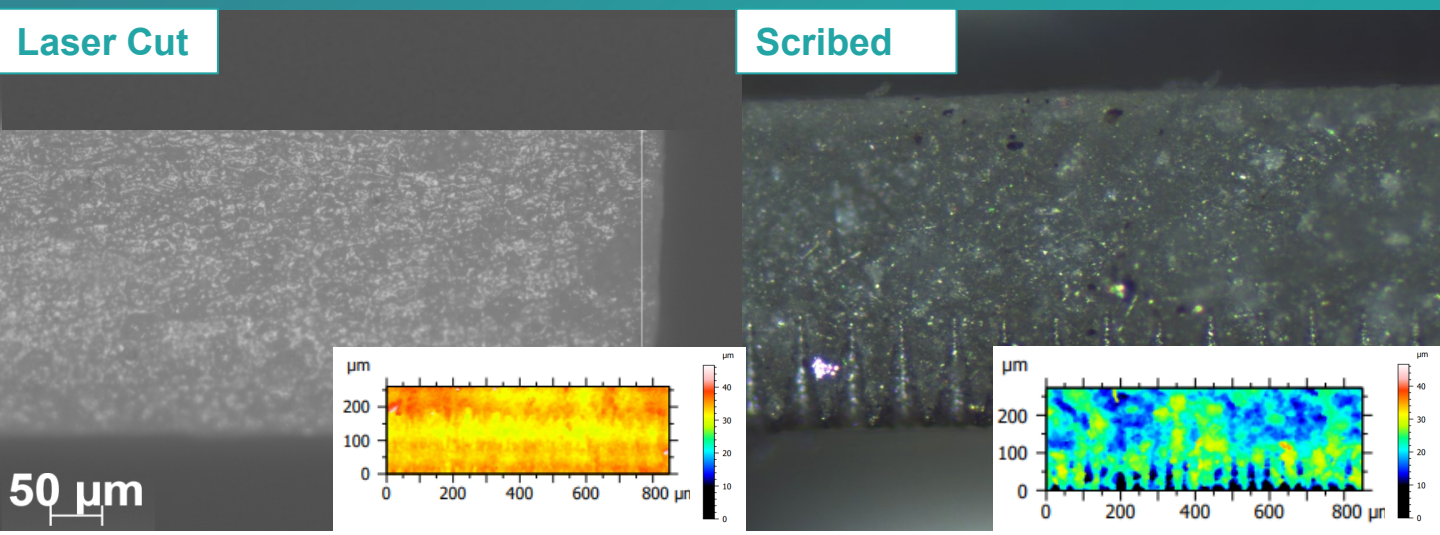
Technology Theme:
LASER PROCESSING / ELECTRIFCATION

LASER CUTTING OF CERAMIC MATERIALS FOR EV APPLICATIONS: ELECTRONICS MANUFACTURING



LASER CUTTING OF CERAMICS USED IN ACTIVE METAL BRAZED SUBSTRATES FOR EV POWER ELECTRONICS

The MTC successfully demonstrated the laser cutting of ultra-thin ceramic tiles, creating high quality cuts that are free from micro cracks, and can be utilised to manufacture active metal braze (AMB) ceramic substrates, ideal for high voltage and current circuit boards, commonly used in power electronics assemblies.

> This project is a great example of MTC collaboration with industrial partners to showcase benefits of laser cutting ceramics in active metal brazed substrates. Lasers offer high precision and repeatability ensuring accurate shapes and provide better control to avoid issues such as undesirable cracking. Use of lasers in AMB technology would allow creation of high-performance power modules with improved thermal management and reduced cost compared to traditional packages.
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> **Hassan Akhtar, Technology Manager, MTC**

THE CHALLENGE

- With the drive for electrification in the automotive sector, power electronic substrates are vital structures for placing semiconductors and interconnects on, to create electronic circuits with long term performance through mechanical robustness and effective thermal shock resilience.
- These substrates are made with an active metal braze (AMB) process whereby 2 layers of copper foil are bonded to either side of a ceramic sheet. The ceramic, typically either Aluminium (AlN) or Silicon Nitride (Si_3N_4), provides excellent thermal conductivity, resistant to high mechanical stress and suitability in a wide range of operating temperatures. Despite this, they are challenging to machine due to these properties as well as being incredibly brittle

MTC'S SOLUTION

- Lasers offer a viable solution to cutting these hard to machine materials. Due to ceramics being prone to thermally induced cracking, a laser process that minimises the heat input into the material is required. Two laser processes were developed for cutting these high-performance ceramic substrates;
- **W**ater **J**et **G**uided **L**aser cutting (WJGL) - the laser beam is guided to the workpiece using a high-pressured waterjet, this provides high accuracy machining capability and minimum thermal effects
- **U**ltra **S**hort **P**ulsed laser cutting (USP) – using a laser with a picosecond pulse duration significantly reduces thermal input into the substrate, minimising thermal damage compared to conventional laser cutting.

This project was funded as part of the first round of Advanced Propulsion Centre's (APC's) Scale Up Readiness Validation funding from the Automotive Transformation Fund (ATF).

THE OUTCOME

- The two laser processes were used to successfully cut both AlN and Si_3N_4 ceramic substrates. The laser cuts showed no micro-cracking, minimal thermal effects, a low taper and a lower surface roughness than current ceramic substrates on the market, cut with traditional processes.
- Using the WJGL, the ceramics could be cut to size, within +/-0.1mm:
    - 0.6mm thick AlN at a process speed of 0.8mm/s which could be increased to 3.3mm/s through using a partial cut and snap approach.
    - A 0.3mm thick Si_3N_4 at a process speed of 3mm/s which could be increased to 10mm/s through using a partial cut and snap approach.

BENEFITS TO THE CLIENT

- Using the WJGL, a complete through cut process was demonstrated as well as a partial cut and snap process, both yielding high quality although the partial cut and snap process improved processing speed by up to 66%.
- The current standard manufacturing method of mechanical scribing gives an uneven surface profile. Using the laser systems available at the MTC, an improved cutting process was developed which gives a lower surface roughness with no microcracks.
- WJGL has been successfully demonstrated in a prototype manufacturing process of an active AMB substrate, within the IUK project; Ceramic Substrates for EV with enhanced laser features (CervSelf) with SGA Technologies and Custom Interconnect Ltd.

> High performance ceramic Active Metal Braze (AMB) substrates are critical to power electronics used in Electric Vehicles. The laser processes developed in CervSELF will improve performance, increase yield and make the manufacture of these substrate more sustainable. The MTC is pleased to be supporting SGA Technologies to bring advanced AMB manufacturing processes to the UK and unlock the huge economic benefits.
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> **Dr. Marc Henry - Electrification Sector Development Manager**

↑ 3x

Processing speed demonstrated using a partial cut and snap process, compared to through cutting

↓ 112%

Reduction in surface roughness of WJGL cut Si_3N_4 compared to the conventional scribing method

10mm/s

Processing speed achieved with the WJGL for Si_3N_4

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