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M4Or1B-05: [Invited] A Cryogenically-Cooled Power Device Packaging in High Altitude Applications: Heterogenous Integration Challenges and Requirements

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This abstract presents a cryogenically-cooled power device packaging in high-altitude applications. The target applications are a more electric aircrafts (MEA) and all/hybrid electric propulsion systems. Typically, higher converter power densities can be achieved over silicon-based devices and GaN HEMT under a cryogenically cooled system, due to a lower on resistance. However, thermal management, size, weight and packaging are still major issues in power stage design. A reduction in converter size and weight are limited by conventional heatsink construction and device attachment methods. Attaching surface-mount (SMT) devices on a conventional fiberglass (FR4) printed circuit boards (PCBs) presents a third packaging issue of thermal management. In order to overcome the problem, many cooling packaging methods have been investigated including heat pipe, liquid cooling, a metal core PCB (MCPCB) and so on. However, these methods have still problems that is how to integrate with proper cryogenic cooling. Thus, it is necessary to secure more heterogenous integration (HI) approaches. In this approach, a power packaging density can be improved at least over 10 times and a cryogenic cooling can be concentrated at the power device. However, there is a lot of technical gaps in terms of a fabrication process and methods as follows: (1) 3DHI packaging for a cryo-cooling (Cross-die connectivity, 3D integration of non-silicon technologies, multi-chip assemblies, heterogeneous interconnect yield, reliability and mechanical stress, multi-layer laser via drilling, cryogenics material selection) and (2) 3DHI Cryo-cooling packaging under a high-altitude (flow rate along the cable with altitude variation, MEMS process for u-cooling channel, heat spread, pressure, leaking and sealing for u-cooling channel and CTE mismatches at extreme high/low temperature). In this abstract, we have investigated a 3DHI-based cooling packaging with a cryogenics temperature. In the final manuscript, a comparative analysis will be provided with regards to a high-power density/packaging.

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