Network of Excellence on Micro-Optics

WP9 Project: Opto-PCB

SIXTH FRAMEWORK PROGRAMME

C. Debaes[a*], J. Van Erps[a], N. Hendrickx[b], T. Alajoki[c], M. Vervaeke[a], M. Karppinen[c], H. Suyal[d], O.Parriaux[e], G. Van Steenberghe[b], M. Taghizadeh[d], P. Karioja[c], P. Van Daele[b], H. Thienpont[a]

[a]Vrije Universiteit Brussel, Dept. of Applied Physics and Photonics (TONA-FirW), Pleinlaan 2, B-1050 Brussel, Belgium;
[b]Ghent University, Dept. of Information Technolgy (INTEC), TFCG Microsystems, Technologiepark 914A, B-9052 Zwijnaarde, Belgium
[c]VTT Research Center of Finland, Kaitovayla 1, PO Box 1100, FI-90571, Oulu, Finland
[d]Heriot-Watt University, School of Engineering and Physical Sciences, EH14 4AS, Edinburgh, United Kingdom
[e]Saint-Etienne University, Laboratoire Traitement du Signal et Instrumentation, Rue Barrouin10, F-4200 Saint-Etienne, France

ABSTRACT

The Opto-PCB is a project originating from the earlier work performed within the framework of WP9. This workpackage is focused on optical interconnects mainly via the integration of optical waveguides on Printed Circuits Boards. As a result of the gained experience, we have identified 3 distinct feature demands for next generation opto-boards that can be fabricated within the NEMO. For each of them we have planned a specific demonstrator. The first feature is the integration and coupling to active optoelectronics devices. We aim here at achieving a 10Gb/s parallel link over 8 channels. The second feature is the integration and coupling towards fiber ribbons. It is the intention of the project to make a demonstrator that investigates the feasibility of in-plane peripheral and and out-of-plane connectors. The third feature request relates to increasing the routing flexibility and the density of the waveguides by embedding multiple layers of optical waveguides in the board. In this demonstrator the fabrication of the multi-layer waveguides will be targeted in combination with the necessary coupling elements that can couple light from one layer to another.

Keywords: coupling structures, fiber connectors, optical interconnects, optoelectronic devices, polymer waveguides

1. INTRODUCTION

Although the adoption of photons for the communication on board-level interconnects has since long been predicted, it is still far from a ubiquitous solution. The recent interest of industry (IBM, Agilent, Siemens C-lab,…) via considerably large R&D programs has however sparked a new interest into the theme of optical interconnects with a sharp focus on embedding of optical waveguides into printed circuit boards. This technology has been the main target of workpackage 9 of the NEMO consortium. Hence, it has created a rather unique position in which different technologies available at the NEMO-partners are combined. The current work has been focusing so far on solving technological issues and in-compatibilities between partners. This project will leverage this work to a next stage.

As a result of the research performed in the first year of the consortium, we were able to identify three technology features which need further development: 1) integration and the coupling to active devices on the board, 2) integration of connectors for fiber and fiber ribbons to extend the optical connection between boards, and 3) integration of multiple layers of optical waveguides on one board.

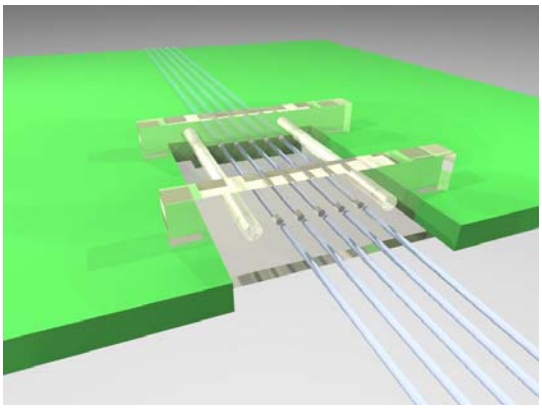
It is the aim of this project to tackle the above feature requests. For each of the above requests we have come up with a distinct demonstrator which will be build in the framework of this project. The fabrication of the demonstrator boards will also allow us to further optimize the fabrication technology of the PCB embedded waveguides.

