Tutorial Title

Reliable and Efficient Packaging of SiC Power Devices for Automotive and Industrial Applications

Instructor Team

Team Chair: Anton Miric, Heraeus Electronics
Co-Speakers: Habib Mustain, Heraeus Electronics

Abstract

Power modules play a key role to provide efficient electricity supply in a wide range of market segments – automotive, industrial, green energies, energy distribution, traction etc. As the market keeps growing, significant effort is spent on increasing its efficiency while decreasing cost and form factor. Continuously smaller die areas are used to reach the required current output - this drives the increased use of SiC semiconductors in power modules. The semiconductor die is the most expensive and only active component in power modules. As such, it is the major driver for new developments of power modules. Due to the smaller size of the semiconductors, it is possible to produce more dies on the same wafer and reduce the associated cost. On the other hand, smaller semiconductors lead to higher power density as the same current is transported through a smaller area, resulting in increased current density per die. This leads to rising power and current density, higher operating temperatures and switching frequencies, especially for wide band gap semiconductors, SiC and GaN. Surging junction temperatures and consequently extended temperature ranges significantly impact the requirements regarding reliability of the complete stack of materials. Also affected are growing prerequisites for heat dissipation and current carrying capacity. All these factors drive use of new packaging materials, e.g., sinter pastes, copper die top connections, new encapsulation materials and substrate materials. It is important to consider the full stack of materials in the power module to reach optimal performance. All it takes is one weak material within the stack to significantly reduce the thermal performance, power density and reliability. New wide band gap materials generate benefits of significantly higher switching frequencies. At the same time, faster switching behavior stimulates overvoltage, which can damage the semiconductor. This is especially valid for higher power density power modules. All this creates the need for the development of new packaging solutions: - increased power loss per chip area requires materials with better heat dissipation. - more power needs better current carrying capability of packaging materials. - elevated operating temperatures require packaging solutions with significantly improved reliability. - increased switching frequencies, especially in combination with high current require improved substrate and module design concepts for reduced parasitic inductance. To illustrate the innovation of new packaging solutions, this tutorial will discuss the following material developments for packaging of SiC power devices: 1. Metal ceramic substrates 2. Sintering technologies for die attach 3. Sintering and soldering technologies for substrate attachment 4. Technologies for interconnection on the top of the die 5. Outlook (encapsulation, low stray inductance substrates)

Instructor Team Biographies

Miric Anton Biography

Anton studied Mechanical Engineering on the University in Zagreb, Croatia and Marketing Management in St. Gallen, Switzerland.

He has worked with electronic packaging materials since 1995, 1st with German company Degussa and from 1992 at German company Heraeus. His positions were Product/ Business/Sales Mgr. and Global Director for Product Line Automotive-Industrial. Focus was on materials: solders, SMT and conductive adhesives, fluxes.

As of 2012 he is focused on power electronics packaging materials, e.g. substrates, joining/bonding and interconnect materials and encapsulation in different positions: VP Business Group Development, VP Product Management, VP Segment Management. As of 2022 he is VP Market Strategy.

Anton published >30 technical papers about electronic materials in Europe and USA. He gave more than 100 Seminars & Workshops all over the world.

An Article “Lead-Free Alloys” won Award as best article published in the Magazine “Soldering & Surface Mount Technology” in 1999.

The paper “Material characterization of advanced cement-based encapsulation systems” was Best Session Paper at the IEEE/ECTC in 2018 San Diego, CA.

Anton is a member of several different associations: ECPE, ZVEI, VDA, iNEMI. From 2016 to 2020 he was member of the Board of Directors of iNEMI. Today he is a member of the PCIM Advisory Board.

Habib Mustain Biography

Habib A. Mustain received his PhD in Electrical Engineering from the University of Arkansas in 2006. He joined Texas Instruments in Dallas in 2007, as a Product Engineer. In September 2009, he moved to Trumpf Photonics as Senior Packaging engineer. From 2011-2019, he was a senior packaging engineer in Power and RF division at Cree/Wolfspeed.

He currently works for Heraeus Electronics as a Power Electronics Segment Manager Americas. In that position, he leads and develops new bonding technique of metal ceramic substrates, as well as engaging with R&D and the development team on new product introduction into the market. He supports and engages in technical discussions with key customers in power modules/discrete packaging activities, supports sales and marketing teams to promote packaging material solutions for power electronics/automotive customers, and provides technical advice/support for the customer solutions groups.

He has published over 20 papers in journal and conference proceedings. Recently he has given a keynote speech on Die top system: Advanced interconnect for power electronics module packaging at the fourth international symposium on 3D power electronics and manufacturing, Miami, FL.