Glossary

Absorption Conversion of light energy into another form by a material. Not equal to loss or attenuation, which includes scattering.

Acceptance Angle The angle over which the core of an optical fiber accepts incoming light; usually measured from the fiber axis. Related to numerical aperture (NA).

Access Network Part of the telecommunication network that connects to individual and corporate users.

Active Component A component that requires external power.

Add-Drop Multiplexer A device that drops and/or adds one or more optical channels to a signal.

ADSL (Asymmetric Digital Subscriber Line) A type of DSL with more bandwidth downstream (to the subscriber) than upstream.

All-Dielectric Cable Cable made entirely of dielectric (insulating) materials without any metal conductors, armor, or strength members.

Analog A signal that varies continuously (e.g., sound waves). Analog signals have frequency and bandwidth measured in hertz.

Ångstrom (Å) A unit of length equal to 0.1 nm.

ATM (Asynchronous Transfer Mode) A digital transmission switching format, with cells containing 5 bytes of header information followed by 48 data bytes.

Attenuation Reduction of the magnitude of an optical signal by any means, including absorption of energy or scattering of light. Measured in decibels per unit length.

Attenuator An optical device that reduces the intensity of transmitted light.

Avalanche Photodiode (APD) A semiconductor photodetector with integral detection and amplification stages. Electrons generated at a *p/n* junction are accelerated in a region where they free an avalanche of other electrons. APDs can detect faint signals but require higher voltages than other semiconductor electronics.

Average Power The average level of power in a signal that varies with time.

AWG See *Waveguide Array.*

Axis The center of an optical fiber.

Backbone System A transmission network that carries high-speed telecommunications between regions (e.g., a nationwide long-distance telephone system). Sometimes used to describe the part of a local area network that carries signals between branching points.

Backscattering Scattering of light in the direction opposite to that in which it was originally traveling.

Bandwidth Information capacity. In analog systems, bandwidth is the range of frequencies transmitted; in digital systems, it is the data rate.

Baud Strictly speaking, the number of signal-level transitions per second in digital data. For some common coding schemes, this equals bits per second, but this is not true for more complex coding, and it is often misused. Bits per second is less ambiguous.

Beamsplitter A device that divides incident light into two separate beams.

Bidirectional Operating in both directions. Bidirectional couplers split or combine light the same way when it passes through them in either direction. Bidirectional transmission sends signals in both directions, sometimes through the same fiber.

Birefringent Having a refractive index that differs for light of different polarizations.

Bit Error Rate (BER) The fraction of bits transmitted incorrectly.

Bragg Scattering Scattering of light caused by a change in refractive index, as used in *fiber Bragg gratings* and *distributed Bragg reflectors.*

Broadband Covering a wide range of frequencies or having a high data rate. Broadband Internet service, including fiber to the home, DSL and cable modems, has a much higher data rate than dial-up service.

Broadcast Transmission Sending the same signal to many different places, like a television broadcasting station. Broadcast transmission can be over optical fibers if the same signal is delivered to many subscribers.

Bundle (of fibers) A rigid or flexible group of fibers assembled in a unit. Coherent fiber bundles have fibers arranged in the same way on each end and can transmit images.

Byte Eight bits of digital data. (Sometimes parity and check bits are included, so one "byte" may include 10 bits, but only 8 of them are data.)

Carrier In technology, the wave that is modulated with a signal carrying information. In business, a company that provides telecommunication services.

Category 5 A type of twisted-pair copper cable designed to transmit high-speed signals.

CATV An acronym for cable television, derived from Community Antenna TeleVision.

C-Band Wavelengths of 1530 to 1565 nm, where erbium-doped fiber amplifiers have their strongest gain. Normally erbium-fiber amplifiers operate in either C- or L-band.

Cell A fixed-length data packet transmitted in certain digital systems such as ATM. Also the area served by one cellular phone tower, and sometimes slang for a cellular telephone.

Central Office A telephone company facility for switching signals among local telephone circuits; connects to subscriber telephones. Also called a switching office.

Channel A distinct signal in a transmission medium. Optical channels are signals transmitted through the same fiber at different wavelengths.

Chirp A variation in optical wavelength that arises from directly modulating a diode laser source.

Chromatic Dispersion Wavelength-dependent pulse spreading in optical fibers, measured in picoseconds (of pulse spreading) per nanometer (of source bandwidth) per kilometer (of fiber length). It is the sum of waveguide and material dispersion.

Circuit Originally a physical connection that transmits electricity or signals. Now also a communication channel that guarantees a fixed transmission capacity.

Circuit Switching Making temporary physical or virtual connections between two points, which guarantees a fixed transmission capacity.

Cladding The layer of glass or other transparent material surrounding the light-carrying core of an

optical fiber. It has a lower refractive index than the core and thus confines light in the core. Coatings may be applied over the cladding.

