Technical ceramics

General presentation

Technical ceramic materials are made u… non-metallic phases, with essentiall… completely glassy and generall… powdery compact in the fo…

These compounds … etc.) and non-metallic (… …s, carbides, nitrides, b…

According to C. Palmonari and G. Timellini
(Centro di Ricerca e Sperimentazione per l'Industria Ceramica-Bologna)
La Ceramica N ° 1/1986)

Ceramic materials are generally hard and brittle at break while sometimes being characterized by very high mechanical strengths.

“Technical” ceramics are prepared from synthetic materials or purified natural materials. We can distinguish “oxid[illegible]ramics and “non-oxide” ceramics.

OXID CERAMICS

They are characterized, compared [illegible]ing temperature and great chemic[illegible]e.

Properties	[illegible]	[illegible]	[illegible]
Melting temperat[illegible]	[illegible]	[illegible]	2720
D[illegible]	[illegible]	[illegible]	6.05
[illegible]	[illegible]	75	800 – 1 200
[illegible]	[illegible]	0.4	10.5
[illegible]	[illegible]50	High	250
[illegible]	> 10^{12}	10^{10}	>10^{7}
Therma[illegible].K^{-1})	36	1.5	2.9
Hardness (GPa)	25	5	14
K_{1C} (MPa.m-1/2)	3 – 4.5	0.6	7 - 12

Alumina Al_2O_3 is made from bauxite (hydrated alumina), mainly used for its properties of stability, purity, refractoriness, chemical inertia , etc.
A quarter of the alumina produced passes through the refractories.

Silica SiO_2 is a vitreous silica, due to its low coefficient of expansion and the absence of change in crystalline phase in temperature, it has an excellent resistance to thermal shock.

Zirconia ZrO_2 exists in one of the three crystalline fo[illegible] (allotropic forms) monoclinic –1100 ° C - quadratic - 2300 ° [illegible] 2700 ° C (fusion). It is necessary to stabilize the zirco[illegible] high temperature structures in order to avoi[illegible] cooling. The addition of a few perce[illegible] lead to this result.

Oxide ceramics are als[illegible] [illegible]ical engineering becau[illegible] [illegible]al properties (ce[illegible] [illegible] the world market fo[illegible]

[illegible]	[illegible]	Compounds	Uses
[illegible]	[illegible]	Al_2O_3, BeO, MgO	Substrates
	[illegible]ectric	$BaTiO_3$, $SrTiO_3$	Capacitors
	piezoelectric	$Pb(Zr,Ti)O_3$	Sensors, actuators
(electr[illegible] [illegible]al ele[illegible])	semiconductors	NiO, CoO, Cu2O	NTC thermistors
		$BaTiO_3$	PTC thermistors
		$ZnO-Bi_2O_3$, SiC	Varistors
		TiO_2, SnO_2, SiC	Electrodes
		ZrO_2, $LaCrO_3$	MHD conversion
	superconductors	$YBa_2Cu_3O_7$	Trains, computers
	ion conductors	Al_2O_3 beta	Drums
		ZrO_2	Oxygen sensor, batteries
Magnetic (electromagnetic)	soft ferrite	Mn, $Zn(Fe_2O_4)$	Memories
		Ni, $Zn(Fe_2O_4)$	Inductors H.F.
	garnets	$Y_3Fe_5O_{12}$	Radars, satellites
	hard ferrites	$BaO-6Fe_2O_3$	Magnets
Optical (electro-optic)	semiconductors	$CdS-Cu_2S$	Photovoltaic cells
	piezoelectric	$(Pb,La)(Zr,Ti)O_3$	Electro-optics
	luminescent	Zn_2SiO_4	TV screens, lasers

NON-OXIDIZED CERAMICS

The most common are carbides such as SiC, the transition metal carbides TiC, ZrC, HfC as well as VxC, NbxC, TaxC, MoxC, WxC and nitrides such as Si_3N_4, AlN, TiN, etc.
Overall , these materials will have high hardness (B[illegible]TiC, SiC, WC, etc.), low toughness compared to that of m[illegible]lloys (generally <10 MPa.m²) reflecting their britt[illegible]ood resistance to corrosion and wear.

Properties	[illegible]	[illegible]
T decomposition (° C[illegible]	[illegible]	[illegible]
Densit[illegible]	[illegible]	[illegible]
Est[illegible]	[illegible]	8 000
[illegible]	[illegible]	± 300
[illegible]	[illegible] - 33	16 - 25
[illegible]	240 - 520	415 - 965
[illegible]	1.5 - 8	2.5 - 8
Coe[illegible]l expansion ($10^{-6}.K^{-1}$)	4.3 – 5.5	3.1
Thermal conductivity (W.m-1.K-1)	40 - 120	16 - 25
Electrical resistivity (Ω.cm)	10 - 40	40

At high temperature, they have a mechanical resistance which can be higher than that of common metals and alloys, good resistance to creep and to oxidation (especially Si3N4). From the point of view of thermal characteristics, they have a very low coefficient of thermal expansion (especially SiC) and a more or less high thermal conductivity depending on the type of material (that of AlN is high).

The properties depend on the processing methods which control grain size, porosity, characteristics of the grain boundaries and for which the table on the previous page gives some orders of magnitude.

Some applications of non-oxide ceramics: abras [illegible] valves and fittings (Al_2O_3, SiC), bearings and frictio [illegible] automobile (Si_3N_4), grinding parts (SiC, S [illegible] nozzles (SiC, W_2C, Al_2O_3), dispersing [illegible] composites for anti-abrasive a [illegible] SiC, BN-SiC, ZrC-TiB_2), high t [illegible] reactors (B_4C, SiC, ZrC) [illegible] gain of 5 compared to g [illegible] (Si_3N_4, SiC), cosmetics [illegible] AlN), cutting tools (cer [illegible] N, SiC, SiAlON, etc.).