CHALLENGES AND SOLUTIONS IN HIGH VACUUM SOLDERING AND BRAZING

T. Ohnweiler[1], S. Reeve[1], M. Mungenast[1], D. Becker[1], F. Uhlemann-Kölly[1], T. Gould[2], R. Binns[2], C. Barton[2]

[1]Carbolite Gero GmbH & CO. KG, Hesselbachstraße 15, 75242 Neuhausen (Germany)

[2]Carbolite Gero Ltd., 15 Parsons Ln, Hope Road, Hope Valley S33 6RB (United Kingdom)

LEADING HEAT TECHNOLOGY

part of VERDER scientific

VERDER scientific

ENABLING PROGRESS.

HEAT TREATMENT
ELEMENTAL ANALYSIS
MATERIALOGRAPHY & HARDNESS TESTING
MILLING & SIEVING
PARTICLE CHARACTERIZATION
PHARMACEUTICAL TESTING

Under the roof of VERDER SCIENTIFIC we support thousands of customers worldwide in realizing the ambition we share. As their technology partner behind the scenes, we deliver the solutions they need to make progress and to improve the everyday lives of countless people. Together, we make the world a healthier, safer and more sustainable place.

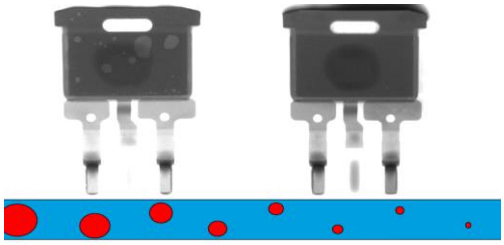
www.verder-scientific.com

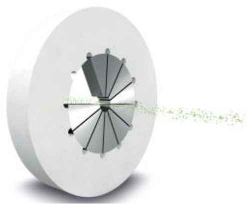
TABLE OF CONTENT

1 INTRODUCTION

Nowadays, numerous electronic components, such as those employed in satellites or aircraft, must endure harsh conditions, including vacuum or elevated temperatures. The fabrication of these electronic components necessitates the bonding of heterogeneous materials.

1.1 APPLICATION EXAMPLE





Component	Electronic component	12-pole element
Application	Satellites, Radar tubes	Deflectors, Correctors
Description	Left: conventional connection with embedded gas impurities. Right: connection established by high vacuum soldering and brazing with almost no impurities. Pictures are kindly provided by EADS Germany.	The deflection or correction of charged particle electron or ion beams require so called multipole elements. Since they need to be incorporated in vacuum, the connection must be established by high vacuum soldering and brazing.

1.2 CHALLENGES

The chemical physical bonding between the materials can be metal-to-metal or insulator-to-metal. This connection must be robust, resistant to high temperatures, and compatible with vacuum conditions.

When subjected to vacuum or elevated temperatures, the presence of flux on an electronic component can lead to detrimental effects. The flux, which comprises acids and salts, transitions to a gaseous state due to its high vapor pressure. The subsequent condensation of flux material on insulators can create conductive pathways, resulting in leakage currents that may compromise the integrity of the costly component. Regrettably, the most active (and thus corrosive) fluxes tend to establish the most robust connections. Certain material attributes, such as vacuum resistance, are unattainable under standard atmospheric manufacturing conditions. Additionally, a notable issue with conventional atmospheres is the inevitable incorporation of gas impurities into the connection surface.

The resolution to this issue lies in employing high vacuum soldering and brazing techniques. In both methods, the bond between the two disparate materials is established through a third metallic substance, known as the solder or brazing filler material. The key difference between soldering and brazing is that soldering involves reversible adhesion, primarily, while brazing leads to the irreversible diffusion of the materials, resulting in a significantly stronger bond. The entire procedure is conducted in either a high-vacuum (HV) or an ultra-high vacuum (UHV) setting. Such environments eliminate the risk of oxidation and permit the use of flux-free solder materials.

