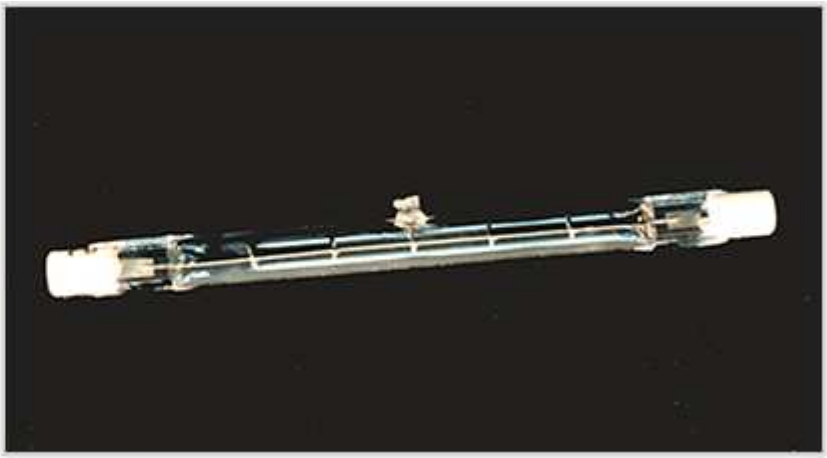
Description

Image



Caption

1. Halogen bulb. © Stefan Wernli, stef at en.wikipedia - (CC BY-SA 2.5) 2. Silica glass used for very high-power lamp envelopes. © Granta Design

The material

Fused silica, a glass of great transparency, is nearly pure SiO2, it has an exceptionally high melting point and is difficult to work, but, more than any other glass, it resists temperature and thermal shock.

Composition (summary)

SiO2

General properties

Density		135	-	139	lb/ft^3
Price	*	2.82	-	4.7	USD/lb
Date first used		1905			

Mechanical properties

Young's modulus		9.86	-	10.7	10^6 psi
Shear modulus	*	4.05	-	4.68	10^6 psi
Bulk modulus		4.93	-	5.22	10^6 psi
Poisson's ratio		0.15	-	0.19	
Yield strength (elastic limit)	*	6.53	-	22.5	ksi
Tensile strength	*	6.53	-	22.5	ksi
Compressive strength		160	-	232	ksi
Elongation		0			% strain
Hardness - Vickers		450	-	950	HV
Fatigue strength at 10^7 cycles	*	6.24	-	20.7	ksi
Fracture toughness		0.546	-	0.728	ksi.in^0.5

Mechanical loss coefficient (tan delta)		8e-6	-	2e-5	

Thermal properties

Glass temperature	*	1.75e3	-	2.83e3	°F
Maximum service temperature		1.65e3	-	2.55e3	°F
Minimum service temperature		-460			°F
Thermal conductor or insulator?		Poor insulator			
Thermal conductivity		0.809	-	0.867	BTU.ft/h.ft^2.F
Specific heat capacity		0.162	-	0.174	BTU/lb.°F
Thermal expansion coefficient		0.306	-	0.417	µstrain/°F

Electrical properties

Electrical conductor or insulator?		Good insulator			
Electrical resistivity		1e23	-	1e27	µohm.cm
Dielectric constant (relative permittivity)		3.7	-	3.9	
Dissipation factor (dielectric loss tangent)		2e-5	-	6e-5	
Dielectric strength (dielectric breakdown)		838	-	965	V/mil

Optical properties

Transparency		Optical Quality			
Refractive index		1.46			

Critical Materials Risk

High critical material risk?		No			

Processability

Castability		1	-	2	
Moldability		2	-	3	
Weldability		3	-	4	

Durability: water and aqueous solutions

Water (fresh)		Excellent			
Water (salt)		Excellent			
Soils, acidic (peat)		Excellent			
Soils, alkaline (clay)		Excellent			
Wine		Excellent			

Durability: acids

Acetic acid (10%)		Excellent			
Acetic acid (glacial)		Excellent			
Citric acid (10%)		Excellent			
Hydrochloric acid (10%)		Excellent			

