Multi-Dimensional Ultrasonic Copper Bonding – New Challenges for Tool Design

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Abstract

In power electronics, copper connector pins are e.g. used to connect control boards with power modules. The new chip generation based on SiC and GaN technology increase the power density of semiconductor modules significantly with junction temperatures reaching 200°C. To enable reliable operation at such high temperature, the soldering of these connector pins should be substituted by a multi-dimensional copper-copper bonding technology. A copper pin welded directly on DBC substrate also simplifies the assembly. With this aim, a proper bond tool and a suitable connector pin geometry are designed.

This paper presents a two-dimensional trajectory approach for ultrasonic bonding of copper pieces, e.g. connector pins, with the intention to minimize mechanical stresses exposed to the substrate. This is achieved using a multi-dimensional vibration system with multiple transducers known from flip chip bonding. Applying a planar relative motion between the bonding piece and the substrate increases the induced frictional power compared to one-dimensional excitation. The core of this work is the development of a new tool design which enables a reliable and effective transmission of the multidimensional vibration into the contact area between nail-shaped bonding piece and substrate. For this purpose, different bonding tool as well as bonding piece designs are discussed. A proper bonding tool design is selected based on the simulated alternatives. This tool is examined in bonding experiments and the results are presented. In addition, different grades of hardness for bonding piece and substrate are examined as well as different bonding parameters. Optical inspection of the bonded area shows the emergence of initial micro welds in form of a ring which is growing in direction of the interface boundaries with increasing bonding duration.