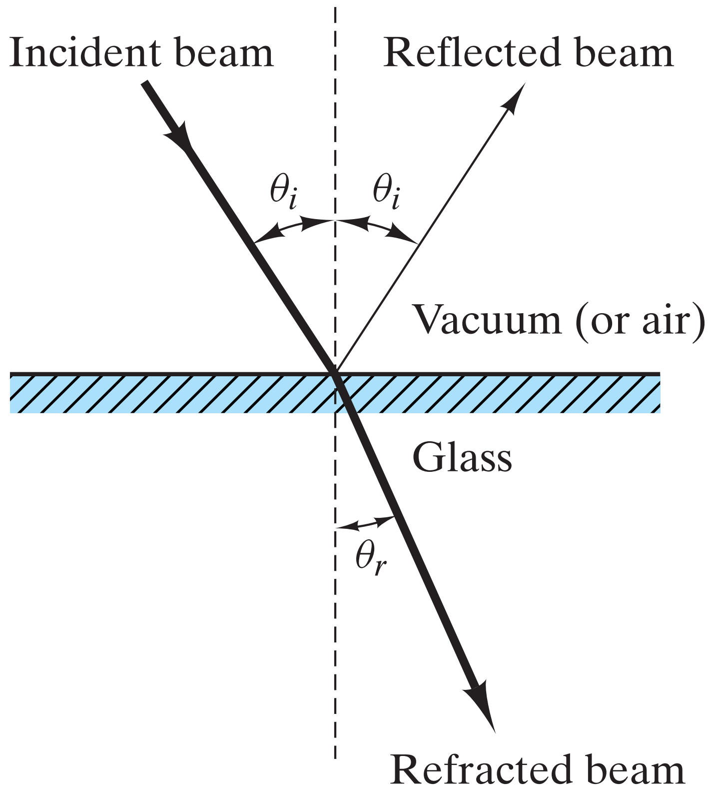


Figure 16-4 *Reflection of light at the surface of a transparent material occurs along with refraction.*

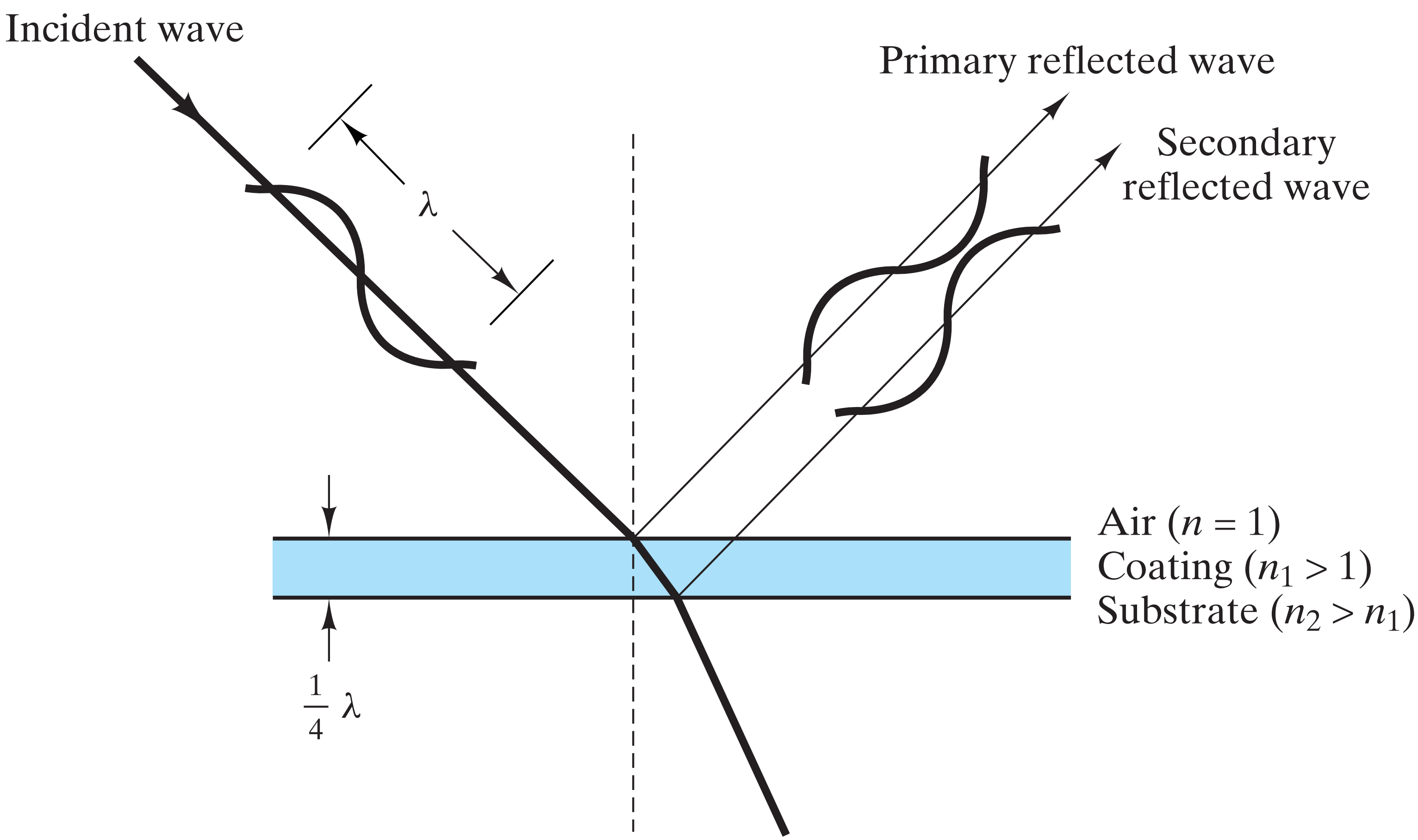


Figure 16-5 *Use of a "one-quarter-wavelength" thick coating minimizes surface reflectivity. The coating has an intermediate index of refraction and the primary reflected wave is just canceled by the secondary reflected wave of equal magnitude and opposite phase. Such coatings are commonly used on microscope lenses.*

