Glossary

A

Abrasive. A hard and wear-resistant material (commonly a ceramic) that is used to wear, grind, or cut away other material.

Absorption. The optical phenomenon whereby the energy of a photon of light is assimilated within a substance, normally by electronic polarization or by an electron excitation event.

Acceptor level. For a semiconductor or insulator, an energy level lying within yet near the bottom of the energy band gap, which may accept electrons from the valence band, leaving behind holes. The level is normally introduced by an impurity atom.

Activation energy (Q). The energy required to initiate a reaction, such as diffusion.

Activation polarization. The condition wherein the rate of an electrochemical reaction is controlled by the one slowest step in a sequence of steps that occur in series.

Addition (or chain reaction) polymerization. The process by which bifunctional monomer units are attached one at a time, in chainlike fashion, to form a linear polymer macromolecule.

Adhesive. A substance that bonds together the surfaces of two other materials (termed adherends).

Age hardening. See **Precipitation hardening.**

Allotropy. The possibility of existence of two or more different crystal structures for a substance (generally an elemental solid).

Alloy. A metallic substance that is composed of two or more elements.

Alloy steel. A ferrous (or iron-based) alloy that contains appreciable concentrations of alloying elements (other than C and residual amounts of Mn, Si, S, and P). These alloying elements are usually added to improve mechanical and corrosion resistance properties.

Alternating copolymer. A copolymer in which two different mer units alternate positions along the molecular chain.

Amorphous. Having a noncrystalline structure.

Anelastic deformation. Time-dependent elastic (nonpermanent) deformation.

Anion. A negatively charged, nonmetallic ion.

Anisotropic. Exhibiting different values of a property in different crystallographic directions.

Annealing. A generic term used to denote a heat treatment wherein the microstructure and, consequently, the properties of a material are altered. "Annealing" frequently refers to a heat treatment whereby a previously cold-worked metal is softened by allowing it to recrystallize.

Annealing point (glass). That temperature at which residual stresses in a glass are eliminated within about 15 min; this corresponds to a glass viscosity of about 10^{12} Pa-s (10^{13} P).

Anode. The electrode in an electrochemical cell or galvanic couple that experiences oxidation, or gives up electrons.

Antiferromagnetism. A phenomenon observed in some materials (e.g., MnO); complete magnetic moment cancellation occurs as a result of antiparallel coupling of adjacent atoms or ions. The macroscopic solid possesses no net magnetic moment.

Artificial aging. For precipitation hardening, aging above room temperature.

Atactic. A type of polymer chain configuration wherein side groups are randomly positioned on one side of the chain or the other.

Athermal transformation. A reaction that is not thermally activated, and usually diffusionless, as with the martensitic transformation. Normally, the transformation takes place with great speed (i.e., is independent of time), and the extent of reaction depends on temperature.

Atomic mass unit (amu). A measure of atomic mass; one twelfth of the mass of an atom of C^{12}.

Atomic number (Z). For a chemical element, the number of protons within the atomic nucleus.

Atomic packing factor (APF). The fraction of the volume of a unit cell that is occupied by "hard sphere" atoms or ions.

Atomic vibration. The vibration of an atom about its normal position in a substance.

Atomic weight (A). The weighted average of the atomic masses of an atom's naturally occurring isotopes. It may be expressed in terms of atomic mass units (on an atomic basis), or the mass per mole of atoms.

Atom percent (at%). Concentration specification on the basis of the number of moles (or atoms) of a particular element relative to the

total number of moles (or atoms) of all elements within an alloy.

Austenite. Face-centered cubic iron; also iron and steel alloys that have the FCC crystal structure.

Austenitizing. Forming austenite by heating a ferrous alloy above its upper critical temperature—to within the austenite phase region from the phase diagram.

B

Bainite. An austenitic transformation product found in some steels and cast irons. It forms at temperatures between those at which pearlite and martensite transformations occur. The microstructure consists of α-ferrite and a fine dispersion of cementite.

Band gap energy (E_g). For semiconductors and insulators, the energies that lie between the valence and conduction bands; for intrinsic materials, electrons are forbidden to have energies within this range.

Bifunctional. Designating monomer units that have two active bonding positions.

Block copolymer. A linear copolymer in which identical mer units are clustered in blocks along the molecular chain.

Body-centered cubic (BCC). A common crystal structure found in some elemental metals. Within the cubic unit cell, atoms are located at corner and cell center positions.

Bohr atomic model. An early atomic model, in which electrons are assumed to revolve around the nucleus in discrete orbitals.

Bohr magneton (μ_B). The most fundamental magnetic moment, of magnitude 9.27×10^{-24} A-m^2.

Boltzmann's constant (k). A thermal energy constant having the value of 1.38×10^{-23} J/atom-K (8.62×10^{-5} eV/atom-K). See also **Gas constant.**

Bonding energy. The energy required to separate two atoms that are chemically bonded to each other. It may be expressed on a per-atom basis, or per mole of atoms.

Bragg's law. A relationship (Equation 3.9) which stipulates the condition for diffraction by a set of crystallographic planes.

Branched polymer. A polymer having a molecular structure of secondary chains that extend from the primary main chains.

Brass. A copper-rich copper–zinc alloy.

Brazing. A metal joining technique that uses a molten filler metal alloy having a melting temperature greater than about 425°C (800°F).

Brittle fracture. Fracture that occurs by rapid crack propagation and without appreciable macroscopic deformation.

Bronze. A copper-rich copper–tin alloy; aluminum, silicon, and nickel bronzes are also possible.

Burgers vector (b). A vector that denotes the magnitude and direction of lattice distortion associated with a dislocation.

C

Calcination. A high-temperature reaction whereby one solid material dissociates to form a gas and another solid. It is one step in the production of cement.

Capacitance (C). The charge-storing ability of a capacitor, defined as the magnitude of charge stored on either plate divided by the applied voltage.

Carbon-carbon composite. A composite that is composed of continuous fibers of carbon that are imbedded in a carbon matrix. The matrix was originally a polymer resin that was subsequently pyrolyzed to form carbon.

Carburizing. The process by which the surface carbon concentration of a ferrous alloy is increased by diffusion from the surrounding environment.

Case hardening. Hardening of the outer surface (or "case") of a steel component by a carburizing or nitriding process; used to improve wear and fatigue resistance.

Cast iron. Generically, a ferrous alloy, the carbon content of which is greater than the maximum solubility in austenite at the eutectic temperature. Most commercial cast irons contain between 3.0 and 4.5 wt% C, and between 1 and 3 wt% Si.

Cathode. The electrode in an electrochemical cell or galvanic couple at which a reduction reaction occurs; thus the electrode that receives electrons from an external circuit.

Cathodic protection. A means of corrosion prevention whereby electrons are supplied to the structure to be protected from an external source such as another more reactive metal or a dc power supply.

Cation. A positively charged metallic ion.

Cement. A substance (often a ceramic) that by chemical reaction binds particulate aggregates into a cohesive structure. With hydraulic cements the chemical reaction is one of hydration, involving water.

Cementite. Iron carbide (Fe_3C).

Ceramic. A compound of metallic and nonmetallic elements, for which the interatomic bonding is predominantly ionic.

Ceramic-matrix composite (*CMC*). A composite for which both matrix and dispersed phases are ceramic materials. The dispersed phase is normally added to improve fracture toughness.

Cermet. A composite material consisting of a combination of ceramic and metallic materials. The most common cermets are the cemented carbides, composed of an extremely hard ceramic (e.g., WC, TiC), bonded together by a ductile metal such as cobalt or nickel.

