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## **Fine ceramics (advanced ceramics, advanced technical ceramics) — Vocabulary**

*Céramiques techniques — Vocabulaire*



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## Foreword

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ISO 20507 was prepared by Technical Committee ISO/TC 206, *Fine ceramics*.

# Fine ceramics (advanced ceramics, advanced technical ceramics) — Vocabulary

## 1 Scope

This International Standard provides a list of terms and associated definitions which are typically used for fine ceramic (advanced ceramic, advanced technical ceramic) materials, products, applications, properties and processes. The document contains, in separate lists, those abbreviations which have found general acceptance in the scientific and technical literature; they are given together with the corresponding terms and definitions or descriptions.

In this International Standard, the terms are defined using the words “fine ceramic”. The definitions apply equally to “advanced ceramics” and “advanced technical ceramics”, which are considered to be equivalent.

This International Standard does not include terms which, though used in the field of fine ceramics, are of a more general nature and are also well known in other fields of technology.

NOTE Terms and definitions of a more general nature are available in ASTM C 1145<sup>[1]</sup>, CEN/WI 89<sup>[2]</sup> and JIS R 1600:1998<sup>[3]</sup>. A list of some ISO Standards and Draft ISO Standards of ISO/TC 206 “Fine ceramics” containing terms defined in this ISO Standard is given in the Bibliography.

## 2 Terms and definitions

### 2.1 General terms

#### 2.1.1

**advanced ceramic**  
**advanced technical ceramic**  
**fine ceramic**

highly engineered, high performance, predominately non-metallic, inorganic, ceramic material having specific functional attributes

NOTE The use of fine ceramics, advanced ceramics and advanced technical ceramics is interchangeably accepted in business, trade, scientific literature and ISO Standards.

#### 2.1.2

**bioceramic**

fine ceramic employed in or used as a medical device which is intended to interact with biological systems

NOTE 1 Bioceramics typically comprise products to repair or replace bone, teeth and hard tissue or to support soft tissue and/or control its function.

NOTE 2 Implants require a degree of biocompatibility.

NOTE 3 Bioceramics that are intended to interact actively with biological systems are often based on crystalline hydroxy(l)apatite; also partially crystallized glass or glass-bonded ceramic is used.

#### 2.1.3

**carbon-carbon composite**

fine ceramic composed of a carbon matrix containing carbon fibre reinforcement

NOTE A carbon-carbon composite can be used as furnace parts or heat resistant tiles for a space shuttle.

**2.1.4**

**ceramic**, adj

pertaining to the essential characteristics of a ceramic and to the material, product manufacturing process or technology

**2.1.5**

**ceramic**, noun

inorganic, essentially non-metallic, substantially crystalline product manufactured under the influence of elevated temperatures

NOTE The concept "ceramic" comprises products based on clay as raw material and also materials which are typically based on oxides, nitrides, carbides, silicides, borides.

**2.1.6**

**ceramic capacitor**

capacitor in which the dielectric material is a ceramic

NOTE e.g., BL (Boundary Layer) capacitor; multi-layer ceramic capacitor.

**2.1.7**

**ceramic catalyst carrier**

nonreactive substrate to support a catalyst

NOTE A ceramic catalyst carrier is typically made with a thin wall, has a large surface area and is used in contact with fluid matter.

**2.1.8**

**ceramic coating**

layer of oxide ceramic and/or non-oxide ceramic adhering to a substrate

NOTE 1 Ceramic coatings are produced by a variety of processes, e.g. dipping, plasma spraying, sol-gel coating process, physical vapour deposition or chemical vapour deposition coating process.

NOTE 2 Ceramic coatings are usually subdivided into thin ceramic coatings (< 10 µm) and thick coatings (≥ 10 µm).

**2.1.9**

**ceramic cutting tool**

tool for machining operations, consisting of a fine ceramic having excellent wear, damage and heat resistance

NOTE Machining includes operations such as turning, drilling and milling.

**2.1.10**

**ceramic filters**

**2.1.10.1**

**electrical**

filter using a piezoelectric ceramic as a resonator

**2.1.10.2**

**porous**

porous ceramic matter to be used in filtering gas or liquid

**2.1.11**

**ceramic for electrical applications**

electrical ceramic (deprecated)

electroceramic used in electro-technical applications because of its intrinsic properties

NOTE 1 These intrinsic properties include electrical insulation, mechanical strength and corrosion resistance.

NOTE 2 This term includes ceramics for passive electrical applications, i.e. ceramics with no active electrical behaviour, having a high electrical resistivity, used for electrical insulation functions.

NOTE 3 This term may apply to silicate ceramics such as steatite and electrical porcelain.

#### 2.1.12

##### **ceramic for electronic applications**

electronic ceramic (deprecated)

fine ceramic used in electrical and electronic engineering because of intrinsic, electrically related properties

#### 2.1.13

##### **ceramic for nuclear applications**

nuclear ceramic (deprecated)

fine ceramic having specific material properties required for use in the generation of nuclear energy

NOTE Ceramics for nuclear applications include materials for nuclear fuels, neutron absorbers, burnable neutron poisons, diffusion barrier coatings and inert container elements.

#### 2.1.14

##### **ceramic for optical applications**

##### **optical ceramic**

fine ceramic used in optical applications because of its intrinsic properties

NOTE 1 e.g., transparent alumina is used for high pressure sodium lamp envelopes.

NOTE 2 Optical ceramics are tailored to typically exploit transmission, reflection, absorption of visible and near-visible electromagnetic radiation.

#### 2.1.15

##### **ceramic heating resistor**

heater making use of an electric conductive or a semiconductive property of ceramics

#### 2.1.16

##### **ceramic honeycomb**

fine ceramic having many holes with a typically honeycomb shape

NOTE A ceramic honeycomb is typically used as a ceramic catalyst carrier, a filter or a heat exchanger regenerator, and is typically made of cordierite, mullite or aluminium titanate.

#### 2.1.17

##### **ceramic ionic conductor**

electroceramic in which ions are transported by an electric potential or chemical gradient

#### 2.1.18

##### **ceramic matrix composite**

##### **CMC**

fine ceramic composed of a ceramic matrix containing reinforcement

NOTE The reinforcement is often continuous, i.e. ceramic filaments, distributed in one or more spatial directions, but this term is also used for discontinuous reinforcement, e.g. short ceramic fibres, ceramic whiskers, ceramic platelets or ceramic particles.

#### 2.1.19

##### **ceramic optical waveguide**

optical waveguide formed on the surface of a ceramic substrate

NOTE Optical single crystal of  $\text{LiNbO}_3$  is typically used as a ceramic substrate.

**2.1.20**

**ceramic sensor**

sensor making use of semiconductive, magnetic or dielectric properties of a fine ceramic

**2.1.21**

**ceramic substrate**

ceramic body, sheet or layer of material on which some other active or useful material or component may be deposited or laid

NOTE e.g., an electronic circuit laid on an alumina ceramic sheet. 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.

