Ceramic-Metal-Assemblies for Vacuum Technology

FRIATEC AG manufactures such ceramic-metal-assemblies in customized dimensions. The components, made of FRIALIT F99.7 and metal, display only minimal leakage and out-gassing rates, and are thus ideal for use in ultra-high vacuum (UHV) conditions. Corresponding metal parts provide easy connection to further components.

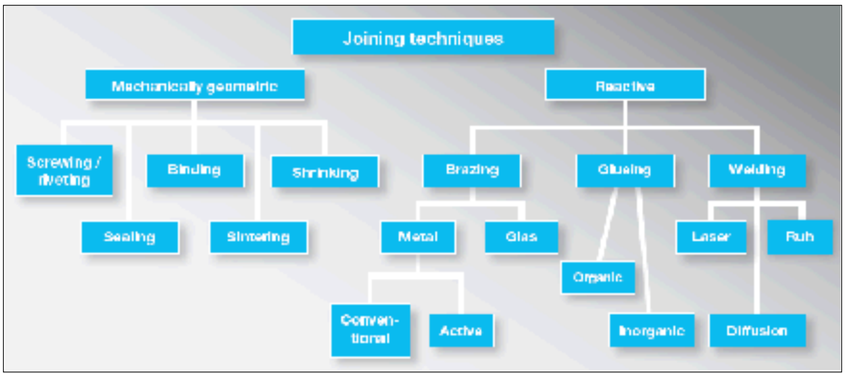

Fig. 1
Joining techniques

Tab. 1
Vacuum brazes – selection

Braze Material	Interval [°C]
Ag Cu 28	780
Ag Cu 26,6 Pd 5	807–810
Ag Cu 21 Pd 25	910–950
Au Ni 18	950
Cu Ce 10	900–1000
Au Cu 65	1000–2000

Introduction

Ceramic-metal-assemblies and insulating parts are an important condition for the operating function of a variety of technical tools and plants. Many varieties of insulating materials are available for the breadth of applications of such construction parts.

Oxide ceramic materials represent only a relatively small segment of this spectrum. They will usually be applied only when there is a demand for properties, which are not provided by other, cheaper materials. One example is the need for a high level of electric resistance and mechanical strength for temperatures above 500 °C with a simultaneous resistance to quick changes in temperature.

In such cases, alumina is usually the only suitable insulating material. Apart from very few exceptions, it is vital for the use of products that the ceramic is joined flush and vacuum tight with metal parts.

Keywords
joining, ceramic-metal-assemblies

Joining techniques

Fig. 1 [1] shows an overview of standard joining techniques used today for ceramic-metal and ceramic-ceramic joints. The MoMn procedure, which is mostly used for flush and vacuum tight joints of these materials is based on research which goes back to the first half of the last century [2, 3, 4].

Brazing MoMn-metallized ceramic

The MoMn-procedure is based on a suspension of the pulverized inorganic components in an organic ink system. This suspension is applied to the surface of the ceramic and a metallizing layer is created by a firing process which clings tightly to the surface [5, 6].

As the majority of the standard vacuum brazes does not wet the metallization it is plated by 2–5 µm thick Nickel using galvanic or chemical procedures. The ceramic, once it has been prepared in this way, is then brazed to the appropriate metal parts in a reducing atmosphere or in a sufficiently high vacuum.

Silver copper eutectic alloy is used as standard material. Fig. 2 shows a cross-section of the joined area of the compound 99,7 % Al_2O_3-ceramic/AgCu28/Mo. This combination of materials achieves strength values of more than 200 MPa during tensile tests according to [8] at room temperature. With increased demands on application temperature, corrosion features and where metals are used which are not wetted by

