Technical Briefing:

Microwave transparent environmental barriers (windows)

Microwave environmental barriers are specialty components that provide atmospheric isolation between the power supply, waveguides and the vacuum furnace. Their construction requires the use of microwave transparent window materials and carefully engineered frames.

Background

At Hadron we are constantly developing new materials and designs for components to be used with microwave (MW) technology. One such component is the environmental barrier (or window) which is employed in vacuum or atmosphere controlled furnaces, see Figure 1. A good *window* is critical for the operation of the system as high MW power has to travel through the material with minimum reflection and absorption. Reflection affects efficiency (less power going into the furnace) and power supply operation (heating). Additionally, it makes it difficult to distinguish from reflected power coming from the "load" in the chamber which in turn can cause operation problems (tuning). Absorption of microwave energy is the other concern as it will incur an increase of the temperature of the window material and seals (such as o-rings). Proper selection or engineering of the window material (Table I) focuses on minimizing reflection and absorption while maintaining physical integrity and proper vacuum or atmospheric isolation. Additionally, there are design features that can improve the power rating and temperature characteristics of the windows.

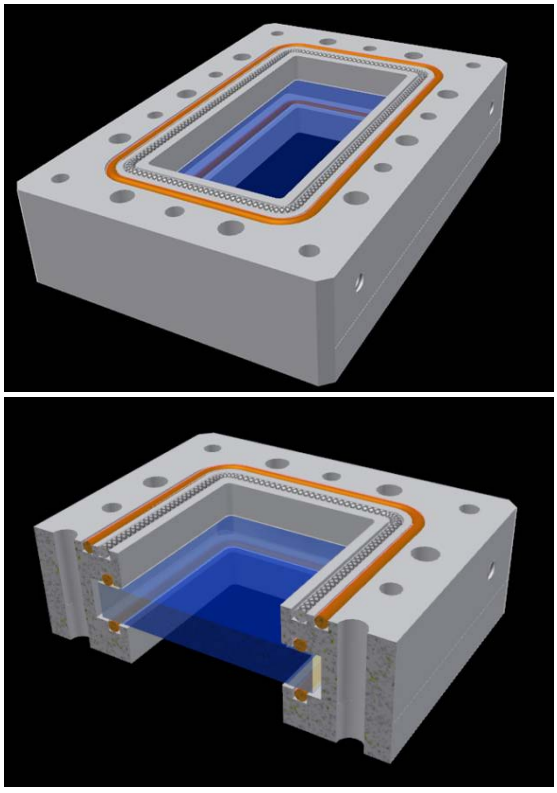

Figure 1. Hadron standard microwave environmental barrier.

1) Window material: in selecting the materials presented below we have considered properties such as dielectric constant (ε) and loss tangent (δ) among others. With the exception of sapphire all the other window materials are available at Hadron up to WR430.

	reflection	absorption	Maximum operating temperature
Sapphire (single crystal Al_2O_3)	Fair	Excellent	Excellent (1500C)
Polycrystalline Al_2O_3	Fair	Good*	Excellent (1500C)
Fused silica (quartz)	Good	Good	Very good (1000C)
Teflon	Excellent	Good	Fair (≤300C)
CLP-MW	Excellent	Excellent	Fair/poor (≤100C)

* absorption will depend on density and purity of the sintered material

2) Specialty sealing materials: In the standard window configuration the MW transparent material is mounted to a frame and the vacuum (or atmospheric isolation) seal is provided by an o-ring. The advantage of the o-ring type seal is that it enables the operator to completely disassemble the window and exchange or conduct maintenance (clean up) on individual components. However, typical elastomer seals (such as silicone and viton) not only can couple with microwave energy but also have relatively low melting and boiling points. To mitigate this problem Hadron has developed a gasket material with reduced microwave absorption characteristics that provides excellent sealing characteristics in vacuum up to 10^{-6} Torr level.
3) Window cooling: In many instances despite the best characteristics of window materials, there is still a possibility that the window will heat up either due to inadequate tuning, excessive power input or heat conduction from the hot zone. To prevent damage to its components and to allow extended operation at higher powers, the windows can be cooled either by closed circuit water or other refrigerant fluids (glycol) or by built-in convective fins (natural convection or forced) [proprietary Hadron design].
4) Special features: On occasion, due to inadequate tuning settings or special waveguide configuration, the gasket material can be exposed to microwave energy, see Figure 2. Hadron has developed an electromagnetic shielding (EMS) feature for the gaskets [proprietary]. This currently undergoing patent submission process and will be commercially available shortly.

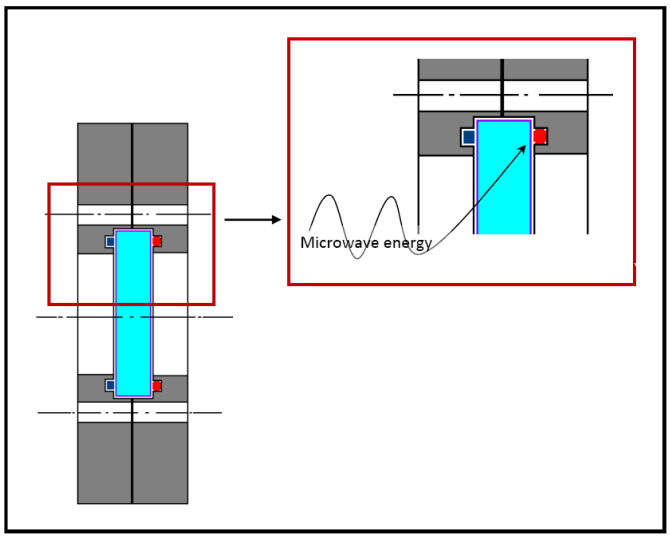

Figure 2. schematic representation of how the o-ring in the environment barrier can be exposed to microwave

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