Chain-folded model. For crystalline polymers, a model that describes the structure of platelet crystallites. Molecular alignment is accomplished by chain folding that occurs at the crystallite faces.

Charpy test. One of two tests (see also **Izod test**) that may be used to measure the impact energy or notch toughness of a standard notched

specimen. An impact blow is imparted to the specimen by means of a weighted pendulum.

Cis. For polymers, a prefix denoting a type of molecular structure. For some unsaturated carbon chain atoms within a mer unit, a side atom or group may be situated on one side of the chain or directly opposite at a 180° rotation position. In a cis structure, two such side groups within the same mer reside on the same side (e.g., *cis*-isoprene).

Coarse pearlite. Pearlite for which the alternating ferrite and cementite layers are relatively thick.

Coercivity (or coercive field, H_c). The applied magnetic field necessary to reduce to zero the magnetic flux density of a magnetized ferromagnetic or ferrimagnetic material.

Cold working. The plastic deformation of a metal at a temperature below that at which it recrystallizes.

Color. Visual perception that is stimulated by the combination of wavelengths of light that are transmitted to the eye.

Colorant. An additive that imparts a specific color to a polymer.

Component. A chemical constituent (element or compound) of an alloy, which may be used to specify its composition.

Composition (C_i). The relative content of a particular element or constituent (i) within an alloy, usually expressed in weight percent or atom percent.

Concentration. See **Composition.**

Concentration gradient (dC/dx). The slope of the concentration profile at a specific position.

Concentration polarization. The condition wherein the rate of an electrochemical reaction is limited by the rate of diffusion in the solution.

Concentration profile. The curve that results when the concentration of a chemical species is plotted versus position in a material.

Concrete. A composite material consisting of aggregate particles bound together in a solid body by a cement.

Condensation (or step reaction) polymerization. The formation of polymer macromolecules by an intermolecular reaction involving at least two monomer species, usually with the production of a by-product of low molecular weight, such as water.

Conduction band. For electrical insulators and semiconductors, the lowest lying electron energy band that is empty of electrons at 0 K. Conduction electrons are those that have been excited to states within this band.

Conductivity, electrical (σ). The proportionality constant between current density and applied electric field; also a measure of the ease with which a material is capable of conducting an electric current.

Congruent transformation. A transformation of one phase to another of the same composition.

Continuous cooling transformation (*CCT*) diagram. A plot of temperature versus the logarithm of time for a steel alloy of definite composition. Used to indicate when transformations occur as the initially austenitized material is continuously cooled at a specified rate; in addition, the final microstructure and mechanical characteristics may be predicted.

Coordination number. The number of atomic or ionic nearest neighbors.

Copolymer. A polymer that consists of two or more dissimilar mer units in combination along its molecular chains.

Corrosion. Deteriorative loss of a metal as a result of dissolution environmental reactions.

Corrosion fatigue. A type of failure that results from the simultaneous action of a cyclic stress and chemical attack.

Corrosion penetration rate (CPR). Thickness loss of material per unit of time as a result of corrosion; usually expressed in terms of mils per year or millimeters per year.

Coulombic force. A force between charged particles such as ions; the force is attractive when the particles are of opposite charge.

Covalent bond. A primary interatomic bond that is formed by the sharing of electrons between neighboring atoms.

Creep. The time-dependent permanent deformation that occurs under stress; for most materials it is important only at elevated temperatures.

Crevice corrosion. A form of corrosion that occurs within narrow crevices and under deposits of dirt or corrosion products (i.e., in regions of localized depletion of oxygen in the solution).

Critical resolved shear stress (τ_{crss}). That shear stress, resolved within a slip plane and direction, which is required to initiate slip.

Crosslinked polymer. A polymer in which adjacent linear molecular chains are joined at various positions by covalent bonds.

Crystalline. The state of a solid material characterized by a periodic and repeating three-dimensional array of atoms, ions, or molecules.

Crystallinity. For polymers, the state wherein a periodic and repeating atomic arrangement is achieved by molecular chain alignment.

Crystallite. A region within a crystalline polymer in which all the molecular chains are ordered and aligned.

Crystal structure. For crystalline materials, the manner in which atoms or ions are arrayed in space. It is defined in terms of the unit cell geometry and the atom positions within the unit cell.

Crystal system. A scheme by which crystal structures are classified according to unit cell geometry. This geometry is specified in terms of the relationships between edge lengths and interaxial angles. There are seven different crystal systems.

Curie temperature (T_c). That temperature above which a ferromag-

netic or ferrimagnetic material becomes paramagnetic.

D

Defect structure. Relating to the kinds and concentrations of vacancies and interstitials in a ceramic compound.

Degradation. A term used to denote the deteriorative processes that occur with polymeric materials. These processes include swelling, dissolution, and chain scission.

Degree of polymerization. The average number of mer units per polymer chain molecule.

Design stress (σ_d). Product of the calculated stress level (on the basis of estimated maximum load) and a design factor (which has a value greater than unity). Used to protect against unanticipated failure.

Devitrification. The process in which a glass (noncrystalline or vitreous solid) transforms to a crystalline solid.

Diamagnetism. A weak form of induced or nonpermanent magnetism for which the magnetic susceptibility is negative.

Dielectric. Any material that is electrically insulating.

Dielectric constant (ϵ_r). The ratio of the permittivity of a medium to that of a vacuum. Often called the relative dielectric constant or relative permittivity.

Dielectric displacement (D). The magnitude of charge per unit area of capacitor plate.

Dielectric (breakdown) strength. The magnitude of an electric field necessary to cause significant current passage through a dielectric material.

Diffraction (x-ray). Constructive interference of x-ray beams that are scattered by atoms of a crystal.

Diffusion. Mass transport by atomic motion.

Diffusion coefficient (D). The constant of proportionality between the diffusion flux and the concentration gradient in Fick's first law. Its magnitude is indicative of the rate of atomic diffusion.

Diffusion flux (J). The quantity of mass diffusing through and perpendicular to a unit cross-sectional area of material per unit time.

Diode. An electronic device that rectifies an electrical current—i.e., allows current flow in one direction only.

Dipole (electric). A pair of equal yet opposite electrical charges that are separated by a small distance.

Dislocation. A linear crystalline defect around which there is atomic misalignment. Plastic deformation corresponds to the motion of dislocations in response to an applied shear stress. Edge, screw, and mixed dislocations are possible.

Dislocation density. The total dislocation length per unit volume of material; alternately, the number of dislocations that intersect a unit area of a random surface section.

Dislocation line. The line that extends along the end of the extra half-plane of atoms for an edge dislocation, and along the center of the spiral of a screw dislocation.

Dispersed phase. For composites and some two-phase alloys, the discontinuous phase that is surrounded by the matrix phase.

Dispersion strengthening. A means of strengthening materials wherein very small particles (usually less than 0.1 μm) of a hard yet inert phase are uniformly dispersed within a load-bearing matrix phase.

Domain. A volume region of a ferromagnetic or ferrimagnetic material in which all atomic or ionic magnetic moments are aligned in the same direction.

Donor level. For a semiconductor or insulator, an energy level lying within yet near the top of the energy band gap, and from which electrons may be excited into the conduction band. It is normally introduced by an impurity atom.

Doping. The intentional alloying of semiconducting materials with controlled concentrations of donor or acceptor impurities.

Drawing (metals). A forming technique used to fabricate metal wire and tubing. Deformation is accomplished by pulling the material through a die by means of a tensile force applied on the exit side.

Drawing (polymers). A deformation technique wherein polymer fibers are strengthened by elongation.

Driving force. The impetus behind a reaction, such as diffusion, grain growth, or a phase transformation. Usually attendant to the reaction is a reduction in some type of energy (e.g., free energy).

