Description

Image

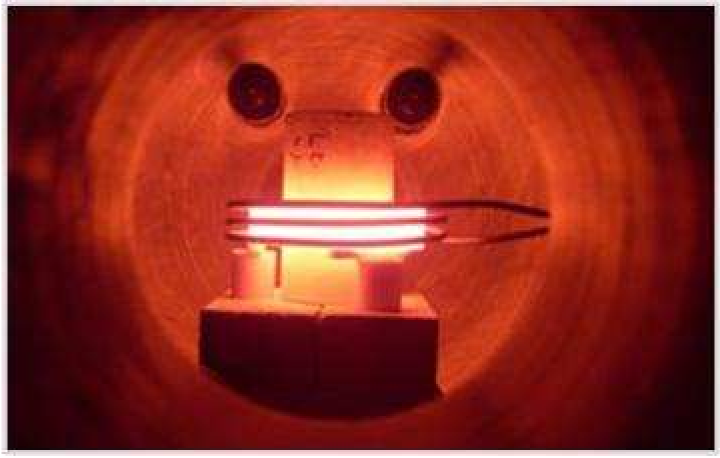

Image caption

(1) Low temperature diffusion bonding of aluminosilicate ceramic pieces © TWI Ltd (2) A glass bowl made by the casting process and welded. The central line indicates that a "breakaway mold" was used to make the piece © Zaereth at Wikimedia Commons [Public domain]

The process

Joining ceramics poses problems because they are hard and brittle. Mechanical fasteners generally require holes, and create high clamping forces and stress concentrations. Conventional welding is impractical: the melting temperatures of ceramics are very high and residual stresses lead to cracking. Adhesives stick to ceramics, but few are reliable above 300 C, where ceramics are often used. Two processes by-pass these difficulties: Diffusion and Glaze bonding. In DIFFUSION BONDING the surfaces to be joined are cleaned, pressed into close contact and heated in vacuum or a controlled atmosphere. Solid state diffusion creates the bond, which is of high quality, but the process is slow and the temperatures are high. GLAZE BONDING depends on the fact that molten glass wets and bonds to almost anything. To exploit this, the surfaces to be joined are first coated with a thin layer of finely-ground glass slurry, with the composition chosen to melt at a temperature well below that for diffusion bonding, and with maximum compatibility between the two surfaces to be joined. A small pressure is applied across the interface and the assembly is heated, melting the glass and forming a thin, but strong bonding layer.

Process schematic

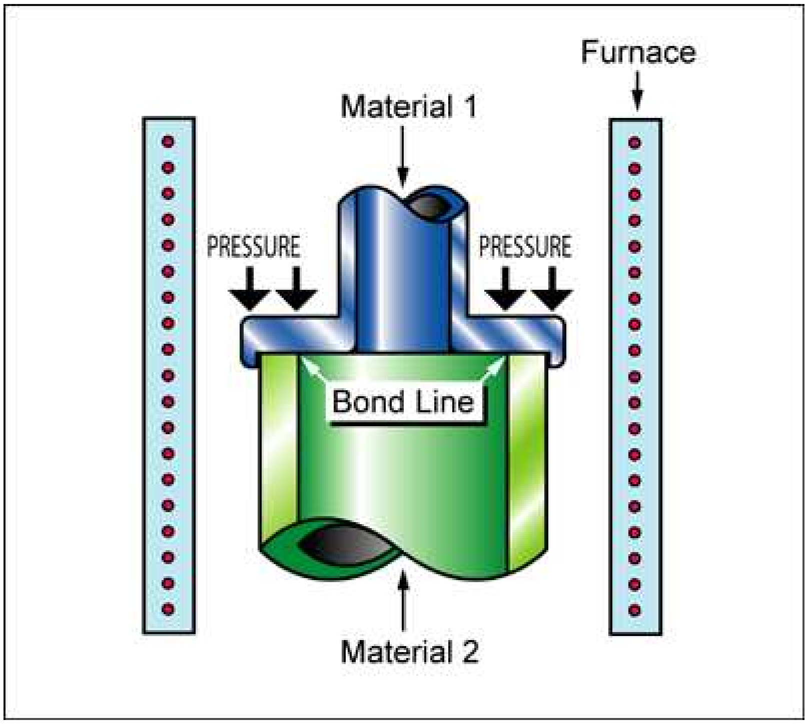

Figure caption

Diffusion bonding: the parts are bonded by interdiffusion, often with the formation of interface compounds. In glaze bonding, a thin layer of glass is placed at the interface.

Material compatibility

Ceramics	✔
Glasses	✔

Function compatibility

Electrically conductive	✘
Thermally conductive	✔
Watertight/airtight	✔
Demountable	✘

Joint geometry compatibility

Lap	✔
Butt	✔
Sleeve	✔
Scarf	✔
Tee	✔

Load compatibility

Tension	✔
Compression	✔
Shear	✔

Bending	✔
Torsion	✔
Peeling	✔

Economic compatibility

Relative tooling cost	low
Relative equipment cost	medium
Labor intensity	medium

Physical and quality attributes

Range of section thickness	39.4	-	3.94e3	mil
Unequal thicknesses	✔			
Processing temperature	932	-	1.47e3	°F

Process characteristics

Discrete	✔

Supporting information

Design guidelines

The processes allow differing materials to be joined: ceramic to ceramic, ceramic to glass, metal to ceramic, metal to metal. Glaze bonding is particularly versatile: tailoring the glass to match the requirements of melting temperature and thermal expansion allows bonds between metal and ceramic. There are no process limits on shape, provided the mating surfaces match closely, a pressure can be applied to them, and the whole assembly can survive the heat required for processing (500 - 1500 ºC, depending on process and material).

Technical notes

To make materials bond by diffusion requires temperatures above 3/4 of their melting temperature, and a modest pressure to keep the surfaces together. Ceramics melt at very high temperatures - so the processing temperatures are high. Diffusion bonding of metals is particularly attractive for titanium (otherwise difficult to bond) and for metal matrix and ceramic composites (which are even worse). Glaze bonding overcomes this by creating an interfacial layer that bonds closely to both surfaces, but melts at a much lower temperature. It is essential that the glaze bond be thin; when it is, it is as strong as the ceramics it can bond. But the greatest strength of the two processes is that they can bond metals to ceramics, provided the two are compatible, or a mutually compatible interlayer is placed between them.

Typical uses

Diffusion and glaze bonding are the principal ways of making ceramic-ceramic and ceramic-metal joints.

The economics

These processes are energy-intensive and slow. But for some material combinations this is the only

The environment

The environmental impact is low except in one regard: energy demand is high.

Links

MaterialUniverse
Reference