CLEC (Competitive Local Exchange Carrier) A company that offers local telephone service in competition against dominant phone companies.

Coarse Wavelength-Division Multiplexing (CWDM) Transmitting signals at multiple wavelengths through the same fiber with wide spacing between optical channels. Standard spacing is 20 nanometers.

Coating An outer plastic layer applied over the cladding of a fiber for mechanical protection.

Coax Coaxial cable—cable with a central metallic conductor surrounded by an insulator that is covered by a metallic sheath that runs the length of the cable.

Coherent Bundle (of fibers) Fibers packaged together in a bundle so they retain a fixed arrangement at the two ends and can transmit an image.

Compression Reducing the number of bits needed to encode a digital signal, typically by eliminating long strings of identical bits or bits that do not change in successive sampling intervals (e.g., video frames).

Connector A device mounted on the end of a fiber-optic cable, light source, receiver, or housing that mates to a similar device to couple light into and out of optical fibers. A connector joins two fiber ends, or one fiber end and a light source or detector.

Copper Industry slang for metal wire, either twisted-pair or coaxial cable.

Core The central part of an optical fiber that guides light.

Coupler A device that connects three or more fiber ends, dividing one input between two or more outputs or combining two or more inputs into one output.

Coupling Transfer of light into or out of an optical fiber. (Note that coupling does not require a coupler.)

Critical Angle The angle at which light in a high-refractive-index material undergoes total internal reflection.

Cut-Back Measurement Measurement of optical loss, made by cutting a fiber. It compares loss of a short segment with loss of a longer one.

Cutoff Wavelength The longest wavelength at which a single-mode fiber can transmit two modes, or (equivalently) the shortest wavelength at which a single-mode fiber carries only one mode.

Cycles per Second The frequency of a wave, or number of oscillations it makes per second. One cycle per second equals one hertz.

Dark Current The noise current generated by a photodiode in the dark.

Dark Fiber Optical fiber installed without transmitter and receiver, usually to provide expansion capacity. Some carriers lease dark fibers to other companies that add equipment to transmit signals through them.

Data Link A fiber system transmitting digital data between two points.

dBm Decibels relative to 1 mW.

dBμ Decibels relative to 1 μW.

DBR See *Distributed Bragg Reflection.*

Decibel (dB) A logarithmic comparison of power levels, defined as ten times the base-10 logarithm of the ratio of the two power levels. One-tenth of a bel.

Demultiplexer A device that separates a multiplexed signal into its original components; the inverse of a multiplexer.

Dense Wavelength-Division Multiplexing (DWDM) Transmitting signals at multiple closely spaced wavelengths through the same fiber. Channel spacing is usually 200, 100, or 50 GHz, corresponding to about 1.6, 0.8, or 0.4 nm respectively.

Detector A device that generates an electrical signal when illuminated by light. The most common fiber-optic detectors are photodiodes.

DFB See *Distributed Feedback.*

Dielectric Nonconductive.

Dielectric Filter An optical filter that selectively transmits one wavelength and reflects others based on interference effects inside the structure. Also called *interference filter.*

Digital Encoded as a signal in discrete levels, typically binary 1s and 0s.

Digital Subscriber Line (DSL) A service that transmits digital signals to homes at speeds of hundreds of kilobits to tens of megabits per second over twisted-pair wires at higher frequencies than voice telephone signals. There are several variations.

Diode An electronic device that lets current flow in only one direction. Semiconductor diodes used in fiber optics contain a junction between regions of different doping. They include light emitters (LEDs and laser diodes) and detectors (photodiodes).

Diode Laser A semiconductor diode that generates laser light. A current flowing through the diode causes electrons and holes to recombine at the junction layer between *p*- and *n*-doped regions, producing excited states that can release energy in the form of light.

Directional Coupler A coupler in which light is transmitted differently when it goes in different directions.

Discrimination Circuit Electronics that decide whether a digital signal is a 1 or a 0.

Dispersion The stretching of light pulses as they travel in an optical fiber, which increases their duration.

Dispersion Compensation Typically, adding fibers or other components with chromatic dispersion that offsets the chromatic dispersion of a fiber-optic transmission line. Compensation is also possible for polarization-mode dispersion, but it is more difficult and rarely needed. Electronic dispersion compensation is also possible.

Dispersion-Shifted Fiber Optical fiber with nominal wavelength of zero chromatic dispersion shifted away from 1310 nm. Sometimes used for zero dispersion-shifted fiber, which has zero chromatic dispersion at 1550 nm and is not used in DWDM systems.

Dispersion Slope The change in chromatic dispersion with wavelength.

Distributed Bragg Reflection Reflection of light caused by periodic changes in refractive index in a stack of layers of different composition or—equivalently—by a corrugation at the boundary between two semiconductor layers. The period and the refractive index select one wavelength.