[*] Christof.Debaes@vub.ac.be; phone +32 2 629 18 14; fax +32 2 629 34 50; http://tona.vub.ac.be/Tona

2. METHODOLY

A first important aspect of this project will be the further optimization of the necessary basic building blocks for embedding optical waveguides within PCBs and the required step towards integration of different technologies available at the partners. Here, two technologies will be targeted: a first consists of the laser ablation (UG) and in a second the photo-definition of waveguides is realized by a direct laser writing process (HWU). These tasks concerning the waveguide preparation and waveguide fabrication are grouped together in a first part of the project and include furthermore tasks for: laser ablation for the fabrication of the tilted mirrors and the cavities for inserts (UG), optical loss characterization of the waveguides by cut-back measurements (UG), measurement of the loss and tolerance of the laser-defined 45° mirrors and out-of-plane inserts (VUB), waveguide roughness measurements and mirror angle characterization (VUB) and first reliability measurements (UG). The partner TSI will furthermore evaluate the achieved coupling efficiency for the angled coupling facets and compare the results with an alternative approach which will be based on resonant grating couplers.

In a second part of the project a first demonstrator is targeted which will demonstrate that the consortium can integrate the opto-PCB waveguides with active devices such as VCSELs and detectors (and solve some important packaging problems underway). This task involves the development of an optical link from VCSEL array to photodiode array. Commercially available 10Gbps components and optoelectronic packaging available at VTT will be used. Samples form this part of the project, specifically fabricated for this objective, will contain 8 waveguides on a 250µm pitch and have laser ablated cavities for the introduction of a pluggable DPW deflection insert (VUB). Both out-of-plane couplers with and without integrated micro-lenses will be considered and delivered to VTT, who will take care of the mounting and assembly of at least two samples. Also the use of laser ablated 45° micro-mirrors embedded directly in the waveguides by laser ablation (UG) will be considered for coupling. Different assembly methods will be investigated.


Schematic Figure of the in-plane connector

In a third part of the project a second demonstrator is targeted to demonstrate the coupling of light form the embedded waveguide into fiber ribbons. Indeed, many applications require light, generated on a board or brought into a rack, to be transported through the system to another board for processing. The objective of this task is to develop prototypes of connector elements that can be efficiently mated with the optical waveguides within PCBs. The study will encompass the fabrication of two types of fiber connectors: out-of-plane and in-plane connectors. The first type, the out-of-plane fiber connectors, will couple light from multi-mode fiber ribbons positioned perpendicularly to the board into the optical waveguides (preferably using commercially available fiber ribbons). This solution will contain: a circuit board with the waveguides on an optical layer, micro-mirrors created by laser ablation or laser cavities with DPW micro-optical inserts to deflect and/or collimate light out of the propagation plane. The solution will also contain the appropriate mechanical mating structures for the optical connectors. The second type of connector will connect the optical waveguides to fiber ribbons positioned in the same plane as the board and will be based on similar technology. A schematic view of the in-plane connector demonstration can be viewed in the figure. To host the connector, the board will include a cut-out part and precise laser ablated cavities to position the connector. The connector will consist of fiber hole plates, MT pins and array of fibers.

In a fourth and last part of the project the introduction of multi-layer optical waveguides will be demonstrated. These multi-layers allow more flexible routing of the optical signals avoiding difficult and possibly lossy crossings and also fully exploit the 2-D character of the optoelectronic components. The project plan follows the strategy set out within NEMO WP9 to build the earliest versions of the technology demonstrators. The laser ablated cavities allow for the introduction of pluggable DPW inserts for inter- and intra-layer coupling (VUB).

ACKNOWLEDGEMENTS

C. Debaes and J. Van Erps are indebted to the Fund for Scientific Research-Flanders (FWO) for their financial support. N. Hendrickx was financially supported by the Flemish IWT