

# Glossary

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## Abbreviations and Acronyms

ACAP	—Advanced Composite Airframe Program	DOE	—U.S. Department of Energy
ACCP	—Advanced Ceramics and Composites Partnership	DTI	—Department of Trade and Industry (United Kingdom)
ACerS	—American Ceramics Society	DTIC	—Defense Technical Information Center
AIChE	—American Institute of Chemical Engineers	EAP	—Experimental Aircraft Program
AIST	—Agency of Industrial Science and Technology (Japan)	EAR	—Export Administration Regulations
Al-Li alloys	—aluminum-lithium alloys	EC	—European Community
AMRF	—Automated Manufacturing Research Facility	EFA	—European Fighter Aircraft
ARALL	—aramid-reinforced aluminum composite	EG	—electrogalvanization
ASTM	—American Society for the Testing of Materials	ELISA	—Export License Status Advisor
BRITE	—Basic Research in Industrial Technologies for Europe	ERC	—Engineering Research Center
BMFT	—Ministry for Research and Technology (West Germany)	EURAM, EURAM II	—European Research on Advanced Materials Programs
CAD	—computer-aided design	EUREKA	—a European cooperative research program
CAFE	—corporate average fleet fuel economy	FAA	—Federal Aviation Administration
CAM	—computer-aided manufacturing	FAR	—Federal Acquisition Regulations
CAMDEC	—Ceramic Advanced Manufacturing Development and Engineering Center	FDA	—Food and Drug Administration
CARE	—Ceramic Applications for Reciprocating Engines (United Kingdom)	FMS	—Federation of Materials Societies
CBC	—chemically-bonded ceramic	FRP	—fiber-reinforced plastics
CMC	—ceramic matrix composite	GIRI	—Government Industrial Research Institutes (Japan)
CNC machines	—computer numerically controlled machine tools	GIFRP	—glass fiber-reinforced plastic
CNRS	—Centre Nationale de la Recherche Scientifique (France)	GNP	—Gross National Product
CoCom	—Coordinating Committee for Multilateral Export Controls	GPa	—gigapascal (billions of newtons per square meter)
CoGSME	—Composites Group of the Society of Manufacturing Engineers	GrFRP	—graphite fiber-reinforced plastic
COMAT	—Committee on Materials	HIP	—hot isostatic pressing
CVD	—chemical vapor deposition	HPC	—high-performance ceramics
DAR	—Defense Acquisition Regulations	HSLA	—high-strength, low-alloy steel
DARPA	—Defense Advanced Research Projects Agency	HSRTM	—high-speed resin transfer molding
DoD	—U.S. Department of Defense	IDE	—investigational device exemption
		IEA	—International Energy Agency
		IOP-TK	—innovation-Oriented Research Program—Technical Ceramics (Netherlands)
		IR&D	—Independent Research and Development
		IRSIA	—Institute for the Encouragement of Scientific Research in Industry and Agriculture (Belgium)