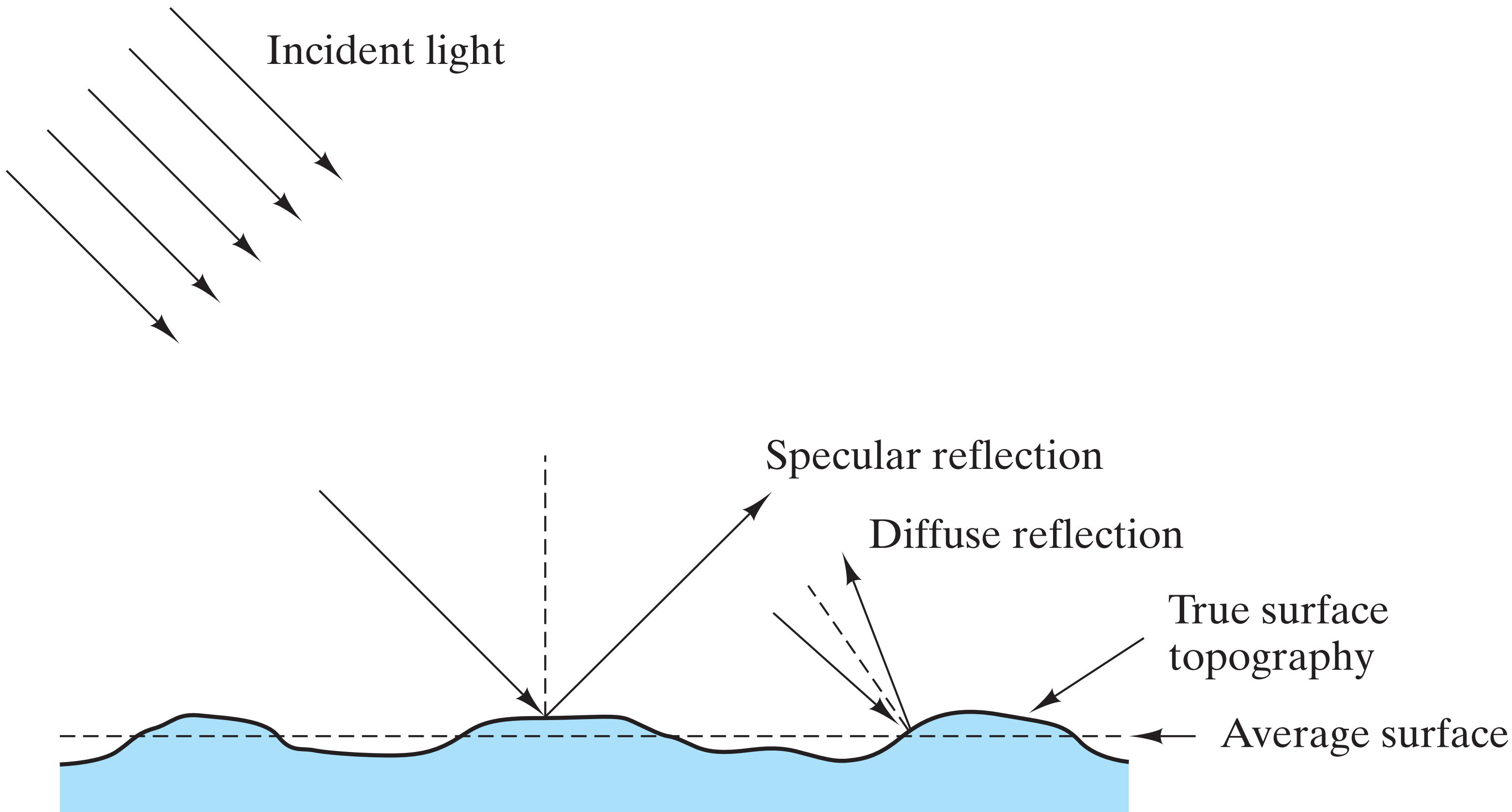


Figure 16-6 *Specular reflection occurs relative to the "average" surface, and diffuse reflection occurs relative to locally nonparallel surface elements.*

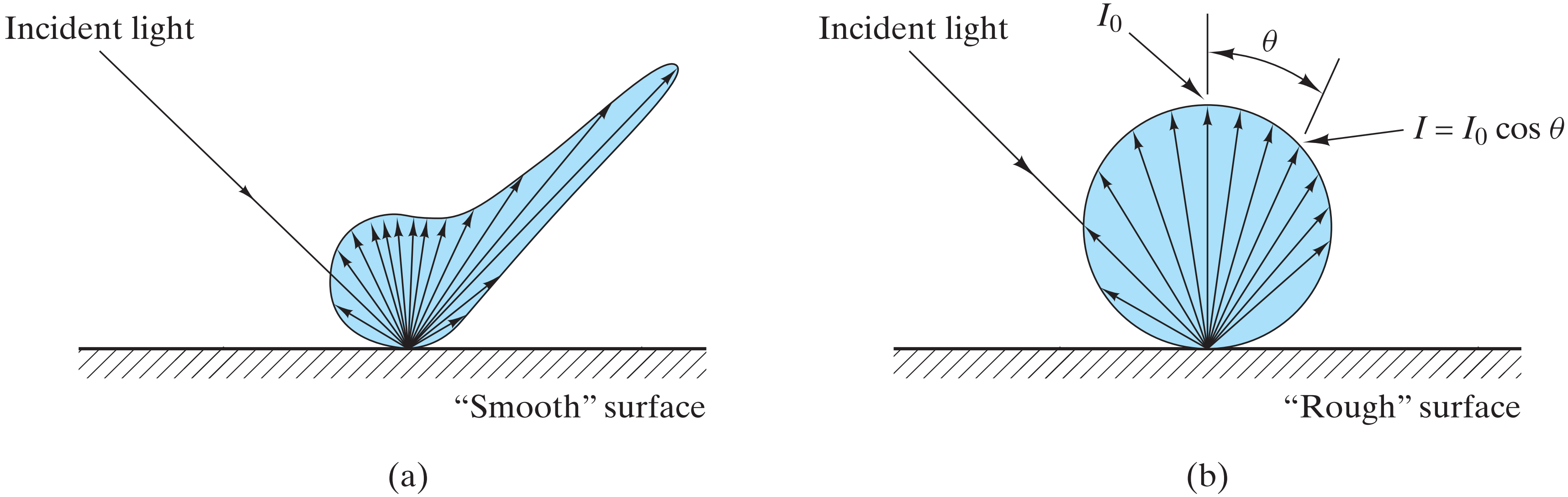


Figure 16-7 *Polar diagrams illustrate the directional intensity of reflection from (a) a "smooth" surface with predominantly specular reflection and (b) a "rough" surface with completely diffuse reflection.*

