“Low-temperature Sintering of Nanosilver Paste for Lead-free Chip Attach”

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ABSTRACT

European power module manufacturers pioneered the development of a silver sintering technology, called low-temperature joining technology (LTJT) for lead-free chip attach. Sintered chips on substrate are shown to have better performance and significantly higher reliability at chip junction temperature over 175°C. However, the European process is complex requiring pressure of 20 to 40 MPa to lower the sintering temperature of micron-size silver flakes/powder down to around 250°C. A nanomaterial technology involving the use of silver nanoparticles is described to achieve low-temperature sintering without any applied pressure. The nanosilver paste can be readily stencil-printed or dispensed on substrate for die-attach in air or controlled atmosphere at temperature below 260°C and under zero pressure with small power chips or low pressure of 3 MPa with large IGBT (Insulated Gate Bipolar Transistor) chips. Findings on the sintering behavior of the nanosilver paste and properties of the sintered joints are presented to demonstrate the nanosilver-enabled LTJT as a promising lead-free chip-attach solution with improved thermal and electrical performance and thermo-mechanical reliability of power devices and modules. As a specific application example, the nanosilver-enabled LTJT was used to make planar power modules in which both sides of the IGBT chips were bonded by the sintered nanosilver joint. The planar power modules have low parasitic inductances thus less ringing noises from the device-switching action and can be cooled from both sides of the devices to improve heat dissipation. Details on the design and processing of the double-side cooled power modules and test results on their electrical and thermal performance will be presented.

Biographical Sketch on Guo-Quan (GQ) Lu

Dr. Guo-Quan (GQ) Lu is a professor jointly appointed between the Department of Materials Science and Engineering and the Bradley Department of Electrical and Computer Engineering at Virginia Tech. He has a double-major bachelor’s degree in Physics and Metallurgical Engineering and Materials Science from Carnegie-Mellon University and a Ph.D. in Applied Physics/Materials Science from Harvard University. Between 1990 and 1992, he worked for Alcoa Electronic Packaging, Inc., at Alcoa Technical Center. In 1992, Dr. Lu joined the faculty of the

Department of Materials Science and Engineering at Virginia Tech. His research activities and interests include materials and processing development for applications in microelectronics, power electronics, optoelectronics, sensors, and nanotechnology. Dr. Lu has published over 100 papers in journals and conference proceedings. He was the 1995 winner of Virginia Tech Sporn Award for excellence in teaching of engineering subjects and was the recipient of a National Science Foundation CAREER award in 1995. His development of nanoscale silver paste, nanoTach®, for low-temperature joining of semiconductor chips won 2007 R&D 100 award. The product is being commercialized by NBE Technologies, LLC. Dr. Lu is a recipient of the Chinese NSF Outstanding Overseas Young Scholar Grant (B) and has held a Cheung Kong Guest Professorship in the School of Materials Science and Engineering at Tianjin University, China.