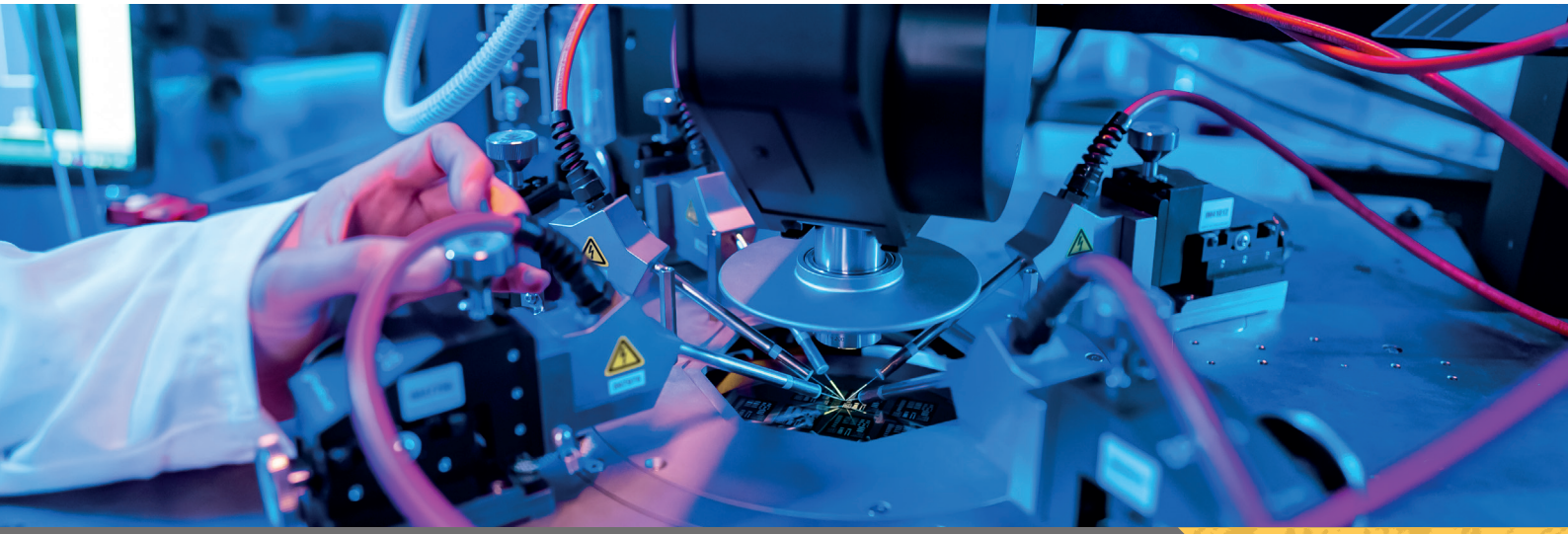
UNIVERSITY OF CAMBRIDGE

ADVANCED MATERIALS RESEARCH & INNOVATION

Liquid Metal for Ultra Low Thermomechanical Stress in Power Electronics Packaging

Innovative use of non-toxic liquid metal GaInAg fluidic connections in SiC power electronics packaging dramatically reduces thermomechanical stress, enhancing reliability and performance. This breakthrough significantly extends the lifespan of power modules, offering industries a cost-effective and eco-friendly packaging solution. It was achieved through the Royce High-Voltage Electrical Characterisation Suite.



Electrical-characterisation Suite

Includes: a Cascade Tesla, 200 mm, high voltage, high current semiautomatic probe station, a Keysight B1505A Semiconductor Parametric Analyser/Curve Tracer, number of stand-alone, high precision Source Measure Units (SMUs) and a high voltage capable, Keysight 2 GHz Oscilloscope. This set of equipment allows testing and characterisation of devices and materials in wafer, die or packaged forms, very accurately from -55 °C to +300 °C. Ratings of the equipment are up to 200 A and 3 kV for wafer level measurements using the probe station and 0.01 fA to 1500 A and 10 kV for packaged samples. B1505A also has C-V capability from 1 kHz to 5 MHz with a combined DC voltage rating of 3 kV. The oscilloscope with the high voltage probe can capture switching transients up to 4 kV.

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CHALLENGE

Thermomechanical stress is a major cause of failures in power electronics due to the varying thermal expansion coefficients of materials within a device package. Traditional solutions often employ stronger rigid connections to combat this stress, but these methods can exacerbate stress and reduce reliability. SiC devices are particularly vulnerable. However, the demand for SiC power devices is growing rapidly, with market forecasts predicting a CAGR of over 15% in the coming decade. Our project introduces an innovative approach using fluidic connections with non-toxic liquid metal (GaInAg).

RESULTS

"The support from the Royce Institute was instrumental in the success of this project. They provided access to the Power Device Analyzer and Curve Tracer, which was crucial for detailed comparisons between conventional soldered packaging and LM packaging. Using the curve tracer, we validated the electrical performance and insulation properties of the LM-based packaging design, demonstrating its feasibility for power electronics. The curve tracer allowed us to verify that the LM packaging could significantly reduce thermal stress without impacting $R_{DS(ON)}$ while also providing better insulation performance and reliability. Additionally, Dr. Nishad Udugampola assisted in testing and taught me how to use the curve tracer, ensuring accurate and reliable results. This support helped reduce the project cost by minimizing the need for external testing services and leveraging advanced in-house equipment and expertise." Wei Mu, University of Cambridge.

Contact royce@maxwell.cam.ac.uk to use Royce Cambridge equipment

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"Our research introduces a novel application of liquid metal in power electronics packaging, significantly reducing thermomechanical stress and enhancing reliability and lifespan. This work paves the way for innovative, eco-friendly, reliable, low-thermal-stress packaging designs in the industry."

Wei Mu
Cambridge Researcher, Cambridge Power Electronics Laboratory at the University of Cambridge

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