**2.1.22**

**ceramic varistor**

ceramic material having high electrical resistivity at low voltage but high electrical conductivity at high voltage

NOTE A zinc oxide varistor can be used as a protector in an electronic circuit.

**2.1.23**

**cermet**

composite material consisting of at least one distinct metallic and one distinct ceramic phase, the latter normally being present at a volume fraction greater than 50 %

NOTE 1 The ceramic phase, typically, has high hardness, high thermal strength, good corrosion resistance and the metallic phase has good toughness and elastoplastic behaviour.

NOTE 2 The term "cermet" is a contracted form of ceramic metal.

NOTE 3 Materials containing typically less than 50 % by volume of ceramic phase are commonly called "metal matrix composites".

**2.1.24**

**coated ceramic**

ceramic coated by a layer or multi-layers of organic or inorganic material

**2.1.25**

**continuous fibre ceramic composite**

**CFCC**

ceramic matrix composite in which the reinforcing phase(s) consist(s) of continuous filaments, fibres, yarn or knitted or woven fabrics

**2.1.26**

**diamond-like carbon**

form of carbon made by a CVD process, having hardness much higher than ordinary carbon but lower than diamond

NOTE Diamond-like carbon is typically used as a hard coat material for cutting tools or memory disks.

**2.1.27**

**dielectric ceramic**

**ceramic dielectric**

electroceramic having controlled dielectric properties

**2.1.28**

**discontinuous fibre-reinforced ceramic composite**

ceramic matrix composite material reinforced by chopped fibres

**2.1.29**

**far-infrared radiative ceramic**

fine ceramic with specific property to radiate in the far-infrared



NOTE Far-infrared radiative ceramics are typically used as heaters for industrial and domestic applications.

**2.1.30  
ferrite**

fine ceramic with ferrimagnetic behaviour, having ferric oxide as a major constituent

NOTE Magnetic ceramic is used as a synonym of ferrite, but encompasses non-oxide containing materials as well.

**2.1.31  
ferroelectric ceramic**

non-linear polarizable electroceramic, generally with a high level of permittivity, exhibiting hysteresis in the variation of the dielectric polarization as a function of the electric field strength and in the temperature dependence of the permittivity

NOTE Polarization results in electrostrictive, piezoelectric, pyroelectric and/or electro-optic properties, which disappear above the transition or Curie temperature.

**2.1.32  
functional ceramic**

fine ceramic, the intrinsic properties of which are employed to provide an active function

NOTE e.g., electronic or ionic conductor, component with magnetic, chemical or mechanical sensing function.

**2.1.33  
functionally graded ceramic**

fine ceramic, the properties of which are deliberately varied from one region to another through spatial control of composition and/or microstructure

**2.1.34  
glass-ceramic**

fine ceramic derived from bulk glass or glass powder by controlled devitrification

NOTE The glass is thermally treated to induce a substantial amount of crystallinity on a fine scale.

**2.1.35  
hard ferrite**

ferrite having strong magnetic anisotropy and high coercivity

NOTE e.g., barium hexaferrite, used as permanent magnets in loudspeakers; strontium hexaferrite, used as permanent magnet segments in electric motors.

**2.1.36  
high-temperature superconductor  
HTS  
HTSC**

superconducting ceramic having superconducting properties at temperatures above 77 K, the boiling point of liquid nitrogen

NOTE Superconducting ceramics typically comprise certain combinations of oxides of copper, rare earths, barium, strontium, calcium, thallium and/or mercury.

**2.1.37  
in-plane reinforced (2D) ceramic matrix composite**

ceramic matrix composite with continuous reinforcement, which is distributed principally in two directions

NOTE The reinforcement comprises typically ceramic filaments.

**2.1.38  
machinable ceramic**

ceramic that, after the last consolidation heat treatment, can be machined to tight tolerances using conventional hardmetal or abrasive tools

NOTE 1 e.g., boron nitride, glass-ceramics and porous aluminas.

NOTE 2 The natural mineral talc and pyrophyllite, machined and heat-treated, are sometimes also referred to as a machinable ceramics.

**2.1.39  
metallized ceramic**

fine ceramic product with a coherent, predominantly metal layer applied to its surface

NOTE 1 Processes for metallization include painting, printing, electrolytic deposition and physical vapour deposition.

NOTE 2 Metallization is carried out for specific modification of surface properties or to produce an interlayer for promoting the formation of a high integrity bond with another material (often metallic).

**2.1.40  
monolithic ceramic**

fine ceramic which has undergone consolidation through sintering to obtain a microstructure consisting predominantly of ceramic grains of one or more phases which are homogeneously distributed on a scale which is small compared to the dimensions of the part

NOTE 1 Ceramic parts with low or moderate porosity are included, whereas ceramic matrix composites with ceramic filaments are excluded.

NOTE 2 A secondary phase can also be non-ceramic.

**2.1.41  
multidirectional ceramic matrix composite**

ceramic matrix composite with continuous reinforcement which is spatially distributed in at least three directions

NOTE The reinforcement typically comprises ceramic filaments.

**2.1.42  
nanocomposite ceramic**

composite with highly designed microstructure in which fine particles of nanometers in size are dispersed in a ceramic matrix

SEE **particulate reinforced ceramic matrix composite** (2.1.46).

**2.1.43  
non-oxide ceramic**

fine ceramic produced primarily from substantially pure metallic carbides, nitrides, borides or silicides or from mixtures and/or solid solutions thereof

**2.1.44  
opto-electronic ceramic**

electroceramic, typically a ferroelectric ceramic in which the optical properties are controlled by electrical means

**2.1.45  
oxide ceramic**

fine ceramic produced primarily from substantially pure, metallic oxides or from mixtures and/or solid solutions thereof

NOTE This term may also be applied to ceramics other than fine ceramics.

**2.1.46  
particulate reinforced ceramic matrix composite**

ceramic matrix composite in which the reinforcing components are particles of equiaxed or platelet geometry (in contrast to whiskers or short fibres)

SEE **nanocomposite ceramic** (2.1.42)

**2.1.47****piezoelectric ceramic**  
**piezoceramic**

electroceramic, typically a ferroelectric ceramic, in which the elastic and dielectric properties are coupled, with practically linear dependence, between the magnitude and direction of mechanical force applied and the electric charge created, or conversely, between the strength and direction of an electric driving field and the elastic deformation obtained

NOTE 1 Typical piezoelectrics are barium titanate and lead zirconium titanate.

NOTE 2 Elastic deformation under the influence of an electric driving field is termed the inverse piezoelectric effect.

NOTE 3 Piezoelectric ceramics are capable of transforming mechanical energy into electrical energy or signals and vice versa.

**2.1.48****silicate ceramic**

ceramic, made mainly from minerals and/or other siliceous raw materials, resulting in a microstructure with a substantial amount of silicate phases

NOTE Electrical porcelain and steatite ceramic are typical silicate ceramics.