Hydrochloric acid (36%)	Excellent
Hydrofluoric acid (40%)	Unacceptable
Nitric acid (10%)	Excellent
Nitric acid (70%)	Excellent
Phosphoric acid (10%)	Excellent
Phosphoric acid (85%)	Excellent
Sulfuric acid (10%)	Excellent
Sulfuric acid (70%)	Excellent

Durability: alkalis

Sodium hydroxide (10%)	Acceptable
Sodium hydroxide (60%)	Limited use

Durability: fuels, oils and solvents

Amyl acetate	Excellent
Benzene	Excellent
Carbon tetrachloride	Excellent
Chloroform	Excellent
Crude oil	Excellent
Diesel oil	Excellent
Lubricating oil	Excellent
Paraffin oil (kerosene)	Excellent
Petrol (gasoline)	Excellent
Silicone fluids	Excellent
Toluene	Excellent
Turpentine	Excellent
Vegetable oils (general)	Excellent
White spirit	Excellent

Durability: alcohols, aldehydes, ketones

Acetaldehyde	Excellent
Acetone	Excellent
Ethyl alcohol (ethanol)	Excellent
Ethylene glycol	Excellent
Formaldehyde (40%)	Excellent
Glycerol	Excellent
Methyl alcohol (methanol)	Excellent

Durability: halogens and gases

Chlorine gas (dry)	Excellent
Fluorine (gas)	Limited use

O2 (oxygen gas)	Excellent
Sulfur dioxide (gas)	Excellent

Durability: built environments

Industrial atmosphere	Excellent
Rural atmosphere	Excellent
Marine atmosphere	Excellent
UV radiation (sunlight)	Excellent

Durability: flammability

Flammability	Non-flammable

Durability: thermal environments

Tolerance to cryogenic temperatures	Excellent
Tolerance up to 150 C (302 F)	Excellent
Tolerance up to 250 C (482 F)	Excellent
Tolerance up to 450 C (842 F)	Excellent
Tolerance up to 850 C (1562 F)	Excellent
Tolerance above 850 C (1562 F)	Excellent

Primary material production: energy, CO2 and water

Embodied energy, primary production	* 4.05e3	-	4.49e3	kcal/lb
CO2 footprint, primary production	* 2.2	-	2.43	lb/lb
Water usage	* 0.159	-	0.176	gal(US)/lb
Eco-indicator 99	75.7			millipoints/kg

Material processing: energy

Glass molding energy	* 1.55e3	-	1.87e3	kcal/lb
Grinding energy (per unit wt removed)	* 1.51e4	-	1.66e4	kcal/lb

Material processing: CO2 footprint

Glass molding CO2	* 1.14	-	1.38	lb/lb
Grinding CO2 (per unit wt removed)	* 10.4	-	11.5	lb/lb

Material recycling: energy, CO2 and recycle fraction

Recycle	✓			
Embodied energy, recycling	* 3.14e3	-	3.47e3	kcal/lb
CO2 footprint, recycling	* 2.28	-	2.52	lb/lb
Recycle fraction in current supply	23.8	-	26.3	%
Downcycle	✓			
Combust for energy recovery	✗			
Landfill	✓			

Biodegrade	✗
Toxicity rating	Non-toxic
A renewable resource?	✗

Environmental notes

Silica, the prime ingredient of glass, is the commonest compound in the earths crust, though it is harder to find it in a form sufficiently pure to make glass. Nonetheless, the ingredients of glass are ubiquitous, and the material is readily recycled at the end of its life.

Supporting information

Design guidelines

Silica glass is exceptionally hard to shape, requiring either very high working temperatures or special process by which it is formed after working. This makes it much more expensive than soda lime or borosilicate glass.

Typical uses

Space vehicle windows, wind tunnel windows, lenses and mirrors, ultrasonic delay lines, crucibles for semiconductor crystal growing, spectrophotometric optical systems, high temperature glass applications, envelopes for high wattage lamps, thermal barrier coatings.

Tradenames

Lucalox

Links

Reference

ProcessUniverse

Producers