Ductile fracture. A mode of fracture that is attended by extensive gross plastic deformation.

Ductile iron. A cast iron that is alloyed with silicon and a small concentration of magnesium and/or cerium and in which the free graphite exists in nodular form. Sometimes called nodular iron.

Ductile-to-brittle transition. The transition from ductile to brittle behavior with a decrease in temperature exhibited by BCC alloys; the temperature range over which the transition occurs is determined by Charpy and Izod impact tests.

Ductility. A measure of a material's ability to undergo appreciable plastic deformation before fracture; it may be expressed as percent elongation (%EL) or percent reduction in area (%RA) from a tensile test.

E

Edge dislocation. A linear crystalline defect associated with the lattice distortion produced in the vicinity of the end of an extra half-plane of atoms within a crystal. The Burgers vector is perpendicular to the dislocation line.

Elastic deformation. Deformation that is nonpermanent, that is, totally recovered upon release of an applied stress.

Elastic recovery. Nonpermanent deformation that is recovered or regained upon the release of a mechanical stress.

Elastomer. A polymeric material that may experience large and reversible elastic deformations.

Electrical conductivity. See **Conductivity, electrical.**

Electric dipole. See **Dipole (electric).**

Electric field ($\mathscr{E}$). The gradient of voltage.

Electroluminescence. The emission of visible light by a p–n junction across which a forward-biased voltage is applied.

Electrolyte. A solution through which an electric current may be carried by the motion of ions.

Electromotive force (emf) series. A ranking of metallic elements according to their standard electrochemical cell potentials.

Electron configuration. For an atom, the manner in which possible electron states are filled with electrons.

Electronegative. For an atom, having a tendency to accept valence electrons. Also, a term used to describe nonmetallic elements.

Electron energy band. A series of electron energy states that are very closely spaced with respect to energy.

Electroneutrality. The state of having exactly the same numbers of positive and negative electrical charges (ionic and electronic), that is, of being electrically neutral.

Electron state (level). One of a set of discrete, quantized energies that are allowed for electrons. In the atomic case each state is specified by four quantum numbers.

Electron volt (eV). A convenient unit of energy for atomic and subatomic systems. It is equivalent to the energy acquired by an electron when it falls through an electric potential of 1 volt.

Electropositive. For an atom, having a tendency to release valence electrons. Also, a term used to describe metallic elements.

Endurance limit. See **Fatigue limit.**

Energy band gap. See **Band gap energy.**

Engineering strain. See **Strain, engineering.**

Engineering stress. See **Stress, engineering.**

Equilibrium (phase). The state of a system where the phase characteristics remain constant over indefinite time periods. At equilibrium the free energy is a minimum.

Erosion–corrosion. A form of corrosion that arises from the combined action of chemical attack and mechanical wear.

Eutectic phase. One of the two phases found in the eutectic structure.

Eutectic reaction. A reaction wherein, upon cooling, a liquid phase transforms isothermally and reversibly into two intimately mixed solid phases.

Eutectic structure. A two-phase microstructure resulting from the solidification of a liquid having the eutectic composition; the phases exist as lamellae that alternate with one another.

Eutectoid reaction. A reaction wherein, upon cooling, one solid phase transforms isothermally and reversibly into two new solid phases that are intimately mixed.

Excited state. An electron energy state, not normally occupied, to which an electron may be promoted (from a lower energy state) by the absorption of some type of energy (e.g., heat, radiative).

Extrinsic semiconductor. A semiconducting material for which the electrical behavior is determined by impurities.

Extrusion. A forming technique whereby a material is forced, by compression, through a die orifice.

F

Face-centered cubic (FCC). A crystal structure found in some of the common elemental metals. Within the cubic unit cell, atoms are located at all corner and face-centered positions.

Fatigue. Failure, at relatively low stress levels, of structures that are subjected to fluctuating and cyclic stresses.

Fatigue life (N_f). The total number of stress cycles that will cause a fatigue failure at some specified stress amplitude.

Fatigue limit. For fatigue, the maximum stress amplitude level below which a material can endure an essentially infinite number of stress cycles and not fail.

Fatigue strength. The maximum stress level that a material can sustain, without failing, for some specified number of cycles.

Fermi energy (E_f). For a metal, the energy corresponding to the highest filled electron state at 0 K.

Ferrimagnetism. Permanent and large magnetizations found in some ceramic materials. It results from antiparallel spin coupling and incomplete magnetic moment cancellation.

Ferrite (ceramic). Ceramic oxide materials composed of both divalent and trivalent cations (e.g., Fe^{2+} and Fe^{3+}), some of which are ferrimagnetic.

Ferrite (iron). Body-centered cubic iron; also iron and steel alloys that have the BCC crystal structure.

Ferroelectric. A dielectric material that may exhibit polarization in the absence of an electric field.

Ferromagnetism. Permanent and large magnetizations found in some metals (e.g., Fe, Ni, and Co), which result from the parallel alignment of neighboring magnetic moments.

Ferrous alloy. A metal alloy for which iron is the prime constituent.

Fiber. Any polymer, metal, or ceramic that has been drawn into a long and thin filament.

Fiber-reinforced composite. A composite in which the dispersed phase is in the form of a fiber (i.e., a filament that has a large length-to-diameter ratio).

Fiber reinforcement. Strengthening or reinforcement of a relatively weak material by embedding a

strong fiber phase within the weak matrix material.

Fick's first law. The diffusion flux is proportional to the concentration gradient. This relationship is employed for steady-state diffusion situations.

Fick's second law. The time rate of change of concentration is proportional to the second derivative of concentration. This relationship is employed in nonsteady-state diffusion situations.

Filler. An inert foreign substance added to a polymer to improve or modify its properties.

Fine pearlite. Pearlite for which the alternating ferrite and cementite layers are relatively thin.

Firing. A high temperature heat treatment that increases the density and strength of a ceramic piece.

Flame retardant. A polymer additive that increases flammability resistance.

Flexural strength (σ_{fs}). Stress at fracture from a bend (or flexure) test.

Fluorescence. Luminescence that occurs for times much less than a second after an electron excitation event.

Foam. A polymer that has been made porous (or spongelike) by the incorporation of gas bubbles.

Forging. Mechanical forming of a metal by heating and hammering.

Forward bias. The conducting bias for a p–n junction rectifier such that electron flow is to the n side of the junction.

Fracture mechanics. A technique of fracture analysis used to determine the stress level at which preexisting cracks of known size will propagate, leading to fracture.

Fracture toughness (K_c). Critical value of the stress intensity factor for which crack extension occurs.

Free electron. An electron that has been excited into an energy state above the Fermi energy (or into the conduction band for semiconductors and insulators) and may participate in the electrical conduction process.

Free energy. A thermodynamic quantity that is a function of both the internal energy and entropy (or randomness) of a system. At equilibrium, the free energy is at a minimum.

Frenkel defect. In an ionic solid, a cation–vacancy and cation–interstitial pair.

Full annealing. For ferrous alloys, austenitizing, followed by cooling slowly to room temperature.

G

Galvanic corrosion. The preferential corrosion of the more chemically active of two metals that are electrically coupled and exposed to an electrolyte.

Galvanic series. A ranking of metals and alloys as to their relative electrochemical reactivity in seawater.

Gas constant (R). Boltzmann's constant per mole of atoms. R = 8.31 J/mol-K (1.987 cal/mol-K).

Gibbs phase rule. For a system at equilibrium, an equation (Equation 9.16) that expresses the relationship between the number of phases present and the number of externally controllable variables.