Helmut Mayer, Sven Wacker
FRIATEC AG
68229 Mannheim
Germany

sven.wacker@friatec.de
www.friatec.de

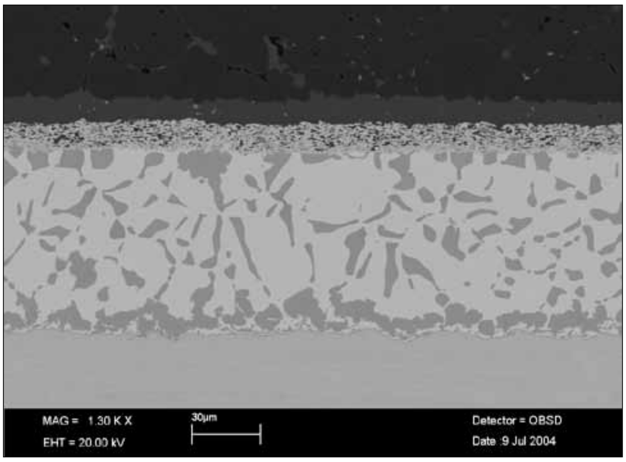

Fig. 2
Cross section of metallized and brazed Al_2O_3 ceramic

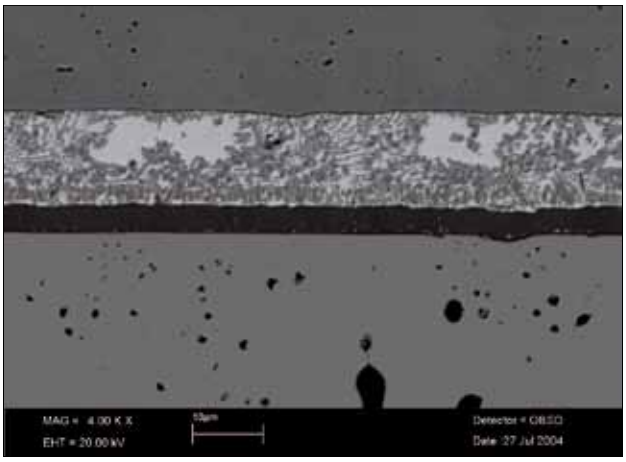

Fig. 3
Cross section of active brazed ZrO_2 ceramic

this braze, brazes with increased melting properties are used. Tab. 1 gives an overview [7].

Direct brazing

This procedure is based on the use of brazes with a low metal content, e.g. Ti, Zr, Hf. They wet Al_2O_3, which means that there is no need for prior metallization. The strength values of active brazed Al_2O_3-ceramic/Ni42-compounds achieve values of brazed and metallized compounds [9, 10]. Fig. 3 gives a further example of the joining area of a ZrO_2 ceramic and steel joint brazed by $AgCu_{26}$, $5Ti_3$.
However, while active brazing is an attractive option for technical and economic reasons, it has to be said that when it is used especially on feedthroughs, the braze does not flow into the braze gap but remains in the braze depot. If this peculiarity is considered in certain constructions there are ways around this restriction.

Choice of materials and construction

According to [11] approx 70 % of variable manufacturing costs arise during construction. This value originates from the automobile industry and may be transferred to electric feedthroughs and insulating parts only with certain provisos; however it proves that responsibility to provide the customer with a product which is meeting his or her expectations lies in the construction process, while at the same time making sure the product is manufactured at a competitive price. This means:

- Realization of the required features using simple solutions and standardized starting products
- Construction adapted to ceramics
- Streamlined construction.

The choice of suitable ceramic and metal materials initially requires thorough knowledge of application conditions. Tab. 2 gives an overview over central requirements in the three joining areas ceramic, joining area