Distributed Feedback Feedback arising from reflection distributed through a structure.

Distributed-Feedback Laser A diode laser with a corrugation in the electrically pumped part of the laser, which selects the laser wavelength by reflecting that wavelength back into the active layer.

Doping Addition of small quantities of an impurity to a material to provide desired characteristics. Semiconductors are doped to produce the desired concentration of current carriers.

Drop A cable that delivers service to an individual customer.

DSL See *Digital Subscriber Line.*

DTV Digital television.

Duplex In cables, one that contains two fibers. For connectors, one that connects two pairs of fibers. For data transmission, full-duplex transmitters and receivers simultaneously send and receive signals in both directions, but half-duplex cannot do both at the same time.

DWDM See *Dense Wavelength-Division Multiplexing.*

Edge-Emitting Diode An LED that emits light from its edge, producing more directional output than LEDs that emit from their top surface.

Edge-Emitting Laser A semiconductor laser that emits light in the plane of its junction from the edge of the chip.

Electro-Absorption Modulator A semiconductor diode reverse-modulated so it modulates light passing through it.

Electromagnetic Interference (EMI) Noise generated when stray electromagnetic fields induce currents in electrical conductors.

Electromagnetic Radiation Waves made up of oscillating electrical and magnetic fields perpendicular to one another and traveling at the speed of light. Can also be viewed as photons or quanta of energy. Electromagnetic radiation includes radio waves, microwaves, infrared, visible light, ultraviolet radiation, X rays, and gamma rays.

EMI See *Electromagnetic Interference.*

Endoscope A fiber-optic bundle used for imaging and viewing inside the human body.

Erbium Band The range of wavelengths where erbium-doped fiber amplifiers are used, from 1530 to 1610 nm.

Erbium-Doped Fiber Amplifier (EDFA) Optical fiber doped with the rare earth element erbium, which can amplify light at 1530 to 1610 nm when pumped by an external light source.

Ethernet A local-area network standard. The original Ethernet transmits 10 Mbit/s. Other versions are Fast Ethernet at 100 Mbit/s, Gigabit Ethernet at 1 Gbit/s, and 10-Gigabit Ethernet.

Evanescent Wave Guided light waves that extend beyond the boundary of a fiber core into the cladding. Evanescent waves can transfer energy between waveguides.

Excess Loss Loss of a passive coupler above that inherent in dividing light among the output ports.

External Modulation Modulation of output of a light source by an external device.

Extrinsic Loss Splice losses arising from the splicing process itself.

Eye Pattern A pattern formed by overlaying traces of a series of transmitted pulses in a visual display. The more open the eye, the sharper the distinction between on and off pulses.

Fabry-Perot A resonant cavity formed by a pair of mirrors aligned parallel to each other. A Fabry-Perot laser is a diode laser with its edge facets cleaved so they form a Fabry-Perot cavity.

Ferrule A tube within a connector with a central hole that contains and aligns a fiber.

Fiber Amplifier An optical fiber doped to amplify light from an external source. The most important type is the erbium-doped fiber amplifier.

Fiber Bragg Grating An optical fiber in which the core refractive index varies periodically along its length, causing Bragg scattering at wavelengths selected by the period and refractive index. A fiber Bragg grating reflects the selected wavelength and transmits others.

Fiber Distributed Data Interface (FDDI) A standard for a 100-Mbit/s fiber-optic local-area network.

Fiber-Optic Gyroscope A coil of optical fiber that can detect rotation about its axis.

Fiber to the Curb (FTTC) Fiber-optic service to a node that is connected by wires to several nearby homes, typically on a block.

Fiber to the Home (FTTH) A network in which optical fibers bring signals all the way to homes.

Fiber to the Premises (FTTP) Distribution of signals through fiber optics all the way to individual residences. Functionally the same as fiber to the home.

Fibre Channel A standard for data transmission among storage devices and computers over fiber or copper.

FITL Fiber in the loop.

Fluoride Glasses Materials that have the amorphous structure of glass but are made of fluoride compounds (e.g., zirconium fluoride) rather than oxide compounds (e.g., silica).

Forward Error Correction Adding extra bits to a block of data bits to detect and correct errors in transmission.

Frame A fixed-length block of data transmitted as a unit; SONET transmits frames. In video, one of a series of images shown in sequence.

Free-Space Optics Light signals transmitted through air rather than fibers.

Frequency The number of times an electromagnetic wave oscillates in a second, or the number of wave peaks that pass a point in a second; measured in hertz.

Frequency-Division Multiplexing Combining analog signals by assigning each a different carrier frequency and merging them in a single signal with a broad range of frequencies.