ITAR	—International Traffic in Arms Regulations	OTA	—Office of Technology Assessment
ITPA	—Industrial Technology Promotion Association	PAN	—polyacrylonitrile
IVL	—individual validated license	PBT	—poly (phenylbenzo-bisthiazole)
JAPATIC	—Japan Patent Information Center	PEEK	—polyether etherketone
JDB	—Japan Development Bank	PES	—polyether sulfone
JFCA	—Japan Fine Ceramics Association	PET	—polyethyleneterephthalate
JFCC	—Japan Fine Ceramics Center	PMC	—polymer matrix composite
JITA	—Japan Industrial Technology Association	PPS	—polyphenylene sulphide
JRDC	—Japan Research and Development Corporation	PVD	—physical vapor deposition
ksi	—thousand pounds per square inch	R&D	—research and development
LCP	—liquid crystal polymer	RANN Program	—Research Applied to National Needs Program
LEFM	—linear elastic fracture mechanics	RIM	—reaction injection molding
ManTech Program	—Manufacturing Technologies Program	RST	—rapid solidification technology
MAP	—Manufacturing Automation Protocol	RTM	—resin transfer molding
MDF cement	—macro-defect free cement	SAE	—Society of Automotive Engineers
MITI	—Ministry of International Trade and Industry (Japan)	SACMA	—Suppliers of Advanced Composite Materials Association
MMC	—metal matrix composite	SAIC	—Science Applications International Corporation
MPa	—megapascal (millions of newtons per square meter)	SAMPE	—Society for the Advancement of Material and Process Engineering
Msi	—millions of pounds per square inch	SBIR Program	—Small Business Innovation Research Program
NACRA	—National Applied Ceramic Research Association	SDI	—Strategic Defense Initiative
NASA	—National Aeronautics and Space Administration	SIC code	—Standard Industrial Classification code
NASP	—National Aerospace Plane	SME	—Society of Manufacturing Engineers
NBS	—National Bureau of Standards	SMC	—sheet molding compound
NC machines	—numerically controlled machine tools	SPE	—Society of Plastics Engineers
NCMC	—National Critical Materials Council	SPI	—Society of the Plastics Industry
NDT, NDE	—nondestructive testing, nondestructive evaluation	SPIE	—Society of Photo-Optical Instrumentation Engineers
NIRIM	—National Institute for Research on Inorganic Materials (Japan)	SSRI	—Swedish Silicate Research Institute
NRDC	—National Research and Development Corporation (United Kingdom)	STA	—Science and Technology Agency (Japan)
NSF	—National Science Foundation	STELA	—System for Tracking Export License Applications
NTIS	—National Technical Information Service	USACA	—United States Advanced Ceramics Association
		VAMAS	—Versailles Project on Advanced Materials and Standards

## Glossary of Terms

- ablative materials:** Materials that protect the structure of aircraft or missiles from the high temperatures generated by air friction by themselves becoming melted or vaporized.
- adiabatic:** Referring to any process in which there is no gain or loss of heat.
- advanced ceramics:** Ceramics made from extremely pure starting materials and consolidated at high temperatures to yield dense, durable structures.
- advanced composites:** Polymer matrix composites reinforced with continuous fibers, usually graphite, aramid, or high-stiffness glass; these composites generally have high strength and stiffness, light weight, and are relatively expensive.
- advanced materials:** Materials that are built up from constituents and whose properties are tailored to meet the requirements of specific end uses.
- aggregate:** **Inert filler material such as sand or gravel used with a cementing medium to form concrete or mortar.**
- alloy:** **A material having metallic properties and consisting of two or more elements.**
- anisotropic:** **Showing different physical or mechanical properties in different directions.**
- aramid:** Lightweight polyaromatic amide fibers having excellent high temperature, flame, and electrical properties. **These fibers are used as high-strength reinforcement in composites.**
- axial:** **In advanced composites, referring to the direction parallel to the orientation of the continuous fiber reinforcement.**
- bioceramics or biomaterials:** **Ceramics or other materials that are compatible with biological tissues, and that therefore can be used inside the body.**
- brittle fracture:** **A break in a brittle material due to the propagation of cracks originating at flaws.**
- carbon/carbon composites:** **Composites consisting of pyrolyzed carbon matrices reinforced with carbon fibers; with appropriate coatings to prevent oxidation, these composites are capable of withstanding extremely high temperatures.**
- carbon/graphite:** **These fibers, which are the dominant reinforcement in "advanced" composites, are produced by pyrolysis of an organic precursor, e.g. polyacrylonitrile (PAN), or petroleum pitch, in an inert atmosphere. Depending on the process temperature, fibers having high strength or high elastic modulus may be produced.**
- cement:** **A dry powder made from silica, alumina, lime, iron oxide, and magnesia that forms a hardened paste when mixed with water; it may be used in this form as a structural material, or used as a binder with aggregate to form concrete.**
- ceramic:** **An inorganic, nonmetallic solid.**
- ceramic matrix composite:** **A composite consisting of a ceramic matrix reinforced with ceramic particulates, whiskers, or fibers.**
- charge pattern:** **The pattern of resins and reinforcements introduced into a mold prior to the molding process.**
- chemically-bonded ceramics:** **Used here to distinguish advanced cements and concretes, which are consolidated through chemical reactions at ambient temperatures (generally involving uptake of water) from high performance ceramics, such as silicon nitride and silicon carbide, which are densified at high temperatures.**
- coefficient of thermal expansion:** **The change in volume of a material associated with a 1 degree increase in temperature.**
- composite:** **Any combination of particles, whiskers, or fibers in a common matrix.**
- compressive stress:** **A stress that causes an elastic body to shorten in the direction of the applied force.**
- concrete:** **A mixture of aggregate, water, and a binder (usually portland cement) that hardens to a stone-like condition when dry.**
- consolidation of parts:** **Integration of a number of formerly discrete parts into a single part that encompasses several functions; a key advantage of engineered materials such as ceramics and composites.**
- continuous fiber:** **A reinforcing fiber in a composite that has a length comparable to the dimensions of the structure.**
- creep:** **A time-dependent strain of a solid, caused by stress.**
- critical material:** **A material whose availability is considered to be extremely important in time of national emergency or for the economic well-being of a nation.**
- cross-linking:** **The formation of chemical bonds between formerly separate polymer chains.**
- crystal:** **A homogeneous solid in which the atoms or molecules are arranged in a regularly repeating pattern.**
- curing:** **Process in which thermosetting resins are converted by chemical reactions into solid, crosslinked structures; usually accomplished by the application of heat and pressure.**
- deflection:** **Deformation of a material produced without fracture.**
- deformation, plastic deformation:** **Any alteration of shape or dimensions of a body caused by stresses, thermal expansion or contraction, chemical or metallurgical transformations, or shrinkage and expansion due to moisture change.**
- delamination:** **Separation of a layered structure into its constituent layers.**