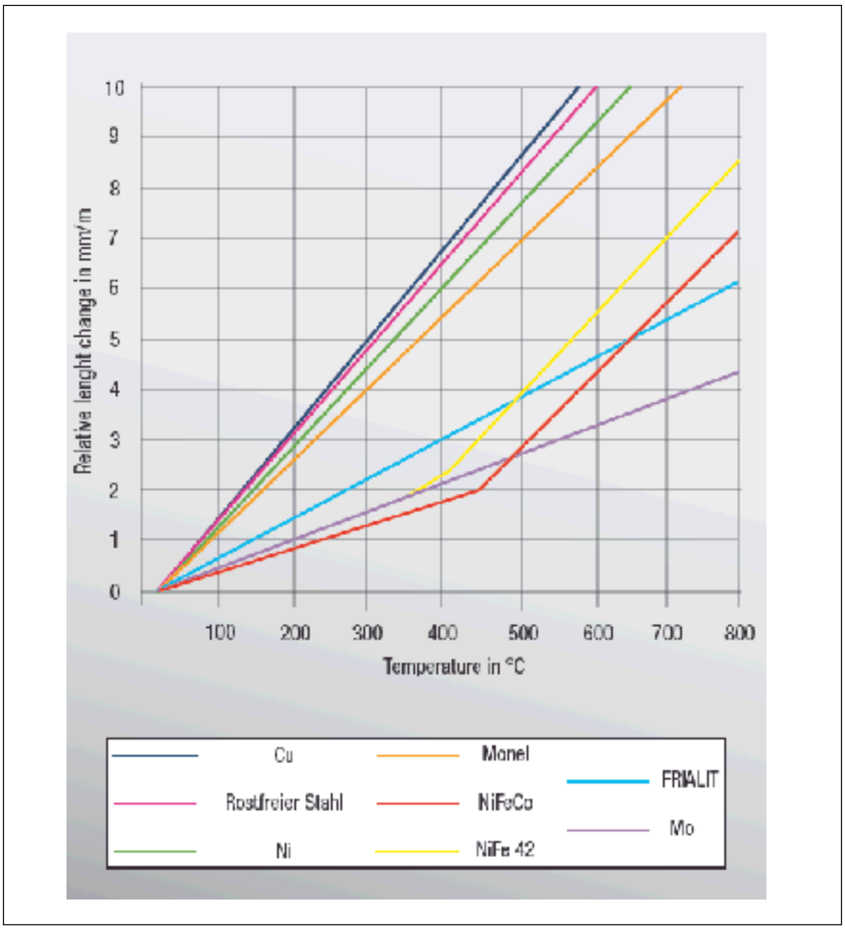

Fig. 4
Thermal expansion of metals compared with ceramic

Tab. 2
Central requirements

Properties	Focus on: Ceramic	Focus on: Joining Zone	Focus on: Metal
Electric:			
Breakdown voltage	+		
Sparkover voltage	+		
Creepage path	+		
Dielectric constants	+		
Resistance	+		
Magnetic			+
Thermal:			
Temperature during application		+	
Definition of temperature shock		+	
Mechanic: Strength		+	
Geometric:			
Size tolerance			+
Surface roughness	+		
Leak rate: Helium		+	

Fig. 5
Various single-/multipin feedthroughs and standoffs

Fig. 6
Various sensors and high pressure feedthroughs

and metal. Designing the joining construction takes place in line with the geometric indications by the user and the thermal suitability of the chosen materials (Fig. 5).

Application examples

Metallized oxide ceramics and ceramic-metal-assemblies are the basis for various applied physics applications in extreme environments. Through intensive discussions with our engineers, our partners are able to develop their products to achieve maximum efficiency in all fields of technology. The results are customized ceramic-metal-assemblies which satisfy the highest demands.

Brazed metal-ceramic connections are particularly suitable for use at higher temperatures up to 600 °C. Most of the feedthroughs can be used at temperatures down as far as –270 °C. The thermal shock resistance of the feedthroughs depends on the size and shape of the parts and is approximately 180 °C [12].

Independently of this, if the product is used at high or low temperatures and high voltages, its functionality remains the properties.

Ceramic-metal assemblies and insulating parts are used e.g. in the following areas:

Electrical engineering

- Single terminal and multiterminal feedthroughs
- Isolating tubes for fluids, gases and ultra-high vacuum
- High pressure feedthroughs for onshore/offshore technology
- Standoffs.

Measurement and control technology

- Components for sensor technology
- Cable end plugs for thermocouples and heating elements
- Pressure-sealed feedthroughs for flow and filling level measurement
- Housing for magnetic positioner sensor.

Medical technology

The X-ray image intensifier is the core of computerised tomography. It enables a physician to make the safest diagnosis whilst keeping the radiation exposure of the patient to a minimum. The key components of the X-ray image intensifier and X-ray sources are parts of oxide ceramics, developed between the application special-

ists of the manufacturer and the ceramic specialists.
The products of oxide ceramics are the combination of decades of comprehensive know-how and intensive development work in close cooperation with a customer-orientated producer.

Components for Accelerator technology
Particle accelerators are used throughout the world in research and development as well as in the medical field. They make it possible to view the minutest particles in existence, facilitate new scientific discoveries and open the door to new therapeutic approaches in the treatment of cancer.
Renowned institutions include the European Organisation for Nuclear Research (CERN) in Switzerland with the Large Hadron Collider (LHC), the German Electron Synchrotron (DESY), the Heidelberg Ion-Beam Therapy Center (HIT) and many more.
Such institutions strongly prefer the use of ceramic-metall-assemblies made of High-Performance Ceramics. Due to their excellent properties, these components are used for high-voltage insulation or for beam deflection through fast pulsed magnets.
Examples:
- Dipole, kicker and quadrupole chambers for beam deflection and focusing
- Coupling windows for high frequency
- Isolators for high voltage, segmented isolators for DC-guns
- Metallized ceramics for stochastic beam cooling vacuum technology

Fig. 7
Rotating X-ray tube for computed tomography

Fig. 8
Image intensifier for radiology

Fig. 9
Ceramic chambers for beam deflection

- Feedthroughs for different voltages and currents
- Insulators and tube-to-tube insulators for mechanical engineering and construction.

Due to the non-magnetic properties of oxide ceramics, rapid switching times can be achieved by means of very rapidly changing magnetic fields. In the case of metallic components, induced eddy currents prevent these rapid switch times. In order to remove the image charges on the inside walls, however, a thin Ti or TiN coating is applied.

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