Laser Processing of LTCC (Low Temperature Co-fired Ceramic)

HERIOT WATT UNIVERSITY

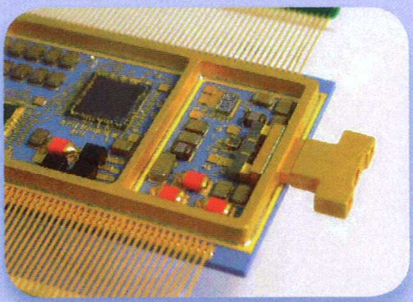

Figure 1 : High speed opto-electronic module assembled on LTCC.

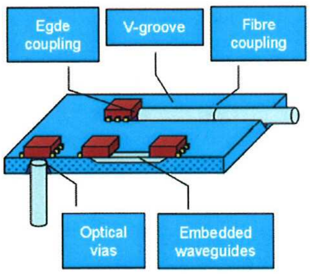

Figure 2 : Opto-electronic integration with LTCC.

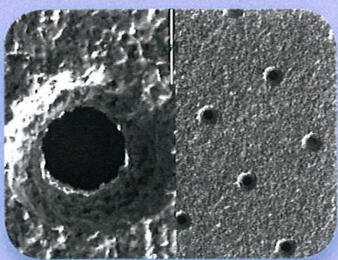

Figure 3 : Micro-vias in LTCC green material created by a single CO_2 laser pulse. Via diameter 40 μm.

Figure 4 : LTCC goes Celtic: a demonstration of the CO_2 laser precision machining capabilities. Structure is 2mm wide.

Rationale

It is widely recognised that the packaging of state-of-the-art electronic devices constitutes a major part of fabrication cost. LTCC (Low Temperature Co-fired Ceramic) technology became available to the consumer electronics industry in the mid-nineties in response to the demand for a flexible and cost effective packaging solution. LTCC is characterised by GHz band operation and thermal management capabilities better than conventional materials such as FR4. LTCC technology uses the concept of a layered design facilitating the manufacture of multi-level devices of increasing density and complexity, which for instance enables the integration of resistive, reactive, magnetic, and other components into the PCB. The interconnect between layers is achieved by microvias, which are currently punched mechanically in the green state material.

Having been used in military, automotive and avionics applications since the eighties, LTCC has proved to be capable of highly reliable operation in harsh environments. LTCC is now showing promise as a vehicle for the integration of electronic, micro-optic, mechanic and fluidic systems.

Research Aims

The currently employed mechanical methods of punching and milling for processing of green LTCC offer rather limited functionality. Furthermore, the drive to decrease the size of the features below 100 micron means that mechanical techniques are approaching their performance limits. In this research we aim to develop cost-effective and efficient laser-based techniques for precision machining of LTCC. This will enable the next generation of functionality by permitting the integration of electronics with micromechanics, microfluidics, and fibre-optics for applications in microfluidic systems, lab-on-chip devices and advanced sensor designs.

Research Objectives

- Provide a materials science based understanding of the laser interaction processes for LTCC materials, particularly for ablation, surface and sub-surface melting, glass transformation, dopant in-diffusion and cladding.
- Investigate laser machining and via drilling of LTTC materials for reduced feature size and arbitrary shaped structures in electronics and related applications.
- Develop techniques to create surface or buried optical waveguides, both multimode and singlemode.
- Develop methods for the alignment and fixture of external optical fibres to on-board photonic components.
- Investigate glass welding and other mechanical effects produced by laser melting.
- Investigate the use of laser processing in the formation of optical structures to provide coupling between waveguides.
- Evaluate the performance of the new photonics capability, aided by our industrial partners.

Research Outcomes

- A novel 'cold' laser ablation technique has been developed that permits high speed and high resolution laser processing of 'green' LTCC using a low power CO_2 laser.
- A particle ejection model involving both the alumina ceramic grains and the organic binder has been developed to explain the high material removal rates of >100μm per pulse.
- Lateral processing resolution of <50μm and depth resolution comparable to ceramic grain size with no heat-effected zone or other deleterious thermal effects has been achieved.
- Low loss optical loss butt coupling of singlemode fibres has been demonstrated using alignment structures laser-machined in LTCC.

Collaborators

University of Leeds

Faraday Partnerships

EPPIC

Heraeus

CELESTICA