**2.1.49****soft ferrite**

ferrite having a weak magnetic anisotropy, resulting in high magnetic permeability and low magnetic loss

NOTE e.g., manganese-zinc-ferro-ferrite with spinel type crystal structure, used for coils, transformers for energy conversion; ferrite with garnet-type crystal structure, such as yttrium iron garnet, used for microwave applications.

**2.1.50****structural ceramic**

fine ceramic employed primarily in structural applications for its mechanical or thermomechanical performance

NOTE The term "structural ceramic" is also applied to clay products for constructional purposes.

**2.1.51****superconducting ceramic**

electroceramic showing practically zero electrical resistance below a certain temperature

NOTE Superconducting ceramics typically comprise certain combinations of oxides of copper, rare earths, barium, strontium, calcium, thallium and/or mercury and most of them are high-temperature superconductors.

**2.1.52****surface-modified ceramic**

fine ceramic in which the surface has been subjected to a deliberate physical or compositional modification

NOTE 1 Surface modification is normally intended to enhance properties or performance.

NOTE 2 Modification processes include ion diffusion, ion exchange and chemical reactions such as oxidation.

**2.1.53****thick ceramic coating**

ceramic coating of a thickness typically equal to or greater than 10  $\mu\text{m}$

NOTE Thick ceramic coatings are produced typically by thick film technology such as dipping (slurry), screen printing or plasma spraying and so on.

**2.1.54****thin ceramic coating**

ceramic coating of a thickness typically less than 10  $\mu\text{m}$

NOTE Thin ceramic coatings are produced typically by thin film technology such as sol-gel coating process (dipping, spin coating), physical vapour deposition coating process.

### 2.1.55

#### **unidirectional (1D) ceramic matrix composite**

ceramic matrix composite with continuous reinforcement which is distributed in one single direction

NOTE The reinforcement typically comprises ceramic filaments.

## 2.2 Terms for form and processing

### 2.2.1

#### **as-fired surface**

external surface of a ceramic product after sintering

NOTE The as-fired surface may be relatively rough compared with surfaces machined after sintering and may have e.g. pits and adherent debris.

### 2.2.2

#### **binder**

one or more mainly organic compounds which are added to the ceramic body in order to enhance compaction and/or to provide enough strength to the green body to permit handling, green machining, or other operations prior to sintering

### 2.2.3

#### **binder phase**

tough matrix phase embedding a rigid, hard, main, ceramic phase in a composite material

NOTE 1 e.g., binder phase: cobalt, nickel; hard phase: tungsten carbide, tantalum carbide.

NOTE 2 A tough matrix phase reduces the brittleness and crack sensitivity and improves the strength and toughness of the composite material.

### 2.2.4

#### **calcining calcination**

process for changing the chemical composition and/or phases of a powder or powder compact by the action of heat and atmosphere, prior to consolidation and processing

NOTE This process is typically used for the removal of organic material, combined water and/or volatile material from a powder or powder compact.

### 2.2.5

#### **casting drain (hollow) casting**

forming ceramic ware by introducing a body slip into an open, porous mould, and then draining off the remaining slip when the cast piece has reached the desired thickness

### 2.2.6

#### **ceramic agglomerate**

accretion of ceramic particles forming a coherent, but weakly bonded mass

NOTE Ceramic agglomerates are unintentionally generated during manufacture and preparation of ceramic powders for ceramic production and may be difficult to break down.

### 2.2.7

#### **ceramic aggregate**

accretion of ceramic particles forming a coherent mass with strong interfacial bonding

NOTE Ceramic aggregates are intentionally generated during manufacture and preparation of ceramic powders and are difficult to break down.

### 2.2.8

#### **ceramic body**

totality of all inorganic and organic raw material constituents after preparation of ceramic powder but before the shaping and heat treatment to produce a ceramic

### 2.2.9

#### **ceramic fibre**

unit of ceramic matter of relatively short length, characterized by a high length to diameter ratio

NOTE 1 Ceramic fibres may consist of oxide or non-oxide material.

NOTE 2 Ceramic fibres are used as reinforcement in ceramic matrix composites in which case the diameter is usually smaller than 20  $\mu\text{m}$ , the aspect ratio typically being greater than 100.

### 2.2.10

#### **ceramic filament**

unit of ceramic matter of small diameter and very long length, considered to be continuous

NOTE 1 Ceramic filaments may consist of oxide or non-oxide material.

NOTE 2 Ceramic filaments are typically used as reinforcement in ceramic matrix composites, as separate filaments, as tow and as woven or non-woven fabrics.

### 2.2.11

#### **ceramic grain**

individual crystal within the polycrystalline microstructure of a ceramic

NOTE This term is also used for individual, usually hard, particles of abrasive or refractory materials.

### 2.2.12

#### **ceramic granulate**

mass of granules produced from a ceramic body, usually in a free flowing form, used as a feed stock for producing a green body

NOTE There are many granulation processes; the size of the granules is typically 40  $\mu\text{m}$  or greater.

### 2.2.13

#### **ceramic particle**

small quantity of ceramic matter, monocrystalline, polycrystalline or amorphous, in a discrete mass of size and shape controlled by its fabrication process

NOTE Individual particles may accrete into unintentional ceramic agglomerates or intentional ceramic aggregates, or may be processed to form a ceramic granulate.

### 2.2.14

#### **ceramic platelet**

unit of ceramic matter, typically consisting of a single crystal in a plate-like shape

NOTE 1 Ceramic platelets may consist of oxide or non-oxide material.

NOTE 2 Ceramic platelets are used as reinforcement in ceramic matrix composites in which case the width of the platelets is usually smaller than 50  $\mu\text{m}$ .

**2.2.15**

**ceramic (powder) preparation**  
**preparation of ceramic powder**

process of converting powders and additives into a ceramic body, usually by comminution and/or mixing of the powder with binders and lubricants to provide the required chemical and physical characteristics

**2.2.16**

**ceramic precursor**

chemical or mixture of chemicals employed for the manufacture of a ceramic powder, ceramic granulate, thin ceramic coating, monolithic ceramic or a ceramic matrix composite, or ceramic fibres, ceramic whiskers or ceramic platelets, differing in composition from the fabricated ceramic product

NOTE 1 e.g., gaseous silicon tetrachloride used for the formation of silicon nitride; metal alkoxides used for the formation of metal oxide powders.

NOTE 2 This term is usually applied to gas or liquid mixtures which are decomposed to form ceramic materials.

**2.2.17**

**ceramic whisker**

unit of ceramic matter, consisting typically of a single crystal having a needle-like shape

NOTE 1 Ceramic whiskers may consist of oxide or non-oxide material.

NOTE 2 Ceramic whiskers may be used as reinforcement in ceramic matrix composites in which case the diameter of the crystals is usually smaller than 3 µm, the aspect ratio being less than 100.

**2.2.18**

**chemical vapour deposition**  
**CVD**

process for producing a fine ceramic by reacting gaseous species and condensing the reaction product or by heterogeneous reaction at the surface of a substrate

NOTE This process may be used for the preparation of a solid ceramic or a ceramic powder or a coated ceramic or for infiltration of a heated substrate.