- dielectric:** A material that is an electrical insulator or in which an electric field can be sustained with a minimum dissipation in power.
- diffusion:** The movement of mass, in the form of discrete atoms or molecules, through a medium.
- dispersion:** Finely divided particles of one material held in suspension in another material.
- dual-use technology:** A technology with both military and commercial applications.
- ductility:** The ability of a material to be plastically deformed by elongation without fracture.
- E-glass:** A borosilicate glass most used for glass fibers in reinforced plastics.
- elasticity:** The property whereby a solid material deforms under stress but recovers its original configuration when the stress is removed.
- extrusion:** A process in which a hot or cold semisoft solid material, such as metal or plastic, is forced through the orifice of a die to produce a continuously formed piece in the shape of the desired product.
- failure:** Collapse, breakage, or bending of a structure or structural element such that it can no longer fulfill its purpose.
- fatigue:** Failure of a material by cracking resulting from repeated or cyclic stress.
- fiber-reinforced plastic:** An inexpensive, relatively low-strength composite usually consisting of short glass fibers in a polyester or vinylester matrix; to be distinguished from an advanced composite.
- filtration:** A process of separating particulate matter from a fluid, by passing the fluid carrier through a medium that will not pass the particulates.
- flexure:** Any bending deformation of an elastic body in which the points originally lying on any straight line are displaced to form a plane curve.
- fracture stress:** The minimum stress that will cause fracture, also known as fracture strength.
- glass:** A state of matter that is amorphous or disordered like a liquid in structure, hence capable of continuous composition variation and lacking a true melting point, but softening gradually with increasing temperature.
- glass-ceramic:** Solid material, partly crystalline and partly glassy, formed by the controlled crystallization of certain glasses.
- grain:** One of many crystallite comprising a polycrystalline material.
- green state, greenware:** A term for formed ceramic articles in the unfired condition.
- hardness:** Resistance of a material to indentation, scratching, abrasion, or cutting.
- heat exchanger:** A device that transfers heat from one fluid to another or to the environment, e.g. an automobile radiator.
- heat treatment:** Heating and cooling of a material to obtain desired properties or conditions.
- high-strength low-alloy steel:** Steel containing small amounts of niobium or vanadium, and having superior strength, toughness, and resistance to corrosion compared with carbon steel.
- holography:** A technique for recording and later reconstructing the amplitude and phase distributions of a wave disturbance.
- hot isostatic pressing:** A forming or compaction process for ceramic or metal powders in which the mold is flexible and pressure is applied hydrostatically or pneumatically from all sides.
- hot pressing:** Forming a metal powder compact or a ceramic shape by applying unidirectional pressure and heat simultaneously at temperatures high enough for sintering to occur.
- impact strength:** Ability of a material to resist shock loading.
- inclusion:** A flaw in a material consisting of a trapped impurity particle.
- injection molding:** Forming metal, plastic, or ceramic shapes by injecting a measured quantity of the material into shaped molds.
- internal stress, residual stress:** A stress system within a solid (e.g. thermal stresses resulting from rapid cooling from a high temperature) that is not dependent on external forces.
- interphase, interface:** The boundary layer between the matrix and reinforcement in a composite.
- joining:** Coupling together of two materials across the interface between them, e.g. through application of adhesives, welding, brazing, diffusion bonding, etc.
- lay-up:** A process for fabricating composite structures involving placement of sequential layers of matrix-impregnated fibers on a mold surface.
- load:** The weight that is supported by a structure, or mechanical force that is applied to a body.
- Mach number:** The ratio of the speed of a body to the speed of sound in the surrounding fluid.
- matrix:** The composite constituent that binds the reinforcement together and transmits loads between reinforcing fibers.
- merchant market:** The market for intermediate components or materials that can be used in the manufacture of a variety of finished systems.
- metal:** An opaque material with good electrical and thermal conductivities, ductility, and reflectivity;

