Integrated Photonics

Figures and Images for Instructors

Module 2

Silicon Photonic Integrated Circuits and Devices

Optics and Photonics Series

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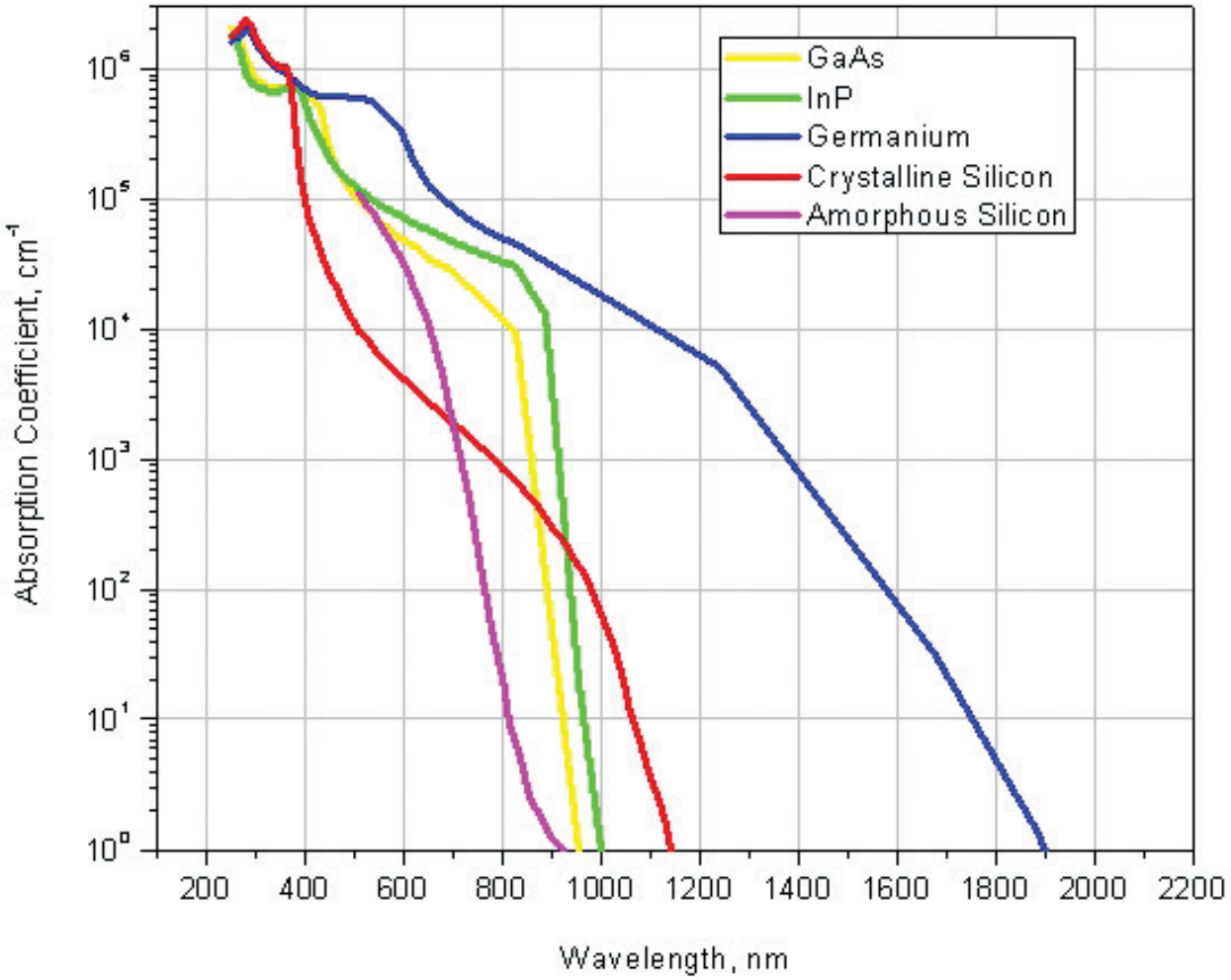


