



Standard Terminology of Advanced Ceramics¹

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1. Scope

1.1 This terminology contains definitions and explanatory notes for the principal words, phrases, and terms used in advanced ceramics technology. The given definitions are technology-specific and are directly applicable to the design, production, testing, analysis, characterization, and use of advanced ceramics for structural, electronic, coating, energy, chemical, nuclear, biomedical, and environmental applications.

1.2 The purpose of the standard terminology is to provide a collected technical resource and reference that promotes a common understanding of the principal technical terms used within the advanced ceramics community and encourages the use of uniform terminology in specifications and reports.

2. Referenced Documents

2.1 ASTM Standards:²

C 242 Terminology of Ceramic Whitewares and Related Products

C 1259 Test Method for Dynamic Young's Modulus, Shear Modulus, and Poisson's Ratio for Advanced Ceramics by Impulse Excitation of Vibration

C 1368 Test Method for Determination of Slow Crack Growth Parameters of Advanced Ceramics by Constant Stress-Rate Flexural Testing at Ambient Temperature

C 1421 Test Methods for Determination of Fracture Toughness of Advanced Ceramics at Ambient Temperature

3. Terminology

absorbed moisture, *n*—water held within the materials and having physical properties not substantially different from ordinary water at the same temperature and pressure.

advanced ceramic, *n*—a highly engineered, high performance, predominately non-metallic, inorganic, ceramic ma-

terial having specific functional attributes.

agglomerate, *n*—*as used in fractography*, a cluster of grains, particles, platelets, or whiskers, or a combination thereof, present in a larger solid mass.

aggregate, *n*—a dense mass of particles held together by strong intermolecular or atomic cohesive forces. It is stable to normal handling and ordinary mixing techniques including high-speed stirring and ultrasonics. **(C 242)**

back-face strain, *n*—the strain as measured with a strain gage mounted longitudinally on the compressive surface of the specimen, opposite the crack or notch mouth (often this is the top surface of the specimen as tested). **(C 1421)**

base exchange, *n*—a surface property exhibited by colloidal inorganic materials, usually clays, whereby absorbed surface cations are replaced by other cations.

body, *n*—the structural portion of a ceramic article, or the material or mixture from which it is made. **(C 242)**

calcine, *v* (**calcination**, *n*)—firing or heating a granular or particulate solid at less than fusion temperature, but sufficient to remove most of its chemically combined volatile matter (that is, H₂O, CO₂) and otherwise to develop the desired properties for use.

capillary action, *n*—the phenomenon of intrusion of a liquid into interconnected small voids, pores, and channels in a solid, resulting from surface tension.

casting, drain (hollow casting), *v*—forming ceramic ware by introducing a body slip into an open, porous mold, and then draining off the remaining slip when the cast piece has reached the desired thickness. **(C 242)**

cermet, *n*—a composite material or article comprised of a ceramic and a metal or metal alloy, interdistributed in any of various geometrical forms but intimately bonded together.

chatter, *n*—an undesirable pattern created on the surface of a work piece, usually at regularly spaced intervals, due to an out-of-round, out-of-balance condition or due to an induced natural frequency, or its harmonics, or both, in a grinding machine.

colloidal particle, *n*—a dispersed particle with a linear dimension of 5 to 100 nm.

comminution, *n*—the act or process of reduction in particle size, usually but not necessarily by grinding or milling.

compositional inhomogeneity, **(CI)**, *n*—*as used in fractography*, a volume-distributed flaw that is a microstructural

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

irregularity related to the nonuniform distribution of an additive, a different crystalline or glass phase or in a multiphase material, the nonuniform distribution of a second phase.

continuous fiber-reinforced ceramic matrix composite, *n*—a ceramic matrix composite in which the reinforcing phase(s) consists of continuous filaments, fibers, yarn, braid, or knitted or woven fabrics.

crack, (CK), *n*—as used in *fractography*, a volume-distributed flaw that is a plane of fracture without complete separation.

crack deflection, *n*—a toughening mechanism in advanced ceramics or ceramic matrix composites characterized by fracture surface roughening and crack tilting/twisting during propagation around grains or a reinforcing component caused by stress fields around the grains or component developed through mismatches in thermal expansion or mechanical properties (such as elastic modulus), or both, between grains or between reinforcement and matrix.

