Anaren’s MSK Products Division designed, built, and tested a high-temperature, co-fired ceramic (HTCC) electronics package for use in oil and gas drilling that proved Anaren's ability to push the boundaries for developing microelectronics packages to survive in difficult high-temperature environments.

Anaren, Inc. is pushing the boundaries of hybrid microelectronic packaging. They have designed, built, and tested a high-temperature, co-fired ceramic (HTCC) electronics package for use in oil and gas drilling, operating over two miles underground.

Although at present the package is rated for an operating temperature of 175°C, the goal is 225°C. The high-aspect ratio form factor of 3.980” x 0.500” increases the difficulty of the challenge. After it has been designed and manufactured, the hermeticity of the package is validated with a fine leak detection test. It has maintained its hermetic seal while being cycled from -55°C to +175°C. Key to this success has been the sophisticated use of finite element analysis (FEA) for the design.

The Package Architecture

The function of the hermetically sealed package is to protect circuitry against oxygen and moisture—two of the most dangerous enemies of hybrid microelectronics.

The difficulty of manufacturing the package arises because different materials with different coefficients of thermal expansion (CTE) are joined together. As the temperature changes, if the layers were independent of each other, they would expand and contract according to the CTE of each layer. Since they are all joined to each other, however, their different rates of expansion and contraction cause stresses to develop in the three layers shown in Figure 1. The critical CTE mismatch is between the alumina substrate and the Kovar ring frame.

If the package is not properly designed to survive these stresses, cracks can develop that will destroy the hermetic seal. The design constraints—high operating temperature and high aspect ratio—increase this danger.

Manufacturing Stresses

The base plate, substrate, and ring frame are joined together by a high-melting point braze filler. In order to manufacture the package, these three must be elevated to the melting point of the braze material. Since the package is designed to operate at a high temperature, it is important to use a braze filler with a high melting point so that there will be no chance of it softening at the expected operating temperature. The high melting point, however, increases the stress levels.

During manufacture, as the temperature is raised toward the melting point of the braze filler, there are no CTE