- properties are related to the structure in which the positively charged nuclei are bonded through a field of mobile electrons which surrounds them, forming a close-packed structure.
- metal matrix composite:** Composite having a metal matrix (often aluminum) reinforced with ceramic particulate, whiskers, or fibers.
- microstructure:** The internal structure of a solid viewed on a distance scale on the order of micrometers. The microstructure is controlled by processing, and determines the performance characteristics of the structure.
- mini-mills:** Steel producers using electric furnaces to generate commodity-grade bar and rod products from steel scrap; to be distinguished from integrated mills, which produce steel products from basic raw materials.
- modulus of elasticity:** A parameter characterizing the stiffness of a material, or its resistance to deformation under stress. For example, steel has a relatively high modulus, while Jello has a low modulus.
- monolithic:** Constructed from a single type of material.
- near-net-shape** The original formation of a part to a shape that is as close to the desired final shape as possible, requiring as few finishing operations as possible.
- nondestructive testing, evaluation:** Any testing method that does not involve damaging or destroying the test sample; includes use of x-rays, ultrasonics, magnetic flux, etc.
- offset:** Agreement by which the seller of a high-technology product transfers relevant production technology to the buyer as a condition of the sale.
- phase:** A region of a material that is physically distinct and is homogeneous in chemical composition.
- pitch:** A complex mixture of partially-polymerized aromatic hydrocarbons derived from heat treatment of coal or petroleum; can be spun into a fiber and pyrolyzed to produce graphite.
- plasticity:** The property of a solid body whereby it undergoes a permanent change in shape or size when subjected to a stress exceeding a particular value, called the yield value.
- polyacrylonitrile:** Organic precursor that can be spun into fibers and pyrolyzed to produce graphite fibers.
- polymer:** Substance made of giant molecules formed by the union of simple molecules (monomers); for example, polymerization of ethylene forms a polyethylene chain.
- polymer matrix composite:** Composite consisting of an organic, polymeric matrix reinforced with particulate, short fibers, or continuous fibers.
- pore, porosity:** Flaw involving unfilled space inside a material that frequently limits the material strength.
- powder metallurgy:** Referring to the fabrication of metallic shapes by compressing metal powders and applying heat without melting to produce a dense, durable structure.
- precursor:** An intermediate material that can be converted to the final desired material by a chemical reaction, often at high temperatures.
- preform:** A compact of fibers in the shape of the final structure that is placed in a mold and impregnated with the matrix to form a composite.
- prepreg:** Fiber reinforcement form (usually tape, woven mat, or broadgoods) that has been preimpregnated with a liquid thermosetting resin and cured to a viscous second stage. Thermoplastic prepregs are also available.
- proof test:** A predetermined test load, greater than the intended service load, to which a specimen is subjected before acceptance for use.
- qualification:** Formal series of tests by which the performance and reliability of a material or system may be evaluated prior to final approval or acceptance.
- radiography:** The technique of producing a photographic image of an opaque specimen by transmitting a beam of x-rays or gamma rays through it onto an adjacent photographic film; the transmitted intensity reflects variations in thickness, density, and chemical composition of the specimen.
- radome:** A strong, thin shell made from a dielectric material, used to house a radar antenna.
- reciprocating (engine or machinery):** Having a motion that repeats itself in a cyclic fashion.
- reexport controls:** Requirements that foreign-based firms wishing to export certain U.S. technologies to third countries must apply to the United States for a license to do so.
- refractory:** Capable of enduring high temperature conditions.
- resin:** Organic polymer, usually a viscous liquid, that can be processed to yield a solid plastic.
- scale-up:** The conversion of a low-volume laboratory process into a high-volume process suitable for commercial production.
- S-glass:** A magnesia-alumina-silicate glass that provides high stiffness fiber reinforcement. Often regarded as the reinforcement fiber dividing "advanced" composites from reinforced plastics.
- shearing stress:** A stress in which the material on one side of a surface pushes on the material on the other side of the surface with a force that is parallel to the surface.