Glass–ceramic. A fine-grained crystalline ceramic material that was formed as a glass and subsequently devitrified (or crystallized).

Glass transition temperature (T_g). That temperature at which, upon cooling, a noncrystalline ceramic or polymer transforms from a supercooled liquid to a rigid glass.

Graft copolymer. A copolymer wherein homopolymer side branches of one mer type are grafted to homopolymer main chains of a different mer.

Grain. An individual crystal in a polycrystalline metal or ceramic.

Grain boundary. The interface separating two adjoining grains having different crystallographic orientations.

Grain growth. The increase in average grain size of a polycrystalline material; for most materials, an elevated-temperature heat treatment is necessary.

Grain size. The average grain diameter as determined from a random cross section.

Gray cast iron. A cast iron alloyed with silicon in which the graphite exists in the form of flakes. A fractured surface appears gray.

Green ceramic body. A ceramic piece, formed as a particulate aggregate, that has been dried but not fired.

Ground state. A normally filled electron energy state from which electron excitation may occur.

H

Hall effect. The phenomenon whereby a force is brought to bear on a moving electron or hole by a magnetic field that is applied perpendicular to the direction of motion. The force direction is perpendicular to both the magnetic field and the particle motion directions.

Hardenability. A measure of the depth to which a specific ferrous alloy may be hardened by the formation of martensite upon quenching from a temperature above the upper critical temperature.

Hard magnetic material. A ferrimagnetic or ferromagnetic material that has large coercive field and remanence values, normally used in permanent magnet applications.

Hardness. The measure of a material's resistance to deformation by surface indentation or by abrasion.

Heat capacity (C_p, C_v). The quantity of heat required to produce a unit temperature rise per mole of material.

Hexagonal close-packed (HCP). A crystal structure found for some metals. The HCP unit cell is of hexagonal geometry and is generated by the stacking of close-packed planes of atoms.

High polymer. A solid polymeric material having a molecular weight greater than about 10,000 g/mol.

High-strength, low-alloy (HSLA) steels. Relatively strong, low-carbon steels, with less than about 10 wt% total of alloying elements.

Hole (electron). For semiconductors and insulators, a vacant electron state in the valence band that behaves as a positive charge carrier in an electric field.

Homopolymer. A polymer having a chain structure in which all mer units are of the same type.

Hot working. Any metal forming operation that is performed above a metal's recrystallization temperature.

Hybrid composite. A composite that is fiber reinforced by two or more types of fibers (e.g., glass and carbon).

Hydrogen bond. A strong secondary interatomic bond that exists between a bound hydrogen atom (its unscreened proton) and the electrons of adjacent atoms.

Hydrogen embrittlement. The loss or reduction of ductility of a metal alloy (often steel) as a result of the diffusion of atomic hydrogen into the material.

Hydroplastic forming. The molding or shaping of clay-based ceramics that have been made plastic and pliable by adding water.

Hypereutectoid alloy. For an alloy system displaying a eutectoid, an alloy for which the concentration of solute is greater than the eutectoid composition.

Hypoeutectoid alloy. For an alloy system displaying a eutectoid, an alloy for which the concentration of solute is less than the eutectoid composition.

Hysteresis (magnetic). The irreversible magnetic flux density-versus-magnetic field strength (B-versus-H) behavior found for ferromagnetic and ferrimagnetic materials; a closed B–H loop is formed upon field reversal.

I

Impact energy (notch toughness). A measure of the energy absorbed during the fracture of a specimen of standard dimensions and geometry when subjected to very rapid (impact) loading. Charpy and Izod impact tests are used to measure this parameter, which is important in assessing the ductile-to-brittle transition behavior of a material.

Imperfection. A deviation from perfection; normally applied to crystalline materials wherein there is a deviation from atomic/molecular order and/or continuity.

Index of refraction (n). The ratio of the velocity of light in a vacuum to the velocity in some medium.

Inhibitor. A chemical substance that, when added in relatively low concentrations, retards a chemical reaction.

Insulator (electrical). A nonmetallic material that has a filled valence band at 0 K and a relatively wide energy band gap. Consequently, the room-temperature electrical conductivity is very low, less than about 10^{-10} $(\Omega\text{-m})^{-1}$.

Integrated circuit. Thousands of electronic circuit elements (transistors, diodes, resistors, capacitors, etc.) incorporated on a very small silicon chip.

Interdiffusion. Diffusion of atoms of one metal into another metal.

Intergranular corrosion. Preferential corrosion along grain boundary regions of polycrystalline materials.

Intergranular fracture. Fracture of polycrystalline materials by crack propagation along grain boundaries.

Intermediate solid solution. A solid solution or phase having a composition range that does not extend to either of the pure components of the system.

Intermetallic compound. A compound of two metals that has a distinct chemical formula. On a phase diagram it appears as an intermediate phase that exists over a very narrow range of compositions.

Interstitial diffusion. A diffusion mechanism whereby atomic motion is from interstitial site to interstitial site.

Interstitial solid solution. A solid solution wherein relatively small solute atoms occupy interstitial positions between the solvent or host atoms.

Intrinsic semiconductor. A semiconductor material for which the electrical behavior is characteristic of the pure material; that is, electrical conductivity depends only on temperature and the band gap energy.

Invariant point. A point on a binary phase diagram at which three phases are in equilibrium.

Ionic bond. A coulombic interatomic bond that exists between two adjacent and oppositely charged ions.

Isomerism. The phenomenon whereby two or more polymer molecules or mer units have the same composition but different structural arrangements and properties.

Isomorphous. Having the same structure. In the phase diagram sense, isomorphicity means having the same crystal structure or complete solid solubility for all compositions (see Figure 9.2*a*).

Isotactic. A type of polymer chain configuration wherein all side groups are positioned on the same side of the chain molecule.

Isothermal. At a constant temperature.

Isothermal transformation (T–T–T) diagram. A plot of temperature versus the logarithm of time for a steel alloy of definite composition. Used to determine when transformations begin and end for an isothermal (constant-temperature) heat treatment of a previously austenitized alloy.

Isotopes. Atoms of the same element that have different atomic masses.

Isotropic. Having identical values of a property in all crystallographic directions.

Izod test. One of two tests (see also **Charpy test**) that may be used to measure the impact energy of a standard notched specimen. An impact blow is imparted to the specimen by a weighted pendulum.

J

Jominy end-quench test. A standardized laboratory test that is used to assess the hardenability of ferrous alloys.

Junction transistor. A semiconducting device composed of appropriately biased *n–p–n* or *p–n–p* junctions, used to amplify an electrical signal.

K

Kinetics. The study of reaction rates and the factors that affect them.

L

Laminar composite. A series of two-dimensional sheets, each having a preferred high-strength direction, fastened one on top of the other at different orientations; strength in the plane of the laminate is highly isotropic.

Large-particle composite. A type of particle-reinforced composite wherein particle-matrix interactions cannot be treated on an atomic level; the particles reinforce the matrix phase.

Laser. Acronym for light amplification by stimulated emission of radiation—a source of light that is coherent.

Lattice. The regular geometrical arrangement of points in crystal space.

Lattice parameters. The combination of unit cell edge lengths and interaxial angles that defines the unit cell geometry.

Lattice strains. Slight displacements of atoms relative to their normal lattice positions, normally imposed by crystalline defects such as dislocations, and interstitial and impurity atoms.

Lever rule. Mathematical expression, such as Equation 9.1b or Equation 9.2b, whereby the relative phase amounts in a two-phase alloy at equilibrium may be computed.

Linear coefficient of thermal expansion. See **Thermal expansion coefficient, linear.**

Linear polymer. A polymer in which each molecule consists of bifunctional mer units joined end to end in a single chain.