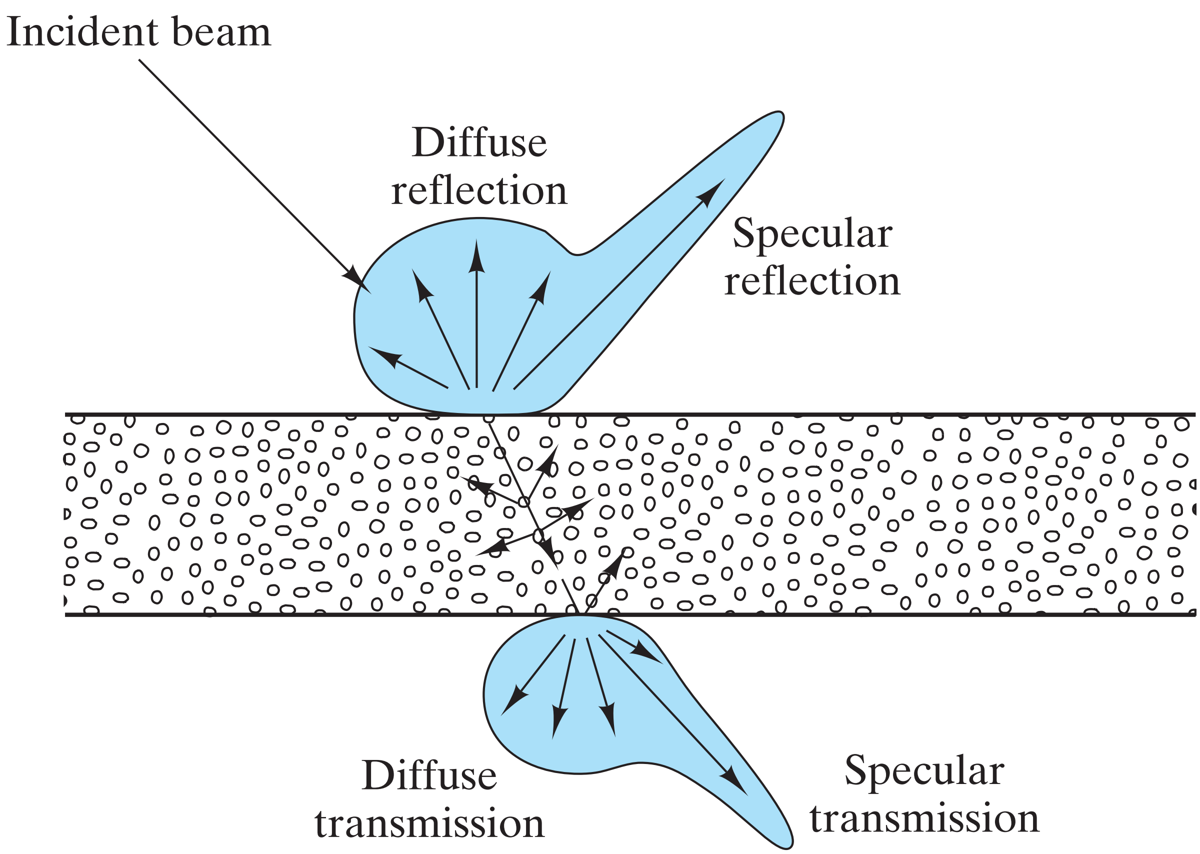


Figure 16-8 *Polar diagrams illustrate reflection and transmission of light through a translucent plate of glass. (From W. D. Kingery, H. K. Bowen, and D. R. Uhlmann,* Introduction to Ceramics, *2nd ed., John Wiley & Sons, Inc., New York, 1976.)*

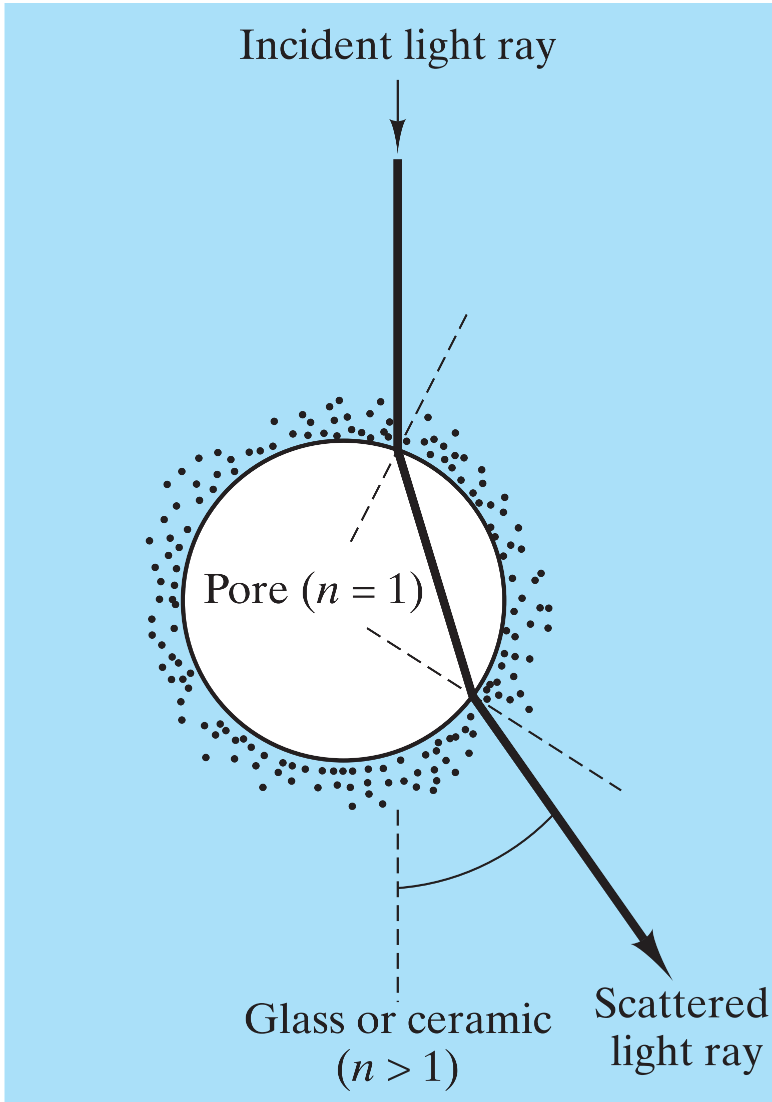


Figure 16-9 *Light scattering is the result of local refraction at interfaces of second-phase particles or pores. The case for scattering by a pore is illustrated here.*