Figure 2-1 *Absorption coefficient of different materials vs. wavelength*

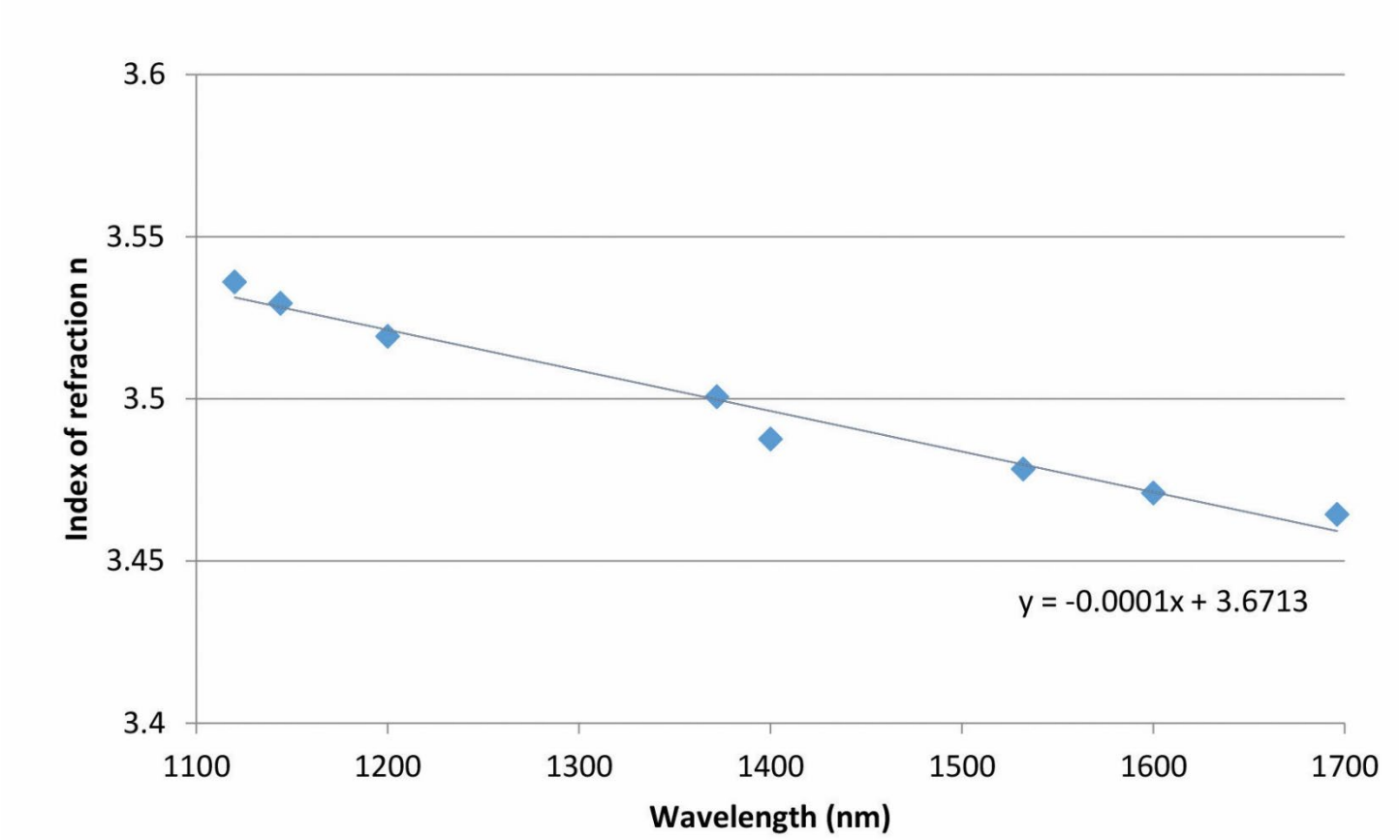


Figure 2-2 *Index of refraction of silicon vs. wavelength*

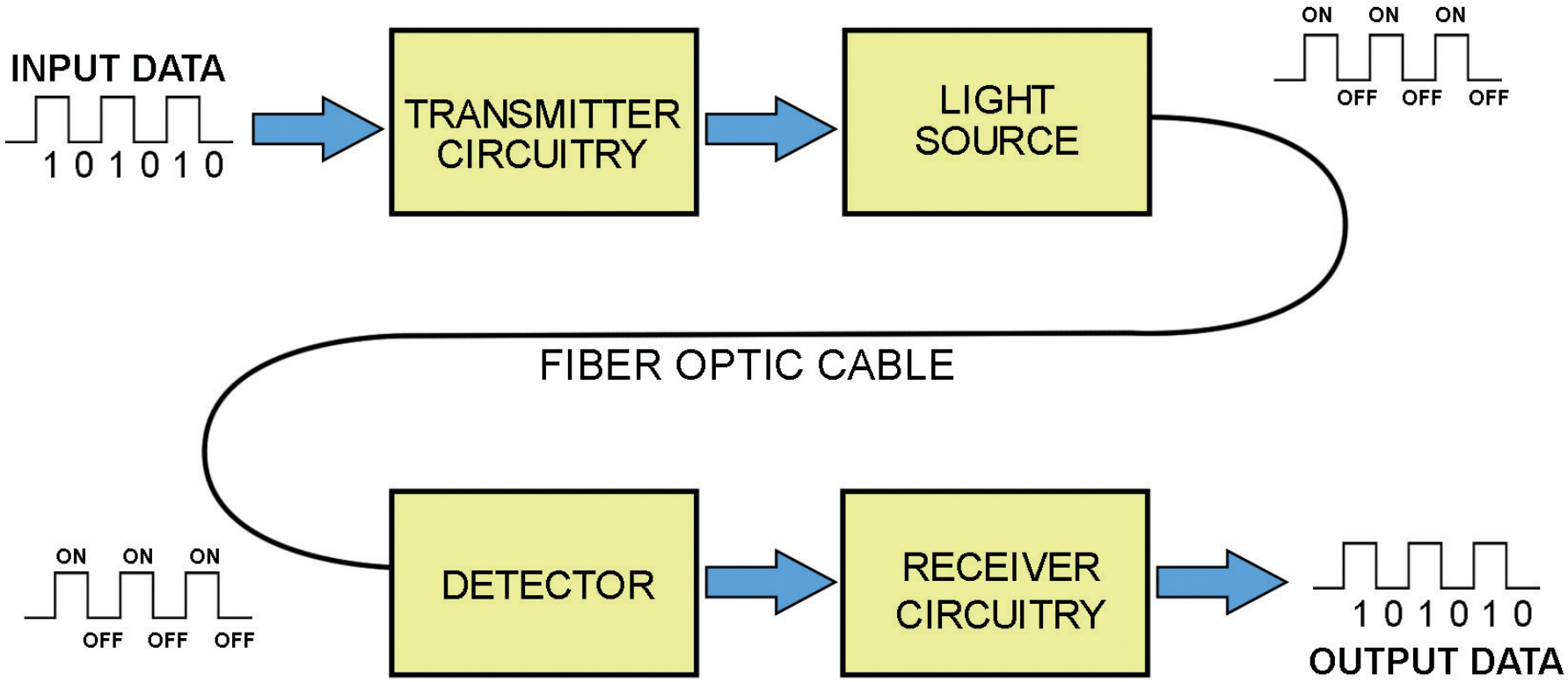


Figure 2-3 *Components of a basic optical fiber transmission system*

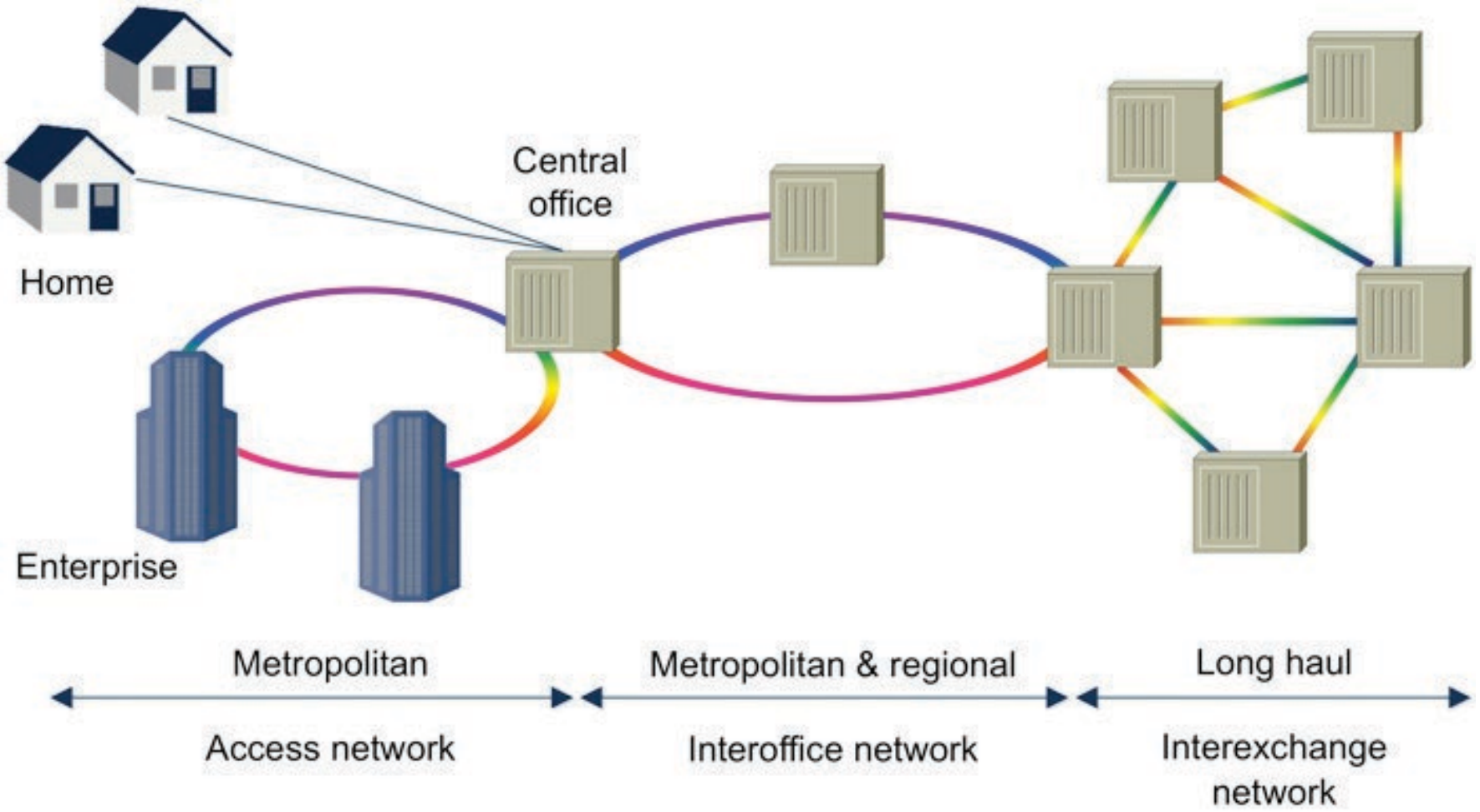


Figure 2-4 *Long haul, regional, and metropolitan networks*

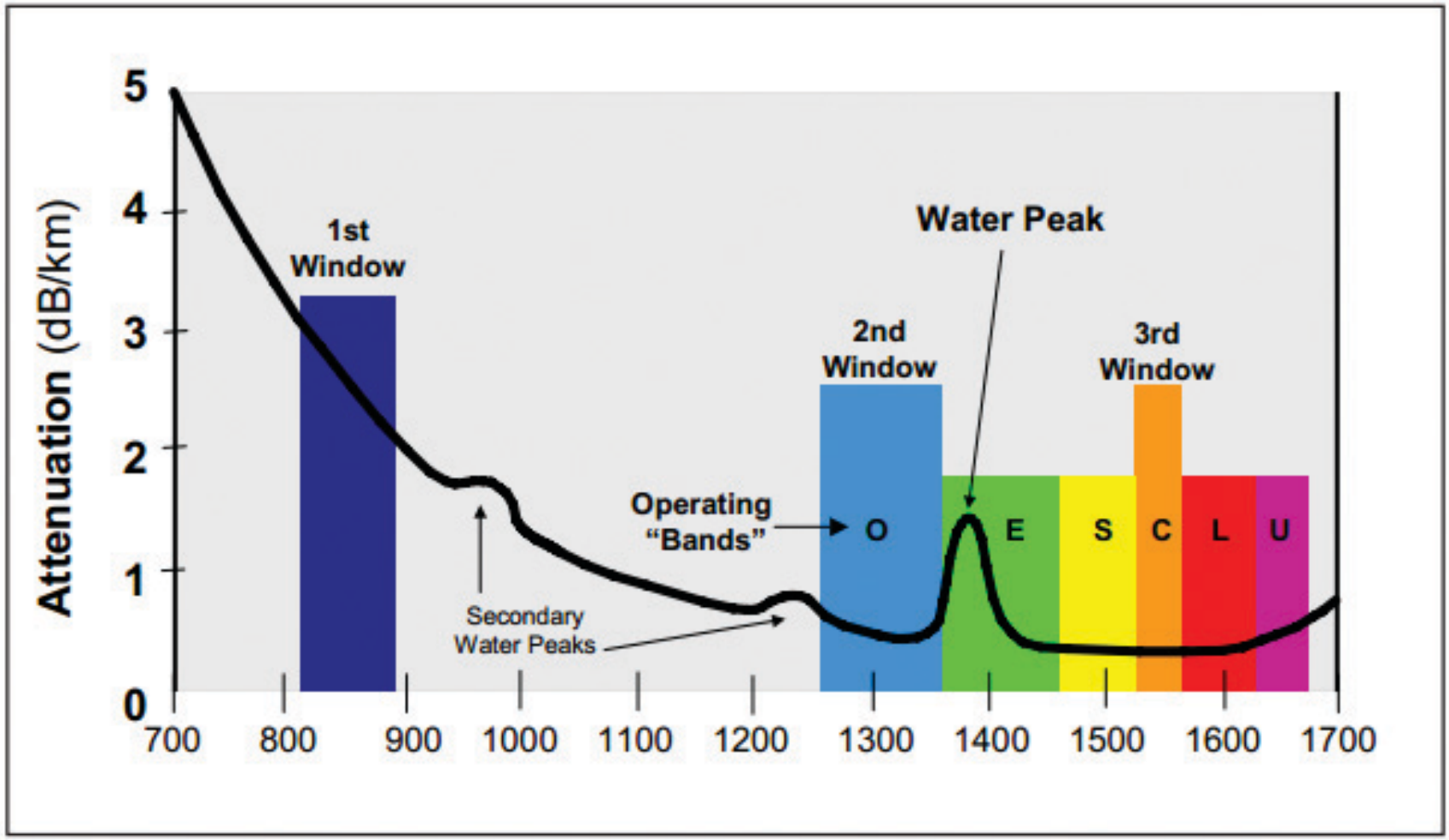


Figure 2-5 *Loss of power in optical fibers vs. wavelength*

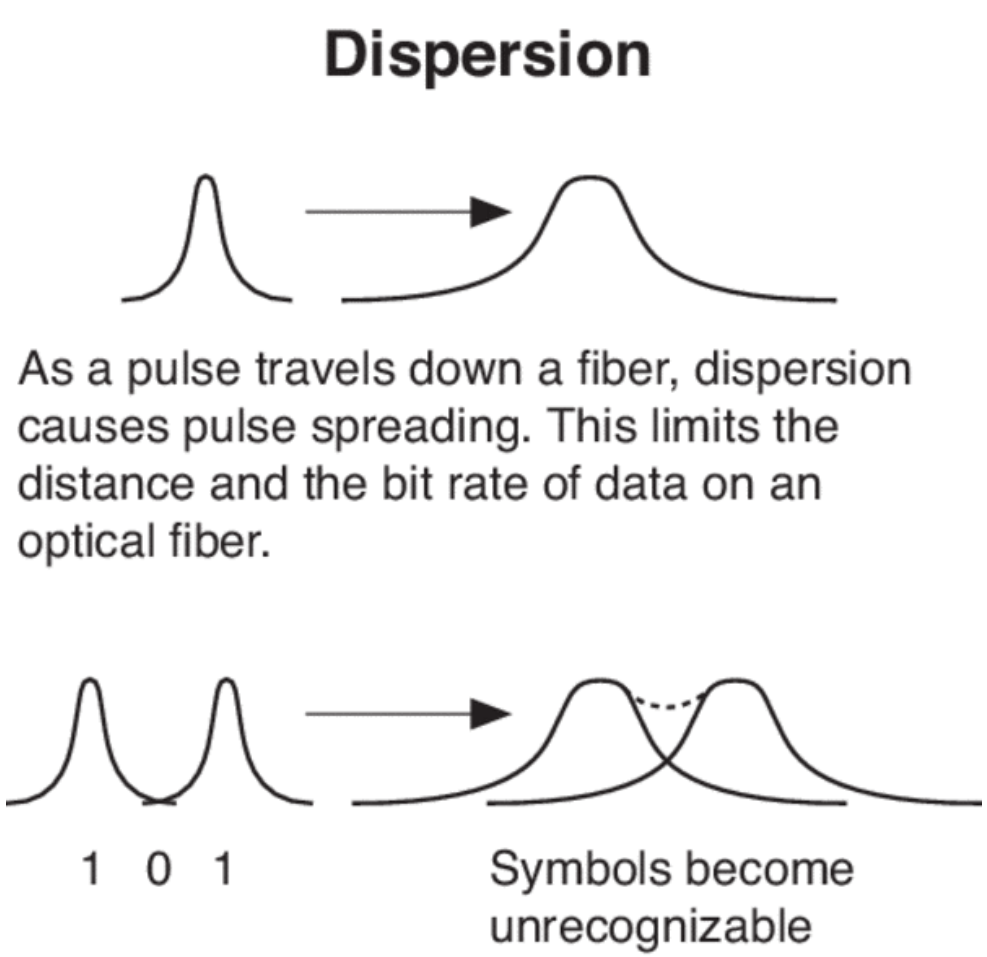


Figure 2-6 *Effect of dispersion on light pulses transmitted through optical fibers*

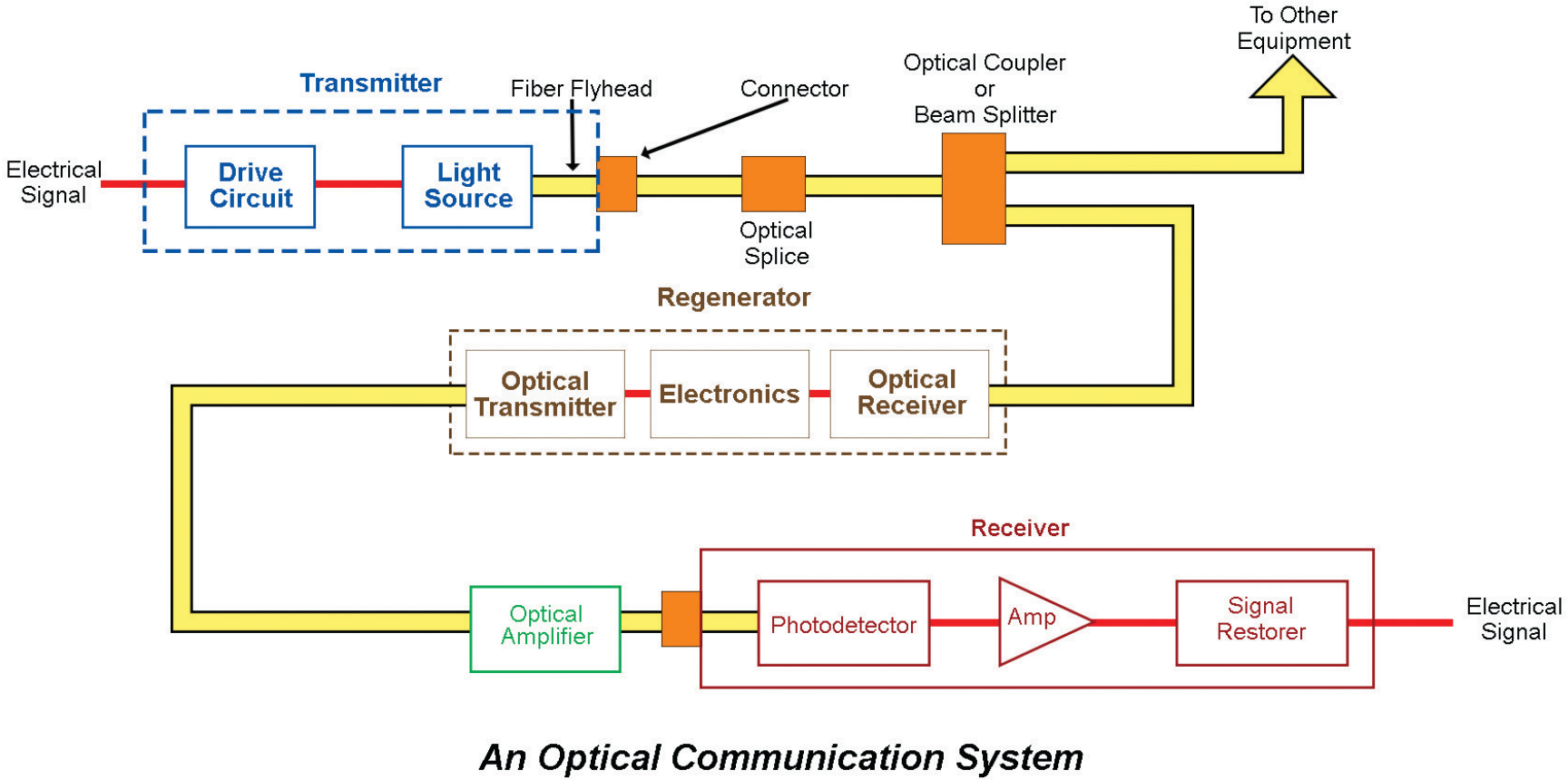


Figure 2-7 *An optical communication system that regenerates the light signal along the transmission path*

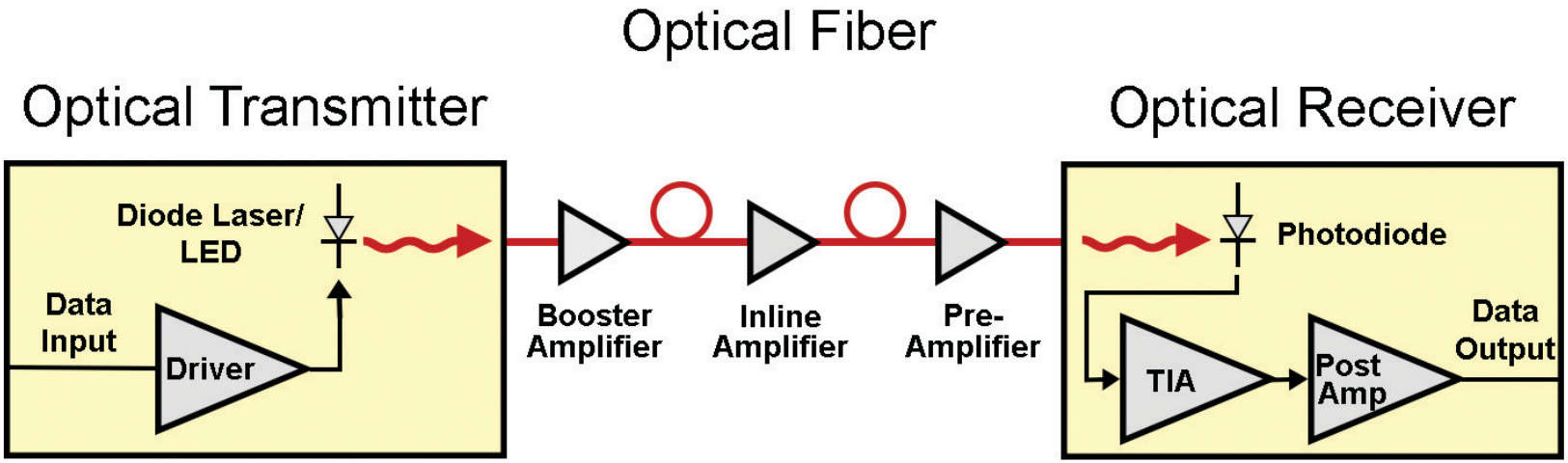


Figure 2-8 *An optical communication system that amplifies the light signal along the transmission path*

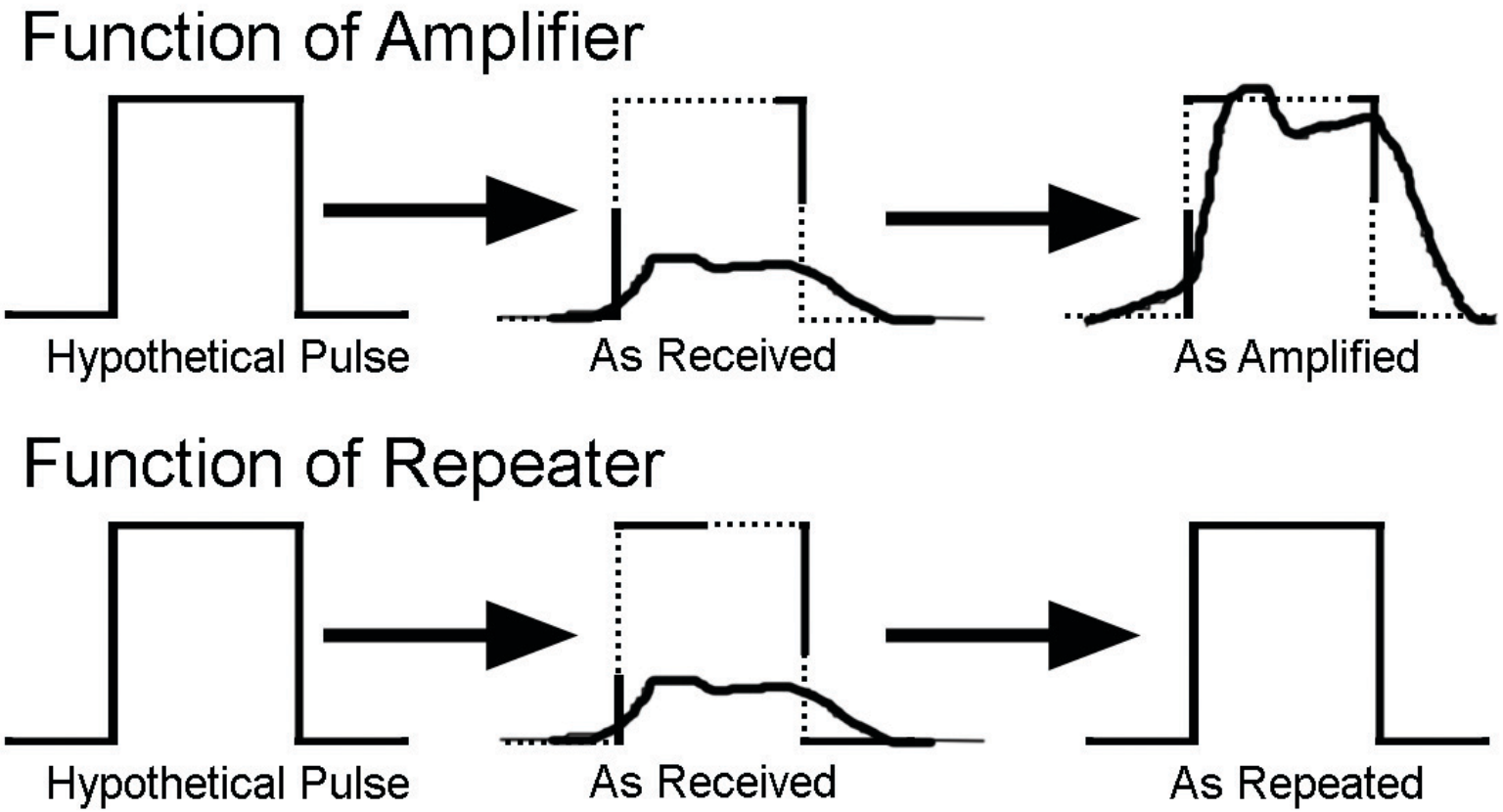
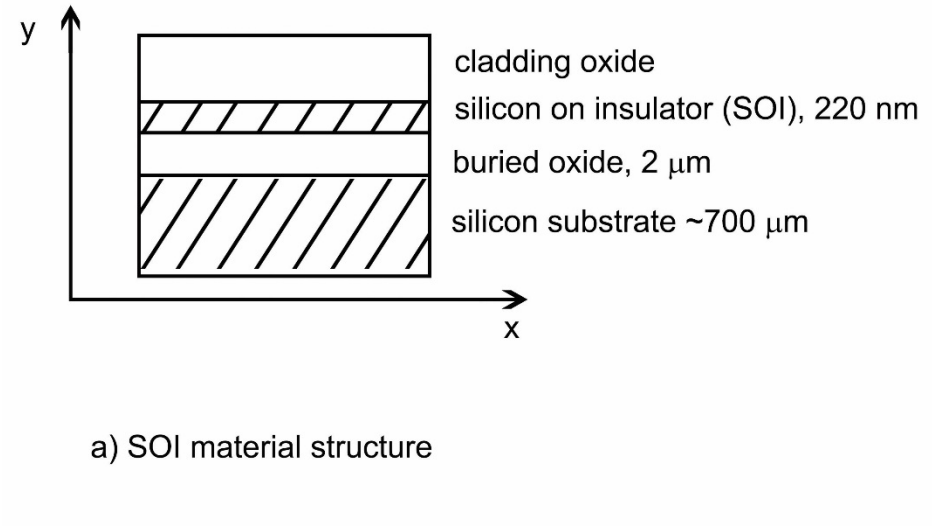


