Université Lille Nord de France
Pôle de Recherche et d'Enseignement Supérieur

Ecole doctorale régionale Sciences Pour l'Ingénieur
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Titre Thèse	**Laser Micromachining for Packaging of Photonic and mmW systems for Ultra-High Data-Rate Telecom**	
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Résumé du sujet : Laser Micromachining for Packaging of Photonic and mmW systems for Ultra-High Data-Rate Telecom

Following the demand for mobile data, global data center traffic will reach 10 zettabytes (1021) per year in 2019. Even if optical communication systems within data centers based on multi-mode VCSEL solutions are still dominating sales due to their lower cost for single channel transceivers, Silicon Photonics (SiP) solution has emerged as a promising candidate for the industrialization of high performance and low cost optical transceivers. SiP interest is mainly related to mega data centers that need up to 2 kms long cable connections. Distance extension as well as increase in aggregated data rate require the use of single mode fiber connections and opens a market for 4 channels parallel (PSM4) and Coarse Wavelength Division Multiplexing (CWDM) applications to achieve 100 and 400 Gb/s optical links.

The high index contrast between silicon core and cladding enables higher integration density and SiP platforms compatibility with CMOS, leading to a low manufacturing cost. Therefore, Photonic Integrated Circuits (PICs) follow the same evolution as electronics: modularity and miniaturization. Although considerable achievements have been made in SiP, the coupling between single mode optical fibers and Silicon-On-Insulator (SOI) waveguides remains a serious challenge. The high index contrast of the SOI platform leads to large mismatch between waveguides and optical fibers resulting in important coupling losses. Grating Couplers (GCs) remain the most suitable solution because light is quasi-vertically coupled between optical fibers and PICs, making possible wafer scale testing. The current approach consists in using the PIC as an interposer and to flip chip the electrical ICs and the laser on it. Fibers are quasi vertically attached to the PIC by the use of UV glue. This approach however suffers from major limitations as active alignment is needed to optimize light coupling between the PIC and the fiber or the laser. This subject therefor proposes the evaluation of a new assembly approach that consists in replacing the silicon PIC interposer by a thin glass one. The distinctive advantages of this approach ensues from:

- The possibility of passive alignment of the PIC (cost reduction).
- The use of standard butt coupling connection in the glass interposer.
- The industrialization possibility of the work by leveraging current electrical thin glass developments with aggressive design rules and through glass vias, by transferring the developed optical passives like waveguides, multi-demultiplexers for WDM applications... to industrial thin glass interposers.

Furthermore, this new approach could able the technology extension to WDM applications that are currently limited by the grating coupler bandwidth in the case of integrated multi-demultiplexers functions by transferring these functions from the PIC to the thin glass interposer.

Beside photonics applications, the manufacture of sub-mmW components and subsystems using conventional methods, such as mechanical machining or metal electro-erosion, is very expensive and suffers from a lack of dimensional accuracy. Machining accuracy and tolerances become a real challenge as the wavelength decreases. For example, the standard dimensions of the WR1.5 waveguide operating in the 500-750 GHz range is 380×191 µm^2. This results in machining accuracies of around 10 µm while maintaining a roughness well below the wavelength. Another objective of this PhD research topic is to implement the laser microstructuring technique for the manufacture of functional blocks integrating standard passive components such as guides, filters, resonators, diplexers, coplanar-rectangular transitions etc...

This subject widely implements the use of laser micromachining techniques in the context of LEAF Equipex project (https://www.youtube.com/watch?v=9uCjtT7uX40&feature=youtu.be)