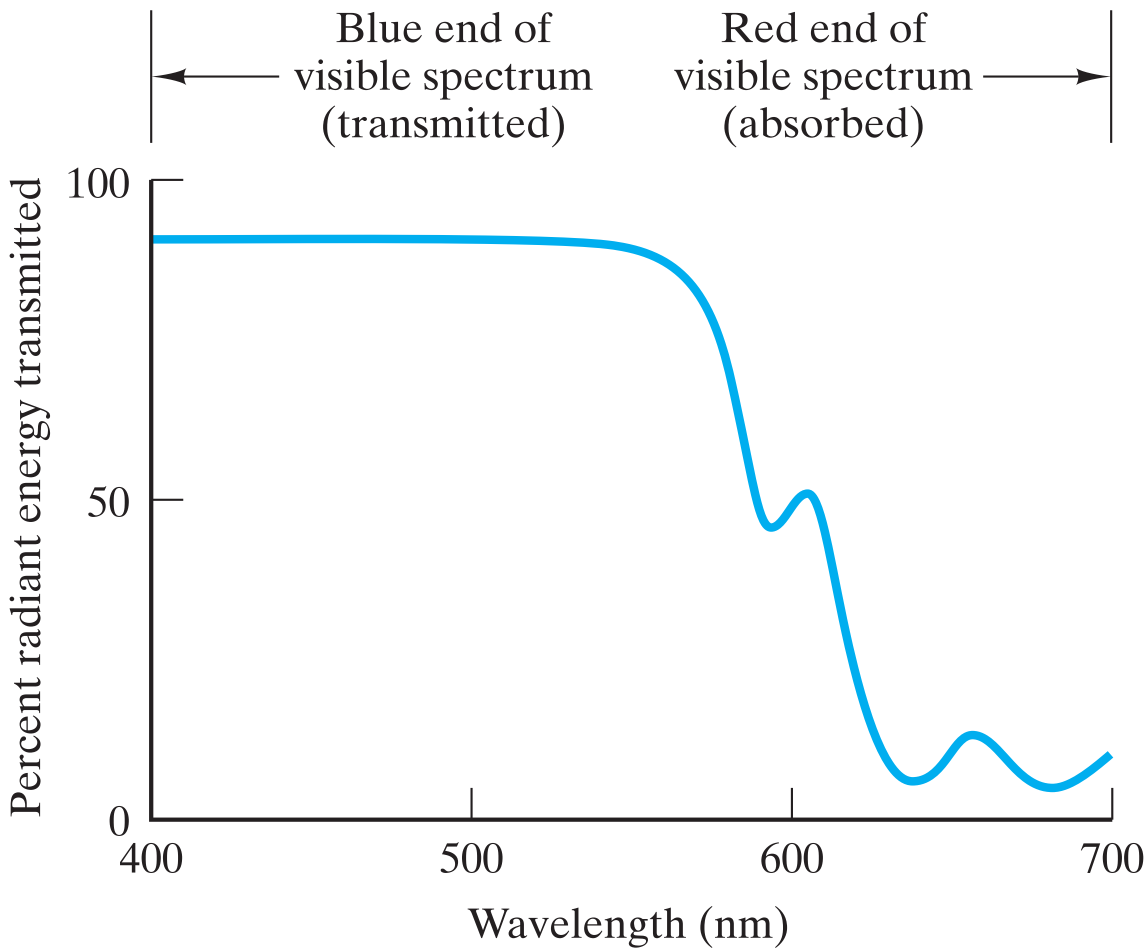


Figure 16-10 *Absorption curve for a silicate glass containing about 1% cobalt oxide. The characteristic blue color of this material is due to the absorption of much of the red end of the visible-light spectrum.*

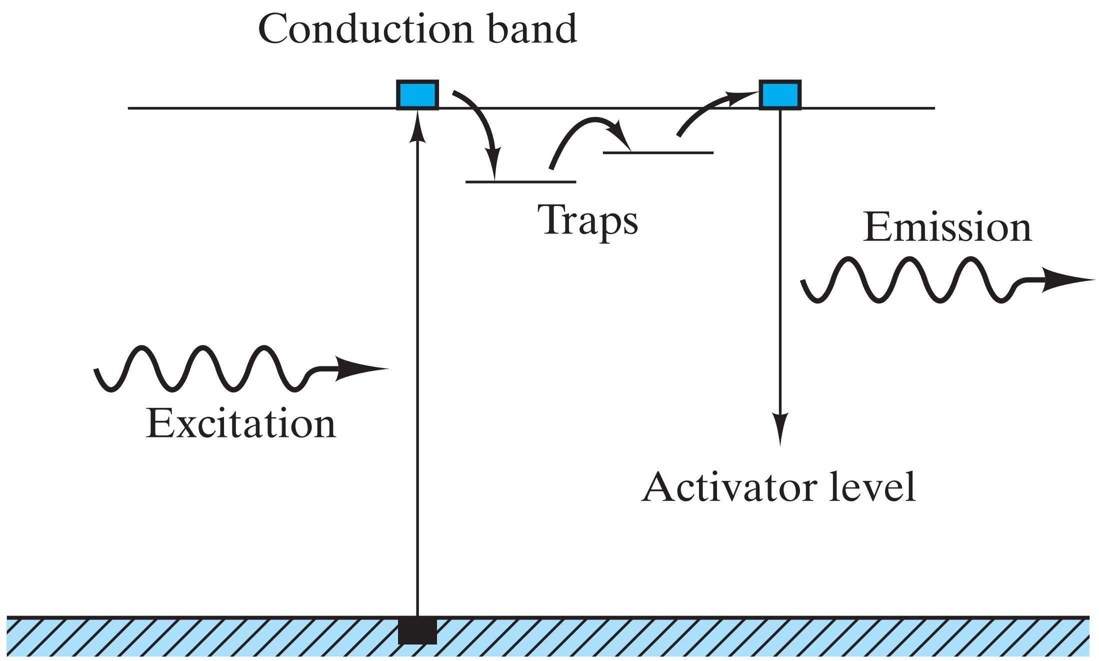


Figure 16-11 *Schematic illustration of a mechanism for luminescence. Various trap and activator energy levels within the energy band gap are produced by impurity additions to the insulating material. Following the excitation of an electron from the valence band to the conduction band, the electron moves among the traps without emitting radiation, is thermally promoted back to the conduction band, and eventually decays to the activator level with the emission of a photon of light. (After R. M. Rose, L. A. Shepard, and J. Wulff, The Structure and Properties of Materials, Vol. 4: Electronic Properties, John Wiley & Sons, Inc., New York, 1966.)*

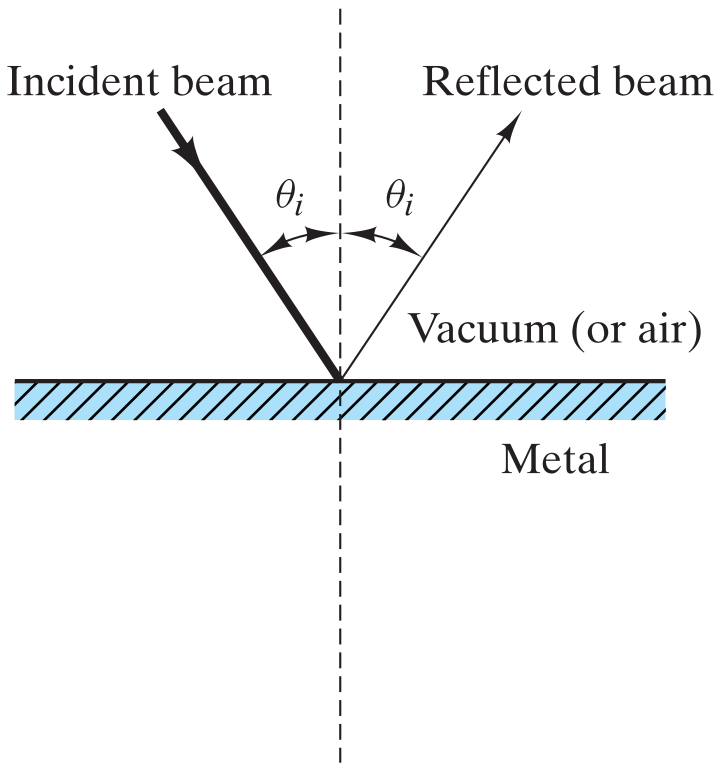
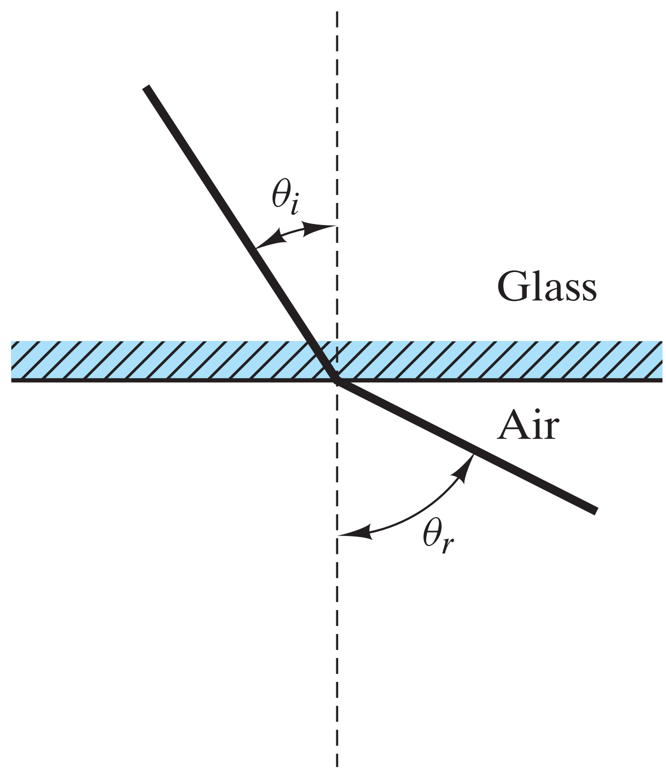