Liquid crystal polymer (*LCP*). A group of polymeric materials having extended and rod-shaped molecules, which, structurally, do not fall within traditional liquid, amorphous, crystalline, or semicrystalline classifications. They are used in digital displays and a variety of applications in electronics and medical equipment industries.

Liquidus line. On a binary phase diagram, that line or boundary separating liquid and liquid + solid phase regions. For an alloy, the liquidus temperature is that temperature at which a solid phase first forms under conditions of equilibrium cooling.

Longitudinal direction. The lengthwise dimension. For a rod or fiber, in the direction of the long axis.

Lower critical temperature. For a steel alloy, the temperature below which, under equilibrium conditions, all austenite has transformed to ferrite and cementite phases.

Luminescence. The emission of visible light as a result of electron decay from an excited state.

M

Macromolecule. A huge molecule made up of thousands of atoms.

Magnetic field strength (*H*). The intensity of an externally applied magnetic field.

Magnetic flux density (*B*). The magnetic field produced in a substance by an external magnetic field.

Magnetic induction (*B*). See **Magnetic flux density.**

Magnetic susceptibility (χ_m). The proportionality constant between the magnetization M and the magnetic field strength H.

Magnetization (*M*). The total magnetic moment per unit volume of material. Also, a measure of the contribution to the magnetic flux by some material within an H field.

Malleable cast iron. White cast iron that has been heat treated to convert the cementite into graphite clusters; a relatively ductile cast iron.

Martensite. A metastable iron phase supersaturated in carbon that is the product of a diffusionless (athermal) transformation from austenite.

Matrix phase. The phase in a composite or two-phase alloy microstructure that is continuous or completely surrounds the other (or dispersed) phase.

Matthiessen's rule. The total electrical resistivity of a metal is equal to the sum of temperature-, impurity-, and cold work-dependent contributions.

Melting point (glass). The temperature at which the viscosity of a glass material is 10 Pa-s (100 P).

Mer. The group of atoms that constitutes a polymer chain repeat unit.

Metal. The electropositive elements and alloys based on these elements. The electron band structure of metals is characterized by a partially filled electron band.

Metallic bond. A primary interatomic bond involving the nondirectional sharing of nonlocalized valence electrons (''sea of electrons'') that are mutually shared by all the atoms in the metallic solid.

Metal-matrix composite (*MMC*). A composite material which has a metal or metal alloy as the matrix phase. The dispersed phase may be particulates, fibers, or whiskers that normally are stiffer, stronger, and/or harder than the matrix.

Metastable. Nonequilibrium state that may persist for a very long time.

Microconstituent. An element of the microstructure that has an identifiable and characteristic structure. It may consist of more than one phase such as with pearlite.

Microscopy. The investigation of microstructural elements using some type of microscope.

Microstructure. The structural features of an alloy (e.g., grain and phase structure) that are subject to observation under a microscope.

Miller indices. A set of three integers (four for hexagonal) that designate crystallographic planes, as determined from reciprocals of fractional axial intercepts.

Mixed dislocation. A dislocation that has both edge and screw components.

Mobility (electron, μ_e, and hole, μ_h). The proportionality constant between the carrier drift velocity and applied electric field; also, a measure of the ease of charge carrier motion.

Modulus of elasticity (E). The ratio of stress to strain when deformation is totally elastic; also a measure of the stiffness of a material.

Molarity (M). Concentration in a liquid solution, in terms of the number of moles of a solute dissolved in 10^6 mm^3 (10^3 cm^3) of solution.

Molding (plastics). Shaping a plastic material by forcing it, under pressure and at an elevated temperature, into a mold cavity.

Mole. The quantity of a substance corresponding to 6.023×10^{23} atoms or molecules.

Molecular chemistry (polymer). With regard only to composition, not the structure of a mer.

Molecular structure (polymer). With regard to atomic arrangements within and interconnections between polymer molecules.

Molecular weight. The sum of the atomic weights of all the atoms in a molecule.

Molecule. A group of atoms that are bound together by primary interatomic bonds.

Monomer. A molecule consisting of a single mer.

MOSFET. Metal-oxide-silicon field effect transistor, an integrated circuit element.

N

***n*-Type semiconductor.** A semiconductor for which the predominant charge carriers responsible for electrical conduction are electrons. Normally, donor impurity atoms give rise to the excess electrons.

Natural aging. For precipitation hardening, aging at room temperature.

Network polymer. A polymer composed of trifunctional mer units that form three-dimensional molecules.

Nodular iron. See **Ductile iron.**

Noncrystalline. The solid state wherein there is no long-range atomic order. Sometimes the terms *amorphous*, *glassy*, and *vitreous* are used synonymously.

Nonferrous alloy. A metal alloy for which iron is *not* the prime constituent.

Nonsteady-state diffusion. The diffusion condition for which there is some net accumulation or depletion of diffusing species. The diffusion flux is dependent on time.

Normalizing. For ferrous alloys, austenitizing above the upper critical temperature, then cooling in air. The objective of this heat treatment is to enhance toughness by refining the grain size.

Nucleation. The initial stage in a phase transformation. It is evidenced by the formation of small particles (nuclei) of the new phase, which are capable of growing.

O

Octahedral position. The void space among close-packed, hard sphere atoms or ions for which there are six nearest neighbors. An octahedron (double pyramid) is circumscribed by lines constructed from centers of adjacent spheres.

Ohm's law. The applied voltage is equal to the product of the current and resistance; equivalently, the current density is equal to the product of the conductivity and electric field intensity.

Opaque. Being impervious to the transmission of light as a result of absorption, reflection, and/or scattering of incident light.

Overaging. During precipitation hardening, aging beyond the point at which strength and hardness are at their maxima.

Oxidation. The removal of one or more electrons from an atom, ion, or molecule.

P

Paramagnetism. A relatively weak form of magnetism that results from the independent alignment of atomic dipoles (magnetic) with an applied magnetic field.

Particle-reinforced composite. A composite for which the dispersed phase is equiaxed.

Passivity. The loss of chemical reactivity, under particular environmental conditions, by some active metals and alloys.

Pauli exclusion principle. The postulate that for an individual atom, at most two electrons, which necessarily have opposite spins, can occupy the same state.

Pearlite. A two-phase microstructure found in some steels and cast irons; it results from the transformation of austenite of eutectoid composition and consists of alternating layers (or lamellae) of α-ferrite and cementite.

Periodic table. The arrangement of the chemical elements with increasing atomic number according to the periodic variation in electron structure. Nonmetallic elements are positioned at the far right-hand side of the table.

Peritectic reaction. A reaction wherein, upon cooling, a solid and a

liquid phase transform isothermally and reversibly to a solid phase having a different composition.

Permeability (magnetic, μ). The proportionality constant between B and H fields. The value of the permeability of a vacuum (μ_0) is 1.257×10^{-6} H/m.

Permittivity (ϵ). The proportionality constant between the dielectric displacement D and the electric field $\mathscr{E}$. The value of the permittivity ϵ_0 for a vacuum is 8.85×10^{-12} F/m.

Phase. A homogeneous portion of a system that has uniform physical and chemical characteristics.

Phase diagram. A graphical representation of the relationships between environmental constraints (e.g., temperature and sometimes pressure), composition, and regions of phase stability, ordinarily under conditions of equilibrium.

Phase equilibrium. See **Equilibrium (phase).**

Phase transformation. A change in the number and/or character of the phases that constitute the microstructure of an alloy.

Phonon. A single quantum of vibrational or elastic energy.

Phosphorescence. Luminescence that occurs at times greater than on the order of a second after an electron excitation event.