Figure 2-9 *Effect of an amplifier vs. a repeater on a degraded optical signal*



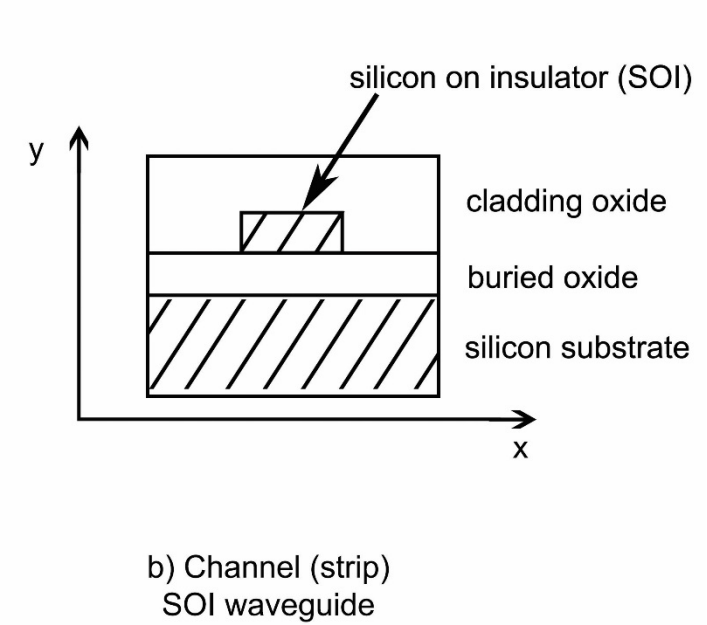


Figure 2-10 a) *SOI material structure*

Figure 2-10 b) *Channel (or strip) SOI waveguide*

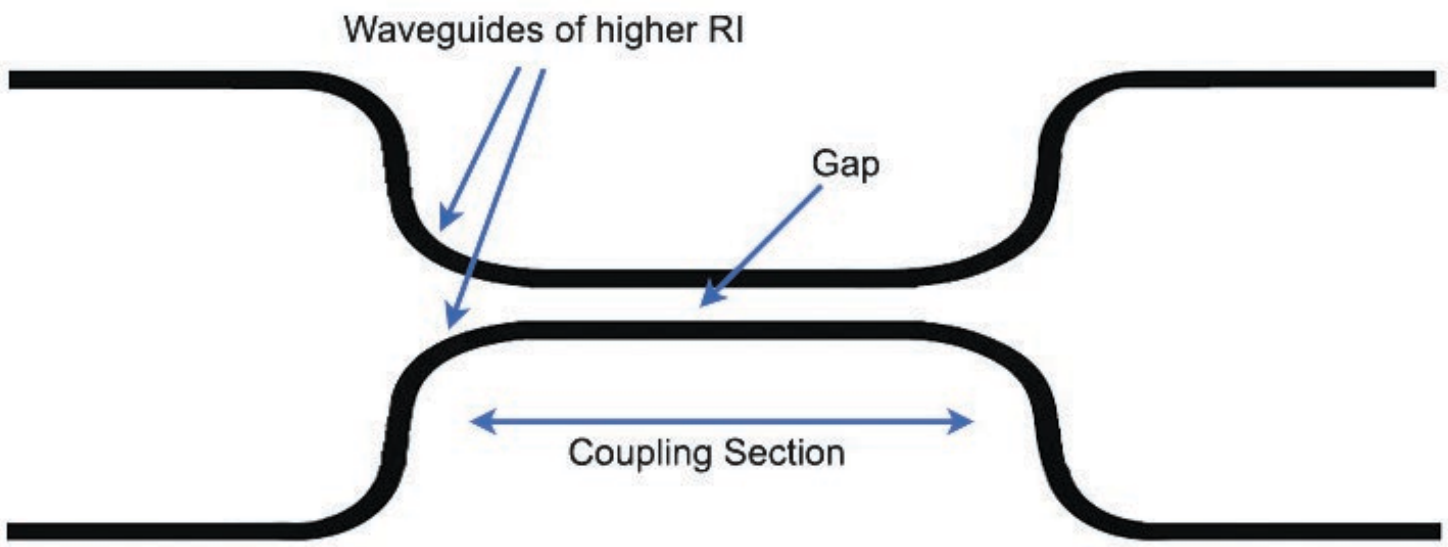


Figure 2-11 *Directional coupler device containing four S-bend waveguides to bring waveguides close to each other and then separate them*

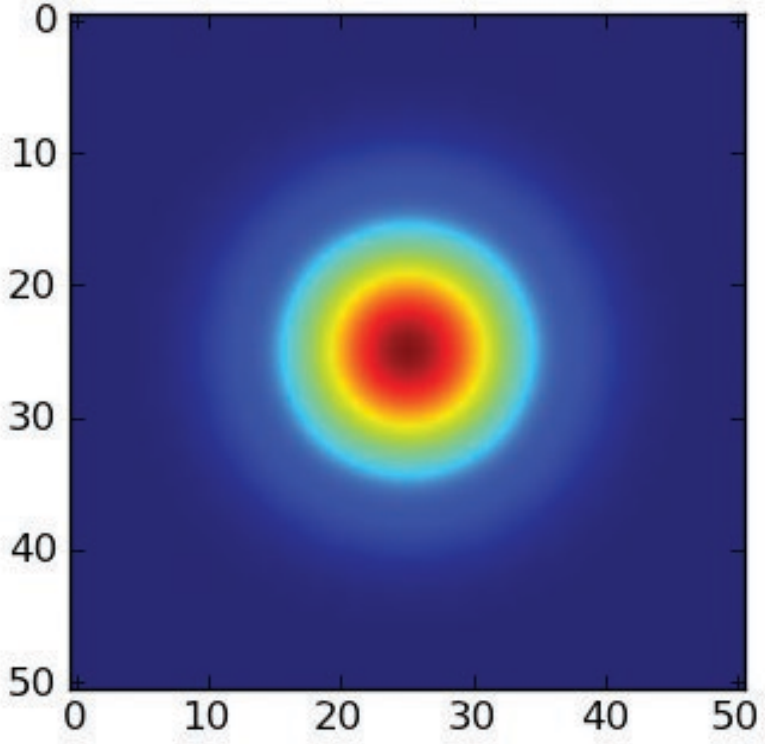


Figure 2-12 a) *Light distribution in optical fiber (TEM_{00})*

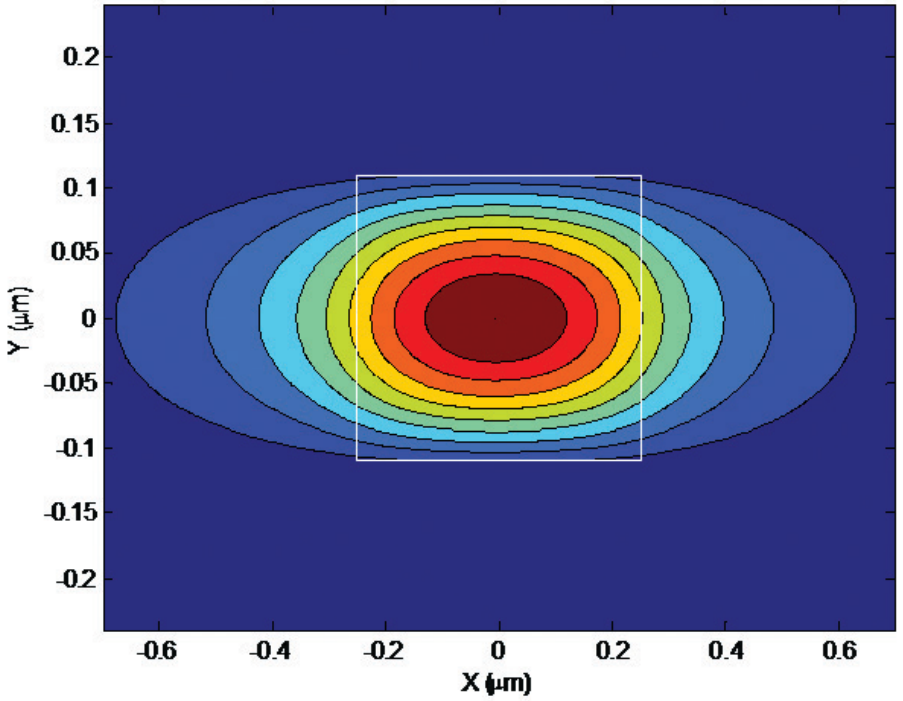


Figure 2-12 b) *SOI waveguide*

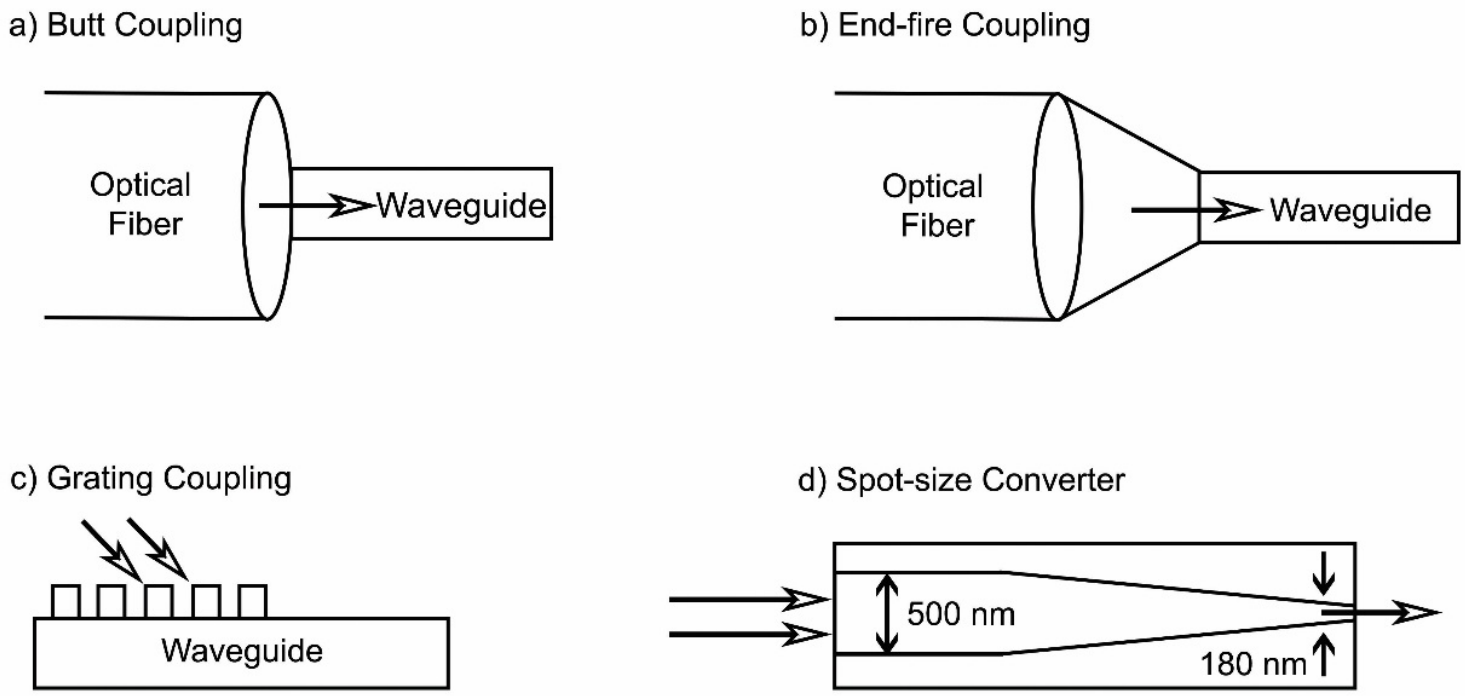


Figure 2-13 a) *Butt coupling*; **b)** *End-fire coupling;* **c)** *Grating coupling;* **d)** *Spot-size converter*

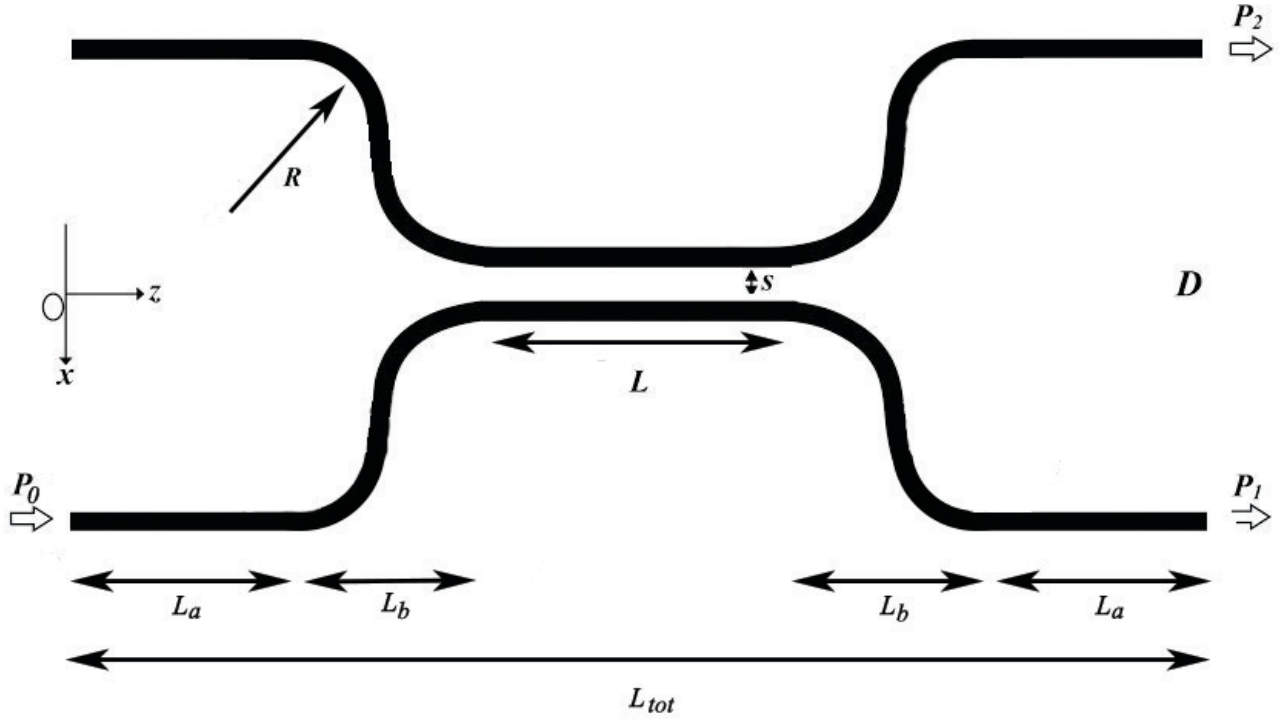


Figure 2-14 *Directional coupler splitting the incident power P_0 into powers P_1 and P_2 in the two output waveguides*