Figure 16-12 *Reflection of light at the surface of an opaque metal occurs without refraction.*



θ_i
Glass
Air
θ_r

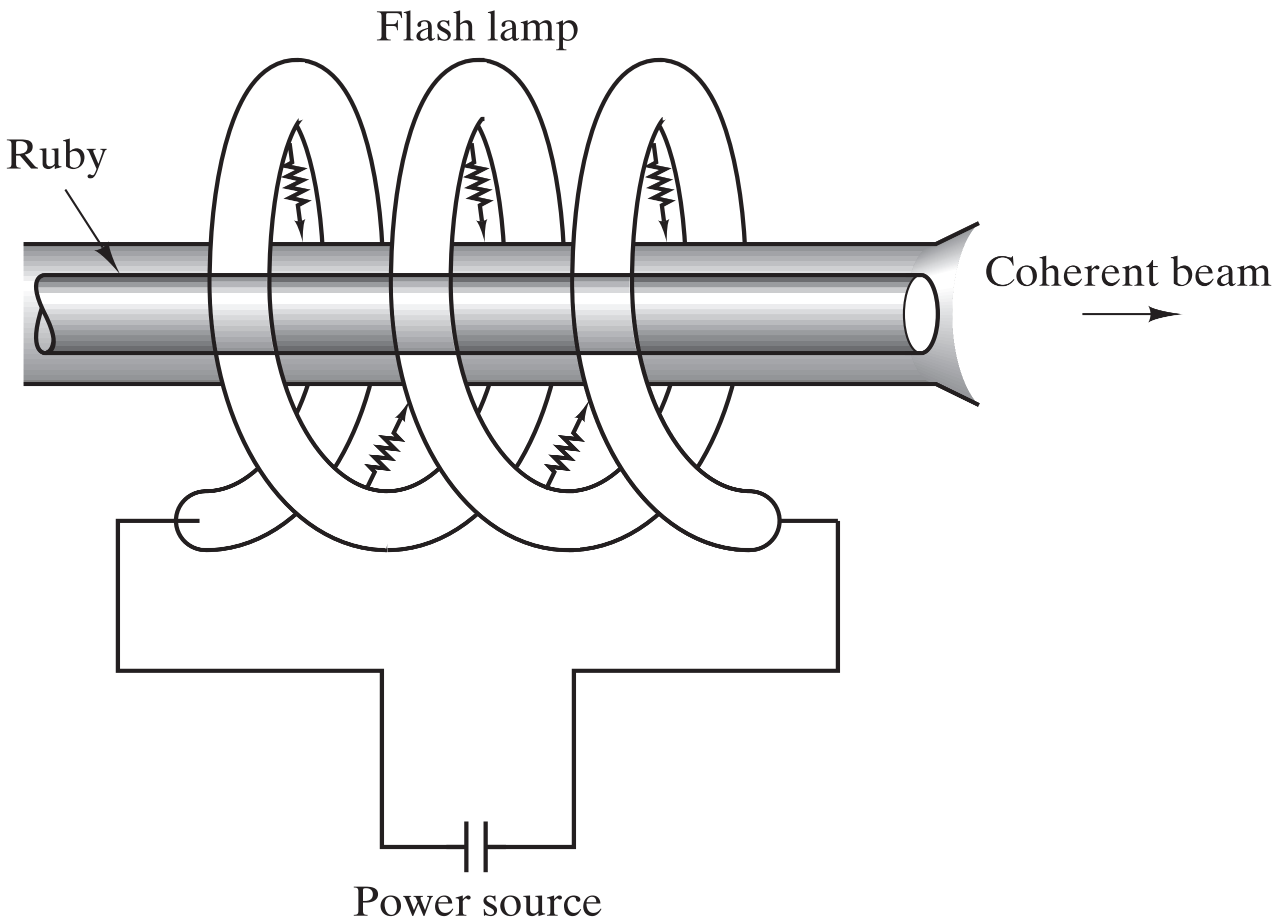


Figure 16-13 *Schematic illustration of a ruby laser. (From R. M. Rose, L. A. Shepard, and J. Wulff, The Structure and Properties of Materials, Vol. 4: Electronic Properties, John Wiley & Sons, Inc., New York, 1966.)*