Photoconductivity. Electrical conductivity that results from photon-induced electron excitations in which light is absorbed.

Photomicrograph. The photograph made with a microscope, which records a microstructural image.

Photon. A quantum unit of electromagnetic energy.

Piezoelectric. A dielectric material in which polarization is induced by the application of external forces.

Pilling–Bedworth ratio (P–B ratio). The ratio of metal oxide volume to metal volume; used to predict whether or not a scale that forms will protect a metal from further oxidation.

Pitting. A form of very localized corrosion wherein small pits or holes form, usually in a vertical direction.

Plain carbon steel. A ferrous alloy in which carbon is the prime alloying element.

Planck's constant (h). A universal constant that has a value of 6.63×10^{-34} J-s. The energy of a photon of electromagnetic radiation is the product of h and the radiation frequency.

Plane strain. The condition, important in fracture mechanical analyses, wherein, for tensile loading, there is zero strain in a direction perpendicular to both the stress axis and the direction of crack propagation; this condition is found in thick plates, and the zero-strain direction is perpendicular to the plate surface.

Plane strain fracture toughness (K_{Ic}). The critical value of the stress intensity factor (i.e., at which crack propagation occurs) for the condition of plane strain.

Plastic. A solid material the primary ingredient of which is an organic polymer of high molecular weight; it may also contain additives such as fillers, plasticizers, flame retardants, and the like.

Plastic deformation. Deformation that is permanent or nonrecoverable after release of the applied load. It is accompanied by permanent atomic displacements.

Plasticizer. A low molecular weight polymer additive that enhances flexibility and workability and reduces stiffness and brittleness.

Point defect. A crystalline defect associated with one or, at most, several atomic sites.

Poisson's ratio (ν). For elastic deformation, the negative ratio of lateral and axial strains that result from an applied axial stress.

Polar molecule. A molecule in which there exists a permanent electric dipole moment by virtue of the asymmetrical distribution of positively and negatively charged regions.

Polarization (P). The total electric dipole moment per unit volume of dielectric material. Also, a measure of the contribution to the total dielectric displacement by a dielectric material.

Polarization (corrosion). The displacement of an electrode potential from its equilibrium value as a result of current flow.

Polarization (electronic). For an atom, the displacement of the center of the negatively charged electron cloud relative to the positive nucleus, which is induced by an electric field.

Polarization (ionic). Polarization as a result of the displacement of anions and cations in opposite directions.

Polarization (orientation). Polarization resulting from the alignment (by rotation) of permanent electric dipole moments with an applied electric field.

Polycrystalline. Referring to crystalline materials that are composed of more than one crystal or grain.

Polymer. A solid, nonmetallic (normally organic) compound of high molecular weight the structure of which is composed of small repeat (or mer) units.

Polymer-matrix composite (*PMC*). A composite material for which the matrix is a polymer resin, and having fibers (normally glass, carbon, or aramid) as the dispersed phase.

Polymorphism. The ability of a solid material to exist in more than one form or crystal structure.

Powder metallurgy (P/M). The fabrication of metal pieces having intricate and precise shapes by the compaction of metal powders, followed by a densification heat treatment.

Precipitation hardening. Hardening and strengthening of a metal alloy by extremely small and uniformly dispersed particles that precipitate from a supersaturated solid

solution; sometimes also called *age hardening*.

Precipitation heat treatment. A heat treatment used to precipitate a new phase from a supersaturated solid solution. For precipitation hardening, it is termed *artificial aging*.

Prepreg. Continuous fiber reinforcement preimpregnated with a polymer resin that is then partially cured.

Prestressed concrete. Concrete into which compressive stresses have been introduced using steel wires or rods.

Primary bonds. Interatomic bonds that are relatively strong and for which bonding energies are relatively large. Primary bonding types are ionic, covalent, and metallic.

Primary phase. A phase that exists in addition to the eutectic structure.

Principle of combined action. The supposition, often valid, that new properties, better properties, better property combinations, and/or a higher level of properties can be fashioned by the judicious combination of two or more distinct materials.

Process annealing. Annealing of previously cold-worked products (commonly steel alloys in sheet or wire form) below the lower critical (eutectoid) temperature.

Proeutectoid cementite. Primary cementite that exists in addition to pearlite for hypereutectoid steels.

Proeutectoid ferrite. Primary ferrite that exists in addition to pearlite for hypoeutectoid steels.

Property. A material trait expressed in terms of the measured response to a specific imposed stimulus.

Proportional limit. The point on a stress–strain curve at which the straight line proportionality between stress and strain ceases.

***p*-Type semiconductor.** A semiconductor for which the predominant charge carriers responsible for electrical conduction are holes. Normally, acceptor impurity atoms give rise to the excess holes.

Q

Quantum mechanics. A branch of physics that deals with atomic and subatomic systems; it allows only discrete values of energy that are separated from one another. By contrast, for classical mechanics, continuous energy values are permissible.

Quantum numbers. A set of four numbers, the values of which are used to label possible electron states. Three of the quantum numbers are integers, which also specify the size, shape, and spatial orientation of an electron's probability density; the fourth number designates spin orientation.

R

Random copolymer. A polymer in which two different mer units are randomly distributed along the molecular chain.

Recovery. The relief of some of the internal strain energy of a previously cold-worked metal, usually by heat treatment.

Recrystallization. The formation of a new set of strain-free grains within a previously cold-worked material; normally an annealing heat treatment is necessary.

Recrystallization temperature. For a particular alloy, the minimum temperature at which complete recrystallization will occur within approximately one hour.

Rectifying junction. A semiconductor p–n junction that is conductive for a current flow in one direction and highly resistive for the opposite direction.

Reduction. The addition of one or more electrons to an atom, ion, or molecule.

Reflection. Deflection of a light beam at the interface between two media.

Refraction. Bending of a light beam upon passing from one medium into another; the velocity of light differs in the two media.

Refractory. A metal or ceramic that may be exposed to extremely high temperatures without deteriorating rapidly or without melting.

Reinforced concrete. Concrete that is reinforced (or strengthened in tension) by the incorporation of steel rods, wires, or mesh.

Relative magnetic permeability (μ_r). The ratio of the magnetic permeability of some medium to that of a vacuum.

Relaxation frequency. The reciprocal of the minimum reorientation time for an electric dipole within an alternating electric field.

Relaxation modulus [$E_r(t)$]. For viscoelastic polymers, the time-dependent modulus of elasticity. It is determined from stress relaxation measurements as the ratio of stress (taken at some time after the load application—normally 10 s) to strain.

Remanence (remanent induction, B_r). For a ferromagnetic or ferrimagnetic material, the magnitude of residual flux density that remains when a magnetic field is removed.

Residual stress. A stress that persists in a material that is free of external forces or temperature gradients.

Resilience. The capacity of a material to absorb energy when it is elastically deformed.

Resistivity (ρ). The reciprocal of electrical conductivity, and a measure of a material's resistance to the passage of electric current.

Resolved shear stress. An applied tensile or compressive stress resolved into a shear component along a specific plane and direction within that plane.

Reverse bias. The insulating bias for a p–n junction rectifier; electrons flow into the p side of the junction.

Rolling. A metal-forming operation that reduces the thickness of

sheet stock; also elongated shapes may be fashioned using grooved circular rolls.

Rule of mixtures. The properties of a multiphase alloy or composite material are a weighted average (usually on the basis of volume) of the properties of the individual constituents.

Rupture. Failure that is accompanied by significant plastic deformation; often associated with creep failure.

S

Sacrificial anode. An active metal or alloy that preferentially corrodes and protects another metal or alloy to which it is electrically coupled.