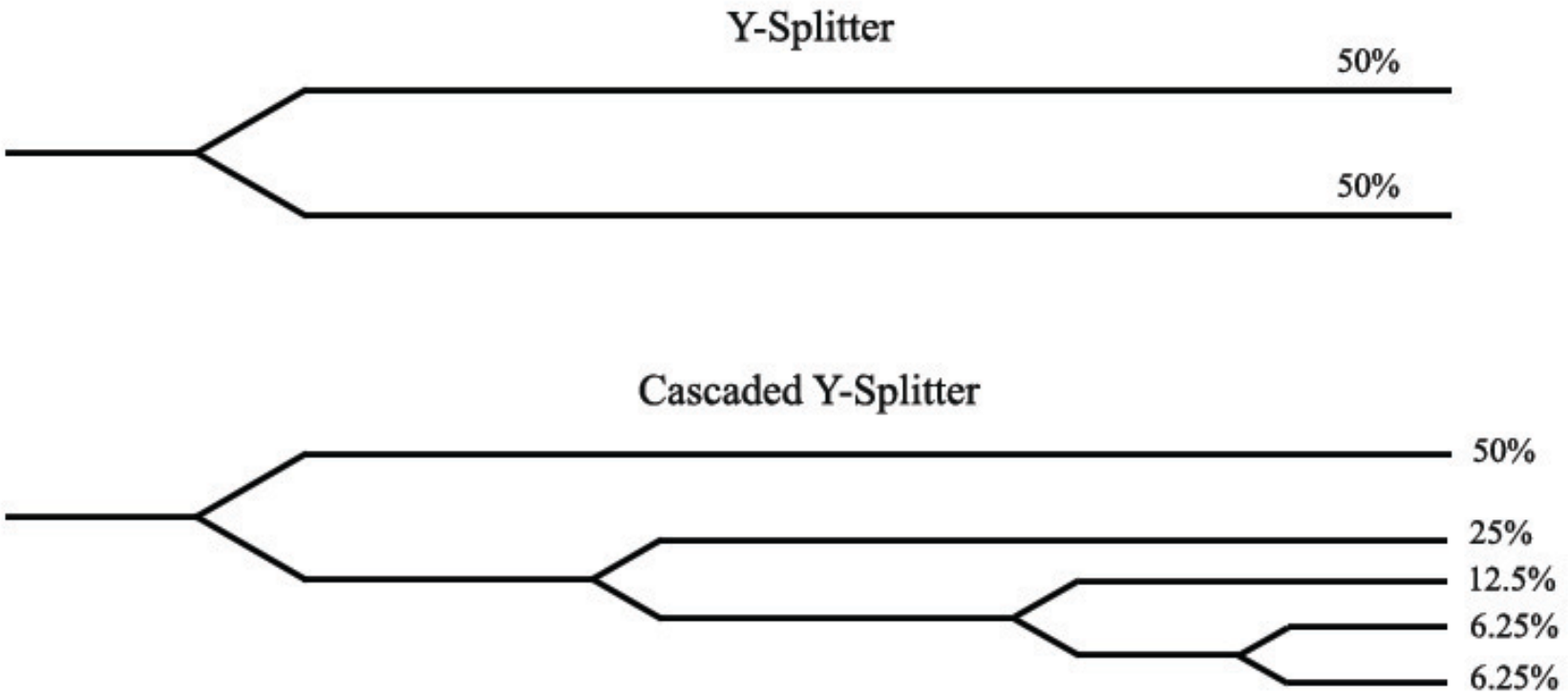


Figure 2-15 *Top: Single Y-branch splitting the incident power into equal powers in the two output waveguides. Bottom: Cascaded Y-branches.*

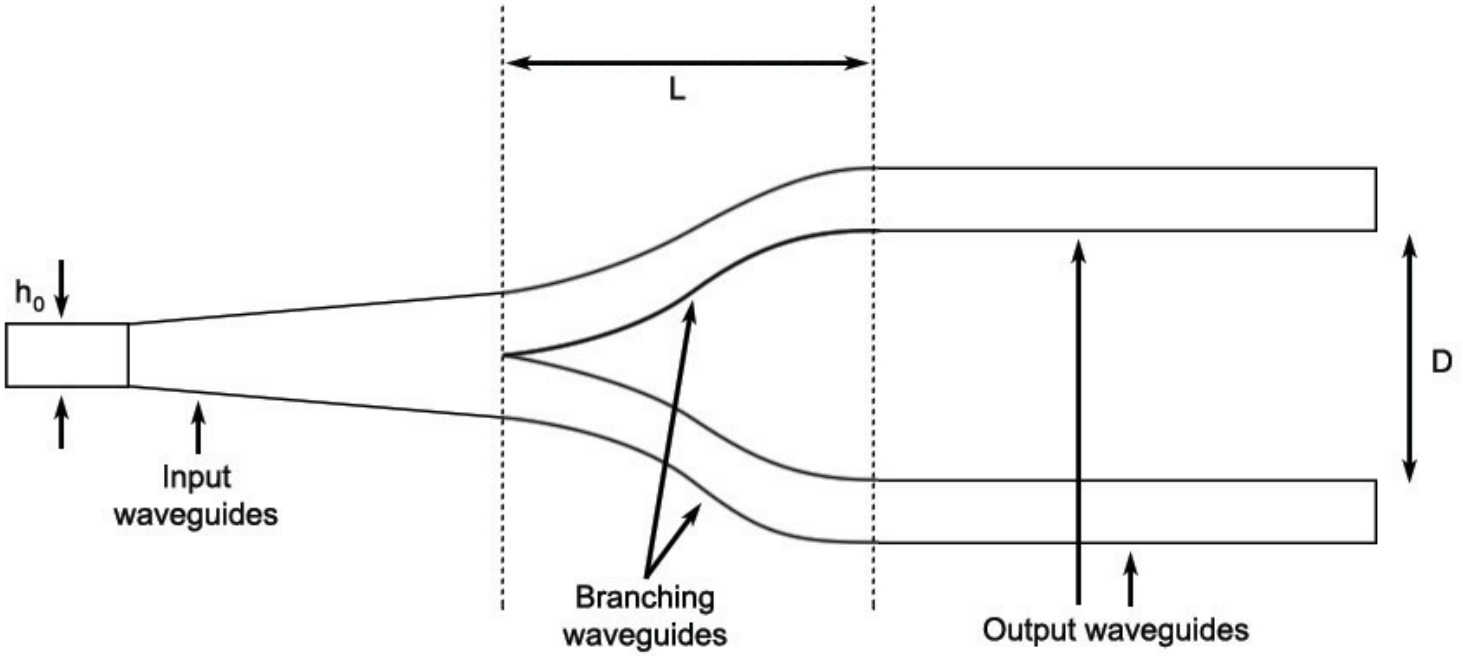


Figure 2-16 *Detailed layout of Y-branch device*

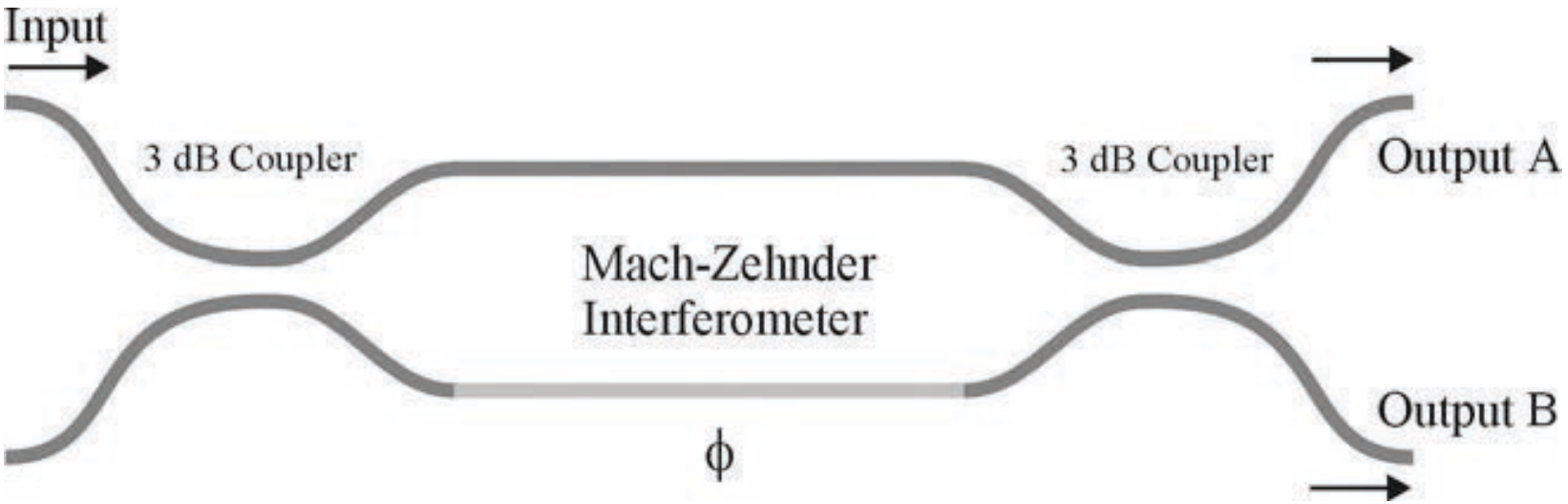


Figure 2-17 *Mach-Zehnder interferometer based on 3dB directional couplers*

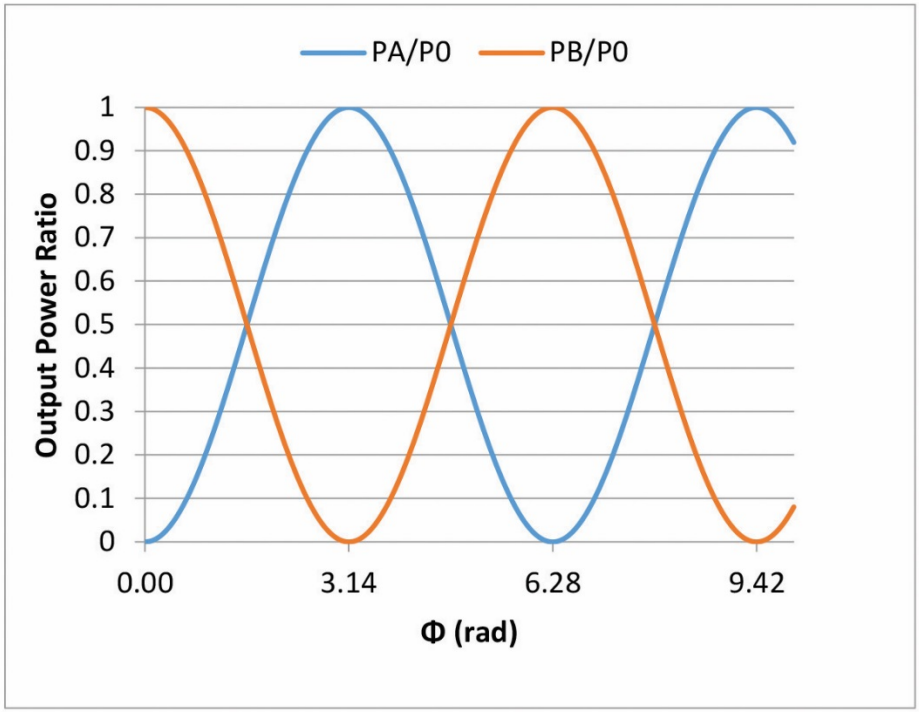


Figure 2-18 a) *Output powers A and B, normalized to input power as a ratio vs. the phase difference between the interferometer arms*

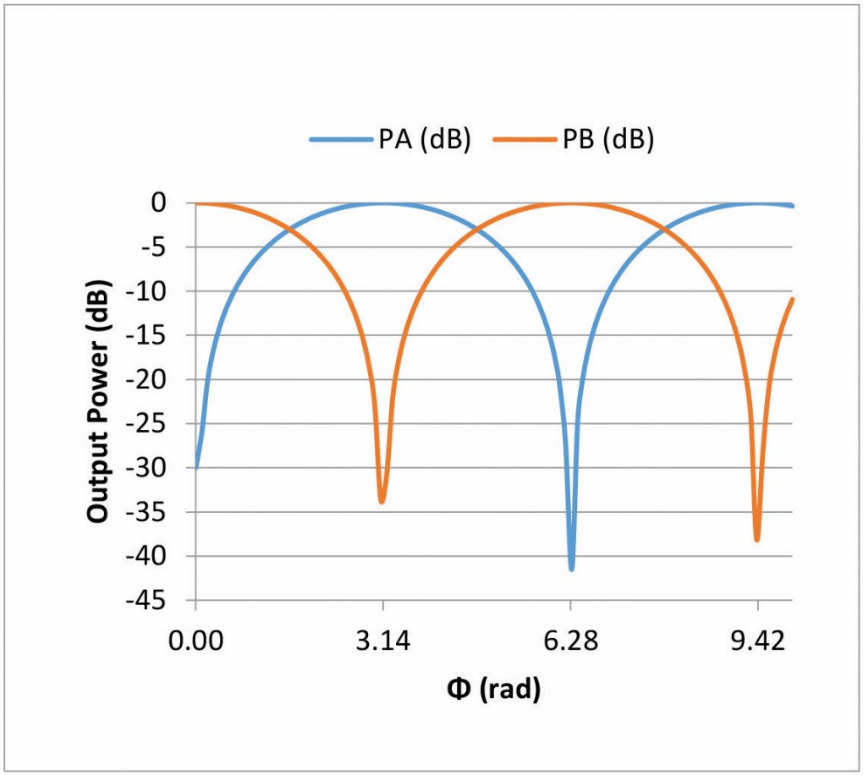


Figure 2-18 b) *Output powers A and B, expressed in dB vs. the phase difference between the interferometer arms*