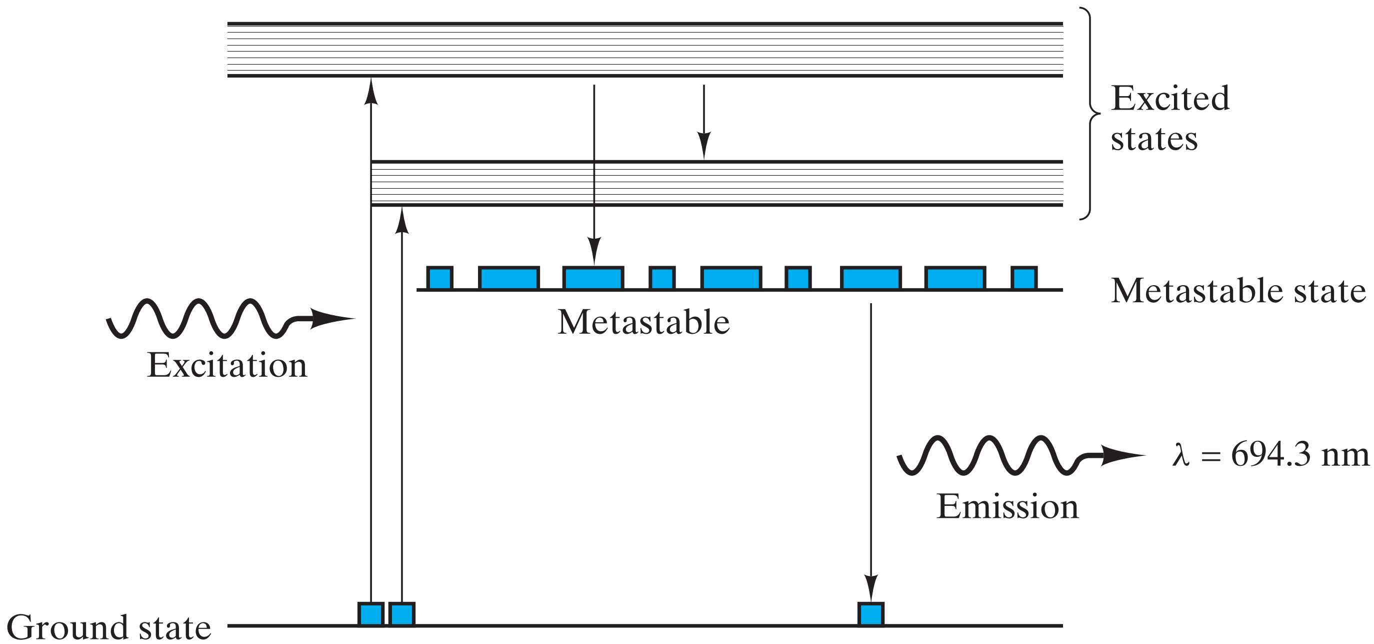


Figure 16-14 *Schematic illustration of the mechanism for the excitation and decay of electrons of a Cr^{3+} ion in a ruby laser. Although a ground-state electron can be promoted to various activated states, only the final decay from the metastable to the ground state produces laser photons of wavelength 694.3 nm. A residence time of up to 3 ms in the metastable state allows a large number of Cr^{3+} ions to emit together, producing a large light pulse. (After R. M. Rose, L. A. Shepard, and J. Wulff, The Structure and Properties of Materials, Vol. 4: Electronic Properties, John Wiley & Sons, Inc., New York, 1966.)*

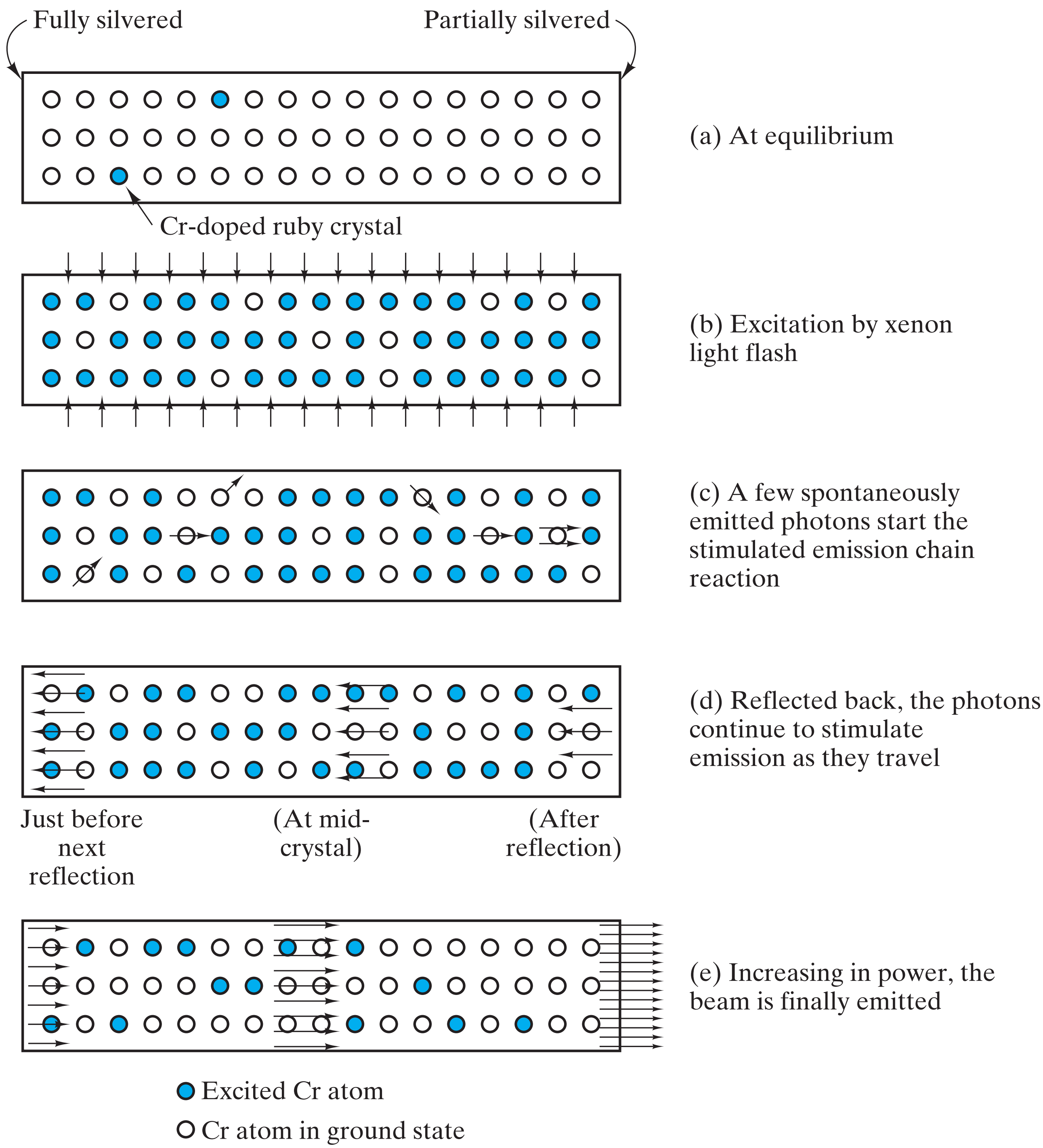


Figure 16-15 *Schematic illustration of stimulated emission and light amplification in a ruby laser. (From R. M. Rose, L. A. Shepard, and J. Wulff, The Structure and Properties of Materials, Vol. 4: Electronic Properties, John Wiley & Sons, Inc., New York, 1966.)*