FTTC See *Fiber to the curb.*

FTTH See *Fiber to the home.*

FTTP See *Fiber to the Premises.*

Full-Duplex In data transmission, transmitters and receivers that simultaneously send and receive signals in both directions.

Fused Fibers A bundle of fibers melted together so they maintain a fixed alignment with respect to each other in a rigid rod.

Fusion Splice A splice made by melting the tips of two fibers together so they form a solid junction.

Gain The increase in signal strength as light passes through an amplifying medium.

Gallium Aluminum Arsenide (GaAlAs) A semiconductor compound used in LEDs, diode lasers, and certain detectors.

Gallium Arsenide (GaAs) A semiconductor compound used in LEDs, diode lasers, detectors, and electronic components.

Gbit/s Gigabits (billion bits) per second.

Glass A solid in which the atoms are arranged randomly instead of ordered in a crystal. In fiber optics, "glass" usually means a silica compound unless otherwise noted.

Graded-Index Fiber A fiber in which the refractive index changes gradually with distance from the fiber axis, rather than abruptly at the core-cladding interface.

Graded-Index Fiber Lens A short segment of graded-index fiber that focuses light passing through it.

Granularity How finely a signal can be broken into its component parts.

Group Delay Time The difference in travel time through a fiber for light of different wavelengths.

Half-Duplex In data transmission, a system in which transmitters and receivers cannot simultaneously send and receive signals.

Hard-Clad Silica Fiber A fiber with a hard plastic cladding surrounding a step-index silica core. (Other plastic-clad silica fibers have a soft plastic cladding.)

Harmonic Frequency A frequency that is an integral multiple of a base frequency.

HDTV High-definition (or high-resolution) television; digital television with higher resolution than present analog systems.

Head-End The central facility where signals are combined for distribution in a cable television system.

Hertz Frequency in cycles per second.

Hierarchy A set of transmission speeds arranged to multiplex signals at successively higher data rates.

Hybrid Fiber/Coax A network that uses fiber to distribute cable-television signals to nodes, which in turn distribute them to homes over coaxial cable.

Index-Matching Gel A gel or fluid with refractive index close to that of glass, which reduces refractive-index discontinuities that can cause reflective losses.

Index of Refraction A quantity that measures how much the speed of light slows down in a material. Designated n, it is the speed of light in a vacuum divided by the speed of light in the material. Also called *refractive index.*

Indium Gallium Arsenide (InGaAs) A semiconductor material used in lasers, LEDs, and detectors.

Indium Gallium Arsenide Phosphide (InGaAsP) A semiconductor material used in lasers, LEDs, and detectors.

Infrared Light with wavelengths longer than 700 nm and shorter than about 1 mm, invisible to the human eye, which we can feel as heat. Glass optical fibers transmit infrared signals at 700 to about 1650 nm in the infrared.

Infrared Fiber Colloquially, optical fiber with best transmission at wavelengths of 2 μm or longer, made of materials other than silica glass.

Injection Laser Another name for a semiconductor or diode laser.

Integrated Optics Optical devices that perform two or more functions and are integrated on a single substrate; analogous to integrated electronic circuits.

Integrated Services Digital Network (ISDN) Originally a standard to transmit two digital voice lines at 64 kbit/s and one 16-kbit/s data channel. Now repackaged as IDSL, a form of DSL, transmitting 128 kbit/s over distances beyond the reach of DSL.

Intensity Power per unit solid angle.

Interference For light, the way that waves add together, depending on their phase. *Constructive interference* occurs when the waves are in phase and their amplitudes add. *Destructive interference* occurs when the waves are 180° out of phase and their amplitudes cancel.

Interference Filter An optical filter that selectively transmits one wavelength and reflects others based on interference effects inside the structure. Also called *dielectric filter.*

Interferometric Sensor A fiber-optic sensor that relies on interference effects.

Interleaver An optical device that separates a series of optical channels so alternating wavelengths emerge out its two ports. The best-known type is a *Mach-Zehnder interferometer.*

Internet Protocol (IP) Standard packet-switched transmission format for the Internet; uses variable-length packets.

Intrinsic Layer A layer of semiconductor that is not doped with impurities to form current carriers.

Intrinsic Losses Splice losses arising from differences in the fibers being spliced.

Irradiance Power per unit area.

Junction Laser A semiconductor diode laser.

Junction Layer The layer between *p*- and *n*-doped semiconductors, where current carriers recombine and emit light in a semiconductor laser or LED.

LAN See *Local-Area Network.*

Large-Core Fiber Usually, a fiber with a core of 200 μm or more.

Laser From *light amplification by stimulated emission of radiation,* one of the wide range of devices that generates light by that principle. Laser light is directional, covers a narrow range of wavelengths, and is more coherent than ordinary light. Semiconductor diode lasers are the usual light sources in fiber-optic systems.

Layer A standard or protocol for signal transmission or processing to perform certain functions. It includes standard interfaces with other layers, which perform other functions.