crack orientation, *n*—a description of the plane and direction of a fracture in relation to a characteristic direction of the product. This identification is designated by a letter or letters indicating the plane and direction of crack extension. The letter or letters represent the direction normal to the crack plane and the direction of crack propagation. (C 1421)

creep, *n*—the time-dependent part of a strain resulting from stress.

deairing, *n*—the process of removing entrapped air or absorbed air from a mass or slurry, usually by application of a vacuum.

depth of penetration, *n*—(1) the distance a penetrant has entered into a solid material as measured from the surface of the material; (2) the maximum depth at which a magnetic or ultrasonic indication can be measured in a test specimen.

diamond paste, *n*—diamond dust dispersed in a paste or slurry for use as a grinding or polishing compound.

diamond tool, *n*—any tool in which the working area is inset with diamonds or diamond dust.

diamond wheel, *n*—a bonded grinding wheel in which the abrasive grains are crushed and sized natural or synthetic diamonds.

discontinuous fiber-reinforced composite, *n*—a ceramic matrix composite material reinforced by chopped fibers.

dish grinder, *n*—a grinding machine equipped with a dish-shaped abrasive wheel as a grinding mechanism

dish wheel, *n*—dish-shaped abrasive grinding wheel.

disk feeder, *n*—a rotating disk beneath the opening of a bin which delivers material from the bin at a specified rate by controlling the rate of rotation of the disk and the size of the gate opening of the bin.

disk grinder, *n*—a grinding machine equipped with a large abrasive disk as the work mechanism.

disk wheel, *n*—a bonded abrasive wheel mounted on a plate so that grinding may be done on the side of the wheel.

drag, *n*—the resistance of the foot or base of a ceramic article

to shrinkage during firing time due to friction with the slab or sagger on which it rests.

dressing, *n*—(1) the process of restoring the efficiency of an abrasive grinding wheel by removal of dulled grains; (2) reshaping the faces of grinding wheels to special contours.

drum dryer, *n*—a heated, rotating drum in which tumbling or cascading raw materials are dried.

drying oven, *n*—a closed unit in which specimens are dried by heating.

dry milling, *n*—the process of reducing the particle size of a substance by milling without the use of a liquid medium.

dry screening, *n*—the process of separating small sizes of granular or powdered solids from coarser particles by passing them through a screen of desired mesh size while in the dry state.

drying shrinkage, *n*—the contraction of a moist body during the drying process, expressed as linear percent of the original length or volume percent of the original volume.

drying, vacuum, *n*—the technique of expediting the removal of moisture from a material or body by the use of a vacuum in conjunction with a conventional drying system.

dual-drum mixer, *n*—a mixer consisting of a long drum containing two compartments separated by a bulkhead with a swinging chute extending through the unit.

durability, *n*—the property of an article of being resistant to physical or chemical damage, or both, under the usual conditions of service, and of being useful over extended periods of time and use.

dust pressing, *n*—the process of forming ceramic bodies of 1.5 % or less water content by pressing in a mold.

elastic limit, *n*—the greatest stress that a material is capable of sustaining without permanent strain remaining upon complete release of the stress. (C 1259)

elastic modulus, *n*—the ratio of stress to strain below the proportional limit. (C 1259)

electric furnace, *n*—a furnace or kiln in which the main source of heat is provided by electrical means.

electrical contact, *n*—any physical contact between two or more parts which will permit the flow of electricity between the parts.

electrophoresis, *n*—the movement of colloidal particles or macromolecules through a solution under the action of an electromotive force applied through electrodes in contact with the solution.

emissivity, *n*—the ratio of the radiation given off by the surface of a body to the radiation given off by a perfect black body at the same temperature.

emulsification, *n*—the process of dispersing an immiscible liquid in another liquid.

endothermic reaction, *n*—a chemical reaction in which heat is absorbed.

endurance, thermal, *n*—the ability of a ceramic product to withstand thermal shock or to withstand deterioration during exposure to high temperatures.

