## Technology Transfer Track Posters

# Glass encapsulated HIP

### Overview

Glass bed encapsulated Hot Isostatic Pressing (HIP) enables the manufacturing of complicated shaped components from ceramics and other powders to high density and to near net size. The glass encapsulation, of the powder compacts, acts, in the high temperature low viscosity state, as a barrier for the Argon gas from penetrating the powder body, and further, transmitting the gas pressure to the powder compact to densify the powder. Thus, enabling the sintering of high-density ceramic components, see figure 1.

### Encapsulation developments

To be able to HIP a body with communicating porosity, as in the case of green body of ceramics, one need an enclosure to stop the pressurized gas to enter the body porosity system. A commonly used method is using a metal canister that is brought under vacuum and then closed off. One of the negative effects of this method is a tendency to wrinkling of the metal canister affecting the shape of the HIPed powder compact.

A similar approach used, is a glass canister, such as a glass tube or similar, brought under vacuum and then closed off. The softening of the glass at higher temperatures makes it more fluid and does not suffer the same degree of canister wrinkling effects. The higher fluidity also enhances the pressure uniformity.

A further development in the glass encapsulation development is the glass bed encapsulation, in which the glass is in the form of glass powder. In figure 2, the evolution over time can be seen for a glass encapsulation technique.

### Glass bed encapsulation

In the glass bed encapsulation technique, the encapsulating “canister” is formed in the HIP-cycle by using a glass powder, that forms a solid/fluid around the object to be sintered, at high temperature. This low viscous glass fills around the sintering object, allowing the complex shapes to be HIPed without experience negative effects from a stiff and wrinkling canister.

Depending on the material to be HIPed, a thin layer protecting the material from reacting with the glass, might be required. This thin layer is added to the green body before the component is put into the glass bed, see figure 1.

In the HIP cycle the temperature is brought up to a temperature such that the glass is in a “molten” state before the Argon pressure is applied.
The glass acts as a canister, stopping the gas from penetrating the powder body and at the same time transfer the gas pressure onto it.
The pressure from the gas densify the powder compact in an isostatic pressure field due to the low viscosity state of the glass surrounding the object. The temperature is increased to the required sintering temperature.

After the sintering cycle, the component is extracted from the glass body.

### Benefits

Since the glass bed acts more like a fluid in the molten state, very complex shapes can be sintered in a HIP cycle, as the glass fills around the shape and into cavities, such as holes.
This together with the isostatic nature of pressure field surrounding the powder compact, near net complex shapes can be produced, allowing to reduce post processing steps that can be costly and difficult in hard ceramics.

### Examples

Various shapes and in various materials have been produced using the glass bed technique, ranging from bearing balls and rollers to complex shapes like turbine wheels, as seen in figure 3. Turbine wheels shown is $Si_3N_4$ material sintered to shape. This encapsulation method is also used for materials such as $B_4C$.