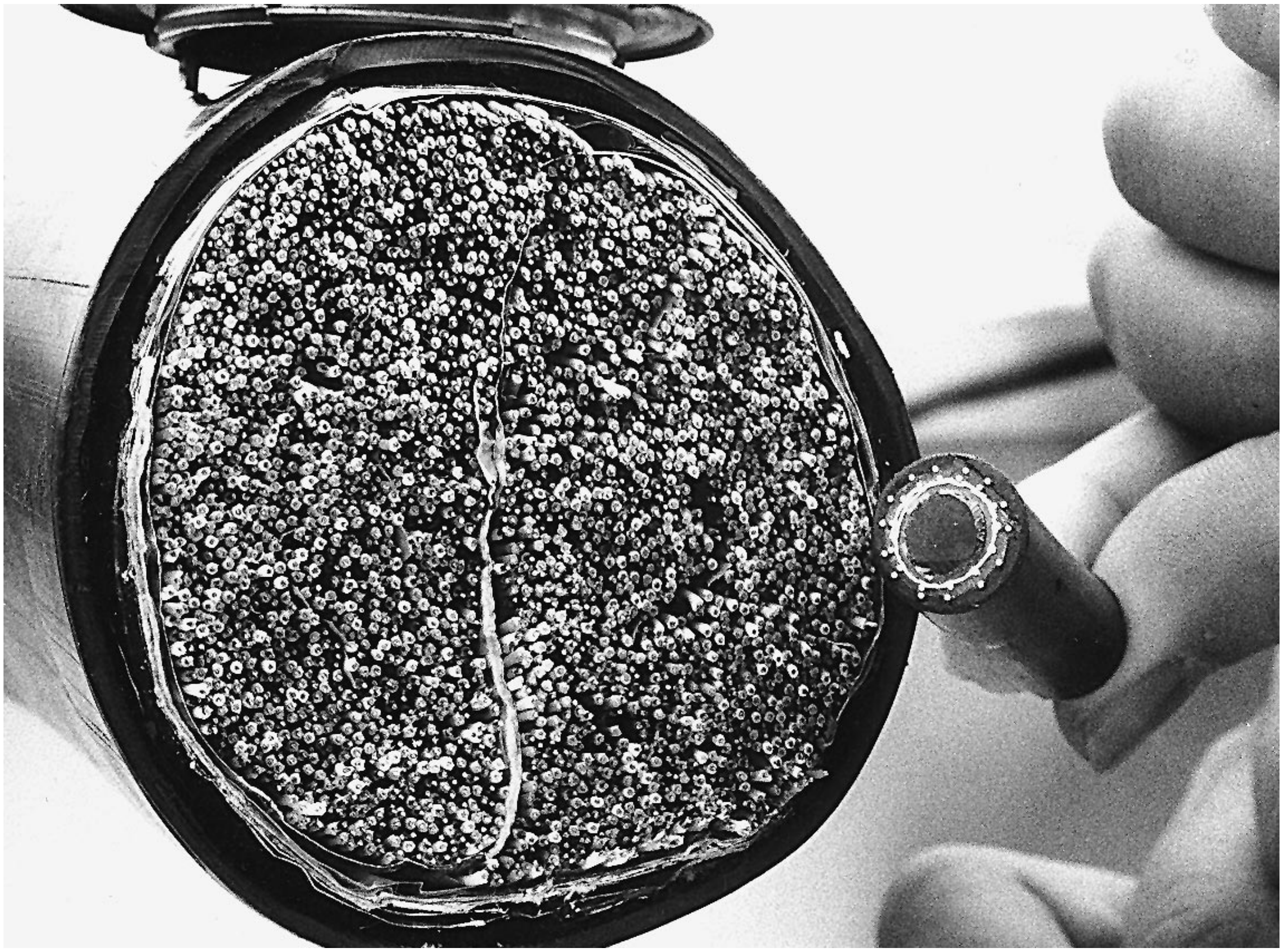


Figure 16-16 *The small cable on the right contains 144 glass fibers and can carry more than three times as many telephone conversations as the traditional (and much larger) copper wire cable on the left. (Courtesy of the San Francisco Examiner.)*

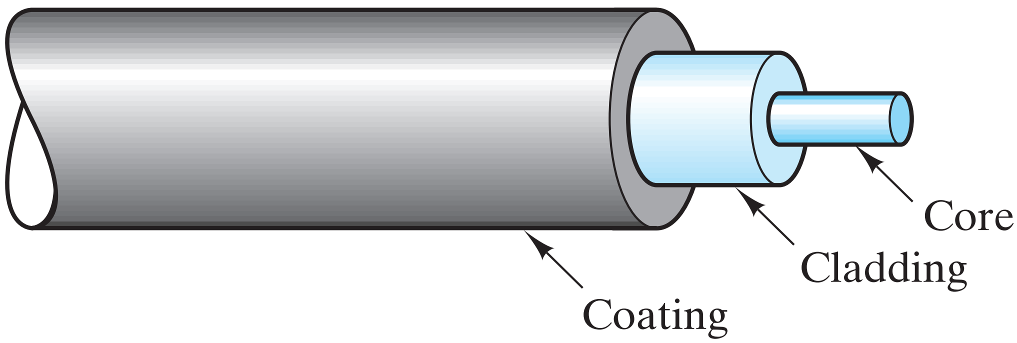


Figure 16-17 *Schematic illustration of the coaxial design of commercial optical fibers.*

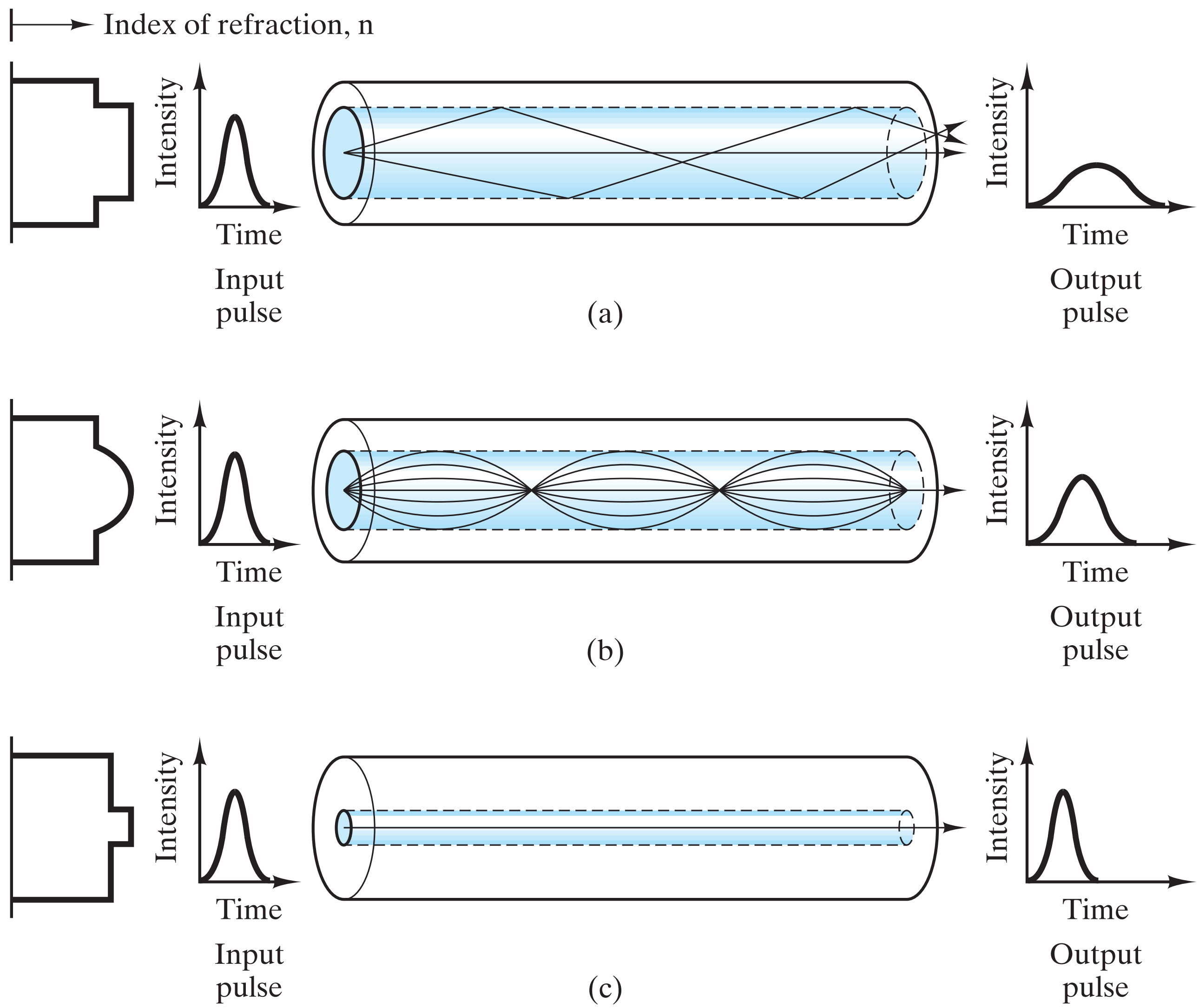


Figure 16-18 *Schematic illustration of (a) step-index, (b) graded-index, and (c) single-mode optical fiber designs.*