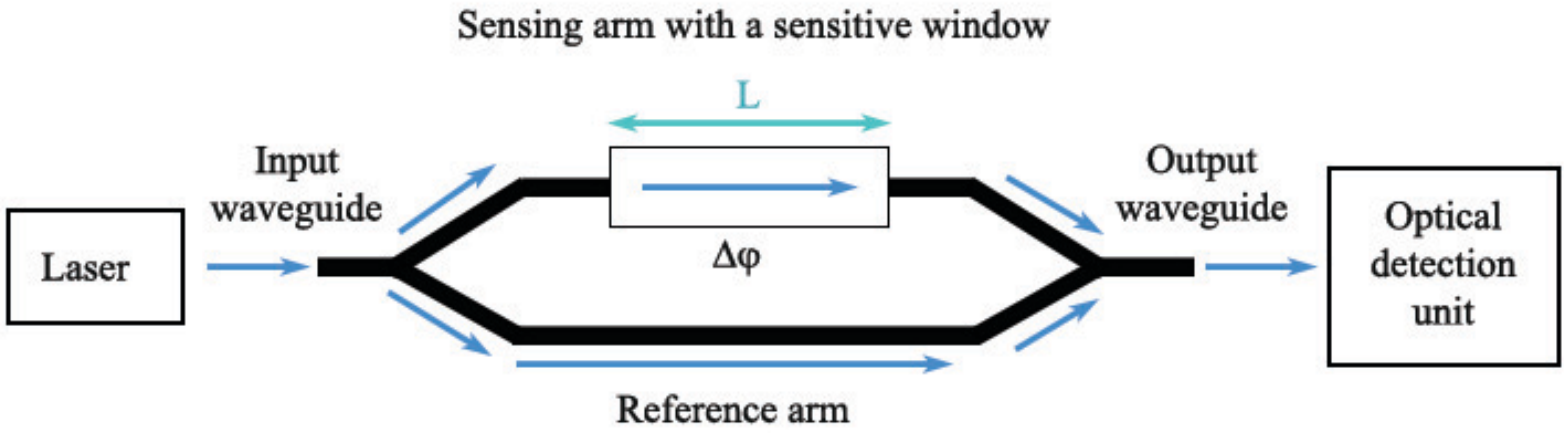


Figure 2-19 *MZI device used in biochemical sensing*

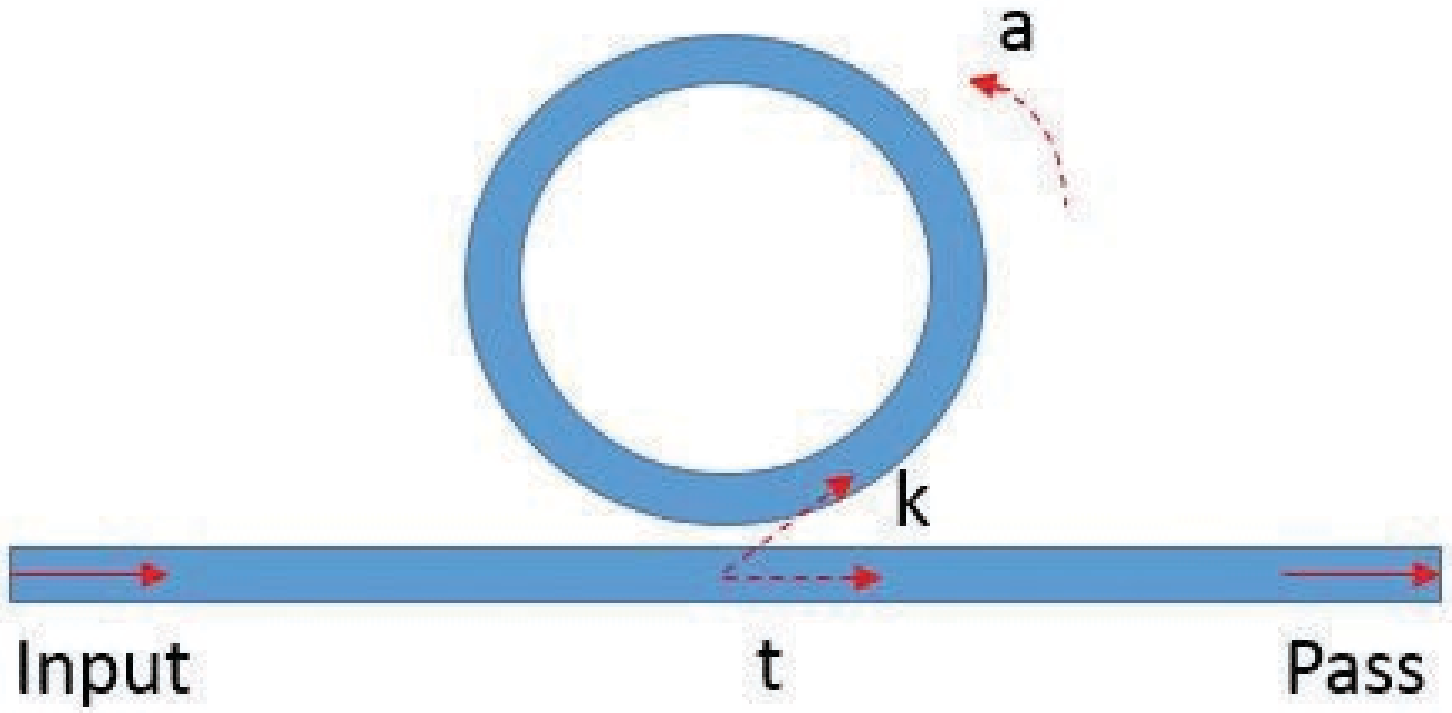


Figure 2-20 *Ring resonator PIC device*

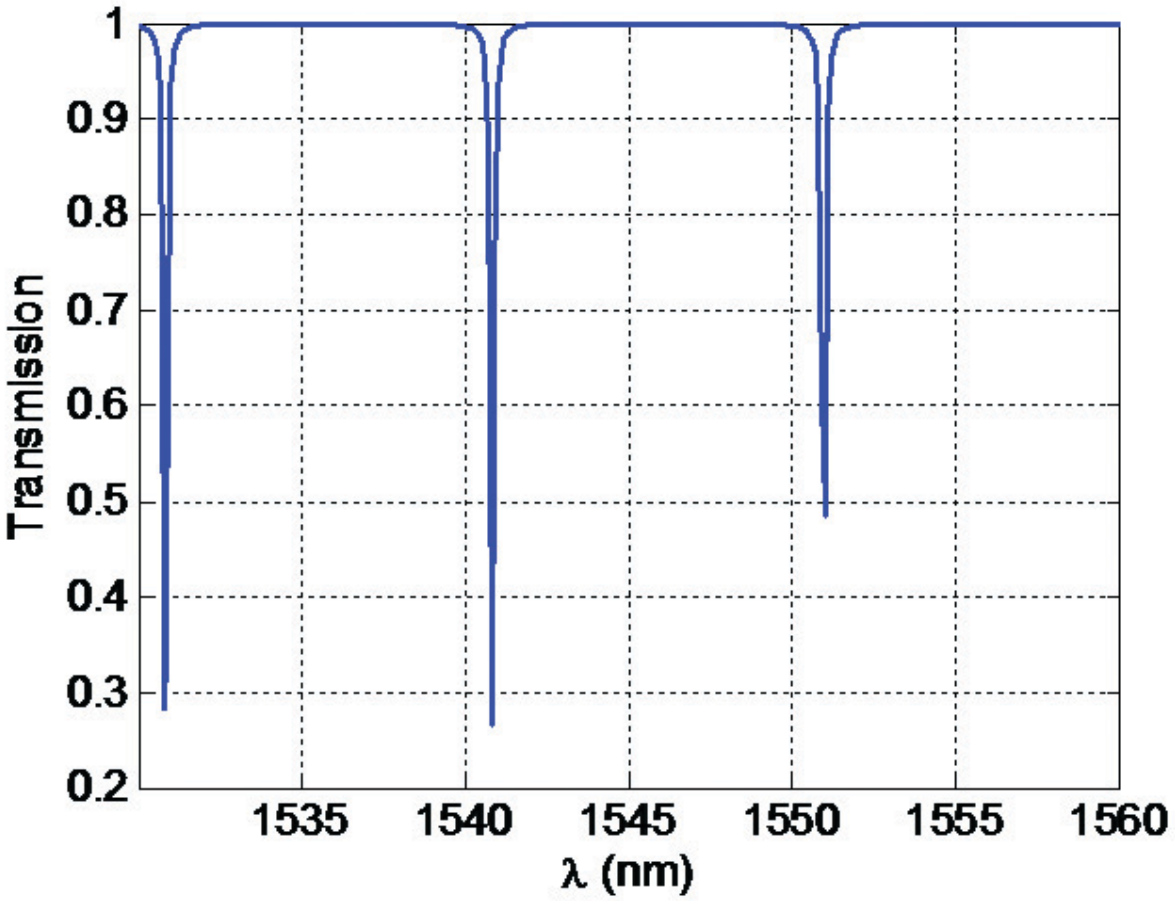


Figure 2-21 *Notch filter transmission vs. wavelength. Resonant wavelengths appear at approximately 1531, 1541, and 1551 nm, with an FSR of about 10 nm.*

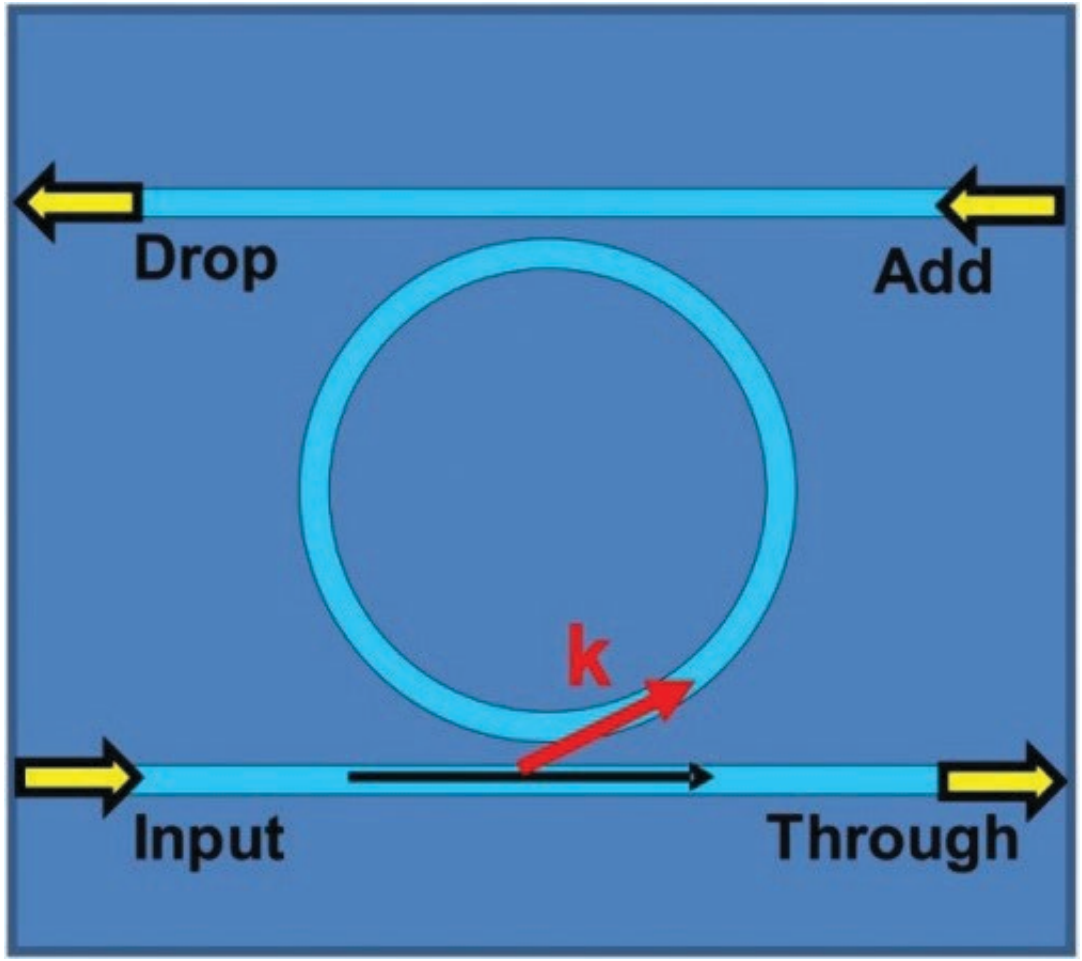


Figure 2-22 *Add-drop filter based on four-port ring resonator device*

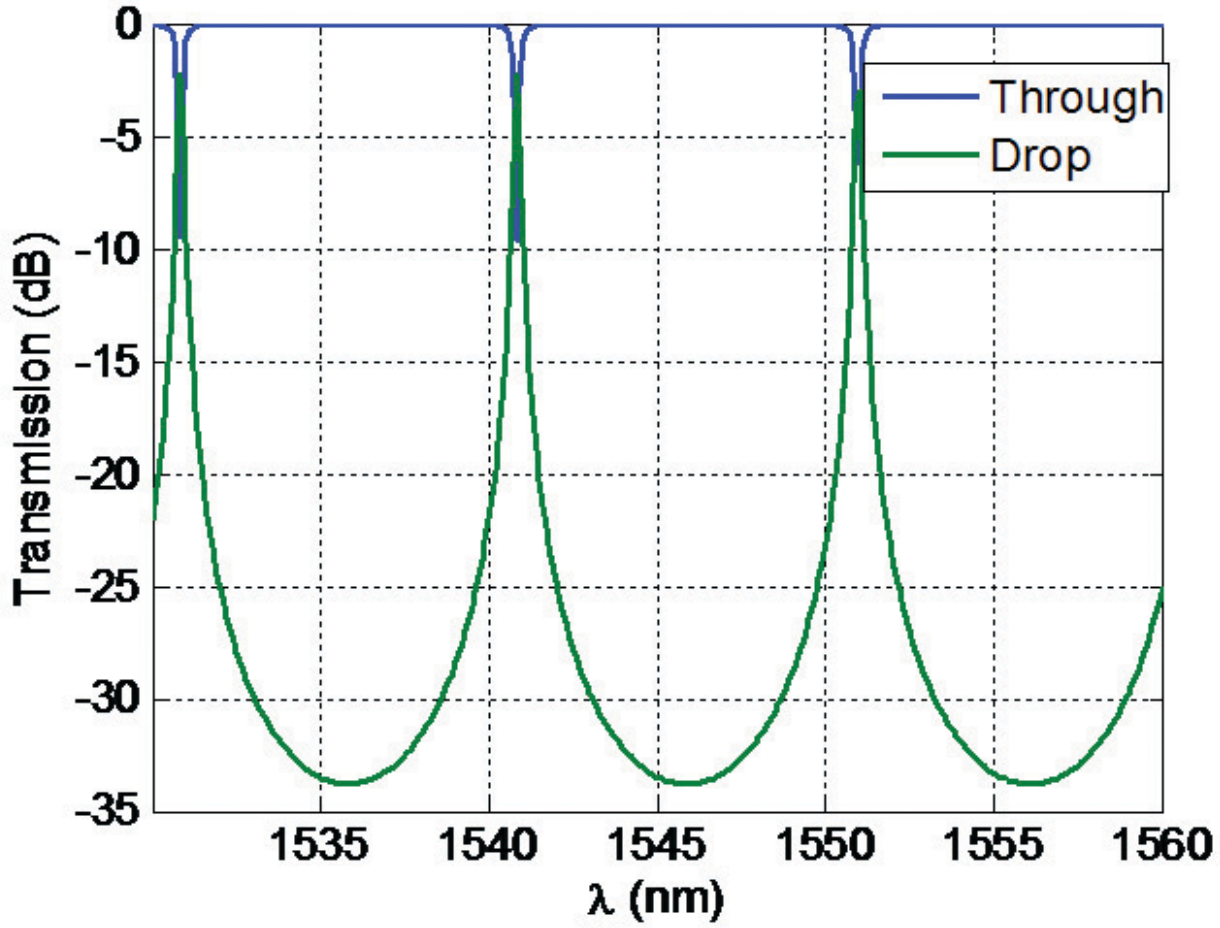


Figure 2-23 *Add-drop filter transmission for the Through and Drop ports vs. wavelength. Resonant wavelengths once again appear at approximately 1531, 1541, and 1551 nm.*

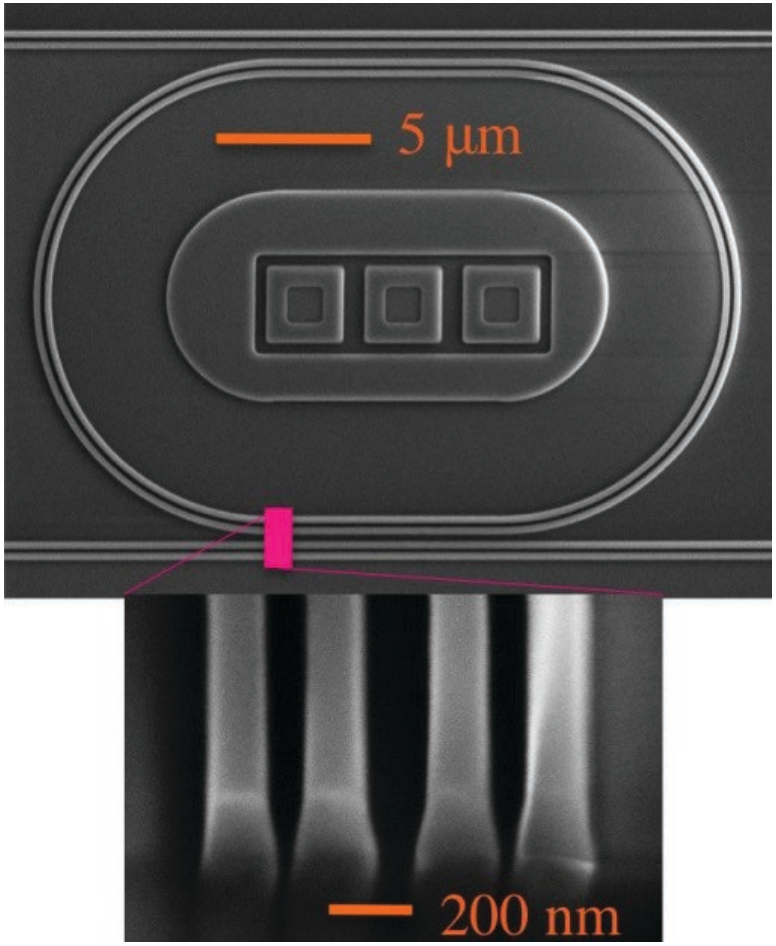


Figure 2-24 *Add-drop filter in racetrack configuration*

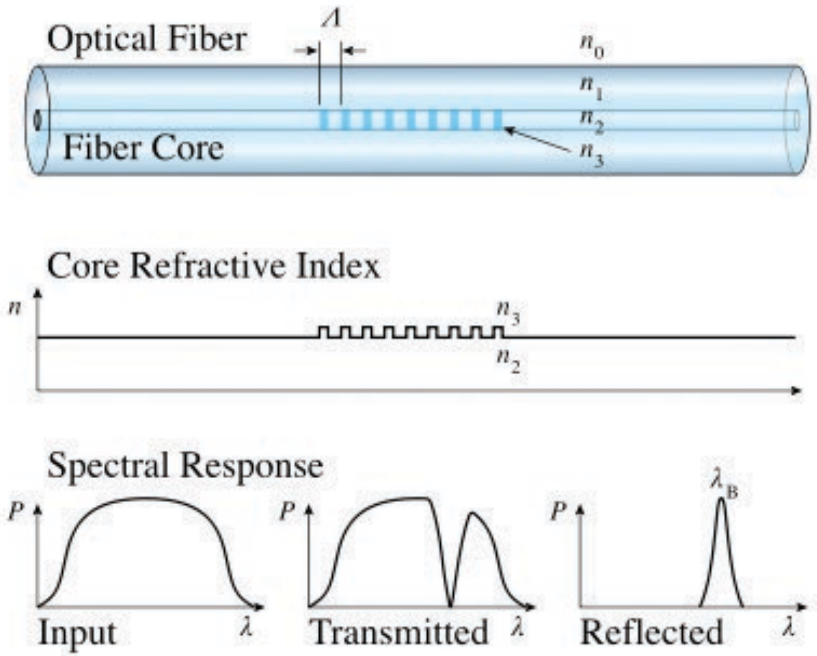


Figure 2-25 a) *Optical fiber Bragg grating and core refractive index along fiber*