L-Band Wavelengths of 1565 to 1625 nm where some erbium-doped fiber amplifiers operate. Separate from the C-band.

LED See *Light-Emitting Diode.*

Legacy Older equipment, generally no longer made.

Light Strictly speaking, electromagnetic radiation visible to the human eye at 400 to 700 nm. Commonly, the term is applied to electromagnetic radiation with properties similar to visible light,

including the invisible near-infrared radiation in most fiber-optic communication systems.

Light-Emitting Diode (LED) A semiconductor diode that emits incoherent light at the junction between *p*- and *n*-doped materials.

Lightguide An optical fiber or fiber bundle.

Light Piping Use of optical fibers to illuminate.

Lightwave An an adjective, a synonym for optical, often (but not always) meaning fiber-optic.

Linewidth The range of wavelengths in an optical signal, sometimes called spectral width.

Local-Area Network (LAN) A network that transmits data among many nodes in a small area (e.g., a building or campus).

Local Loop The part of the telephone network extending from the central (switching) office to the subscriber.

Longitudinal Modes Oscillation modes of a laser along the length of its cavity. Each longitudinal mode contains only a narrow range of wavelengths, so a laser emitting a single longitudinal mode has a narrow bandwidth. Distinct from transverse modes.

Loose Tube A protective tube loosely surrounding a cabled fiber, often filled with gel.

Loss Attenuation of optical signal, normally measured in decibels.

Loss Budget An accounting of overall attenuation in a system.

Mach-Zehnder Interferometer An optical device that separates a series of optical channels so alternating wavelengths emerge out its two ports, sometimes called an *interleaver.*

MAN (Metropolitan-Area Network) A network linking local-area networks, usually within a metropolitan area. MANs normally are private networks that serve one company's facilities; metro networks are public networks run by companies that offer telecommunication services.

Margin Allowance for attenuation in addition to that explicitly accounted for in system design.

Material Dispersion Pulse dispersion caused by variation of a material's refractive index with wavelength.

Mbit/s Megabits (million bits) per second.

Mechanical Splice A splice in which fibers are joined mechanically (e.g., glued or crimped in place) but not fused together.

MEMS (Micro-electro-mechanical systems) Tiny moving elements, often mirrors, fabricated from semiconductor materials.

Mesh A network that makes multiple interconnections between different points.

Metro Network A telecommunication system offering services to a metropolitan area, typically with cable lengths to 200 km.

Microbending Tiny bends in a fiber that allow light to leak out and increase loss.

Micrometer One-millionth of a meter, abbreviated μm.

Micron Short for the preferred form, micrometer.

Modal Dispersion Dispersion arising from differences in the times that different modes take to travel through multimode fiber.

Mode An electromagnetic field distribution that satisfies theoretical requirements for propagation in a waveguide or oscillation in a cavity (e.g., a laser). Light has modes in a fiber or laser.

Mode-Field Diameter The diameter of the one mode of light propagating in a single-mode fiber, slightly larger than core diameter.

Mode Stripper A device that removes high-order modes in a multimode fiber to give standard measurement conditions.

Modulation Changing the properties of a carrier wave so it transmits a signal. Amplitude modulation varies the wave amplitude.

Multimode Transmits or emits multiple modes of light.

Multiple System Operators (MSOs) Companies that operate cable television networks in many communities.

Multiplexer A device that combines two or more signals into a single output.

***n* Region** A semiconductor doped to have an excess of electrons as current carriers.

NA See *Numerical Aperture.*

Nanometer A unit of length, 10^{-9} m. It is part of the SI system and has largely replaced the non-SI Ångstrom (0.1 nm) in technical literature.

Near-Infrared The part of the infrared near the visible spectrum, typically 700 to 1500 or 2000 nm; it is not rigidly defined.

Network A system of cables or other connections that links many terminals or devices, all of which can communicate with each other through the system.

Noise Equivalent Power (NEP) The optical input power to a detector needed to generate an electrical signal equal to the inherent electrical noise.

Nonlinear Effects Interactions that are not proportional to the strength of one light signal. For example, certain interactions are proportional to the square of the light power rather than to the power itself. Nonlinear effects can distort signals.

Nonzero Dispersion-Shifted Fiber Single-mode optical fiber with the wavelength of zero chromatic dispersion shifted outside the C-band. Some types have zero dispersion near 1500 nm, others near 1625 nm. Types with zero dispersion at 1580 nm are not usable in the L-band of erbium-doped fiber amplifiers.

No Return to Zero (NRZ) A digital code in which the signal level is low for a 0 bit and high for a 1 bit and does not return to 0 between successive 1 bits.

Normal (angle) Perpendicular to a surface.

NTSC The analog video broadcast standard used in North America, set by the National Television System Committee.