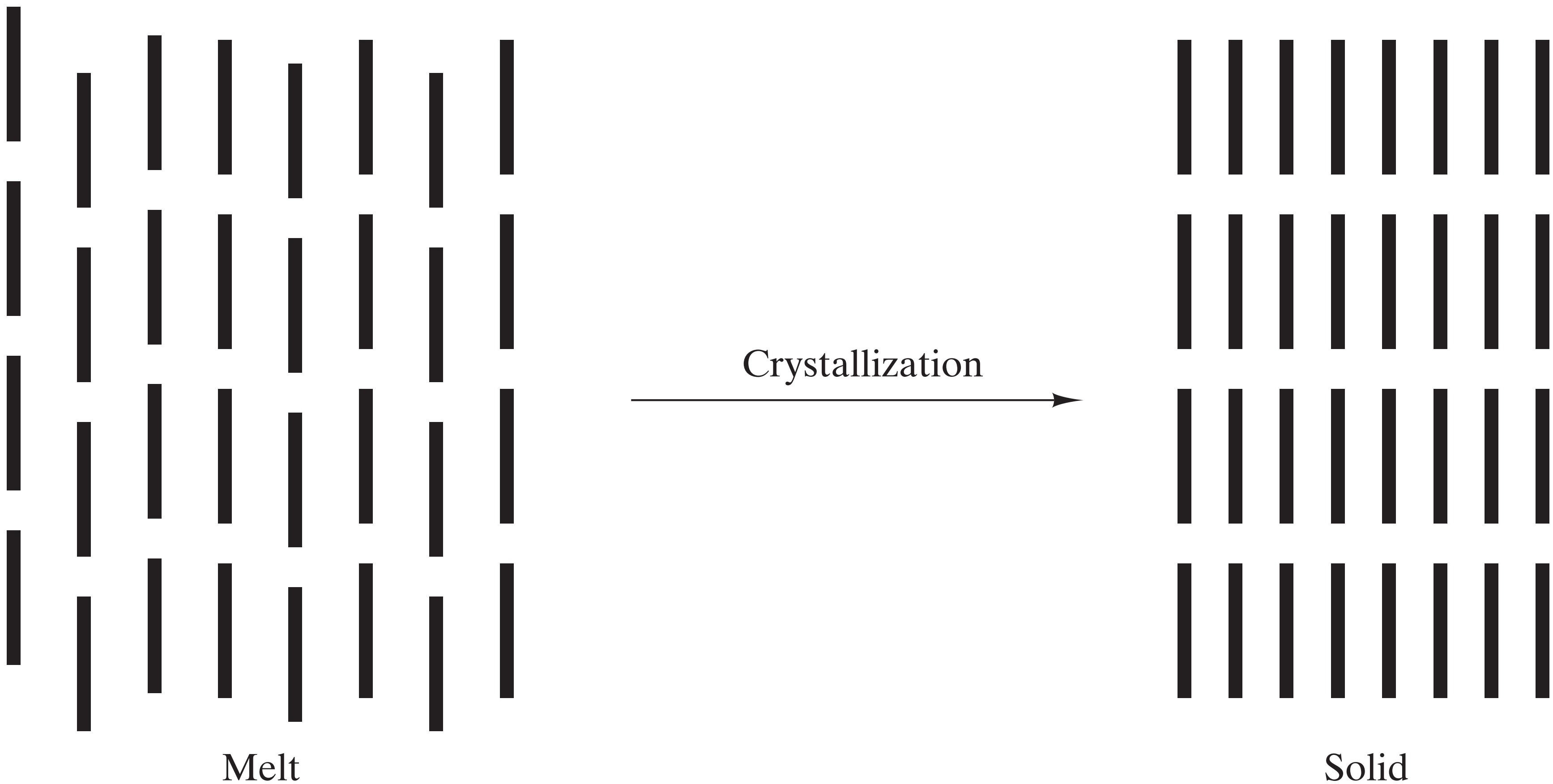


Figure 16-19 *Schematic illustration of the unique structural configuration of liquid crystal polymers.*

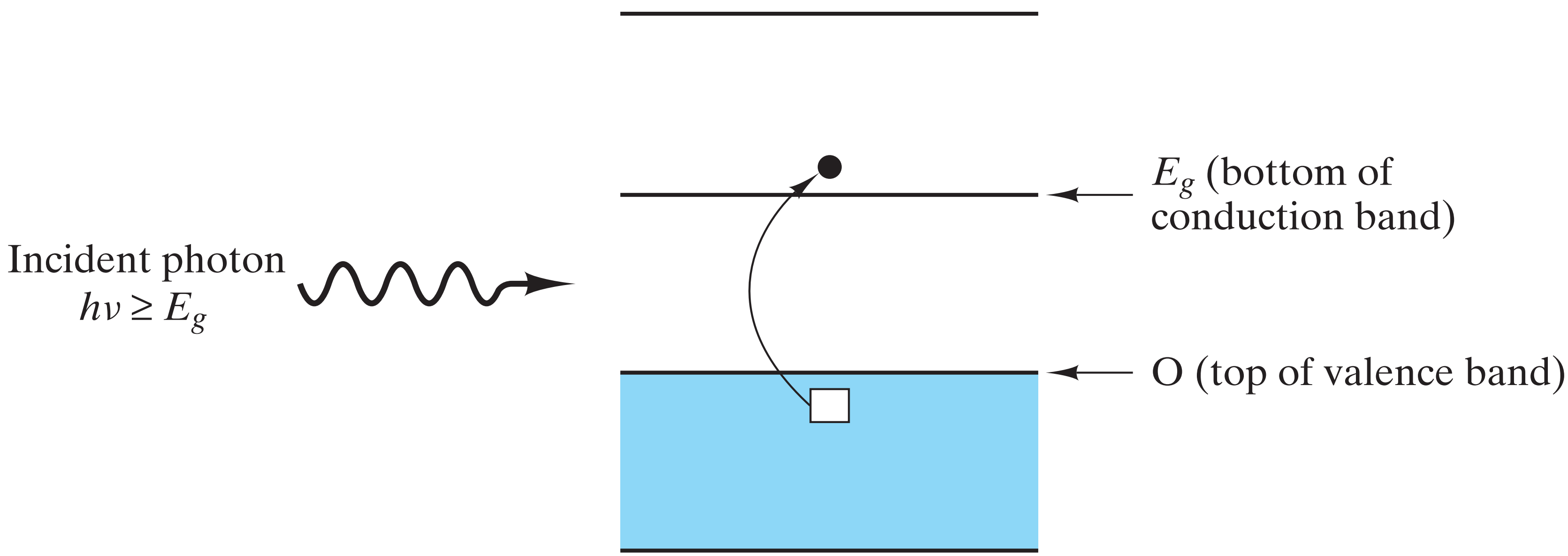


Figure 16-20 *Schematic illustration of photoconduction.*