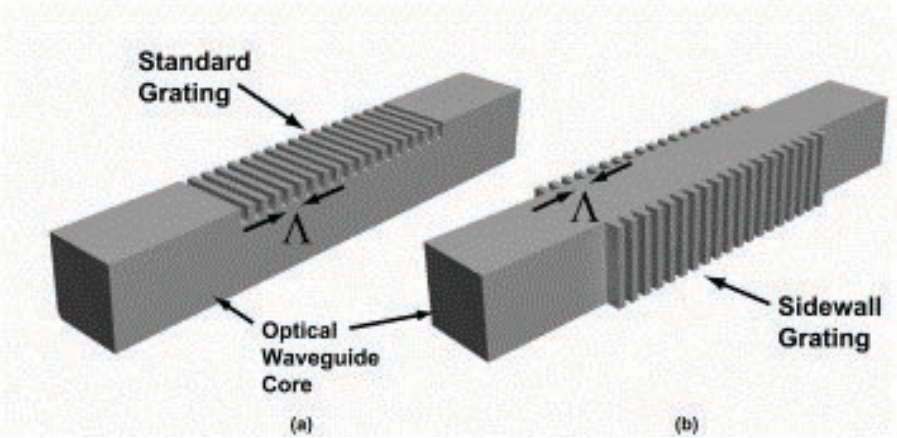


Figure 2-25 b) *Planar waveguide Bragg grating. In one, the grating sits at the top of the waveguide. In the other, the grating is created on the waveguide sidewalls.*

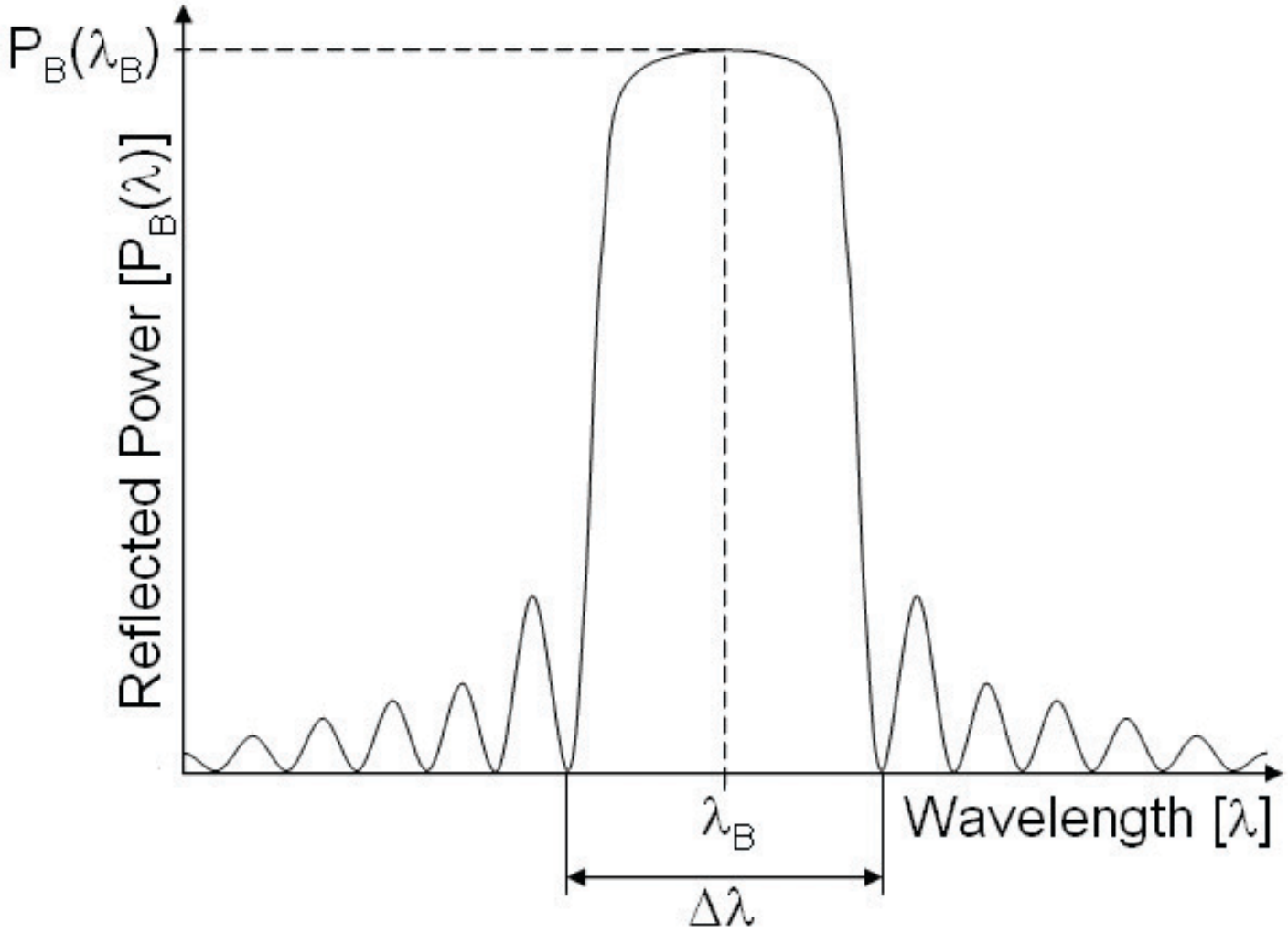


Figure 2-26 *Optical power reflected from a Bragg grating vs. wavelength*

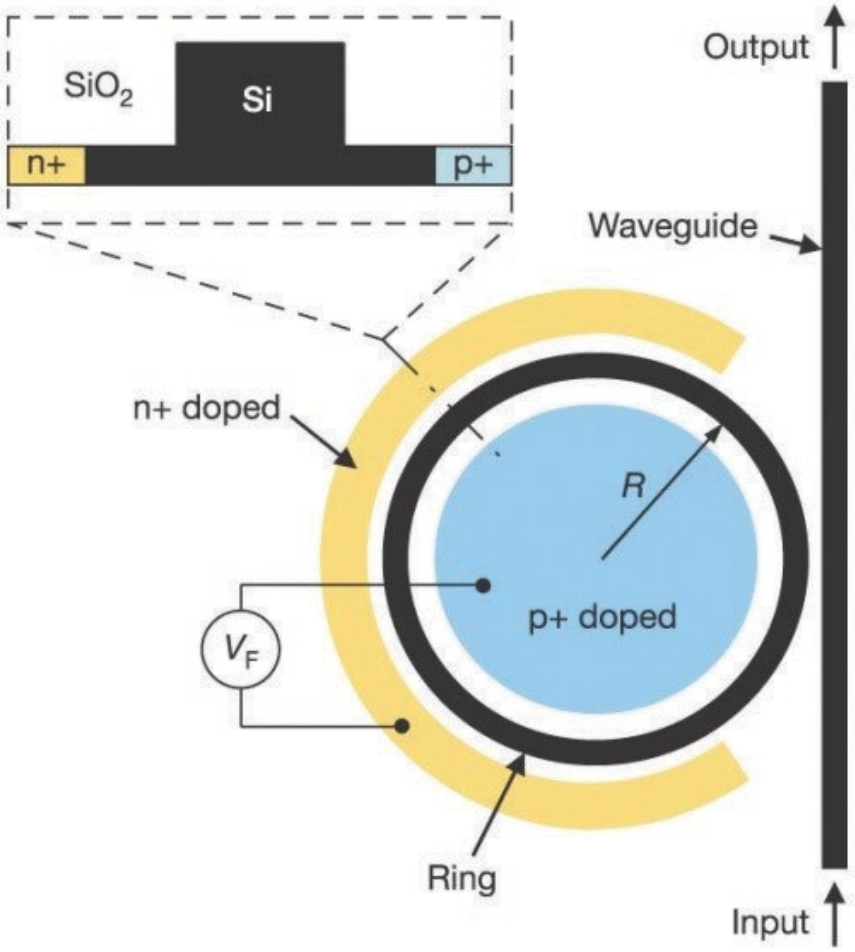


Figure 2-27 *An SOI micro-ring modulator based on the plasma dispersion effect*

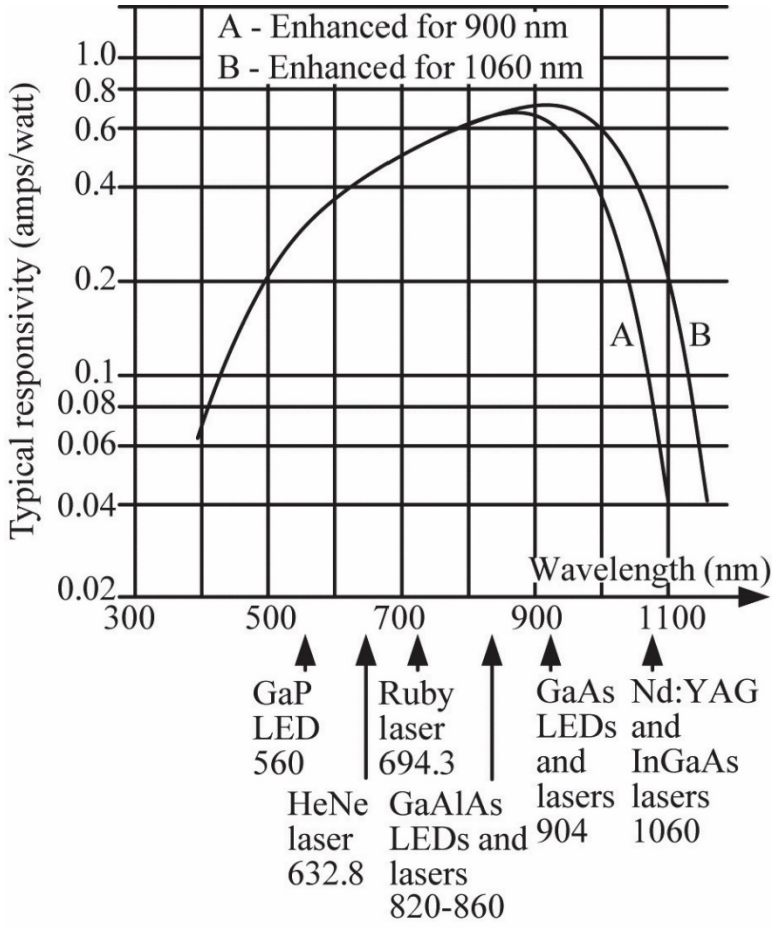


Figure 2-28 *Spectral responsivity of silicon PIN photodiodes*

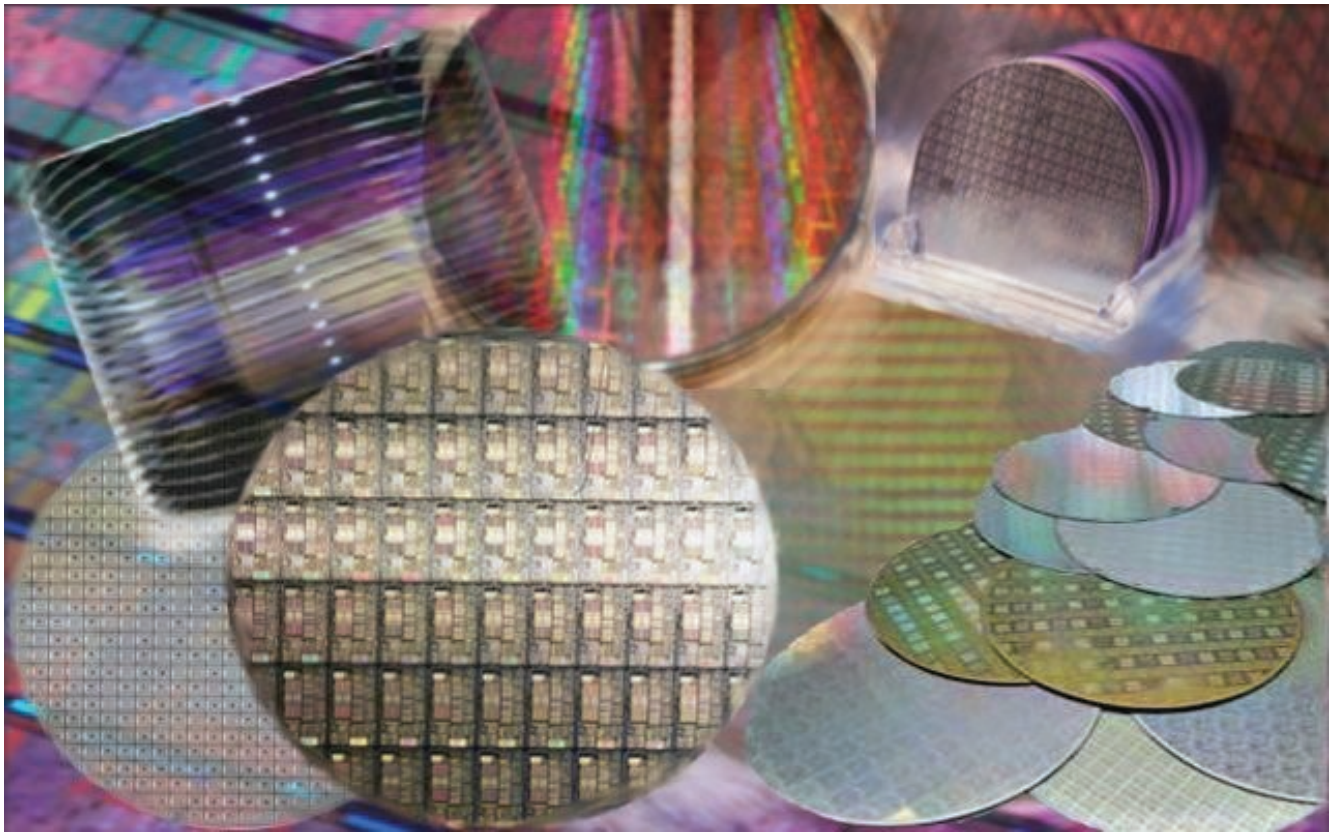


Figure 2-29 *Silicon wafers containing many identical PIC devices created by the fabrication process described in Module 1*

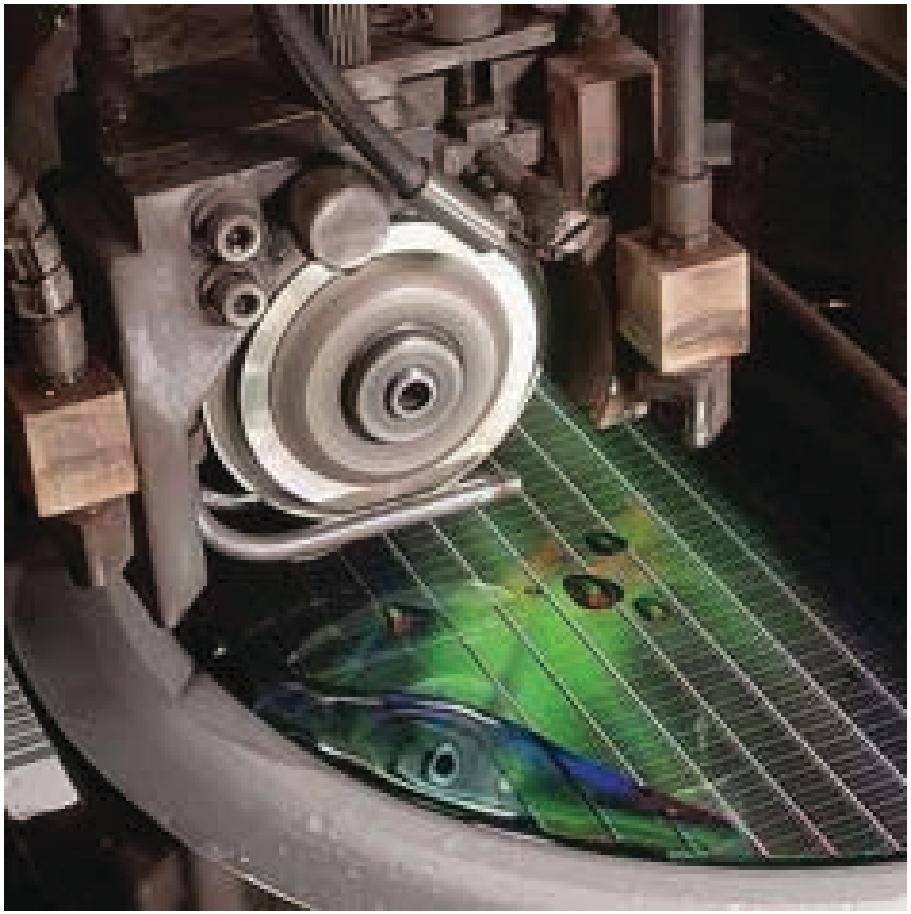


Figure 2-30 *Dicing of wafer into individual devices. Courtesy of Advanced Motion Controls.*