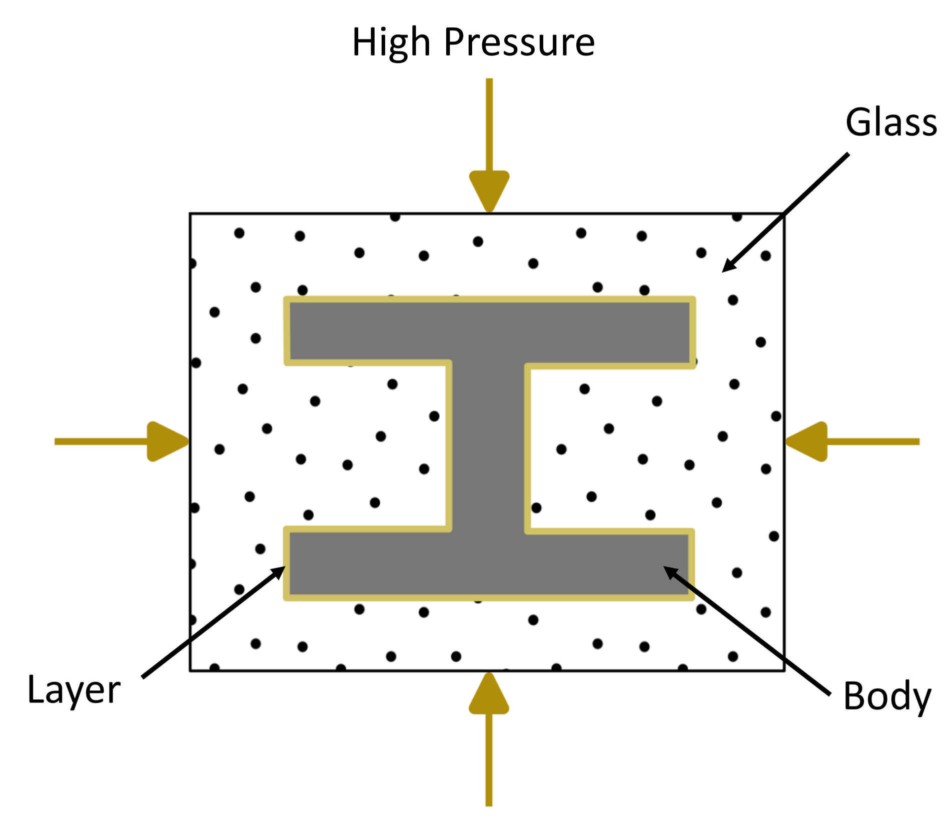


Figure 1 Glass bed encapsulation principle

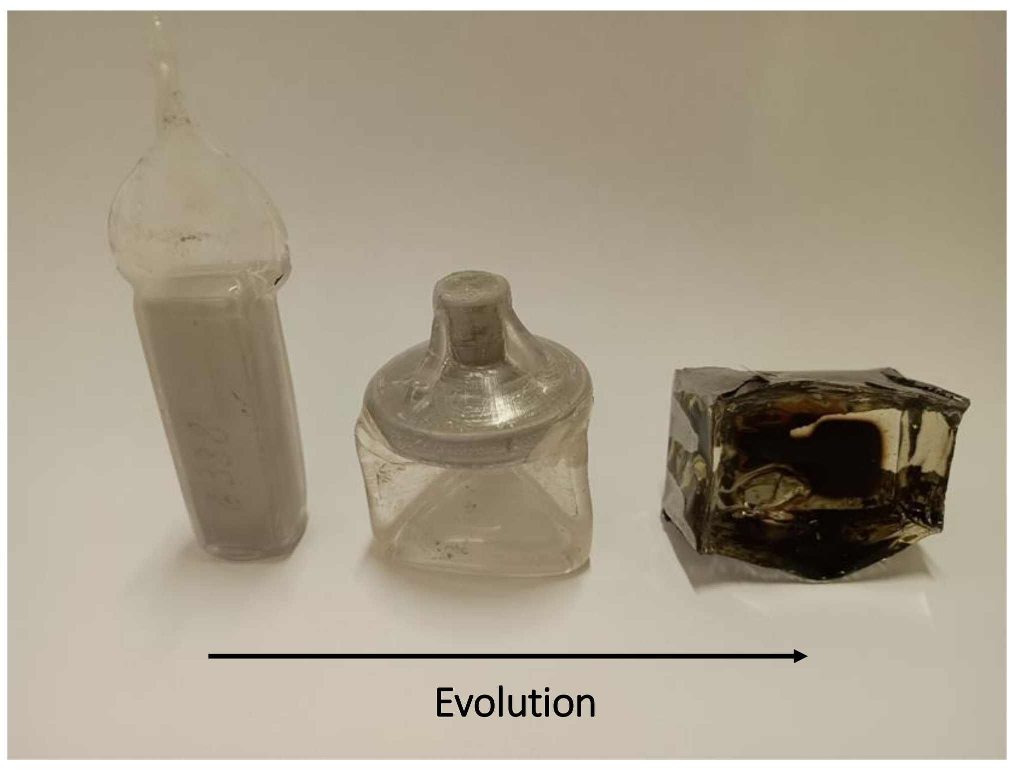


Figure 2 Glass encapsulations

Figure 3 Turbine wheels

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**Reference person**
Bernt-Ola Sandström

**Contacts**
bsandstrom@coorstek.com
www.coorstek.com