- erosion resistance, electrical**, *n*—the resistance of electrical insulating materials to erosion by the action of electrical discharges.
- exothermic reaction**, *n*—a chemical reaction in which heat is evolved.
- extrude**, *v*—to shape a plastic body by forcing the body through a die.
- extruder**, *n*—a device, such as a pug mill, that forces plastic bodies through a die of appropriate shape and size in a continuous column.
- feed, gravity**, *n*—the movement of materials from one container to another container or location by force of gravity.
- filament**, *n*—a long flexible thread of small cross section, usually extruded or drawn.
- film**, *n*—a thin coating or layer of a substance over the surface of another material.
- fineness**, *n*—a measurement number designating the particle size of a material, usually reported as passing a screen of a particular standard size.
- finer**, *n*—the portions of a powder composed of particles smaller than a specified size.
- finish grinding**, *n*—the completion of a grinding operation to obtain a desired surface appearance or accurate dimensions.
- firing expansion**, *n*—the increase in the dimensions of a substance or product during thermal treatment.
- fissures**, *n*—surface defects consisting of narrow openings or cracks.
- fixed-feed grinding**, *n*—the process of feeding a material to be ground to a grinding wheel at a given rate or in specific increments.
- flexural strength**, *n*—a measure of the ultimate strength of a specified beam in bending.
- flexural strength**, *n*—a measure of the strength of a specified beam specimen in bending determined at a given stress rate in a particular environment. (C 1368)
- fluid carrier**, *n*—a fluid in which particles are suspended to facilitate their movement or application.
- fluid-energy mill**, *n*—a size-reduction apparatus in which grinding is achieved by the collision of the particles being ground in a high-velocity stream of air, steam, or other fluid.
- fluorescent penetrant**, *n*—an inspection penetrant which fluoresces or glows in ultraviolet light.
- fluxing agent**, *n*—any substance which will promote fusion of ceramic materials.
- four-point- $\frac{1}{4}$ point flexure**, *n*—configuration of flexural strength testing where a specimen is symmetrically loaded at two locations that are situated one quarter of the overall span, away from the outer two support bearings.
- fractionation, elastic**, *n*—a process in which soft aggregate is separated from harder aggregate by hurling the composite aggregate against a steel plate, the hard particles rebounding farther from the plate than the softer, more friable particles.
- fractography**, *n*—means and methods for characterizing a fractured specimen or component.
- fracture origin**, *n*—the source from which brittle fracture commences.
- fracture, spontaneous**, *n*—cracking or chipping which occurs without immediately apparent external causes.
- fracture toughness**, *n*—a generic term for measures of resistance to crack extension.
- furnace, arc-image**, *n*—a furnace in which high temperatures are produced by focusing radiation from high-temperature arcs into the furnace chamber.
- furnace, image**, *n*—a furnace in which high temperatures are generated by focusing radiation from a high-temperature source, such as the sun or an electric arc.
- furnace, recuperative**, *n*—a furnace equipped with a heat exchanger in which heat is conducted from the combustion products through a system of ducts or through flue walls in a manner so as to preheat the air as it enters the burner to unite with the fuel.
- furnace, regenerative**, *n*—a furnace having a cyclic heat exchanger which alternately receives heat from gaseous combustion products and transfers heat to the air or gas of the fuel mixture before combustion takes place.
- furnace, solar**, *n*—an image-type furnace in which solar radiation is focused into a relatively small area as a source of heat producing extremely high temperatures.
- furnace, thermal gradient**, *n*—a tubular furnace in which a controlled temperature gradient is maintained along its length.
- fuse**, *v*—to melt or join by the use of heat.
- fusion casting**, *n*—the process of forming items by casting molten materials in mold.
- fusion point**, *n*—the temperature or range of temperatures at which melting or softening, as a result of partial melting, of a composition, will occur.
- fusion test**, *n*—any test to determine the temperature or range of temperatures at which fusion takes place, or to determine the flow or other properties of a material at fusion temperatures.
- gel**, *n*—a semisolid system consisting of a network of solid aggregates in which liquid is held.
- handling damage, (HD)**, *n*—*as used in fractography*, scratches, chips, cracks, etc., due to the handling of the specimen/component.
- homogeneous**, *adj*—the condition of a material in which the relevant properties (composition, structure, density, and so forth) are not a function of position for sample size used, so that a small sample taken from any location in an original body is representative of the whole. Practically, the geometrical dimensions of the sample must be large with respect to the size of the individual grains, crystals, components, pores or microcracks.
- hot pressing**, *n*—a fabrication of a ceramic component utilizing temperature and uniaxial pressure to achieve the desired density and shape formation. Densification is achieved by particle rearrangement, viscous/plastic flow, or diffusional transport, or both.
- inclusion, (I)**, *n*—*as used in fractography*, a volume-distributed flaw that is a foreign body from other than the normal composition of the bulk advanced ceramic.
- isotropic**, *n*—having the same value for a property in all directions.
- Knoop Hardness Number (HK)**, *n*—an expression of hardness obtained by dividing the force applied to the Knoop