**2.2.19**

**chemical vapour deposition coating process**  
**CVD coating process**

chemical vapour deposition used for the formation of a fine ceramic coating on a substrate

**2.2.20**

**chemical vapour infiltration**  
**CVI**

chemical vapour deposition used for producing a fine ceramic by heterogeneous reaction at the pore surface of a heated porous ceramic preform

NOTE CVI is typically used to produce ceramic filament reinforced ceramic matrix composites.

**2.2.21**

**cold isostatic pressing**  
**CIP**

process of preparing a green body from a ceramic powder or a ceramic granulate by the use of (pseudo-) isostatic pressure at or near room temperature

NOTE This process is sometimes called "CIPing".

**2.2.22**

**consolidation**

process of rigidizing a ceramic body

NOTE Consolidation methods include mechanical densification, chemical bonding and sintering.

### 2.2.23

#### **doctor blade process**

process to form a ceramic sheet in which ceramic powder, binder and solvent are mixed and spread by a knife edge (or a doctor blade) on to a carrier film

NOTE The doctor blade process is used to form a ceramic sheet with good dimensional accuracy by adjusting the distance between a knife edge (or a doctor blade) and a carrier film.

### 2.2.24

#### **extrude**, verb

to shape a plastic body by forcing material through a die

### 2.2.25

#### **filler**

organic (or rarely inorganic) additive to a ceramic body which burns out or decomposes during firing and creates intentional porosity

NOTE e.g., discrete polymer particles added to a ceramic body with the intention of forming discrete pores.

### 2.2.26

#### **fillers**

#### 2.2.26.1

##### **particulate**

predominantly inert, usually particulate substance, introduced into a fine ceramic body to control processing or properties

NOTE e.g., particles of silicon carbide used as a filler in a silicon-based polymer precursor for dimensional control in subsequent consolidation.

#### 2.2.26.2

##### **particulate ceramic**

predominantly inert, usually particulate ceramic substance typically introduced into a polymer or metallic body to modify properties

NOTE e.g., aluminium oxide or aluminium hydroxide introduced into a polymer to enhance its stiffness and wear resistance.

### 2.2.27

#### **gas pressure sintering**

##### **GPS**

sintering by the combined application of heat and gas pressure

NOTE 1 e.g., gas pressure sintered silicon nitride, GPSSN.

NOTE 2 The gas pressure is typically not greater than 10 MPa.

### 2.2.28

#### **green body**

#### **green part**

ceramic body that is compacted and/or shaped, but not yet heat-treated

### 2.2.29

#### **green machining**

machining of a green body to a predetermined shape

### **2.2.30**

#### **hot isostatic pressing**

##### **HIP**

process of making a fine ceramic by application of an isostatic gas pressure at elevated temperatures

NOTE 1 The object may be an encapsulated powder or green body, or a pre-densified fine ceramic. Gas pressures are typically much greater than 10 MPa.

NOTE 2 This process is sometimes called "HIPing".

### **2.2.31**

#### **(uniaxial) hot pressing**

##### **HP**

process of making a fine ceramic, normally by application of a unidirectional (uniaxial) force at elevated temperature

NOTE For uniaxial hot pressing, an inductively heated graphite die is usually employed.

### **2.2.32**

#### **injection moulding**

##### **IM**

process of shaping a green body by injecting an appropriately formulated mass into a mould or die

### **2.2.33**

#### **liquid-phase sintering**

##### **LPS**

sintering achieved by the presence of a liquid phase

NOTE The amount and properties of the liquid phase are determined by the composition of the green body, temperature and pressure. This process is enhanced by accelerated diffusion and dissolution-precipitation phenomena.

### **2.2.34**

#### **low-pressure chemical vapour deposition**

##### **LPCVD**

chemical vapour deposition at low gas pressure

NOTE The gas pressure is typically less than 0,01 MPa.

### **2.2.35**

#### **machined and refired**

state of treatment of a fine ceramic component that has been machined and subsequently refired to modify the surface properties

### **2.2.36**

#### **manufacture of ceramic powders by flame pyrolysis**

process of formation of ceramic particles by passing reactants through the combustion zone of a flame

### **2.2.37**

#### **manufacture of ceramic powders by gas-phase reaction**

process of formation of ceramic particles from gaseous reactants using an external stimulus

NOTE 1 e.g., silicon nitride powder produced by reaction between silicon tetrachloride gas and ammonia gas.

NOTE 2 External stimuli include heating, electrical discharge and laser irradiation.

### **2.2.38**

#### **manufacture of ceramic powders by sol-gel technique**

process of formation of ceramic particles by using sol-gel processing in which the sol is dispersed into fine droplets before conversion into a gel, followed by further processing

SEE **sol-gel processing** (2.2.54)



NOTE 1 The conversion of sol into gel can be by a reaction such as dehydration. The common route is a hydrolysis reaction followed by condensation to give direct precipitation of fine ceramic particles.

NOTE 2 Further processing includes drying and calcining of gel.

### **2.2.39**

#### **metal-organic chemical vapour deposition**

##### **MOCVD**

chemical vapour deposition using single or mixed metal-organic vapours

### **2.2.40**

#### **microwave sintering**

use of high power, high frequency electromagnetic waves (microwaves) to heat a green body by internal dielectric loss to a sufficient temperature for sintering

NOTE The action of the microwaves may in some cases accelerate the sintering process.

### **2.2.41**

#### **plasma-enhanced chemical vapour deposition**

##### **PECVD**

chemical vapour deposition using a plasma

NOTE The reaction in the gaseous phase can, e.g., be stimulated by application of a plasma formed by coupled laser.

### **2.2.42**

#### **physical vapour deposition**

##### **PVD**

process for producing, e.g., a ceramic film by transport of the required chemical species, some or all of which are generated from a source or sources by physical means such as thermal, electron beam, arc or laser evaporation or sputtering, and deposition on to a prepared substrate with or without the assistance of a reactive atmosphere, ionic bombardment or a gas plasma

### **2.2.43**

#### **polycrystalline diamond**

##### **PCD**

polycrystalline form of carbon with cubic crystalline structure

NOTE 1 Polycrystalline diamond is normally prepared by high-pressure and high-temperature processing to achieve direct bonding between diamond grains.

NOTE 2 Polycrystalline diamond film is normally prepared by low-pressure chemical vapour deposition.

### **2.2.44**

#### **post-sintering**

##### **PS**

sintering after a previous consolidation stage

NOTE e.g., post-sintered reaction-bonded silicon nitride, PSRBSN.

### **2.2.45**

#### **pressureless sintering**

##### **PLS**

sintering in the absence of a raised mechanical or gas pressure

NOTE e.g., pressureless-sintered silicon nitride, PLSSN.

### **2.2.46**

#### **pyrolytic carbon**

form of carbon produced through the thermal decomposition of carbon-containing precursors

NOTE Precursors are, e.g., long-chain polymers or reacting gaseous mixtures.

