Innovative Microelectronics Packaging for In-Vitro Implantable Devices

Faina Zaslavsky

Implantables are already well established as a medical device solution, but this sector is achieving explosive growth with the development of new technologies. This article provides an overview of microelectronics packaging technology evolution, following how designs have been made to accommodate ever increasing demands for lightweight and smaller size modules.

The traditional hybrid packaging approaches were developed to accommodate demanding defense and aerospace applications. The common configuration incorporated a thick film ceramic substrate populated by bare dice, with circuitry connected by gold wire.This was then placed into a metal enclosure and hermetically sealed in an inert gas environment (Figure 1).

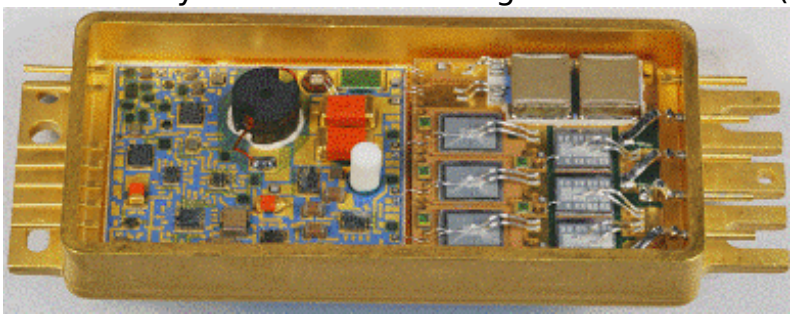

Figure 1: Thick film ceramic substrate populated with components and placed in the gold-plated metal alloy enclosure. This assembly will be hermetically seam welded in a nitrogen environment

All testing and environmental screening of the hermetically sealed devices were performed in compliance with military standards, such as MIL-PRF-38534. This specification establishes the general performance requirements for hybrid microcircuits (hybrid integrated circuit), multi-chip modules, and similar devices. In addition, it specifies the verification and validation requirements for ensuring that these devices meet the applicable performance requirements.

Over the past 30 years, the evolution of medical implantable devices mandated development of alternative technologies to create smaller, biocompatible packages for use within the human body. The established microelectronics packaging techniques and the MIL-standards were utilized to develop multi-chip modules with the same degree of reliability. The difference, however, was that for the implantables entirely different approaches for the device configuration, material choices, and packaging technology were used.

The main focus of the implantable electronic devices was on size and weight. The use of high temperature multi-layer co-fired ceramics with gold plated ring frames for the hermetic seal reduced the device weight by over 30%. It also allowed significantly more circuit layers, reducing overall footprint. This technology was embraced by the developers of devices such as implantable pacemakers, defibrillators, and cochlear implants (Figure 2).

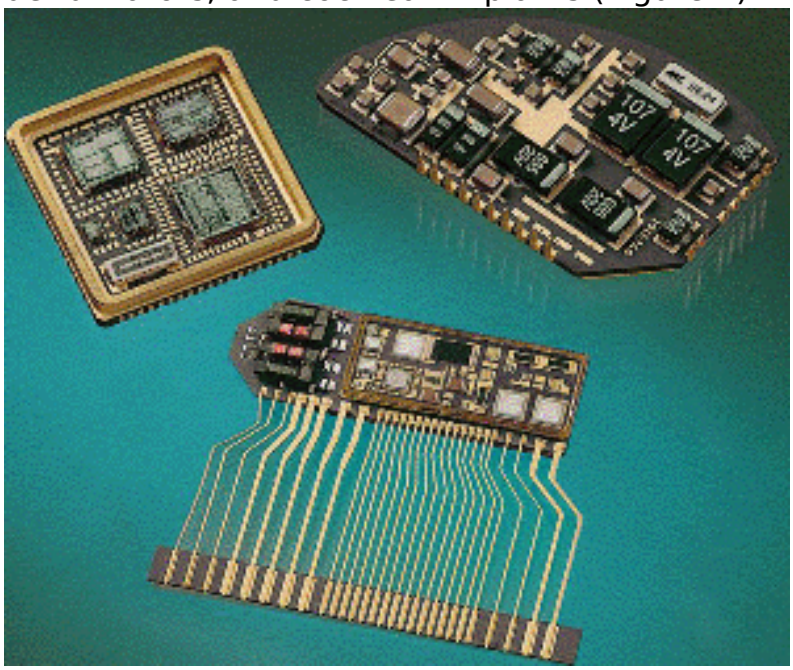

Figure 2: Three configurations of HTCC multi-chip modules: 1. LCC enclosure will be hermetically seam welded (top left); 2. Double-sided enclosure with hermetically seam welded cavity on one side and SM components on the other side (top right); and 3. Double-sided multi-chip module with plastic ring frames and encapsulation

