## Description

**Process schematic**

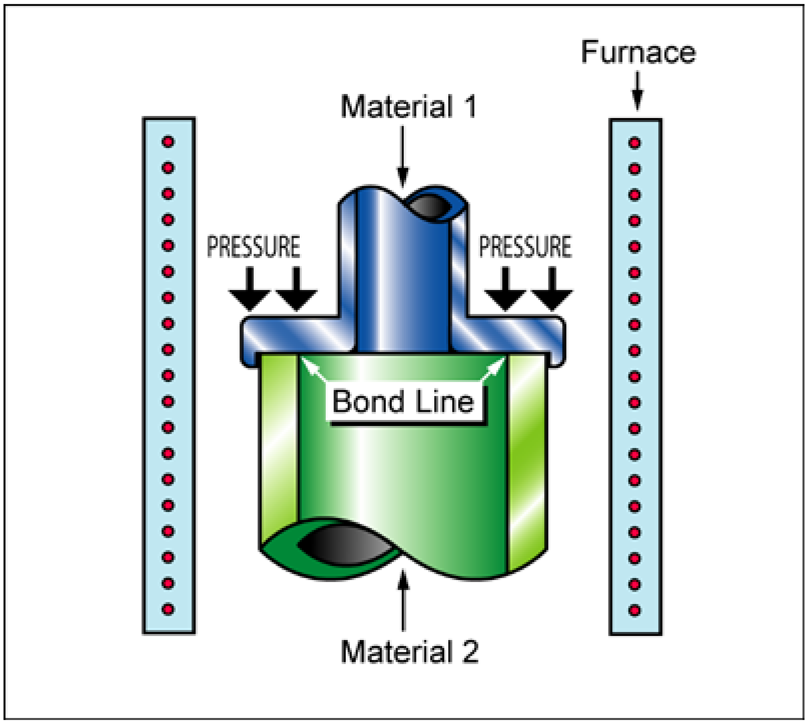


**Figure caption**

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.

**The process**

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. Diffusion bonding is used both for ceramics and metals - among the metals: titanium, metal matrix composites, and certain steels and copper-based alloys are particular candidates.

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.

## Material compatibility

| | |
|---|---|
| Metals - ferrous | ✔ |
| Metals - non-ferrous | ✔ |

## 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 | 1 - 100 mm |
| Unequal thicknesses | ✓ |
| Processing temperature | 500 - 800 °C |

## 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 bonding is used for assembling titanium aircraft panels, and smaller items where dissimilar metals must be joined, or larger structures in which cooling passages or other internal spaces are required.

**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