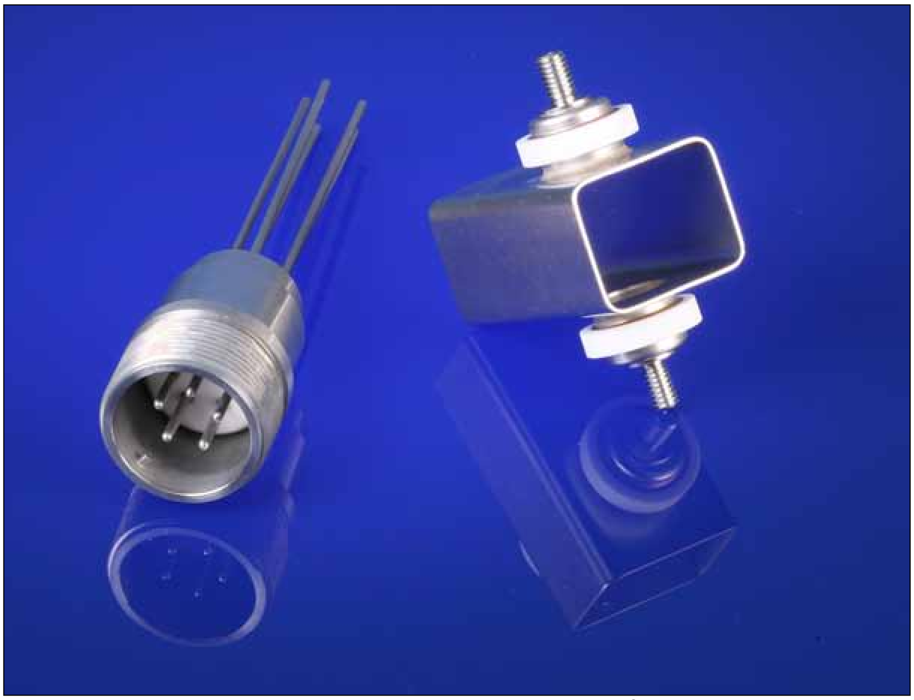

Ceramics are more versatile with characteristics tailored to a specific application (photos courtesy of Morgan Technical Ceramics).

The Expanding Role of Advanced Ceramics in the Aerospace Industry

Keith Parker, Marketing Director, Morgan Technical Ceramics

Aerospace manufacturers face extreme pressure to lower costs while increasing performance and satisfying stringent safety standards. Producers in the commercial airline, defense and space exploration sectors continually seek new materials that are reliable, robust and meet the needs of highly specialized applications. Advanced ceramics, such as alumina, silicon nitride and aluminum nitride, are currently being used to manufacture critical aerospace components because they have several advantageous physical properties. These inorganic, non-metallic materials retain dimensional stability through a range of high temperatures and exhibit very high mechanical strength. They also demonstrate excellent chemical resistance and stiffness-to-weight ratio, thereby providing manufacturers with the ability to design components that offer optimal performance in their intended application.

With the growing use of advanced ceramics in the manufacture of aerospace components, Morgan Technical Ceramics is playing a key role in this industry. Morgan Technical Ceramics, comprised of Morgan Advanced Ceramics and Morgan Electro Ceramics, is a manufacturer of innovative products made from a range of ceramic, glass, precious metal, piezoelectric and dielectric materials.

Instrumentation and Control Systems

Developments in material science, as well as recently introduced manufacturing techniques, have led to the development of advanced ceramics that serve critical functions in aircraft instrumentation and control systems, missile guidance systems, satellite positioning equipment, ignition systems, fire detection and suppression, instrument displays and engine monitoring equipment. Electro ceramic materials (piezo-electric and dielectric) are used in aerospace transducers and sensors such as accelerometers (for measurement of vibration), gyroscopes (for measurement of the acceleration and pitch of aircraft, missiles and satellites) and level sensors (e.g., fuel tanks). The term "piezo-electric" refers to the effect of mechanical pressure causing a crystalline structure to produce a voltage proportional to the pressure. Conversely, when an electric field is applied, the structure changes shape, producing dimensional changes in the material. Engineered piezo-electric polycrystalline ceramics offer several advantages over natural piezo-electric crystals, such as quartz, Rochelle salt and tourmaline. Ceramics are more versatile with physical, chemical and piezo-electric characteristics that can be precisely tailored to specific applications.

One of the most successful commercial aircrafts in recent times, the Boeing 777, uses piezo-ceramic material within the 60 ultrasonic fuel tank probes located on each aircraft. The ultrasonic transducers are installed at a variety of locations in each fuel tank. A pulsed electric field is applied to the piezo-ceramic material, which then responds by oscillating. The resulting sound waves are reflected off the surface of the fuel and picked up by the piezo-electric ceramic transducer. A digital signal processor interprets the 'time of flight' measurement of the sound waves in order to continually indicate the amount of fuel present. Similar ultrasonic fuel probes are also used in fighter aircraft and other level-sensing applications because of their ability to provide highly accurate readings, regardless of the orientation of the aircraft.

Seals and Thermocouples

Advanced ceramics are also suited for aerospace applications that provide a physical interface between different components, due to their ability to withstand the high temperatures, vibration and mechanical shock typically found in aircraft engines and other high-stress locations. Ceramics are commonly found in seals for gas turbine engines, fuel line assembly and thermocouples. Where ceramic/metal assemblies are required, joining the two materials generally involves metallizing the ceramic surface and then brazing the components together.

Aero Engine Component Repair

Research into the development of advanced brazing materials for aero engine component repair has also led to the development of brazing materials suitable for the repair of gas turbine engine components. One example is the use of pre-sintered preforms (PSPs) for high-temperature braze repair applications. With turbine temperatures reaching up to 1,300 degrees C (2,350 degrees F) and the presence of hot corrosive gases, components experience considerable erosion and wear.

The pre-sintered preforms consist of a blend of superalloy and low melting point braze, and are customized to fit the shape of the component and then to be tack-welded into place and brazed. The ability to provide a range of near net thicknesses can eliminate the need for most post-braze machining and extend the life of engine components by up to 300 percent, making it a more reliable and cost effective method than traditional welding, which requires post-braze machining or grinding.

Ion Propulsion

Advanced ceramics are playing a critical role in the development of highly-efficient and cost-effective new technologies for space travel. Morgan Technical Ceramics' division in Erlangen, Germany has been working with a European space development program for a number of years to support its research of ion propulsion systems. A lightweight alternative to traditional chemical propulsion, ion engines have the potential to push spacecraft up to ten times faster with the same fuel consumption, thereby significantly decreasing vehicle size and increasing travel distance.

Ion propulsion technology, which uses electricity to charge heavy gas atoms that accelerate from the spacecraft at high velocity and push it forwards, traditionally incorporated quartz discharge vessels. Quartz has now been replaced by alumina because of the need for a material with the same dielectric properties but with higher structural stability. Alumina is easier to fabricate and offers good thermal shock resistance, ensuring that the chamber can withstand the extremes of temperature that occur during plasma ignition. It is also lighter, which reduces the costs associated with each launch.

Driven by the aerospace industry's demand for higher performance and lower costs, material scientists and ceramics component manufacturers will continue to develop new materials and processes that take advantage of the powerful physical, thermal and electrical properties of advanced ceramic materials.

For more information:

Morgan Technical Ceramics
26 Madison Road
Fairfield, NJ 07004
Phone: (800) 433-0638
www.morgantechnicalceramics.com

Pre-sintered preforms (PSPs) are suitable for high-temp braze repair applications.