The need to simplify and reduce the cost of surgical procedures associated with the implantable defibrillators required further size reductions. Initially, implantable defibrillators were placed under the diaphragm and required a complicated surgery to attach the defibrillator leads to the device and heart. The ultimate goal in device size reduction was the ability to perform a less invasive surgery and allow pectoral implantation. Further reductions of the device footprint was achieved through development of new microelectronic packaging techniques using "green boards" and "hard flex" boards, densely populated with mixed surface mount components and bare dice encapsulated for mechanical protection. This type of implantable

microelectronics did not require an additional enclosure, as it was sealed in its final body-compatible titanium package prior to the sterilization procedure.
Further increases in microelectronics density, driven by the need to enhance device functionality while maintaining the existing footprint, led to the utilization of the flip chip technology and chip scale packaging (CSP). The use of Flip-Chip and CSP allows dice to be connected to the circuit without space-consuming wire bonds. Die stacking is a technique in which chips are placed one atop another to place more circuits in a given amount of board space (Figure 3).

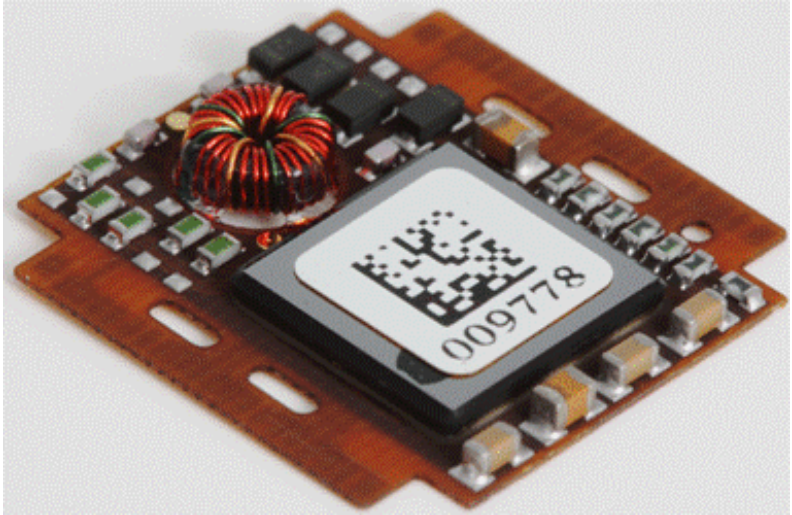

Figure 3: CSP on hard flex board, mixed technology implantable microelectronics circuit

The further evolution of microelectronics packaging innovations will be driven by new developments in the neurostimulation market that is demanding even smaller devices. Neurostimulation devices are designed according to the type of nerve that is being stimulated (central nervous system or peripheral). Some examples are spinal cord stimulators (IPG implants), which are similar to pacemakers; deep brain stimulators; vagus nerve stimulators; sacral nerve stimulators; and gastric electric stimulators. The application specifics will dictate the implant footprint and the packaging technology requirements. Many sensors are extremely small and device microelectronics will require yet more creative microelectronic packaging techniques.

Faina Zaslavsky *is the director of microelectronics solutions for* Crane Aerospace & Electronics *[1]. She is responsible for business growth, customer interface, profit and loss, engineering, and program management. Zaslavsky can be reached at 425-895-5079 or* faina.zaslavsky@crane-eg.com *[2].*

Source URL (retrieved on *05/23/2013 - 9:59am*):
http://www.mdtmag.com/articles/2011/07/innovative-microelectronics-packaging-vitro-implantable-devices

Links:
[1] http://www.craneae.com/microelec

[2] mailto:faina.zaslavsky@crane-eg.com