### 2.2.47

#### **pyrolytic graphite**

form of high-purity graphite produced from the vapour phase by thermal decomposition of carbon-containing gas and deposition on to a substrate

NOTE Pyrolytic graphite usually has a highly oriented microstructure and strongly anisotropic properties.

### 2.2.48

#### **reaction bonding**

##### **RB**

process for producing a fine ceramic by consolidation of a green body by a chemical reaction between gaseous, liquid or solid species at elevated temperature producing a bond between ceramic particles

NOTE 1 e.g., silicon nitride objects can be produced by the reaction of silicon with nitrogen; reaction-bonded silicon nitride, RBSN.

NOTE 2 The use of this term for a process that falls under the definition of reaction sintering is deprecated.

### 2.2.49

#### **reaction sintering**

##### **RS**

process for producing a fine ceramic by consolidation of a green body by a solid state chemical reaction accompanied by solid state sintering at high temperatures to produce a bond between ceramic particles

NOTE 1 e.g., during the production of aluminium titanate ceramics, aluminium titanate can be formed by a solid state reaction between aluminium oxide and titanium oxide.

NOTE 2 The use of this term for liquid or gaseous reaction bonding process is deprecated.

### 2.2.50

#### **reinforcement**

ceramic particles, ceramic whiskers, ceramic platelets, ceramic fibres or ceramic filaments incorporated in a fine ceramic, normally for the purpose of modifying mechanical properties

NOTE 1 The reinforcement may alternatively be non-ceramic.

NOTE 2 The mechanical properties may be modified as regards their strength, toughness, wear resistance, hardness, creep resistance or other characteristics.

NOTE 3 For ceramic matrix composites, continuous reinforcement, i.e. ceramic filaments, is often used.

### 2.2.51

#### **roll compaction**

process of shaping a green body by feeding a granulated ceramic body between contra-rotating rollers which compact it into a strip or sheet

### 2.2.52

#### **self-sustained high temperature synthesis**

##### **SHS**

process for producing a solid fine ceramic in which primarily the heat of the exothermic reaction from reactant(s) is utilized

### 2.2.53

#### **sintering**

process of densification and consolidation of a green body by the application of heat with resulting joining of ceramic particles and increasing contact interfaces due to atom movement within and between the ceramic grains of the developing polycrystalline microstructure

NOTE Sintering may take place either directly or through the agency of a secondary phase, e.g., in reaction sintering and liquid-phase sintering.

### **2.2.54**

#### **sol-gel processing**

chemical synthesis of ceramic materials typically based on hydrolysis of ceramic precursors (alkoxides, acids, hydroxides) and subsequent condensation or aggregation to form sols followed by conversion to a gel and further processing

NOTE 1 A sol is a liquid dispersion of colloidal solid particles of up to several hundred nanometers in size, while a gel is a rigid interconnected network filled with either gas or liquid.

NOTE 2 Further processing includes, e.g., drying, calcining and sintering.

NOTE 3 Organically-modified inorganic networks (ormocers) can be formed by sol-gel processing.

### **2.2.55**

#### **sol-gel coating process**

process for producing a fine ceramic coating on a product by initially covering the surface with ceramic precursor followed by sol-gel processing

### **2.2.56**

#### **sol-gel consolidation technique**

processing technique to produce a fine ceramic by using sol-gel processing in combination with casting, extrusion or impregnation with subsequent drying and sintering

NOTE The size of articles produced by this technique is often limited by the large shrinkage arising from such processes.

### **2.2.57**

#### **spark plasma sintering**

sintering process in which a compact of powder is heated by an electric discharge

### **2.2.58**

#### **tape casting**

process of shaping a green body in the form of a tape by casting a slurry of ceramic body (slip) as a film on a flat surface, followed by drying

NOTE Organic additions to the slip give the tape flexibility and permit forms to be made from it by cutting, stamping or punching, from which components such as substrates, packages and capacitors can be manufactured.

### **2.2.59**

#### **vitreous carbon**

form of carbon derived through solid phase carbonization from a preform comprising an appropriate highly cross-linked polymer

NOTE Vitreous carbon is characterized by a pseudo-amorphous, isotropic structure with low density and non-permeability for gases.

## **2.3 Terms for properties and testing**

### **2.3.1**

#### **bulk density of ceramics**

value obtained by dividing the mass of test specimen by the external volume of ceramic specimen

### **2.3.2**

#### **chip**

piece of material broken off the edge or corner of a ceramic test-piece or component

NOTE When pieces of material break off the edges or corners of a test-piece or component they leave a “chipped area”.

**2.3.3 competing failure modes**

distinguishably different types of fracture initiation processes in ceramic test-pieces or components that result from concurrent critical flaw distributions

**2.3.4 compound critical flaw distribution**

flaw distribution in ceramic test-pieces or components which contain more than one type of strength-controlling flaw not occurring in a purely concurrent manner

NOTE All test-pieces contain flaw type A and some additionally contain a second independent type B.

**2.3.5 compressive stress**

maximum value of uniaxial compressive stress at the instant of collapse of a ceramic test-piece, either by shearing or fragmentation

**2.3.6 concurrent critical flaw distribution  
competing critical flaw distribution**

type of flaw distribution where every ceramic test-piece or component contains representative defects of each independent flaw type which compete with each other to cause failure

**2.3.7 crack**

plane of fracture in a ceramic test-piece or component without complete separation

**2.3.8 critical flaw**

flaw acting as the source of a failure in a ceramic test-piece or component

**2.3.9 critical flaw distribution**

distribution of type, shape and size of critical flaws in a population of ceramic test-pieces or components

**2.3.10 dynamic fatigue**

diminution of mean strength by the process of subcritical crack growth (or slow crack growth) of a batch of ceramic test-pieces or components when subjected to reduced levels of constant stressing rate

NOTE This term is normally applied when elastic behaviour is prevalent.

**2.3.11 exclusive critical flaw distribution**

type of flaw distribution created by mixing and randomizing test-pieces or components from two or more versions or batches of ceramic material where each version contains a single strength-controlling flaw population

NOTE Each test-piece or component contains defects exclusively from a single distribution, but the total data set reflects more than one type of strength-controlling flaw.

**2.3.12 extraneous flaw**

type of flaw observed in the fracture of ceramic test-pieces manufactured for the purpose of a test programme, but which will not appear in manufactured components or vice versa

NOTE e.g. test-pieces may have flaws from machining, which do not occur in the manufactured components.

**2.3.13****flaw**

inhomogeneity, discontinuity or other structural irregularity in ceramic material

NOTE 1 e.g., grain boundary, large grain, pore, impurity, crack.

NOTE 2 The term “flaw” should not be taken to mean that the material is functionally defective, but rather as an inevitable microstructural inhomogeneity.

NOTE 3 When the material is mechanically loaded, a flaw provides a stress concentration and enhances the risk of mechanical failure.

