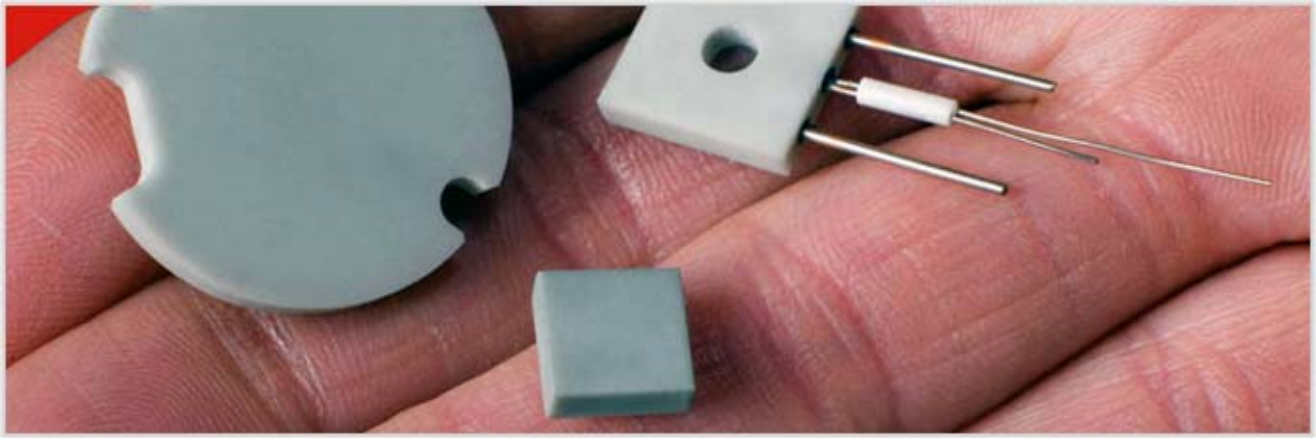
Aluminum nitride

Description

Image



Caption

Aluminum nitride components. © Used with permission from Watlow Electric Manufacturing Company, 2013

The material

Aluminum nitride, (AlN) has an unusual combination of properties: it is an electrical insulator, but an excellent conductor of heat. This is just what is wanted for substrates for high-powered electronics; the substrate must insulate yet conduct the heat out of the microchips. This, and its high strength, chemical stability and low expansion give it a special role as a heat sinks for power electronics. It is transparent to microwaves and RF frequencies, and thus makes good microwave windows.

Composition (summary)

AlN

General properties

Density	204	-	208	lb/ft^3
Price	* 47	-	75.2	USD/lb
Date first used	1984			

Mechanical properties

Young's modulus	43.8	-	50.5	10^6 psi
Shear modulus	18.3	-	20.2	10^6 psi
Bulk modulus	* 29	-	33.6	10^6 psi
Poisson's ratio	0.23	-	0.26	
Yield strength (elastic limit)	* 43.5	-	50.8	ksi
Tensile strength	* 43.5	-	50.8	ksi
Compressive strength	286	-	363	ksi
Elongation	0			% strain
Hardness - Vickers	990	-	1.26e3	HV
Fatigue strength at 10^7 cycles	* 24.4	-	36	ksi
Fracture toughness	2.28	-	3.09	ksi.in^0.5
Mechanical loss coefficient (tan delta)	* 1e-5	-	3e-5	

Thermal properties

Melting point	4.35e3	-	4.54e3	°F
Maximum service temperature	* 1.88e3	-	3.14e3	°F
Minimum service temperature	-460			°F
Thermal conductor or insulator?	Good conductor			
Thermal conductivity	80.9	-	116	BTU.ft/h.ft^2.F
Specific heat capacity	0.186	-	0.196	BTU/lb.°F

Thermal expansion coefficient	2.72	-	3.06	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	1e19	-	1e21	µohm.cm
Dielectric constant (relative permittivity)	8.3	-	9.3	
Dissipation factor (dielectric loss tangent)	5e-4	-	9.2e-4	
Dielectric strength (dielectric breakdown)	432	-	508	V/mil

Optical properties

Transparency	Opaque			

Processability

Moldability	2	-	3	
Machinability	1	-	2	

Eco properties

Embodied energy, primary production	* 2.39e4	-	2.64e4	kcal/lb
CO2 footprint, primary production	* 11.9	-	13.2	lb/lb
Recycle	✕			

Supporting information

Design guidelines

Aluminum nitride is particularly unusual for its high thermal conductivity (among ceramics only beryllia, BeO, and diamond have higher values) combined with a high electrical resistance, low dielectric constant, good corrosion and thermal shock resistance. It is resistant to attack by molten metals, but is hydrolyzed slowly by water. Technical ceramics are formed by the following steps.(a) Pressing, isostatic pressing, powder extrusion (for bars and tubes) or powder injection molding (for intricate, high-volume parts).(b) Green-machining in the unfired state, using standard tools.(c) Firing or "sintering" typically at 1550 - 1700 C for 12 to 20 hours; the part shrinks by about 20%.(d) Diamond grinding to achieve tighter tolerance and surface finish: +/- 10 microns is achievable. The cost of a ceramic part is greatly increased if it has to be diamond-ground. Thus design for net-shape sintering, eliminating step (d) is highly desirable. The standard tolerance for as-fired dimensions is +/- 1% or 125 microns, whichever is greater.

Technical notes

Aluminum nitride is difficult to sinter when pure. To allow sintering between 1600 and 1900 C, additions of CaO or Y2O3 are made.

Typical uses

Microwave windows; insulators for specialty spark plugs and igniters; substrates and packaging for microcircuits; chip carriers; heat sinks; electronic and semiconductor components; windows; heaters; clamp rings; gas distribution plates.

Links

Reference

ProcessUniverse

Producers