indenter by the projected area of the permanent impression made by the indenter.

Knoop indenter, *n*—a rhombic-based pyramidal-shaped diamond indenter with edge angles of 172° 30' and 130° 00'.

large grain(s), (LG), *n*—as used in *fractography*, a volume-distributed flaw that is a single (or cluster of) grain(s) having a size significantly greater than that encompassed by the normal grain size distribution.

liquid infiltration, *v*—densification of a composite by infiltration with a liquid.

DISCUSSION—The required temperatures and pressures are a function of the viscosity/temperature relation of the infiltration liquid. The liquid may be a molten ceramic or it may be a sol or preceramic polymer which is subsequently converted to a solid ceramic through chemical or thermal processing.

machining damage, (MD), *n*—as used in *fractography*, a surface-distributed flaw that is a microcrack(s), chip(s), striation(s), or scratch(es), or a combination of these, created during the machining process.

NOTE 1—Machining may result in the formation of surface or subsurface damage, or both.

particulate reinforced ceramic matrix composite, *n*—a ceramic matrix composite in which the reinforcing components are particles of equiaxed or platelet geometry (in contrast to whiskers or short fibers).

pit, *n*, (PT^s)—as used in *fractography*, a surface-distributed cavity created on the specimen/component due to an interaction/reaction between the material and the testing/service environment, for example, corrosion, oxidation.

Poisson's ratio, *n*—the negative of the ratio of transverse strain to the corresponding axial strain resulting from a uniformly distributed axial stress below the proportional limit of the material.

pore, (P), *n*—as used in *fractography*, a volume-distributed flaw that is a discrete cavity or void in a solid material.

porous region, (PR), *n*—as used in *fractography*, a volume-distributed flaw that is a 3-dimensional zone of porosity or microporosity.

porous seam, (PS), *n*—as used in *fractography*, a volume-distributed flaw that is a 2-dimensional area of porosity or microporosity.

preceramic polymer, *n*—inorganic or organometallic polymers that can be converted (after polymer curing) to a ceramic by a thermal treatment.

DISCUSSION—Such preceramic polymers are commonly used to form non-oxide ceramic, such as silicon carbide, silicone oxycarbide, silicon nitride, and aluminum nitride.

precrack, *n*—a crack that is intentionally induced into the test specimen prior to testing the specimen to fracture (C 1421)

preform, *n*—a preshaped mat or woven structure formed from fibers of whiskers to the desired configuration and reinforcement architecture.

proportional limit stress, *n*—the greatest stress that a material is capable of sustaining without any deviation from proportionality of uniaxial stress to strain (uniaxial Hooke's law).

R-curve, *n*—a plot of crack-extension resistance as a function of stable crack extension. (C 1421)

scintillator, *n*—a transparent substance that emits visible or near ultraviolet light when traversed by an ionizing particle.

screen mesh, *n*—the average number of openings per linear inch of material.

secondary standard, *n*—a standard calibrated by reference to another standard, such as a primary standard. Often, a secondary standard is prepared from typical production-type material.

sedigraph, *n*—an instrument for determining the particle size distribution of a particulate solid, making use of a physical relation between rate of settling (sedimentation) in a liquid and the particle size.

service damage, *n*—as used in *fractography*, scratches, chips, cracks, etc., created during use of the component.