**2.3.14****flaw distribution**

spread of type, shape and size of flaws within a single ceramic test-piece or component

**2.3.15****flexural strength**

maximum stress supported by a specified beam in bending at the instance of failure as determined at a given stress rate in a particular environment.

**2.3.16****four-point flexural strength****four-point bending strength**

strength determined by bending a beam-shaped ceramic test-piece whereby the test-piece is supported on bearings near its ends, and is loaded equally at two positions symmetrically disposed about the centre of the supported span

NOTE The term “quarter-point flexural strength” is sometimes used for the strength as measured by the four-point flexure geometry wherein the load positions are each one-quarter of the support span from the support bearings.

**2.3.17****pore**

internal cavity in a ceramic

NOTE Pores may become exposed by cutting, grinding or polishing. Pores at the surface are usually called pits.

**2.3.18****porous region**

inhomogeneity comprising a concentration of pores in a ceramic

NOTE If interconnected to the surface of a ceramic test-piece or component, such a region will retain dye when dye-tested.

**2.3.19****precrack**

crack that is intentionally induced in the test specimen prior to testing the specimen to fracture

**2.3.20****proof testing**

application of a predetermined stress to a ceramic test-piece or component over a defined period of time to ascertain whether it contains a serious strength-limiting defect

NOTE Removal of the failed test-pieces or components from a batch modifies the failure statistics of the survivors, such that the two-parameter Weibull distribution is typically no longer valid.

**2.3.21****ring-on-ring strength**

maximum value of equibiaxial flexural stress, at fracture, generated in a symmetrical plate-shaped ceramic test-piece by applying forces to opposing sides through dissimilar sized concentric ring contacts

**2.3.22**

**R-curve behaviour**

change in apparent toughness with crack elongation in ceramic test-pieces or components

NOTE This effect may arise as a consequence of changes to microcrack distributions ahead of the crack or of local internal stressing, e.g., through phase transformations, or through uncracked or wedged ligaments behind the crack tip.

**2.3.23**

**self-loaded deformation**

deformation that results when a ceramic test-piece or component distorts under its own weight at elevated temperatures

NOTE Self-loaded flexural deformation is sometimes referred to as "sagging".

**2.3.24**

**static fatigue**

process of weakening by subcritical crack growth (or slow crack growth) under essentially elastic conditions in a ceramic test-piece or component when subjected to a constant load for a long period of time

**2.3.25**

**subcritical crack growth**

**slow crack growth**

extension of existing cracks or flaws in the microstructure of a ceramic test-piece or component under a stress which does not produce instantaneous failure

NOTE Subcritical crack growth can be caused by stress corrosion, creep crack growth or active corrosion.

**2.3.26**

**subcritical crack growth parameters**

**slow crack growth parameters**

parameters describing the relationship between crack growth velocity and stress intensity at the crack tip in a ceramic test-piece or component

**2.3.27**

**thermal shock resistance**

ability of a ceramic test-piece or component to withstand internal stress induced by rapid changes of temperature, without adversely affecting its properties or performance

NOTE 1 Thermal shock resistance is determined by the material properties, the shape and size of the test-piece or component and the thermal environment.

NOTE 2 This term may be used in a more specific sense for a specified type of test, e.g., quenching into water from a high initial temperature.

**2.3.28**

**three-point flexural strength**

**three-point bending strength**

strength determined by bending a beam-shaped ceramic test-piece whereby the test-piece is supported on bearings near its ends and a central load is applied

**2.3.29**

**Weibull distribution**

statistical function often used to describe empirically, the distribution of fracture strengths in a batch of ceramic test-pieces or components

NOTE A Weibull distribution in its simplest form can be characterized by a two-parameter formulation described by the Weibull modulus and the characteristic strength.

### 3 Abbreviations

#### 3.1 Abbreviations for ceramic materials

##### 3.1.1

##### **ALN**

##### **aluminium nitride**

fine ceramic, based principally on aluminium nitride

NOTE Aluminium nitride typically contains a small amount of oxygen.

##### 3.1.2

##### **ALON**

##### **aluminium oxynitride**

fine ceramic, based principally on aluminium oxynitride

NOTE Aluminium oxynitride is generally in a cubic crystalline phase form.

##### 3.1.3

##### **AT**

##### **aluminium titanate**

fine ceramic, based principally on aluminium titanate

NOTE Aluminium titanate as a crystalline phase is sometimes referred to as tialite.

##### 3.1.4

##### **ATZ**

##### **alumina toughened zirconia**

zirconium oxide-based fine ceramic, normally of the TZP type, with aluminium oxide added

NOTE The aluminium oxide addition increases hardness, stiffness and strength.

##### 3.1.5

##### **BN**

##### **boron nitride**

fine ceramic, based principally on boron nitride

NOTE 1 The chemical formula of the compound boron nitride and the abbreviation are identical.

NOTE 2 The abbreviation "BN" is normally applied to material having the hexagonal crystalline structure.

##### 3.1.6

##### **CAS**

##### **calcium aluminosilicate**

fine ceramic, glass or glass-ceramic material based principally on oxides of calcium, aluminium and silicon

NOTE 1 Calcium aluminosilicate typically contains the crystalline phases anorthite, gehlenite or other calcium silicate-based phases.

NOTE 2 Cement phase literature may incorporate numbers into this abbreviation.

##### 3.1.7

##### **CBN**

##### **cubic boron nitride**

fine ceramic, based principally on boron nitride and having a cubic crystalline structure

NOTE Boron nitride in the cubic crystalline form is analogous in structure to diamond.

### 3.1.8

#### CMC

##### ceramic matrix composite

fine ceramic, composed of a ceramic matrix containing reinforcement

NOTE The reinforcement is often continuous, i.e. ceramic filaments, distributed in one or more spatial directions, but this term is also used for discontinuous reinforcement, e.g., short ceramic fibres, ceramic whiskers, ceramic platelets or ceramic particles.

### 3.1.9

#### CSZ

##### cubic stabilized zirconia

fine ceramic, based principally on zirconium oxide, which contains sufficient additional oxide species to retain the cubic crystal modification on cooling from the processing temperature to room temperature

NOTE 1 Theoretically CSZ should contain only the cubic crystal modification, but depending on the composition and the thermal history a small amount of other crystal modifications can be present.

NOTE 2 Typical stabilizers include magnesia, calcia, yttria or other rare-earth species.

### 3.1.10

#### GPSSN

##### gas pressure sintered silicon nitride

fine ceramic, based principally on silicon nitride, densified by gas pressure sintering

NOTE When sintering silicon nitride, the gas atmosphere selected should normally contain nitrogen in order to inhibit the dissociation of the nitride at elevated temperatures.

### 3.1.11

#### HA

##### hydroxy(l)apatite

fine ceramic, based principally on oxides of calcium and phosphorus with hydroxyl ions typically forming the crystalline phase hydroxy(l)apatite

NOTE In English literature the abbreviations HAp and HAP are sometimes used, but their use is deprecated.

