A thin layer of metal deposited on a ceramic part enables brazing to a metal part that has a different coefficient of thermal expansion.

Keith Ferguson
Morgan Technical Ceramics
Fairfield, New Jersey

Ceramic-to-metal bonding has been one of the biggest challenges for manufacturers over the years because of the inherent differences in the thermal expansion coefficients of the two types of materials. By far the most widely preferred and effective method for creating a leak-tight, robust joint between ceramic and metal is by brazing. This starts with the chemical bonding metallization of the ceramic to create a wettable surface on which braze alloy will flow between the two components during the brazing process.

This article describes two applications of metallized ceramics, one for a neutron spallation source, and the other for vacuum electronic devices.

Neutron spallation source
ISIS is a world-class spallation neutron source based at the Rutherford Appleton Laboratory, Oxfordshire, England. The lab recently commissioned a series of highly specialized metallized ceramic components as part of a major expansion project to build a Second Target Station (TS-2).

These components are a fundamental part of the instrumentation, monitoring the intensity of the extracted proton beam. Ceramic vacuum tubes in the first target station were sealed with indium wire, but experience proved that these became unreliable if disturbed. Metallized ceramic offered a solution that provides a 100% reliable vacuum seal within the very tight tolerances of the design.

There were two key challenges. The first was to create a design and a manufacturing process that would produce a robust, high-integrity vacuum seal (leak rate 10^{-8} mbar l/s) across a large component that is 200 mm in diameter. The second was to solve the problem of the difference in thermal co-efficient between the alumina ceramics of the tube and its low-carbon steel flanges. Furthermore, a very tight specification was set for the physical dimensions and cleanliness of the components because of the nature of the project.

The ISIS assembly is 158 mm long, with two nickel-plated low-carbon steel flanges 240 mm in diameter, insulated from each other by a preformed diamond-ground alumina ceramic insulator. Prior to brazing, a coating of moly-manganese is applied to the ceramic insulator and sintered at 1400°C, then electroplated with a layer of nickel. To ensure hermetic integrity of the assembly, the ceramic is brazed in a hydrogen/nitrogen furnace at 850°C to two flanges made of nickel-iron-cobalt steel, chosen because it provides the best thermal expansion match to the ceramic. The ceramic/metal brazed sub-assembly is then welded to the flanges with a stainless steel interface and machined to the final dimensions.

The order from ISIS was for 13 components supplied by the end of 2006. As is usually the case with this sort of project, no extra time or budget was available to produce a prototype to refine the process. Therefore, the experience and expertise of the specialist team were critical to getting it right the first time. Working together, the team solved problems as they arose, and all the components were delivered. Construction of TS-2 began in July 2003, and first neutron production is planned for the autumn of 2007.

Vacuum electronic devices
Metallized ceramic components for vacuum electronic devices are used in continuous-wave and pulsed radar systems, such as those for fighter aircraft. For these components, the challenge is to push the performance envelope of the materials to meet the industry’s demand for higher frequen-
cies. This means smaller components with the same physical properties as the previous larger parts. Smaller size also requires very high precision engineering and close quality control to ensure consistency throughout production.

One such example is a cylinder with an internal diameter of just 0.2 of an inch. The internal surface must be metallized to a very tight thickness tolerance, within 0.007 to 0.0012 of an inch. The metallization process is based on a proprietary molybdenum-manganese (MoMn) refractory ink system, and is matched to specific high-purity alumina ceramic bodies to ensure consistent high-strength bonds. The glass phases in the MoMn metallization bond with the glass phases in the ceramic to form the bond. The metallized surface receives a secondary coating of nickel to seal and improve wettability for later brazing.

High-performance components

Advanced ceramics are meeting the needs for higher-performance critical components in a wide variety of applications. Through a detailed understanding of the ceramic-metal bonding techniques, such as the metallization process, designers and manufacturers are better able to devise these key components.

For more information: Keith Ferguson is Business Development Manager—Western Region, Morgan Technical Ceramics, 414 24th Avenue, San Mateo, CA 94403; tel: 650/208-0391; Keith.Ferguson@morganplc.com; www.morgantechnicalceramics.com.

As a subsidiary of The Morgan Crucible Company, Morgan Advanced Ceramics forms part of the Morgan Technical Ceramics Group. The Group includes Morgan Electro Ceramics and from manufacturing locations in North America, Europe and Asia, it supplies an extensive range of products, including ceramic components, braze alloys, ceramic/metal assemblies, and engineered coatings.

What is ISIS?

ISIS is not an acronym. The name was decided for the opening of the neutron source in 1984 by the then Prime Minister, Margaret Thatcher. Prior to this it had been known as SNS, or Spallation Neutron Source. As principal goddess of ancient Egypt, ISIS was able to bring the dead back to life. The name was considered appropriate for the new neutron source, which inherited many components from previous accelerators in the UK (Nimrod and Nina) and which is located near The River Thames, known locally as The Isis.

The world’s leading pulsed neutron and muon source located at the Rutherford Appleton Laboratory near Oxford, ISIS supports an international community of around 1600 scientists who use neutrons and muons for research in physics, chemistry, materials science, geology, engineering, and biology.

ISIS is the major facility at the Rutherford Appleton Laboratory, and has been operating for over twenty years. The source was approved in 1977, first neutrons were produced in late 1984, and ISIS was officially inaugurated in October 1985. ISIS is currently expanding to twice its size through the construction of a second target station that will lead to new opportunities in soft condensed matter, bio-molecular sciences, advanced materials, and nano-scale science. For more information, visit www.isis.rl.ac.uk.