Safe stress (σ_w). A stress used for design purposes; for ductile metals, it is the yield strength divided by a factor of safety.

Sandwich panel. A type of structural composite consisting of two stiff and strong outer faces that are separated by a lightweight core material.

Saturated. A term describing a carbon atom that participates in only single covalent bonds with four other atoms.

Saturation magnetization, flux density (M_s, B_s). The maximum magnetization (or flux density) for a ferromagnetic or ferrimagnetic material.

Scanning electron microscope (SEM). A microscope that produces an image by using an electron beam that scans the surface of a specimen; an image is produced by reflected electron beams. Examination of surface and/or microstructural features at high magnifications is possible.

Scanning probe microscope (SPM). A microscope that does not produce an image using light radiation. Rather, a very small and sharp probe raster scans across the specimen surface; out-of-surface plane deflections in response to electronic or other interactions with the probe are monitored, from which a topographical map of the specimen surface (on a nanometer scale) is produced.

Schottky defect. In an ionic solid, a defect consisting of a cation–vacancy and anion–vacancy pair.

Scission. A polymer degradation process whereby molecular chain bonds are ruptured by chemical reactions or by exposure to radiation or heat.

Screw dislocation. A linear crystalline defect associated with the lattice distortion created when normally parallel planes are joined together to form a helical ramp. The Burgers vector is parallel to the dislocation line.

Secondary bonds. Interatomic and intermolecular bonds that are relatively weak and for which bonding energies are relatively small. Normally atomic or molecular dipoles are involved. Secondary bonding types are van der Waals and hydrogen.

Selective leaching. A form of corrosion wherein one element or constituent of an alloy is preferentially dissolved.

Self-diffusion. Atomic migration in pure metals.

Self-interstitial. A host atom or ion that is positioned on an interstitial lattice site.

Semiconductor. A nonmetallic material that has a filled valence band at 0 K and a relatively narrow energy band gap. The room temperature electrical conductivity ranges between about 10^{-6} and 10^{4} $(\Omega\text{-m})^{-1}$.

Shear. A force applied so as to cause or tend to cause two adjacent parts of the same body to slide relative to each other, in a direction parallel to their plane of contact.

Shear strain (γ). The tangent of the shear angle that results from an applied shear load.

Shear stress (τ). The instantaneous applied shear load divided by the original cross-sectional area across which it is applied.

Single crystal. A crystalline solid for which the periodic and repeated atomic pattern extends throughout its entirety without interruption.

Sintering. Particle coalescence of a powdered aggregate by diffusion that is accomplished by firing at an elevated temperature.

Slip. Plastic deformation as the result of dislocation motion; also, the shear displacement of two adjacent planes of atoms.

Slip casting. A forming technique used for some ceramic materials. A slip, or suspension of solid particles in water, is poured into a porous mold. A solid layer forms on the inside wall as water is absorbed by the mold, leaving a shell (or ultimately a solid piece) having the shape of the mold.

Slip system. The combination of a crystallographic plane and, within that plane, a crystallographic direction along which slip (i.e., dislocation motion) occurs.

Softening point (glass). The maximum temperature at which a glass piece may be handled without permanent deformation; this corresponds to a viscosity of approximately 4×10^{6} Pa-s (4×10^{7} P).

Soft magnetic material. A ferromagnetic or ferrimagnetic material having a small B versus H hysteresis loop, which may be magnetized and demagnetized with relative ease.

Soldering. A technique for joining metals using a filler metal alloy that has a melting temperature less than about 425°C (800°F). Lead–tin alloys are common solders.

Solid solution. A homogeneous crystalline phase that contains two or more chemical species. Both substitutional and interstitial solid solutions are possible.

Solid-solution strengthening. Hardening and strengthening of metals that result from alloying in which a solid solution is formed. The presence of impurity atoms restricts dislocation mobility.

Solidus line. On a phase diagram, the locus of points at which solidification is complete upon equilibrium cooling, or at which melting begins upon equilibrium heating.

Solubility limit. The maximum concentration of solute that may be added without forming a new phase.

Solute. One component or element of a solution present in a minor concentration. It is dissolved in the solvent.

Solution heat treatment. The process used to form a solid solution by dissolving precipitate particles. Often, the solid solution is supersaturated and metastable at ambient conditions as a result of rapid cooling from an elevated temperature.

Solvent. The component of a solution present in the greatest amount. It is the component that dissolves a solute.

Solvus line. The locus of points on a phase diagram representing the limit of solid solubility as a function of temperature.

Specific heat (c_p, c_v). The heat capacity per unit mass of material.

Specific modulus (specific stiffness). The ratio of elastic modulus to specific gravity for a material.

Specific strength. The ratio of tensile strength to specific gravity for a material.

Spheroidite. Microstructure found in steel alloys consisting of sphere-like cementite particles within an α-ferrite matrix. It is produced by an appropriate elevated-temperature heat treatment of pearlite, bainite, or martensite, and is relatively soft.

Spheroidizing. For steels, a heat treatment carried out at a temperature just below the eutectoid in which the spheroidite microstructure is produced.

Spherulite. An aggregate of ribbonlike polymer crystallites radiating from a common center, which crystallites are separated by amorphous regions.

Spinning. The process by which fibers are formed. A multitude of fibers are spun as molten material is forced through many small orifices.

Stabilizer. A polymer additive that counteracts deteriorative processes.

Stainless steel. A steel alloy that is highly resistant to corrosion in a variety of environments. The predominant alloying element is chromium, which must be present in a concentration of at least 11 wt%; other alloy additions, to include nickel and molybdenum, are also possible.

Standard half-cell. An electrochemical cell consisting of a pure metal immersed in a 1*M* aqueous solution of its ions, which is electrically coupled to the standard hydrogen electrode.

Steady-state diffusion. The diffusion condition for which there is no net accumulation or depletion of diffusing species. The diffusion flux is independent of time.

Stereoisomerism. Polymer isomerism in which side groups within mer units are bonded along the molecular chain in the same order, but in different spatial arrangements.

Stoichiometry. For ionic compounds, the state of having exactly the ratio of cations to anions specified by the chemical formula.

Strain, engineering (ϵ). The change in gauge length of a specimen (in the direction of an applied stress) divided by its original gauge length.

Strain hardening. The increase in hardness and strength of a ductile metal as it is plastically deformed below its recrystallization temperature.

Strain point (glass). The maximum temperature at which glass fractures without plastic deformation; this corresponds to a viscosity of about 3×10^{13} Pa-s (3×10^{14} P).

Strain, true. See **True strain.**

Stress concentration. The concentration or amplification of an applied stress at the tip of a notch or small crack.

Stress corrosion (cracking). A form of failure that results from the combined action of a tensile stress and a corrosion environment; it occurs at lower stress levels than are required when the corrosion environment is absent.

Stress, engineering (σ). The instantaneous load applied to a specimen divided by its cross-sectional area before any deformation.

Stress intensity factor (K). A factor used in fracture mechanics to specify the stress intensity at the tip of a crack.

Stress raiser. A small flaw (internal or surface) or a structural discontinuity at which an applied tensile stress will be amplified and from which cracks may propagate.

Stress relief. A heat treatment for the removal of residual stresses.

Stress, true. See **True stress.**

Structural clay products. Ceramic products made principally of clay and used in applications where structural integrity is important (e.g., bricks, tiles, pipes).

Structural composite. A composite the properties of which depend on the geometrical design of the structural elements. Laminar composites and sandwich panels are two subclasses.

Structure. The arrangement of the internal components of matter: electron structure (on a subatomic level), crystal structure (on an atomic level), and microstructure (on a microscopic level).