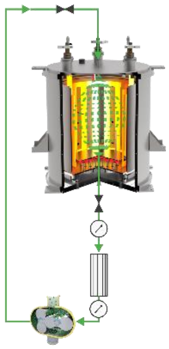
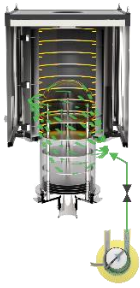
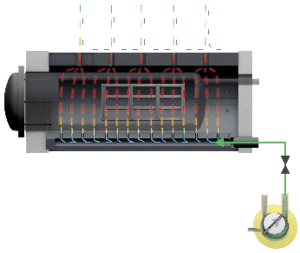
Creating bonds between ceramic and metal is a complex endeavor. For instance, consider a device that comprises 12 titanium electrodes connected to a ceramic ring. The thermal expansion coefficients of ceramic and titanium can vary significantly. The process of forming connections is carried out at temperatures approximately ranging from 800 – 1200 °C, contingent on the choice of filler material. It is imperative to utilize a suitable supporting structure for both the ceramic ring and the 12 distinct electrodes. Identifying the optimal conditions for the dependable manufacture of these devices presents a substantial challenge and requires meticulous monitoring.

The fabrication of these devices necessitates a furnace equipped with specific capabilities. It must be fully sealed to allow for heat treatment within a vacuum environment. The furnace should have the ability to control temperatures up to approximately 1200°C, ensuring superior and reproducible temperature uniformity and stability, tailored to the materials and solder being used. Moreover, the furnace is required to support precise data logging, enabling accurate monitoring and control of the manufacturing process.

To meet the specific vacuum requirements of the customer, the leakage rate can be minimized to less than 10^{-3} mbar·l/s and a high vacuum pumping system is attached. Given that heat transfer in a vacuum occurs solely through heat radiation, as described by Planck's radiation law, achieving optimal temperature uniformity within the hot zone is contingent upon a highly symmetrical design of the furnace. This design consideration is critical for ensuring even heat distribution and, consequently, the quality of the bonding process.

1.3 CARBOLITE GERO SOLUTIONS FOR HIGH VACUUM SOLDERING AND BRAZING

	Cold wall	Hot wall						
Concept	Molybdenum heating cassette. Automatic moving hood.	Quartz retort furnace with automatic moving hood.	Metallic retort furnace. Front loader.				Split tube furnace with quartz, mullite or aluminum oxide (RCA) tube.	
	HBO	**V-L**	**GLO**				**TS**	
								
$T_{max,vac}$	1600°C	1100°C	40 l	120 l	260 l	400 l	Quartz	RCA
			1000°C	800°C	750°C		1100°C	1450°C
p_{end}	< 5 x 10^{-6} mbar						< 5 x 10^{-5} mbar	
High vacuum upgrade	< 1 x 10^{-6} mbar						na	
Uniformity	< ±5 K							
Control accuracy	< ±0,5 K							
Sizes	Ø280x380, 25 l Ø380x480, 60 l	Ø180x300, 7 l Ø300x400, 28 l Ø450x600, 95 l	Ø310x600, 40 l Ø500x940, 120 l Ø640x1100, 260 l Ø640x1500, 400 l				Quartz max: Ø200x1200, 37 l RCA max: Ø88x600, 3 l	

	Option	Standard	Option	Standard
Fast cooling				
	By circulating the gas through the retort incorporating a heat exchanger.	By lifting the hood and air cooling the retort from outside.	By air cooling the retort from outside with side channel blower.	Opening the furnace for a short time drops the temperature by natural air cooling.
Cooling water	Up to 64 l/min (water cooled vessel)	Up to 30 l/min (water cooled flange or door)		Not required or up to 4 l/min

HBO	V-L	GLO	Tube Furnace

1.4 ADVANTAGES

- Precise temperature control and best temperature uniformities
- Best end vacuum and lowest leakage rates
- CF type of sealings instead of polymeric sealings at the relevant flanges
- Double groove extraction of the door/hood flange to reduce the leakage rate
- Special treatment of the inner surface to reduce the surface roughness, and therefore the surface coverage with mainly water. This results in a reduced pump down time in the high vacuum range
- Mechanical decoupling of vibrations from the hot zone
- Turbomolecular pumping system with automatic bypass function for evacuation down to the molecular range
- Full data logging for full process control
- Hydrogen or humidified hydrogen optionally available

SIGN UP FOR OUR NEWSLETTER!

You will occasionally receive **exclusive information** on seminars/webinars, applications and product news.

Subscribe now:

www.carbolite-gero.com/newsletter
(You may unsubscribe any time)

Carbolite Gero Limited
Parsons Lane, Hope
Hope Valley, S33 6RB
United Kingdom

Telephone: +44 1433 620011
info@carbolite-gero.com

Carbolite Gero GmbH & Co. KG
Hesselbachstr. 15
75242 Neuhausen
Germany

Telephone: +49 7234 9522 0
info@carbolite-gero.de

www.carbolite-gero.com

part of VERDER scientific