Numerical Aperture (NA) The sine of half the angle over which a fiber can accept light. Strictly speaking, this is multiplied by the refractive index of the medium containing the light, but for air the index is almost equal to 1.

O-Band Wavelengths of 1270 to 1370 nm, the "original" band for fiber transmission.

OC-*x* Optical Carrier, a carrier rate specified in the SONET standard.

Optical Add-Drop An optical multiplexer that drops and/or adds one or more optical channels to a signal.

Optical Amplifier A device that amplifies an input optical signal without converting it into electrical form. The best developed are optical fibers doped with the rare-earth element erbium.

Optical Channel An optical signal transmitted at one wavelength. WDM systems transmit multiple channels at separate wavelengths.

Optical Circulator A device that transmits light only in one direction through a series of ports, so light can go from port 1 to port 2 and port 2 to port 3, but not from port 2 to port 1.

Optical Isolator A device that transmits light in one direction but blocks light in the opposite direction.

Optical Networking Processing and switching signals in optical form as well as transmitting them optically.

Optical Node The point where signals are transferred from optical fibers to other transmission media, typically twisted-pair wires or coaxial cable.

Optical Performance Monitor A device installed in a WDM system to monitor signals at the transmitted wavelengths.

Optical Spectrum Analyzer An instrument that scans the spectrum to record power as a function of wavelength.

Optical Loss Test Set An optical power meter and light source calibrated for use together.

Optical Switch A switch that operates on light, redirecting optical signals.

Optical Time-Domain Reflectometer (OTDR) An instrument that measures transmission characteristics by sending a short pulse of light down a fiber and observing backscattered light.

Optical Waveguide Technically, any structure that can guide light. Sometimes used as a synonym for optical fiber, it can also apply to planar light waveguides.

***p* Region** Part of a semiconductor doped with electron acceptors in which holes (vacancies in the valence electron level) are the dominant current carriers.

Packet Switching Organizing signals by dividing them into data packets, each containing a header that specifies its destination and data intended for that destination. Separate data packets then are directed to their destinations.

Passive Component A component that doesn't require outside power.

Passive Optical Network A fiber-optic distribution network with no active components between the switching office and the customer.

PCS Fiber See *Plastic-Clad Silica Fiber.*

Peak Power Highest instantaneous power level in a pulse.

Phase The position of a wave in its oscillation cycle.

Photodetector A light detector.

Photodiode A diode that can produce an electrical signal proportional to light falling upon it.

Photonic A term coined for devices that work using photons or light, analogous to "electronic" for devices working with electrons.

Photonic Bandgap A range of wavelengths that cannot propagate in materials with certain internal microstructures.

Photons Quanta of electromagnetic radiation. Light can be viewed as either a wave or a series of photons.

Picosecond One-trillionth (10^{-12}) second.

***pin* Photodiode** A semiconductor detector with an intrinsic (i) region separating the p- and n-doped regions. It has fast linear response and is used in fiber-optic receivers.

Planar Waveguide A flat waveguide formed on the surface of a flat material. The zone of high refractive index is rectangular in cross-section and guides light in the same way as the core of an optical fiber.

Plastic-Clad Silica (PCS) Fiber A step-index multimode fiber in which a silica core is surrounded by a lower-index plastic cladding.

Plastic Fiber An optical fiber made entirely of plastic compounds.

Plenum Cable Cable made of fire-retardant material that meets electrical code requirements (UL 910) for low smoke generation and installation in air spaces.

Plesiochronous Digital Hierarchy The North American Digital Hierarchy of time-division multiplexing rates.

Point-to-Point Transmission Carrying a signal between two points, without branching to other points.

Polarization Alignment of the electric and magnetic fields that make up an electromagnetic wave; normally refers to the electric field. If all light waves have the same alignment, the light is polarized.

Polarization-Maintaining Fiber Fiber that maintains the polarization of light that enters it.

Polarization-Mode Dispersion Dispersion arising from random fluctuations in how fibers transmit light in vertical and horizontal polarizations.

POP An Internet node called a Point of Presence.

Population Inversion A condition in which more atoms are in an upper energy level than in a lower energy level, allowing stimulated emission to occur. A prerequisite for laser action.

POTS (Plain Old Telephone Service) Analog voice telephone lines.

Preform A cylindrical rod of specially prepared and purified glass from which an optical fiber is drawn.

Provisioning Arranging a network to provide services to customers.

Public Switched Telephone Network The network that provides standard voice telephone service, available to anyone who pays for service.

Pulse Dispersion The spreading out of pulses as they travel along an optical fiber.

Pulse Duration The length of a pulse. Usually specified as "full width at half maximum," meaning the time from when the signal reaches half its peak value to the time when it drops below half the peak.

Pump Laser A laser that provides light that excites atoms in a fiber amplifier, putting them in the right state to amplify light.