- sheet molding compound:** An inexpensive, low-strength composite consisting of chopped glass fibers in a polyester matrix, which is produced in sheets that can be compression molded to give the final shape.
- sintering:** Method for the consolidation and densification of metal or ceramic powders by heating without melting.
- slip casting, slip, slurry:** A forming process in the manufacture of shaped refractories, cermets, and other materials in which slip is poured into porous plaster molds. Slip or slurry is a suspension of fine clay in water with a creamy consistency.
- specific strength or stiffness:** The strength or stiffness of a material divided by its density; this property can be used to compare the structural efficiency of various materials.
- strain:** Change in length of an object in response to an applied stress, divided by undistorted length.
- stress:** The force acting across a unit area in a solid material in resisting the separation, compacting, or sliding that is induced by external forces.
- structural materials:** Those materials that support most of the loading on the whole system.
- substrate:** Base surface on which a material adheres, for example a surface to be coated.
- systems approach (to cost or to design):** Consideration of product design, manufacture, testing, and life cycle as an indivisible whole; see consolidation of parts.
- tensile strength, ultimate tensile strength:** The maximum stress that a material subjected to a stretching load can withstand without breaking.
- thermal conductivity:** The rate of heat flow under steady conditions through unit area per unit temperature in the direction perpendicular to the area; the ability of a material to conduct heat.
- thermoplastic resin:** A material containing discrete polymer molecules that will repeatedly soften when heated and harden when cooled; for example, polyethylene, vinyls, nylons, and fluorocarbons.
- thermosetting resin:** An organic material initially having low viscosity that hardens due to the formation of chemical bonds between polymer chains. Once cured, the material cannot be melted or remolded without destroying its original characteristics; examples are epoxies, phenolics, and polyamides.
- toughness:** A parameter measuring the amount of energy required to fracture a material in the presence of flaws.
- transverse:** In advanced composites, referring to the direction perpendicular to the orientation of the continuous fiber reinforcement.
- tribology:** The study of the phenomena and mechanisms of friction, lubrication and wear of surfaces in relative motion.
- turbocharger:** A centrifugal air compressor driven by the flow of exhaust gases and used to increase induction system pressure in an internal combustion reciprocating engine.
- ultrasonic testing:** A nondestructive test method that employs high-frequency mechanical vibration energy to detect and locate structural discontinuities and to measure the thickness of a variety of materials.
- unibody:** Integrated structure containing the chassis as well as elements of the body of an automobile.
- value-added:** The increment by which the value of the output of an operation exceeds the value of the inputs.
- viscoelasticity:** Property of a material that is viscous but that also exhibits certain elastic properties, such as the ability to store energy of deformation, and in which the application of a stress gives rise to a strain that approaches its equilibrium value slowly.
- wear:** Deterioration of a surface due to material removal caused by friction between it and another material.
- nettability:** The ability of any solid surface to be wetted when in contact with a liquid.
- whisker:** A short, single crystal fiber with a length-to-diameter ratio of 10 or more, often used to improve the fracture toughness of ceramics,
- yield strength:** The lowest stress at which a material undergoes plastic deformation. Below this stress, the material is elastic.