### 3.1.12

#### HPSC

##### hot-pressed silicon carbide

fine ceramic, based principally on silicon carbide, densified by the action of an applied force (normally unidirectional) at elevated temperature

### 3.1.13

#### HPSN

##### hot-pressed silicon nitride

fine ceramic, based principally on silicon nitride, densified by the action of an applied force (normally unidirectional) at elevated temperature

### 3.1.14

#### HTS

#### HTSC

##### high-temperature superconductor

superconducting ceramic having superconducting properties at temperatures above 77 K, the boiling point of liquid nitrogen

### 3.1.15

#### LAS

##### lithium aluminosilicate

fine ceramic, typically a glass or glass-ceramic, based principally on oxides of lithium, aluminium and silicon



NOTE Lithium aluminium silicate typically contains crystalline phases such as petalite, beta-eucryptite, or their solid solutions.

### 3.1.16

#### LPSSC

#### liquid-phase sintered silicon carbide

fine ceramic, based principally on silicon carbide, densified by liquid-phase sintering at high temperatures

### 3.1.17

#### MAS

#### magnesium aluminosilicate

fine ceramic, typically a glass or glass-ceramic, based principally on oxides of magnesium, aluminium and silicon

NOTE Magnesium aluminium silicate typically contains the crystalline phase cordierite.

### 3.1.18

#### MAT

#### magnesium aluminium titanate

fine ceramic, based principally on oxides of magnesium, aluminium and titanium

NOTE Magnesium aluminium titanate typically contains the crystalline phase pseudo-brookite.

### 3.1.19

#### PCD

#### polycrystalline diamond

polycrystalline form of carbon with cubic crystalline structure

NOTE 1 Polycrystalline diamond is normally prepared by high-pressure and high-temperature processing to achieve direct bonding between diamond grains.

NOTE 2 Polycrystalline diamond film is normally prepared by low-pressure chemical vapour deposition.

### 3.1.20

#### PLZT

#### lead lanthanum zirconium titanate

fine ceramic based principally on oxides of lead, lanthanum, zirconium and titanium

NOTE Lead lanthanum zirconium titanate typically comprises crystalline perovskite structure phase.

### 3.1.21

#### PMN

#### lead magnesium niobate

fine ceramic, based principally on oxides of lead, magnesium and niobium

NOTE Lead magnesium niobate typically comprises crystalline perovskite structure phase.

### 3.1.22

#### PMNT

#### lead magnesium niobium titanate

#### PMN-PT

#### lead magnesium niobate-lead titanate

fine ceramic, based principally on oxides of lead, magnesium, niobium and titanium

### 3.1.23

#### PSRBSN

#### post-sintered reaction-bonded silicon nitride

fine ceramic, based principally on silicon nitride, which as a green body, comprising elemental silicon and liquid-phase forming sintering aids, is first reaction-bonded in a nitrogen atmosphere, followed by sintering at higher temperatures

NOTE When sintering silicon nitride, the gas atmosphere selected should normally contain nitrogen in order to inhibit the dissociation of the nitride at elevated temperatures.

**3.1.24**

**PSZ**

**partially stabilized zirconia**

fine ceramic, based principally on zirconium oxide, which contains insufficient stabilizing oxide species to retain only the high-temperature cubic crystal modification on cooling from the processing temperature to room temperature

NOTE The stabilizer is typically magnesia, calcia or yttria. Normally the material partially destabilizes on cooling to comprise two or more different modifications.

**3.1.25**

**PZT**

**lead zirconium titanate**

fine ceramic, based principally on oxides of lead, zirconium and titanium

NOTE Lead zirconium titanate typically comprises crystalline perovskite structure phases.

**3.1.26**

**RBAO**

**reaction-bonded aluminium oxide**

fine ceramic, based principally on aluminium oxide, typically densified by the in-situ reaction between oxygen and elemental aluminium inside a green body containing aluminium oxide and aluminium powders

**3.1.27**

**RBSC**

**reaction-bonded silicon carbide**

fine ceramic, based principally on silicon carbide, typically densified by the in-situ reaction between carbon and elemental silicon inside a green body containing silicon carbide, silicon and carbon powders

NOTE 1 The object may be porous if the reaction is with particulate silicon, or dense if the reaction is with liquid silicon by infiltration. In the latter case an elemental silicon phase is normally present.

NOTE 2 The term "reaction-sintered silicon carbide" and the abbreviation "RSSC" are sometimes used, but both are deprecated, because reaction sintering is not involved.

**3.1.28**

**RBSN**

**reaction-bonded silicon nitride**

fine ceramic, based principally on silicon nitride, produced principally by the in-situ reaction of nitrogen with a green body comprising primarily elemental silicon

NOTE 1 Reaction-bonded silicon nitride is usually open porous.

NOTE 2 The term "reaction-sintered silicon nitride" and the abbreviation "RSSN" are sometimes used, but both are deprecated, because reaction sintering is not involved.

**3.1.29**

**RSC**

**recrystallized silicon carbide**

fine ceramic, based principally on silicon carbide, prepared in coarse-grained porous form by sintering at very high temperature

**3.1.30**

**SC**

**silicon carbide**

fine ceramic, based principally on silicon carbide

**3.1.31****SIALON****sialon****silicon aluminium oxynitride**

fine ceramic, based principally on compounds or solid solutions in the four-component silicon-aluminium-oxygen-nitrogen system

NOTE 1 The prefixes  $\alpha$ -,  $\beta$ - or O- may be used in combination with the abbreviation SIALON to indicate the type of crystal structure.

NOTE 2 "Sialon" written in lower case letters has the same meaning as "SIALON" written in upper case letters.

NOTE 3 Compounds and solid solutions with the component close to AlN are often referred to as AlN polytypoids.

**3.1.32****SISC****silicon-infiltrated silicon carbide**

fine ceramic, based principally on silicon carbide rendered non-porous by infiltration with liquid silicon

NOTE The infiltration process may involve reaction bonding.

**3.1.33****SN****silicon nitride**

fine ceramic, based principally on silicon nitride

NOTE The abbreviation "SN" is used only in combination with a processing prefix; when no processing prefix is required, the quasi-chemical formula "SiN" is often used, but this is deprecated.

**3.1.34****SNO****silicon oxynitride**

fine ceramic, based principally on silicon oxynitride

**3.1.35****SSC****sintered silicon carbide**

fine ceramic, based principally on silicon carbide, densified by sintering processes at high temperature in the absence of a raised mechanical or gas pressure

NOTE Usually small amounts of sintering aids are added and a non-oxidizing atmosphere is provided.

**3.1.36****SSN****PLSSN****(pressureless) sintered silicon nitride**

fine ceramic, based principally on silicon nitride, densified by pressureless sintering

NOTE When sintering silicon nitride, the gas atmosphere selected should normally contain nitrogen in order to inhibit the dissociation of the nitride at elevated temperatures.

**3.1.37****TTPSZ****transformation-toughened partially stabilized zirconia**

fine ceramic, based principally on partially stabilized zirconia in which the destabilization on cooling is controlled so as to precipitate zirconia of the tetragonal modification within grains of the cubic modification

NOTE 1 The stabilizer is typically magnesia or yttria and less frequently calcia or mixtures of other oxides.

