Integrated Optical and Electronic Interconnect PCB Manufacturing (OPCB)

IeMRC Flagship Project

Universities: University College London (UCL) (Technical Lead), Heriot-Watt University, Loughborough University

Collaborating Companies: Xyratex Technology (Project Manager), BAE Systems, Renishaw, Stevenage Circuits, Xaar, Cadence, RSoft Design, Exxelis, NPL.

Digital information, encoded onto light signals, is regularly sent down optical fibres over distances varying from a few metres to thousands of kilometres. Fibres have largely replaced traditional copper cables for high performance broadband communication for distances exceeding a metre, as they offer advantages such as lower cost, immunity to electrical interference and weight savings. In the highest speed computers for communication between the central processor arrays and the hard disc storage arrays, through data routing switches, there is now considerable interest in incorporating high speed "optical wiring", by means of plastic light-guides, within large, metre-scale, electrical printed circuit boards (PCBs) combining optical and electrical interconnections (OPCBs). These PCBs (backplanes) are widely used in the electronic cabinets or racks that form the heart of a variety of IT systems and incorporate connectors to allow other OPCBs to be attached at right angles (figure 1).

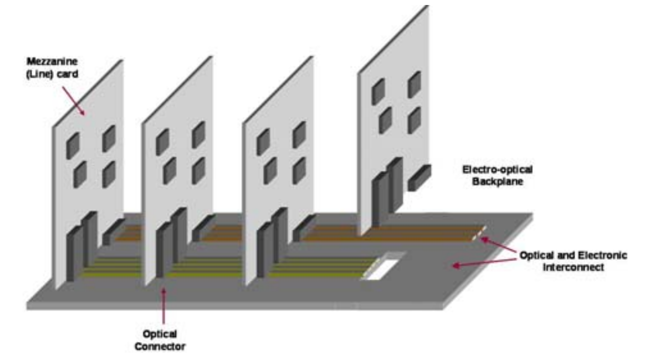


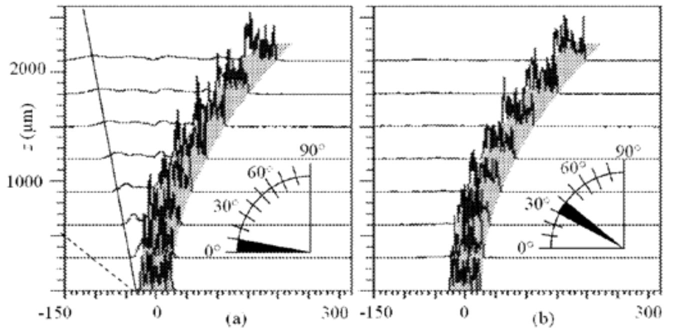
Fig 1: Schematic view of backplane architecture

This three-year research project is exploring novel methods, compatible with traditional multilayer PCB manufacturing processes, for the manufacture of optical waveguides capable of operating at very high data rates within an optical layer laminated into the board. Several process routes are under investigation, each with different levels of risk and cost. The large team of universities and industrial collaborators will enable the preparation, evaluation and exploitation of these processes. In addition, research will consider the requirements of design through the modification of commercial computer aided design software. The three universities are conducting research in the following areas:

Modelling and Characterisation of Waveguide Structures

University College London (UCL) is technical leader of the whole project and is responsible for the layout of the waveguide patterns and for the measurement and characterisation of the waveguides fabricated by the other partners. UCL will perform computer modelling of waveguide components to determine insertion loss and will compare the modelled results with the experimental results and so derive a detailed understanding of the behaviour of coherent light in multimode polymer

Fig 2: Computer simulations of the optical field in a 90° waveguide bend (a) at the start of the bend after a straight input waveguide showing radiated light beyond the outside of the bend, (b) a third of the distance along the bend.



waveguides fabricated by a range of techniques. Figure 2 shows an example of the modelled field in a multimode waveguide bend.

UCL will design novel commercially realisable low cost connector structures and will determine misalignment tolerances. This includes the establishment of the dependence of coupling loss when butt coupled lensed vertical cavity surface emitting lasers (VCSELs) and photodiodes are misaligned in x, y, z and in angle to waveguide end facets.

Laser Direct Writing of Waveguides

Heriot-Watt University is carrying out an experimental study on the viability of the direct UV laser writing technique to form multimode polymer waveguides over large metre-scale areas. The key writing parameters are the intensity profile of the writing beam e.g. Gaussian or top hat, the optical power and the writing speed. The main challenge here is to produce well-defined, low-loss waveguides written at speeds approaching 50 mm/s and this is approximately two orders of magnitude greater than writing speeds we have used previously. HWU has found that the exposure process is non-reciprocal (in the photographic sense) and hence increasing optical power is not a straightforward solution. The writing process and the photo-polymer formulation are being optimised to achieve the higher writing speeds. HWU is also exploring fabrication techniques for producing embedded waveguide 45° out-of-plane and in-plane mirrors that will be compatible with large board processing.

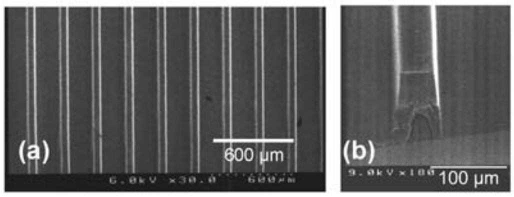
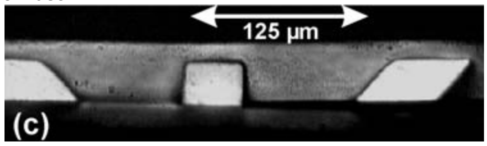


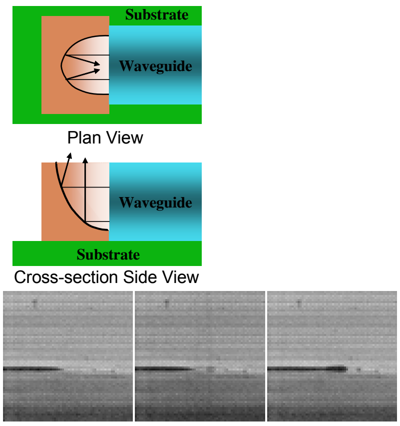
Fig 3: The SEM images in (a) show directly written, unclad polymer waveguides (~50 x 50 µm) on a glass substrate. The guides are on a 250 µm pitch and the cross section of one of the guides is shown in (b) – it was cut using a scalpel blade. The optical microscope image (c) shows an end-on view of the cladded structures fabricated on an FR4 substrate using a normal and ±45° angled beams. These structures were fabricated using a flat-top intensity profile whereas the waveguides in (a) & (b) were fabricated using a focussed Gaussian beam.



Laser Ablation and Inkjet Printing of Waveguides

Loughborough University are investigating the laser ablation of polymer materials to form straight and curved waveguides, but are also examining the preparation of 3D shaped mirrors to act as terminations that will assist the capture and injection of light signals. This requires characterisation and understanding of the ablation process such that wall roughness can be controlled and accurate mirror profiles generated.

In addition to this subtractive method, a significant part of the research is considering the ink jet deposition of polymer waveguide structures. Both functional fluids and solution deposition are being examined. A special focus of this work is the control of the substrate wettability to define the spread and final shape of the liquid droplets, such that the correct waveguide profile is achieved.



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