sieve, *n*—a standard wire mesh or screen, especially when used in graded sets to determine the mesh size or particular size distribution of particulate and granular solids.

sieve analysis, *n*—the particle size distribution of a particulate or granular solid or sample thereof, when determined by passage through and retention on a graded set of sieves.

slow crack growth (SCG), *n*—subcritical crack growth (extension) which may result from, but is not restricted to, such mechanisms as environmentally-assisted stress corrosion or diffusive crack growth. (C 1368, C 1421)

slurry, *n*—any pourable suspension of a high content of insoluble particulate solids in a liquid medium, most often water.

sol, *n*—a liquid dispersion of colloidal solid particles, commonly between 5 and 100 nm in size.

sol-gel processing, *v*—the chemical synthesis of oxides based on the hydrolysis of metal alkoxides to form sols and gels; as liquids, the sols are suitable for casting and infiltration.

solution, *n*—a homogeneous or single-phase, variable-composition mixture of one substance (solute) in another (solvent), in which the former is dispersed as separated molecules, ions, or atoms. The solvent or the solution may be solid, liquid, or gas.

sorption, *n*—in general, the taking up of some substance (sorbate) into or on the surface of another (sorbent), without specification of the type of process.

specimen, *n*—a specific portion of a material or laboratory sample upon which a test is performed or which is selected for that purpose. (Syn. *test specimen*).

stress corrosion, *n*—environmentally induced degradation that results in the formation and growth of cracks and/or damage in glasses and many ceramics when subjected to the combine action of a corroding agent and stress.

DISCUSSION—Such environmental effects commonly include the action of moisture, as well as other corrosive species, often with strong temperature dependence.

sublimation, *n*—the volatilization of a solid directly to the vapor state, without passing through the liquid state.

substrate, *n*—a body, board, or layer of material on which some other active or useful material or component may be deposited or laid, as for example, an electronic circuitry laid on an alumina ceramic board. In catalysis, the formed,

porous, high-surface-area carrier on which the catalytic agent is widely and thinly distributed for reasons of performance and economy.

surface area, specific, *n*—the area, per unit mass of a granular or powdered or formed porous solid, of all external plus internal surfaces that are accessible to a penetrating gas or liquid.

surface tension, *n*—the property, due to molecular forces, by which the surface film of all liquids tends to bring the contained volume into a form having the least area.

surface void, (SV), *n*—*as used in fractography*, a cavity created at the surface/exterior as a consequence of the reaction/interaction between the material and the processing environment, for example, surface reaction layer or bubble that is trapped during processing.

susceptibility, *n*—the ratio of the intrinsic induction due to the magnetization of a material to the induction in space due to the influence of the corresponding magnetizing force.

thermal shock, *n*—a large and rapid temperature change, resulting in large temperature differences within or across a body.

three-point flexure, *n*—configuration of flexural strength testing where a specimen is loaded at a location midway between two support bearings.

tolerance interval, *n*—an interval computed so that it will include at least a stated percentage of the population with a stated probability.

tolerance limits, *n*—bounds of a tolerance interval.

trace, *n*—a constituent or impurity making up only a small portion of the sample, the upper limit of the trace or microconstituent being about 100 µg/g; this upper boundary is not rigidly fixed.

varistor, *n*—a material having an electrical resistance that is sensitive to changes in applied voltage.

Vickers Hardness Number (HV), *n*—an expression of hardness obtained by dividing the force applied to a Vickers indenter by the surface area of the permanent impression made by the indenter.

Vickers indenter, *n*—a square-based pyramidal-shaped diamond indenter with face angles of 136° 00'.

vitrified bond, *n*—a bond created by the fusion of ceramic materials, principally clays and feldspar.

volatile, *adj*—a relative term expressing the tendency to form vapor; that is, at room temperature or in some other temperature domain.

water vapor pressure, *n*—the pressure of water vapor at a given temperature.

wet milling, *n*—the grinding of materials with sufficient liquid to form a slurry.

wetting agent, *n*—a chemical additive which reduces the surface tension of a fluid, inducing it to spread readily on a surface to which it is applied, thus causing wetting of the surface with the fluids.

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