NOTE 2 The use of the abbreviation “Mg-PSZ” (magnesia partially stabilized zirconia) is deprecated for this specific type of zirconia, as opposed to its use for bulk refractories.

**3.1.38**

**TZP**

**tetragonal zirconia polycrystals**

fine ceramic, based principally on zirconium oxide, having a fine-grained structure in which the amount of stabilizing species is controlled such that the principal crystalline phase retained at room temperature is the high-temperature tetragonal modification

NOTE 1 The stabilizer is normally yttria.

NOTE 2 The use of the abbreviation “TPZ” and the term “tetragonal-PSZ” is deprecated.

**3.1.39**

**YAG**

**yttrium aluminium garnet**

fine ceramic, based principally on oxides of yttrium and aluminium

**3.1.40**

**YBCO**

**yttrium barium copper oxide**

superconducting ceramic, based principally on oxides of yttrium, barium and copper

**3.1.41**

**YIG**

**yttrium iron garnet**

fine ceramic, based principally on oxides of yttrium and iron, typically comprising a crystalline phase of the garnet structure

**3.1.42**

**YSZ**

**yttria stabilized zirconia**

cubic stabilized zirconia where yttrium oxide is the stabilizing agent

**3.1.43**

**ZTA**

**zirconia toughened alumina**

fine ceramic, based principally on aluminium oxide with additions of zirconium oxide in various forms to provide modification of mechanical properties

**3.1.44**

**ZTC**

**zirconia toughened ceramic**

fine ceramic, containing zirconia particles in a matrix phase to provide modification of mechanical properties

**3.1.45**

**ZTS**

**zirconium titanium stannate**

**zirconium tin titanate**

fine ceramic, based principally on oxides of zirconium, titanium and tin

NOTE Zirconium titanium stannate typically comprises crystalline perovskite structure phases.

**3.2 Abbreviations for processes**

NOTE The following abbreviations are derived from terms that define processes used to achieve a ceramic product. These abbreviations may be added as a prefix to the abbreviations of ceramic materials as appropriate. In such cases they are used as adjectives, the form of which can be derived from the noun given; for example RBSN means reaction

bonded silicon nitride. In some cases the abbreviation alone also stands for the equipment used for the process, e.g., "CIP" for cold isostatic press.

### 3.2.1

#### CIP

#### **cold isostatic pressing**

process of preparing a green body from a ceramic powder or a ceramic granulate by the use of (pseudo-) isostatic pressure at or near room temperature

NOTE This process is sometimes called "CIPing".

### 3.2.2

#### CVD

#### **chemical vapour deposition**

process for producing a fine ceramic by reacting gaseous species and condensing the reaction product or by heterogeneous reaction at the surface of a substrate

NOTE This process may be used for the preparation of a solid ceramic or a ceramic powder or a coated ceramic or for infiltration of a heated substrate.

### 3.2.3

#### CVI

#### **chemical vapour infiltration**

chemical vapour deposition used for producing a fine ceramic by heterogeneous reaction at the pore surface of a heated porous ceramic preform

NOTE CVI is typically used to produce ceramic filament reinforced ceramic matrix composites.

### 3.2.4

#### GPS

#### **gas pressure sintering**

sintering by the combined application of heat and gas pressure

NOTE 1 e.g., gas pressure sintered silicon nitride, GPSSN.

NOTE 2 The gas pressure is typically no greater than 10 MPa.

### 3.2.5

#### HIP

#### **hot isostatic pressing**

process of making a fine ceramic by application of an isostatic gas pressure at elevated temperatures

NOTE 1 The object may be an encapsulated powder or green body, or a pre-densified fine ceramic with no open porosity. Gas pressures are typically much greater than 10 MPa.

NOTE 2 This process is sometimes called "HIPing".

### 3.2.6

#### HP

#### **(uniaxial) hot pressing**

process of making a fine ceramic, normally by application of a unidirectional (uniaxial) force at elevated temperature

NOTE For uniaxial hot pressing an inductively heated graphite die is usually employed.

### 3.2.7

#### IM

#### **injection moulding**

process of shaping a green body by injecting an appropriately formulated mass into a mould or die

### 3.2.8

#### **LPCVD**

#### **low-pressure chemical vapour deposition**

chemical vapour deposition at low gas pressure

NOTE The gas pressure is typically less than 0,01 MPa.

### 3.2.9

#### **LPS**

#### **liquid-phase sintering**

sintering achieved by the presence of a liquid phase

NOTE The amount and properties of the liquid phase are determined by the composition of the green body, temperature and pressure. This process is enhanced by accelerated diffusion and dissolution-precipitation phenomena.

### 3.2.10

#### **MOCVD**

#### **metal-organic chemical vapour deposition**

chemical vapour deposition using single or mixed metal-organic vapours

### 3.2.11

#### **PECVD**

#### **plasma-enhanced chemical vapour deposition**

chemical vapour deposition using a plasma

NOTE The reaction in the gaseous phase can, e.g., be stimulated by application of a plasma formed by coupled laser.

### 3.2.12

#### **PLS**

#### **pressureless sintering**

sintering in the absence of a raised mechanical or gas pressure

NOTE e.g., pressureless sintered silicon nitride, PLSSN.

### 3.2.13

#### **PS**

#### **post-sintering**

sintering after a previous consolidation stage

NOTE e.g., post-sintered reaction-bonded silicon nitride, PSRBSN.

### 3.2.14

#### **PVD**

#### **physical vapour deposition**

process for producing, e.g., a thin ceramic film by transport of the required chemical species, some or all of which are generated from a source or sources by physical means such as thermal, electron beam, arc or laser evaporation or sputtering, and deposition on to a prepared substrate with or without the assistance of a reactive atmosphere, ionic bombardment or a gas plasma

### 3.2.15

#### **RB**

#### **reaction bonding**

process for producing a fine ceramic by consolidation of a green body by a chemical reaction between gaseous, liquid or solid species at elevated temperature producing a bond between ceramic particles

NOTE 1 e.g., silicon nitride objects can be produced by the reaction of silicon with nitrogen; reaction-bonded silicon nitride, RBSN.

NOTE 2 The use of this term for a process which falls under the definition of reaction sintering is deprecated.

**3.2.16****RS****reaction sintering**

process for producing a fine ceramic by consolidation of a green body by a solid-state chemical reaction accompanied by solid-state sintering at high temperatures to produce a bond between ceramic particles

NOTE 1 e.g., during the production of aluminium titanate ceramics, aluminium titanate can be formed by a solid-state reaction between aluminium oxide and titanium oxide.

NOTE 2 The use of this term for liquid or gaseous reaction bonding processes is deprecated.

**3.2.17****SHS****self-sustained high temperature synthesis**

process for producing a fine ceramic in which, primarily, the heat of the exothermic reaction between ceramic precursor components in a green body is utilized for densification

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