Quantum Efficiency The fraction of photons that strike a detector that produces electron-hole pairs in the output current.

Quaternary A semiconductor compound made of four elements (e.g., InGaAsP).

Radiometer An instrument, distinct from a photometer, used to measure power (watts) of electromagnetic radiation.

Raman Amplifier A fiber that transfers energy from a strong pump beam to amplify a weaker signal at a longer wavelength, using stimulated Raman scattering.

Rayleigh Scattering Light scattering by particles such as atoms or molecules that are much smaller than the wavelength.

Rays Straight lines that represent the path taken by light.

Receiver A device that detects an optical signal and converts it into an electrical form usable by other devices.

Recombination Combination of an electron and a hole in a semiconductor that releases energy, sometimes leading to light emission.

Reduced-Cladding Fibers Fibers with cladding smaller than the standard 125-μm outer diameter.

Refraction The bending of light as it passes between materials of different refractive index.

Refractive Index A quantity that measures how much the speed of light slows down in a material. Designated n, it is the speed of light in a vacuum divided by the speed of light in the material. Also called *index of refraction.*

Refractive-Index Gradient The change in refractive index with distance from the axis of an optical fiber.

Regenerator A receiver-transmitter pair that detects a weak signal, cleans it up, then sends the regenerated signal through another length of fiber.

Repeater A receiver-transmitter pair that detects and amplifies a weak signal for retransmission through another length of optical fiber.

Repetition Rate The number of pulses or data bits per second.

Responsivity The ratio of detector output to input, usually measured in units of amperes per watt (or microamperes per microwatt).

Return to Zero (RZ) A digital coding scheme where signal level is low for a 0 bit and high for a 1 bit during the first half of a bit interval and then in either case returns to zero for the second half of the bit interval.

Ribbon Cables Cables in which many parallel fibers are embedded in a plastic material, forming a flat ribbon-like structure.

Ring A cable that forms a closed loop connecting two or more points, so all points remain connected if the cable breaks at one point.

Rise Time The time it takes output to rise from low levels to peak value. Typically measured as the time to rise from 10% to 90% of maximum output.

ROADM Reconfigurable optical add-drop multiplexer.

Router A device that directs data packets to their destinations using information in their headers to pick the best path. Distinct from *wavelength router.*

S-Band Wavelengths of 1460 to 1530 nm.

Scattering Loss of light that is scattered off atoms in different directions, so it escapes from the fiber core. A major component of fiber attenuation.

SDH See *Synchronous Digital Hierarchy.*

Selfoc Lens A trade name used by the Nippon Sheet Glass Company for a graded-index fiber lens; a segment of graded-index fiber made to serve as a lens.

Semiconductor Laser A laser in which injection of current into a semiconductor diode produces light by recombination of holes and electrons at the junction between *p*- and *n*-doped regions.

Semiconductor Optical Amplifier A semiconductor diode with reflection from its facets suppressed so it can amplify light from an external source, but will not produce a laser beam on its own.

Sheath An outer protective layer of a fiber-optic cable.

SI Units The standard international system of metric units.

Side Bands Bands above and below the carrier frequency that are generated by modulating the carrier.

Signal-to-Noise Ratio The ratio of signal to noise, measured in decibels; an indication of analog signal quality.

Silica Glass Glass made mostly of silicon dioxide, SiO_2, used in conventional optical fibers.

Simplex Single element (e.g., a simplex connector is a single-fiber connector).

Single-Frequency Laser A laser that emits a range of wavelengths small enough to be considered a single frequency.

Single Mode Containing only one mode. When dealing with lasers, beware of ambiguities because of the difference between transverse and longitudinal modes. A laser operating in a single transverse mode typically does not operate in a single longitudinal mode.

Single-Polarization Fibers Optical fibers capable of carrying light in only one polarization.

Smart Structures (or Smart Skins) Materials containing sensors (fiber-optic or other types) to measure their properties during fabrication and use.

Soliton An optical pulse that naturally retains its original shape as it travels along an optical fiber.

SONET (Synchronous Optical Network) A standard for fiber-optic transmission.

Spectral Efficiency A measure of how efficiently data transmission uses the available spectrum, typically in bits per hertz of bandwidth.

Spectrum Range of wavelengths. The optical spectrum, for example, is the range of optical wavelengths.

Splice A permanent junction between two fiber ends.

Splitting Ratio The ratio of power emerging from output ports of a coupler.

Standard Single-Mode Fiber Step-index single-mode fiber with zero dispersion at 1310 nm; the first type used in fiber-optic communications, still widely used.

Star Coupler A coupler with more than three or four ports.

Step-Index Multimode Fiber A step-index fiber with a core large enough to carry light in multiple modes.