Substitutional solid solution. A solid solution wherein the solute atoms replace or substitute for the host atoms.

Superconductivity. A phenomenon observed in some materials: the disappearance of the electrical resistivity at temperatures approaching 0 K.

Supercooling. Cooling to below a phase transition temperature without the occurrence of the transformation.

Superheating. Heating to above a phase transition temperature without the occurrence of the transformation.

Syndiotactic. A type of polymer chain configuration in which side groups regularly alternate positions on opposite sides of the chain.

System. Two meanings are possible: (1) a specific body of material that is being considered, and (2) a series of possible alloys consisting of the same components.

T

Temper designation. A letter–digit code used to designate the mechanical and/or thermal treatment to which a metal alloy has been subjected.

Tempered martensite. The microstructural product resulting from a tempering heat treatment of a martensitic steel. The microstructure consists of extremely small and uniformly dispersed cementite particles embedded within a continuous α-ferrite matrix. Toughness and ductility are enhanced significantly by tempering.

Tempering (glass). See **Thermal tempering.**

Tensile strength (*TS*). The maximum engineering stress, in tension, that may be sustained without fracture. Often termed *ultimate* (*tensile*) *strength*.

Terminal solid solution. A solid solution that exists over a composition range extending to either composition extremity of a binary phase diagram.

Tetrahedral position. The void space among close-packed, hard sphere atoms or ions for which there are four nearest neighbors.

Thermal conductivity (*k*). For steady-state heat flow, the proportionality constant between the heat flux and the temperature gradient. Also, a parameter characterizing the ability of a material to conduct heat.

Thermal expansion coefficient, linear (α_l). The fractional change in length divided by the change in temperature.

Thermal fatigue. A type of fatigue failure wherein the cyclic stresses are introduced by fluctuating thermal stresses.

Thermal shock. The fracture of a brittle material as a result of stresses that are introduced by a rapid temperature change.

Thermal stress. A residual stress introduced within a body resulting from a change in temperature.

Thermal tempering. Increasing the strength of a glass piece by the introduction of residual compressive stresses within the outer surface using an appropriate heat treatment.

Thermally activated transformation. A reaction that depends on atomic thermal fluctuations; the atoms having energies greater than an activation energy will spontaneously react or transform. The rate of this type of transformation depends on temperature according to Equation 10.3.

Thermoplastic (polymer). A polymeric material that softens when heated and hardens upon cooling. While in the softened state, articles may be formed by molding or extrusion.

Thermoplastic elastomer (*TPE*). A copolymeric material that exhibits elastomeric behavior yet is thermoplastic in nature. At the ambient temperature, domains of one mer type form at molecular chain ends that act as physical crosslinks.

Thermosetting (polymer). A polymeric material that, once having cured (or hardened) by a chemical reaction, will not soften or melt when subsequently heated.

Tie line. A horizontal line constructed across a two-phase region of a binary phase diagram; its intersections with the phase boundaries on either end represent the equilibrium compositions of the respective phases at the temperature in question.

Time–temperature–transformation (*T–T–T*) diagram. See **Isothermal transformation diagram.**

Toughness. A measure of the amount of energy absorbed by a material as it fractures. Toughness is indicated by the total area under the material's tensile stress–strain curve.

Trans. For polymers, a prefix denoting a type of molecular structure. To some unsaturated carbon chain atoms within a mer unit, a single side atom or group may be situated on one side of the chain, or directly opposite at a 180° rotation position. In a trans structure, two such side groups within the same mer reside on opposite chain sides (e.g., *trans*-isoprene).

Transformation rate. The reciprocal of the time necessary for a reaction to proceed halfway to its completion.

Transgranular fracture. Fracture of polycrystalline materials by crack propagation through the grains.

Translucent. Having the property of transmitting light only diffusely; objects viewed through a translucent medium are not clearly distinguishable.

Transmission electron microscope (TEM). A microscope that produces an image by using electron beams that are transmitted (pass through) the specimen. Examination of internal features at high magnifications is possible.

Transparent. Having the property of transmitting light with relatively little absorption, reflection, and scattering, such that objects viewed through a transparent medium can be distinguished readily.

Transverse direction. A direction that crosses (usually perpendicularly) the longitudinal or lengthwise direction.

Trifunctional mer. Designating mer units that have three active bonding positions.

True strain (ϵ_T). The natural logarithm of the ratio of instantaneous gauge length to original gauge length of a specimen being deformed by a uniaxial force.

True stress (σ_T). The instantaneous applied load divided by the instantaneous cross-sectional area of a specimen.

U

Ultimate (tensile) strength. See **Tensile strength.**

Ultrahigh molecular weight polyethylene (*UHMWPE*). A polyethylene polymer that has an extremely high molecular weight (approximately 4×10^6 g/mol). Distinctive characteristics of this material include high impact and abrasion resistance, and a low coefficient of friction.

Unit cell. The basic structural unit of a crystal structure. It is generally defined in terms of atom (or ion) positions within a parallelepiped volume.

Unsaturated. A term describing carbon atoms that participate in double or triple covalent bonds and, therefore, do not bond to a maximum of four other atoms.

Upper critical temperature. For a steel alloy, the minimum temperature above which, under equilibrium conditions, only austenite is present.

V

Vacancy. A normally occupied lattice site from which an atom or ion is missing.

Vacancy diffusion. The diffusion mechanism wherein net atomic migration is from lattice site to an adjacent vacancy.

Valence band. For solid materials, the electron energy band that contains the valence electrons.

Valence electrons. The electrons in the outermost occupied electron shell, which participate in interatomic bonding.

van der Waals bond. A secondary interatomic bond between adjacent molecular dipoles, which may be permanent or induced.

Viscoelasticity. A type of deformation exhibiting the mechanical characteristics of viscous flow and elastic deformation.

Viscosity (η). The ratio of the magnitude of an applied shear stress to the velocity gradient that it produces; that is, a measure of a noncrystalline material's resistance to permanent deformation.

Vitrification. During firing of a ceramic body, the formation of a liquid phase that upon cooling becomes a glass-bonding matrix.

Vulcanization. Nonreversible chemical reaction involving sulfur or other suitable agent wherein cross-links are formed between molecular chains in rubber materials. The rubber's modulus of elasticity and strength are enhanced.

W

Wave-mechanical model. Atomic model in which electrons are treated as being wavelike.

Weight percent (wt%). Concentration specification on the basis of weight (or mass) of a particular element relative to the total alloy weight (or mass).

Weld decay. Intergranular corrosion that occurs in some welded stainless steels at regions adjacent to the weld.

Welding. A technique for joining metals in which actual melting of the pieces to be joined occurs in the vicinity of the bond. A filler metal may be used to facilitate the process.

Whisker. A very thin, single crystal of high perfection that has an extremely large length-to-diameter ratio. Whiskers are used as the reinforcing phase in some composites.

White cast iron. A low-silicon and very brittle cast iron, in which the carbon is in combined form as cementite; a fractured surface appears white.

Whiteware. A clay-based ceramic product that becomes white after high-temperature firing; whitewares include porcelain, china, and plumbing sanitary ware.

Working point (glass). The temperature at which a glass is easily deformed, which corresponds to a viscosity of 10^3 Pa-s (10^4 P).

Wrought alloy. A metal alloy that is relatively ductile and amenable to hot working or cold working during fabrication.

Y

Yielding. The onset of plastic deformation.

Yield strength (σ_y). The stress required to produce a very slight yet specified amount of plastic strain; a strain offset of 0.002 is commonly used.

Young's modulus. See **Modulus of elasticity.**