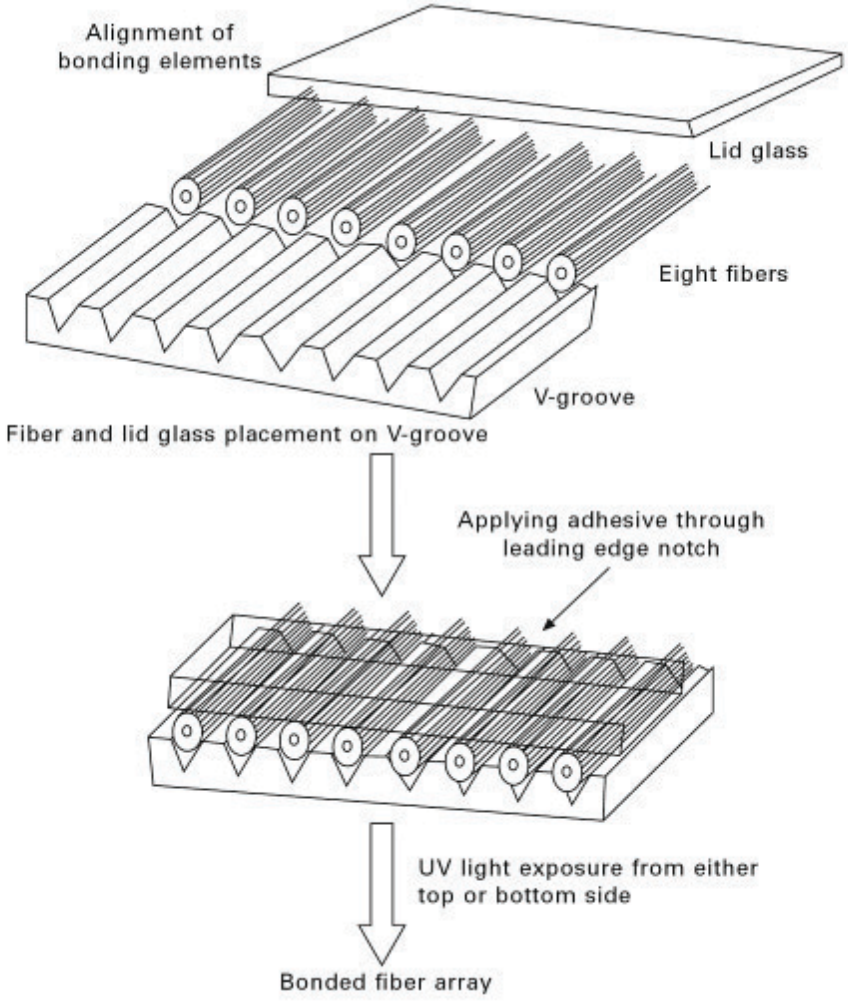


Figure 2-31 *Fiber array fabrication*

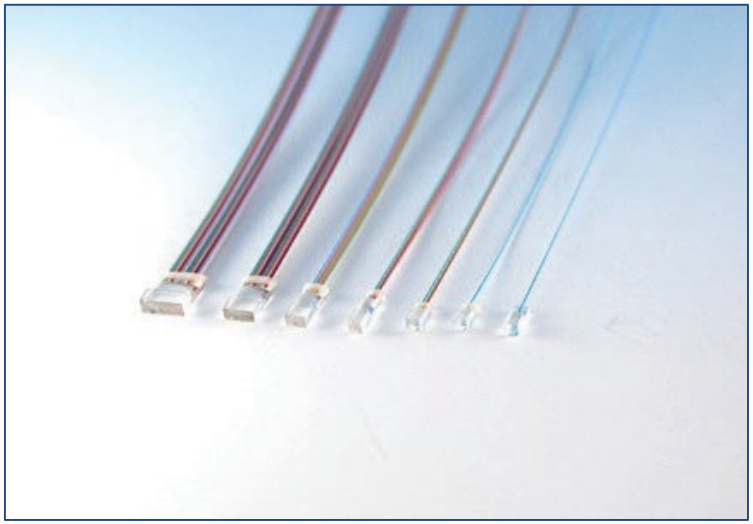


Figure 2-32 a) *Fiber arrays, courtesy of AiDi*

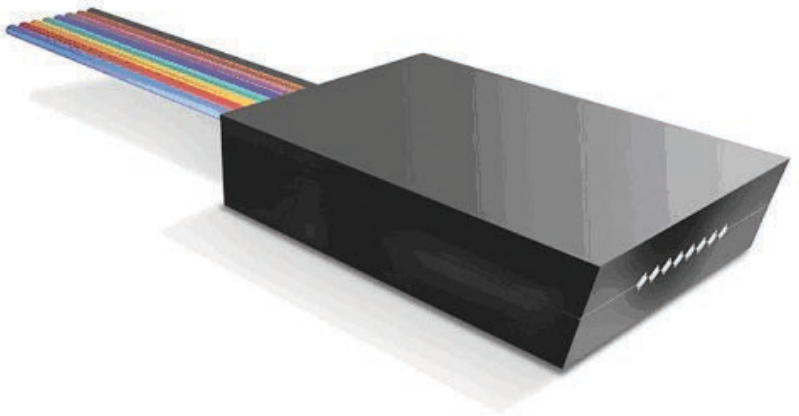


Figure 2-32 b) *Fiber array, courtesy of Hantech. This fiber array is angle polished to avoid back reflections of the optical signal.*