Step-Index Single-Mode Fiber A step-index fiber with a small core capable of carrying light in only one mode; this type has zero dispersion at 1310 nm.

Stimulated Raman Scattering Interactions between light and atoms in a transparent material that convert energy from one wavelength to another.

Subscriber Loop The part of the telephone network from a central office to individual subscribers.

Surface-Emitting Diode An LED that emits light from its flat surface rather than its side. Simple and inexpensive, with emission spread over a wide angle.

Surface-Emitting Laser A semiconductor laser that emits light from the wafer surface.

Switch A device that directs light or electricity along different paths, such as fibers or wires.

Switched Network A network that routes signals to their destinations by switching circuits, such as the telephone system.

Synchronous Digital Hierarchy (SDH) The international version of SONET, the Synchronous Optical Network standard. The biggest difference is in the names of the transmission rates.

Synchronous Optical Network See *SONET.*

Tbit/s Terabits (trillion, or 10^{12} bits) per second.

T Carrier A system transmitting signals at one of the standard levels in the North American digital hierarchy.

T Coupler A coupler with three ports.

TDM See *Time-Division Multiplexing.*

Ternary A semiconductor compound made of three elements (e.g., GaAlAs).

Thermo-Optic Switches Optical switches controlled by temperature-induced changes in refractive index.

III-V (3-5) Semiconductor A semiconductor compound made of one or more elements from the IIIA column of the periodic table (Al, Ga, and In) and one or more elements from the VA column (N, P, As, or Sb). Used in LEDs, diode lasers, and detectors.

Threshold Current The minimum current needed to sustain laser action in a diode laser.

Tight Buffer A material tightly surrounding a fiber in a cable, holding it rigidly in place.

Time-Division Multiplexing (TDM) Digital multiplexing by taking one bit or byte of data at a time from separate signals and combining them in a single bit stream.

Total Internal Reflection Total reflection of light back into a material when it strikes the interface with a material having a lower refractive index at an angle below a critical value.

Transceiver A combination of transmitter and receiver providing both output and input interfaces with a device.

Transmitter A light source packaged with drive electronics to produce an optical signal.

Transverse Modes Modes across the width of a waveguide, fiber, or laser. Distinct from longitudinal modes, which are along the length of a laser.

Tree A network architecture in which transmission routes branch out from a central point.

Trunk Line A transmission line running between telephone switching offices or from a cable-TV headend to a distribution node.

Twisted Pair Pair of copper wires twisted around each other. The standard way to connect individual voice telephones, widely used for other low-speed communications.

Ultraviolet Electromagnetic waves invisible to the human eye, with wavelengths about 10 to 400 nm, shorter than visible light.

VCSEL (Vertical-Cavity Surface-Emitting Laser) A semiconductor laser in which light oscillates vertically (perpendicular to the junction plane) and emerges from the surface of the wafer rather than from the edge of the chip.

Video on Demand A service that delivers programs from a video library to subscribers through a communications network.

Visible Light Electromagnetic radiation visible to the human eye at wavelengths of 400 to 700 nm.

VOA (Variable Optical Attenuator) An attenuator in which the attenuation can be varied.

Voice Telephone service, including fax, fixed phones, and mobile phones.

Voice Circuit A circuit capable of carrying one telephone conversation or its equivalent; the standard subunit in which telecommunication capacity is counted. The U.S. analog equivalent is 4 kHz. The digital equivalent is 64 kbit/s.

Voice over Internet Protocol (VoIP) Transmission of voice signals over the Internet as packets using Internet Protocol rather than over the conventional telephone network.

WAN Wide-area network.

Waveguide A structure that guides electromagnetic waves along its length. An optical fiber is an optical waveguide.

Waveguide Array An array of curved planar waveguides that separates many optical channels at once. Also called an *array waveguide* (AWG).

Waveguide Dispersion The part of chromatic dispersion arising from the different speeds light travels in the core and cladding of a single-mode fiber (i.e., from the fiber's waveguide structure).

Wavelength The distance an electromagnetic wave travels in the time it takes to oscillate through a complete cycle. Wavelengths of light are measured in nanometers (10^{-9} m) or micrometers (10^{-6} m).

Wavelength-Division Multiplexing (WDM) Multiplexing of signals by transmitting them at different wavelengths through the same fiber.

Wavelength Router An optical device that directs input signals according to their wavelength.

Window A wavelength region where fibers have low attenuation, used for transmitting signals.

Wireless Transmitted without wires, in practice using radio waves, microwaves, or light through the air.

Zero Dispersion-Shifted Fiber Fiber with zero chromatic dispersion shifted to 1550 nm, used before the advent of DWDM.

Zero-Dispersion Wavelength Wavelength at which net chromatic dispersion of an optical fiber is nominally zero. Arises where waveguide dispersion cancels out material dispersion.

Index

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T