Heterogeneous Assembly of a MEMS Neuro-Prosthetic System

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In recent years, Micro Electro Mechanical Structure (MEMS) based passive electrode arrays have been used to characterize the electrical signals of different regions of the brain. These extracted signals have enabled researchers to determine the source of thoughts that can contribute to body movements and may lay the foundation for development of neuro-prosthetic devices capable of correcting various brain disorders. Unfortunately, current constraints caused by the passive design of electrodes limit the quality of signal extracted from the brain. To that end, a joint research team from California Institute of Technology and Jet Propulsion Laboratory is investigating the possibility of developing a fully miniaturized, smart implantable neuro-prosthetic system, by combining integrated electronics with the MEMS based electrode array. The researchers believe that the presence of integrated electronics can significantly enhance the quality of the electronic signals from the brain. This discussion will focus on the electronic packaging task of the aforementioned neuro-prosthetic program. The goal of the packaging task is to design and fabricate a package (1) to interface electrically between a MEMS electrode array, capable of extracting signals from brain, and an electronic chip, capable of providing on chip conditioning/processing of extracted data and (2) to deliver the output data to a detector located outside the body. Assembly of the electronic chip and the MEMS device (10 x 10 array (4 mm x 4 mm) of fine 1 mm long, electrically isolated Si electrodes) will be performed using area array flip chip technology. Active development efforts include (1) investigation of different interconnects/underbump metallizations/metallic solders/conductive epoxies, (2) evaluation of biocompatible coatings/underfills (capable of serving as a protective layer for electronics while meeting human body compatibility requirements), (3) verification of reliability (confirm compatibility, perform detailed characterization of materials, and subject fabricated packages to potential service environments), and (4) final assembly based on design criteria obtained from (1) – (3). The brittle nature of the fine electrode array adds the challenge of maintaining electrode integrity during processing; therefore, handling fixtures capable of withstanding processing conditions must be fabricated. Preliminary evaluation of incoming electrode arrays revealed the added challenge of potential contamination and its influence on electrical signal and solderability. Therefore, incoming and outgoing inspection criteria are also under development.