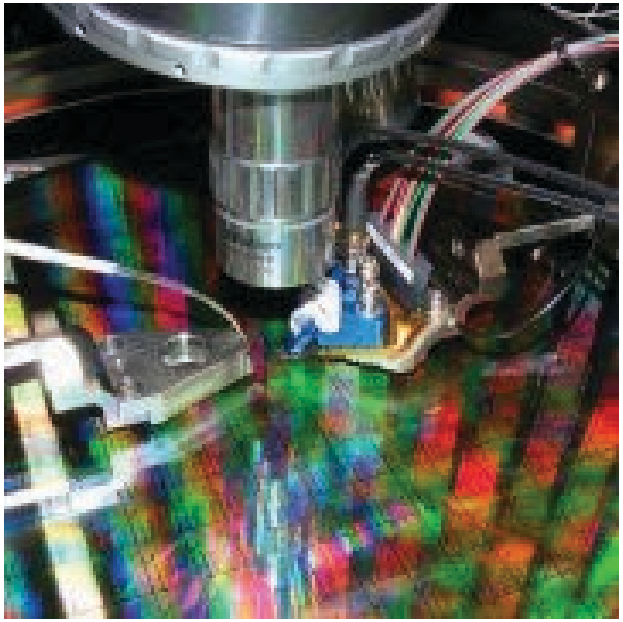


Figure 2-33 a) *Wafer level testing of PICs, courtesy of ACTPHAST*

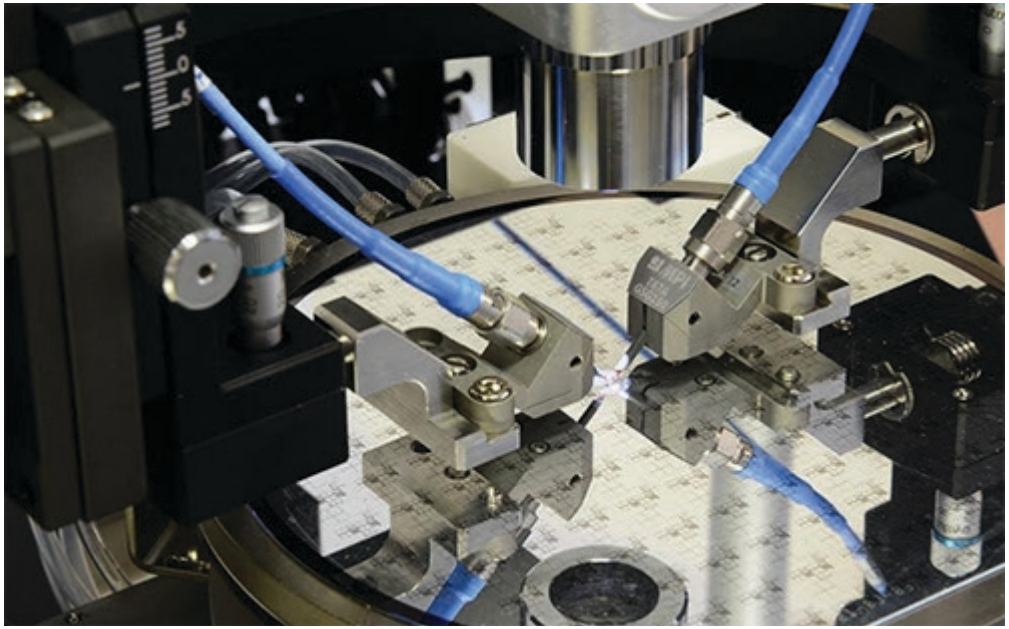


Figure 2-33 b) *Wafer level testing of PICs, courtesy of VI Systems*

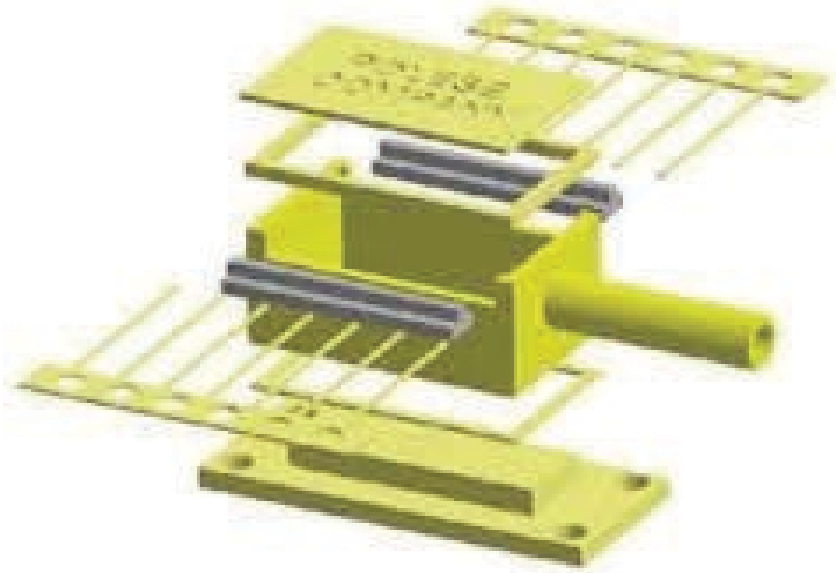


Figure 2-34 a) *Typical diode laser package*

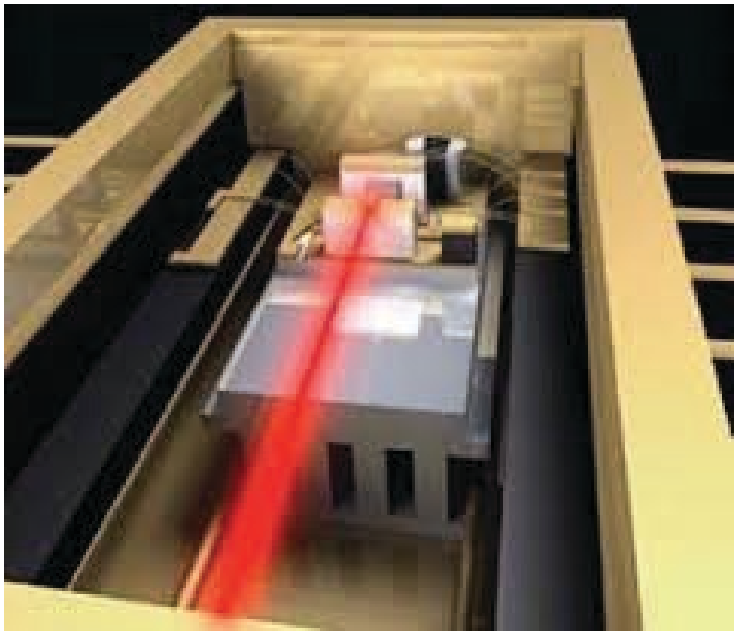


Figure 2-34 b) *Typical packaged device*

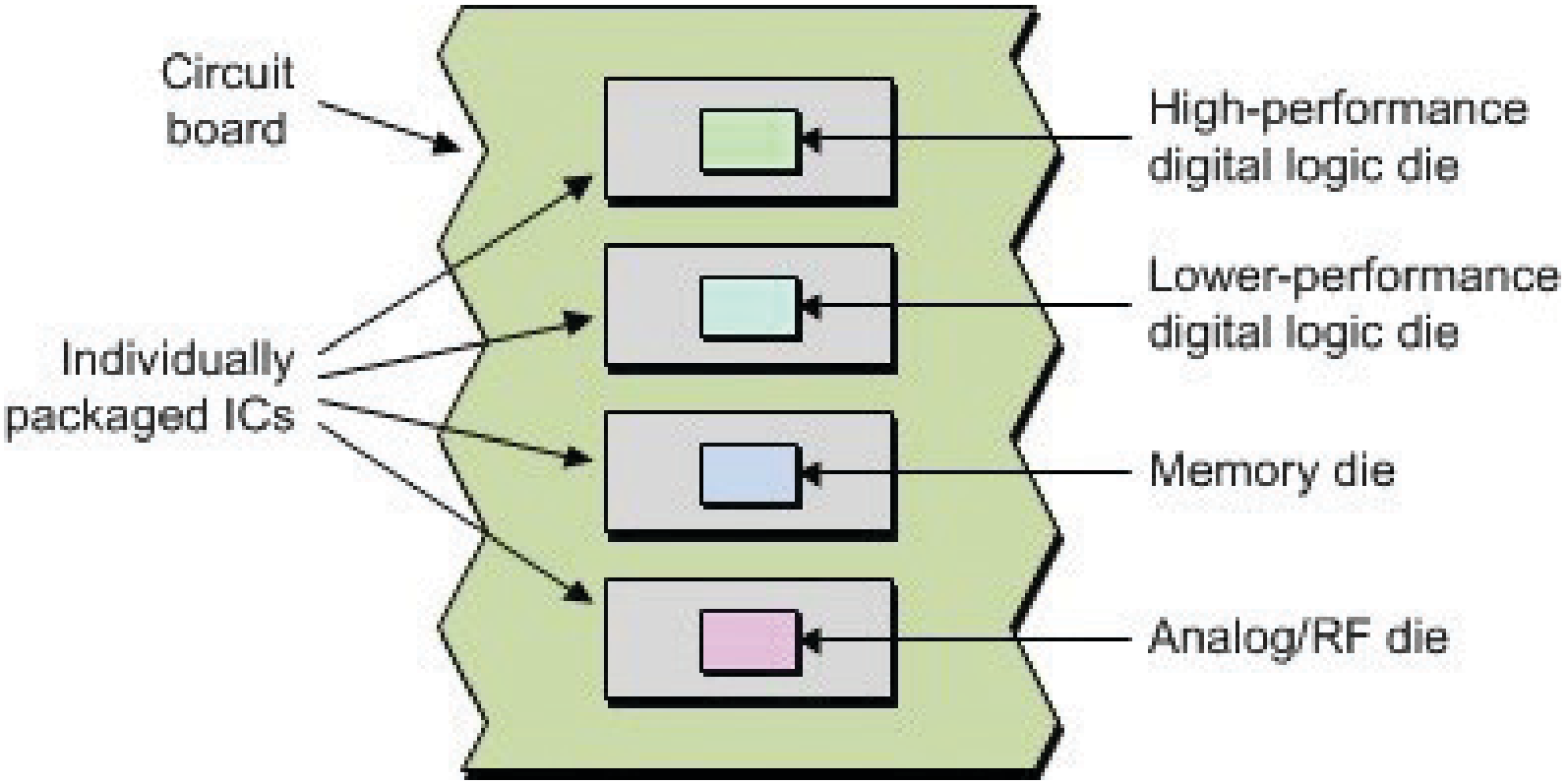


Figure 2-35 *Circuit board with individually packaged chips*

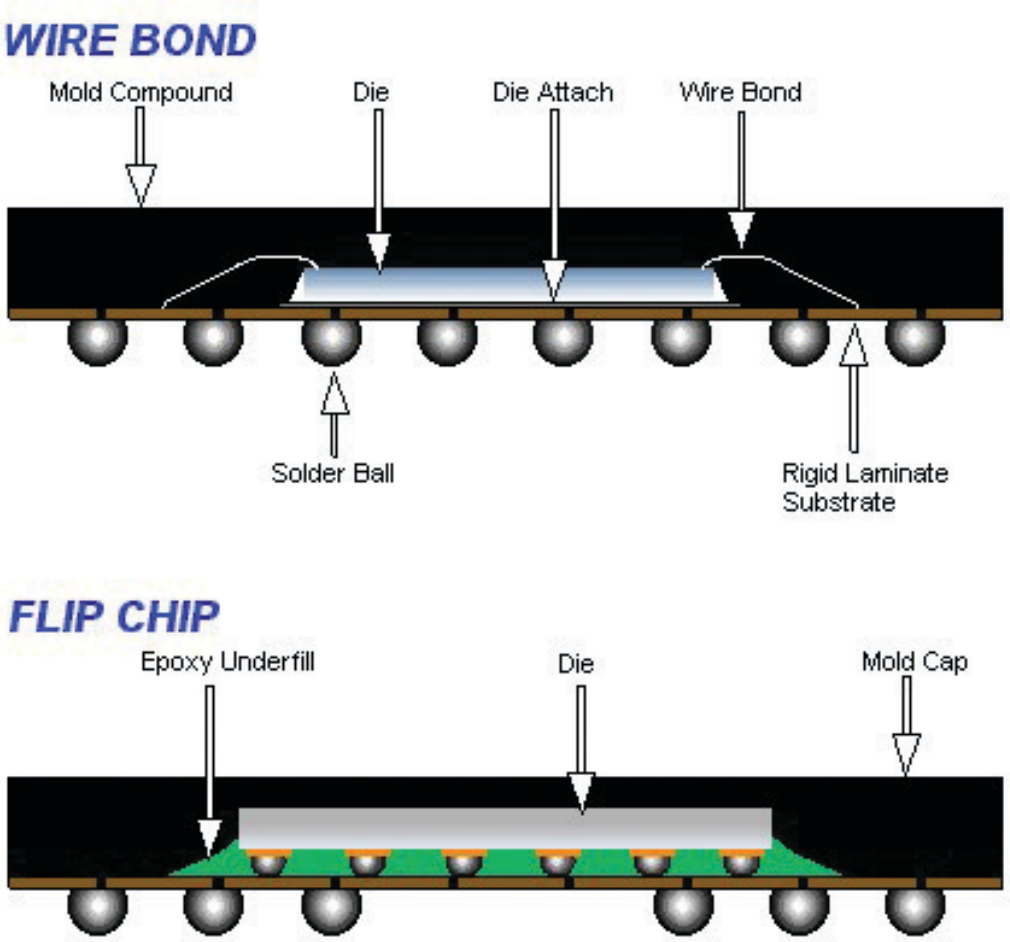


Figure 2-36 *Wire bond vs. flip-chip technologies*

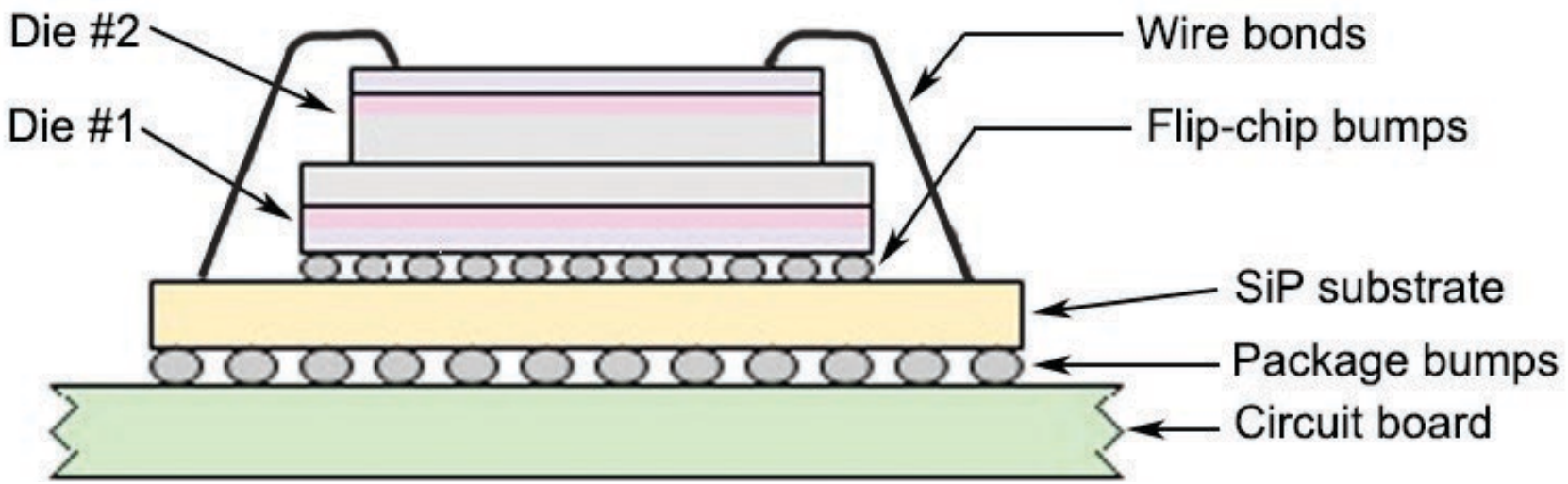


Figure 2-37 *Example of a packaged 3D stacked system*

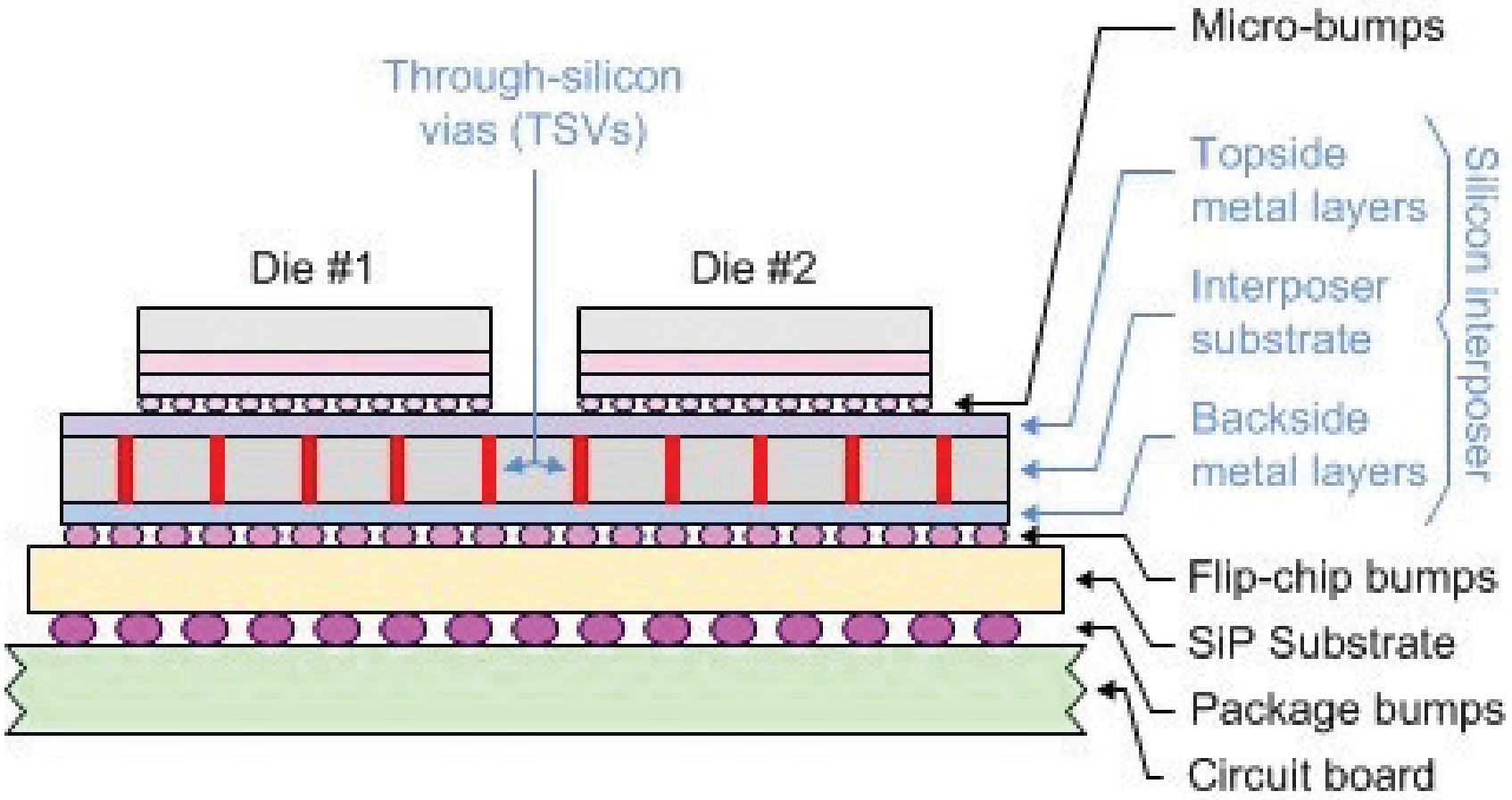


Figure 2-38 *A 2.5D system packaged using a silicon interposer and TSVs*

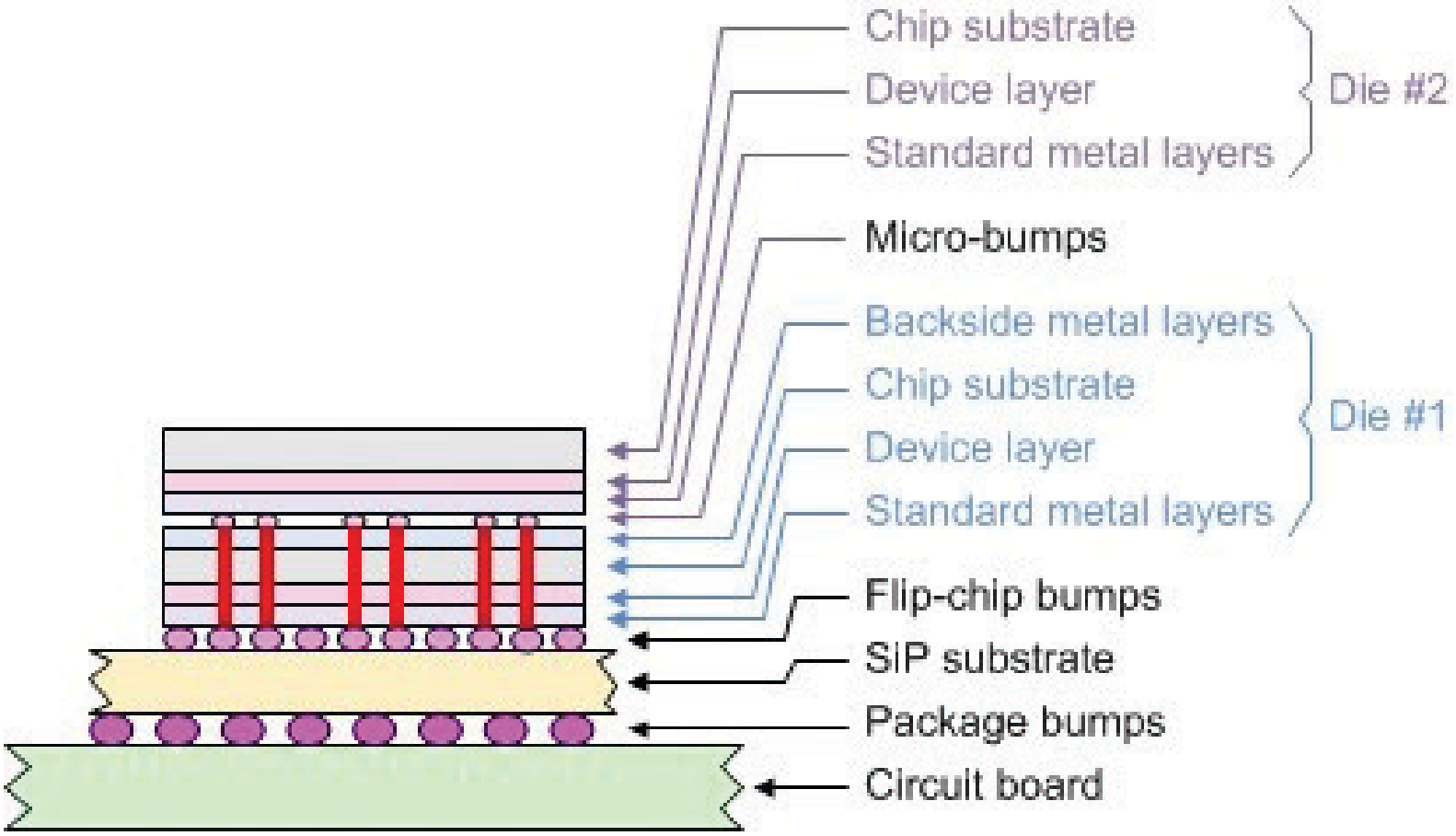


Figure 2-39 *A 3D system packaged using TSVs*

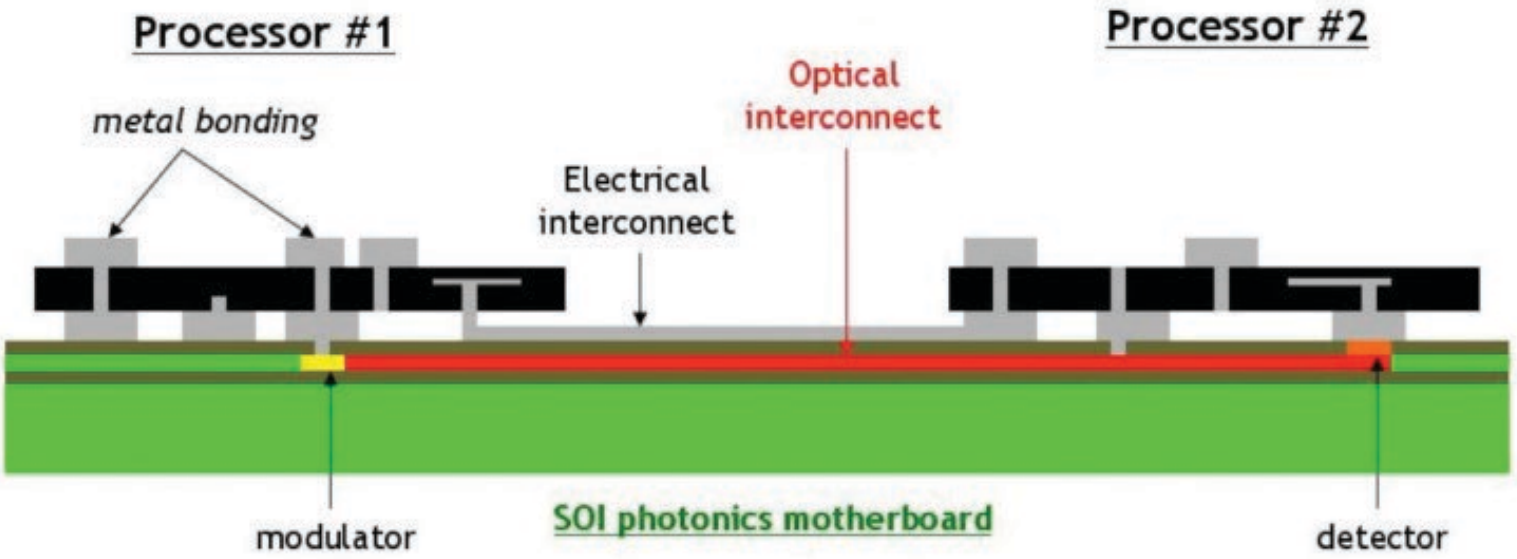


Figure 2-40 *Optical interconnect between two processor chips. Courtesy of APIC Corporation.*