Automated Alignment and Bonding of 3D Stacked Fibers to 2D Planar Photonic Waveguides through Ultrafast Laser Writing.

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OBJECTIVE

1. To develop technology capability for in situ photonic wire writing through two photon polymerizations for minimizing chip to fiber misalignment.
2. To develop an automated image registration-based method to calculate the photonic wire path in situ and fabricate it.
3. Increase the shoreline density through photonic wire bonding of 3D stacked fibers to 2D planar PIC waveguides.

INDUSTRY NEED

Even with the huge advancement of photonic technologies, 70-80% cost of a silicon photonics module stems from packaging costs as compared to only about 20% for an electronic module. Primary challenges in photonic packaging lies in stringent alignment tolerances unlike electronic packaging. At present, the attachment of fiber to the on-chip waveguide is done with highly customized, epoxy-based, separate sequential alignment methods. This presents reliability and scalability challenges that need to be addressed. Achieving higher channel density for increased communication rate in a PIC is another target that the co-packaged optics community has been looking at since the last few years. In this aspect, the major bottleneck has been the relatively large dimension of the fiber compared to the width of the photonic waveguides. The co-packaged optics community has now started to look at 3D integration of fiber stack and their subsequent alignment to 2D planar waveguides in a PIC.

PROPOSED APPROACH

In this project, initial effort will be towards demonstrating the feasibility and fabrication of photonic wire bond connecting the end facet of the fiber to the edge of the waveguide. To solve scalability issues ranging from serial nature of the laser direct writing, an automated image processing-based technique will be implemented. The same approach will then be used for connecting an array consisting of multiple fibers to multiple waveguides. The process throughput can be improved through splitting the incident writing laser beam into multiple beamlets using a diffractive optical element or a spatial light modulator. Finally, the methodology can be extended in the third dimension enabling bonding of fiber array stacked vertically to a planar two-dimensional array of waveguides.

Design and Demonstrate Prototype

Two versions of the prototypes are proposed in this work. The first prototype (Fig. 1) will be the demonstration of photonic wire bonded connection between a planar array of fiber to a planar row of photonic waveguides. The second prototype will be the demonstration of photonic wire bonded connections between a three-dimensional stack of planar array of fiber to a planar row of photonic waveguides. An appropriate test vehicle will be constructed to measure the coupling loss and the propagation loss of the photonic wire.

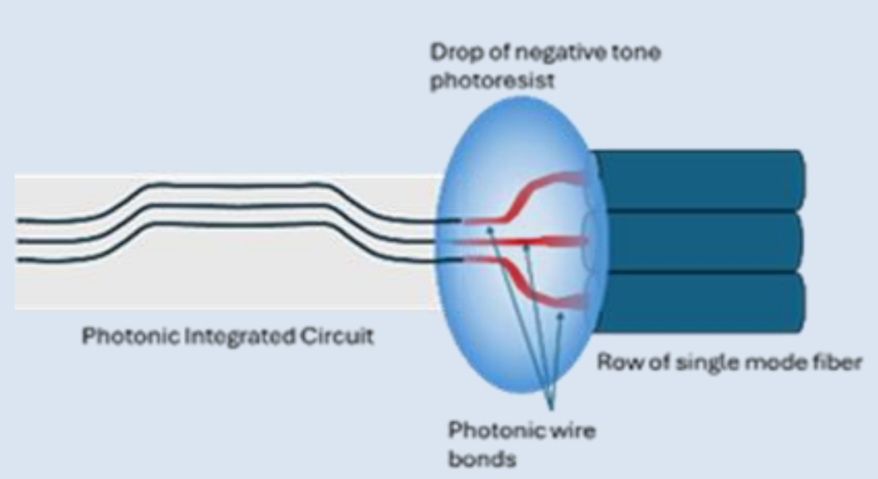

Fig.1.Schematic of photonic wire bonded connections between a) a planar array of fiber facet to a planar row of waveguides

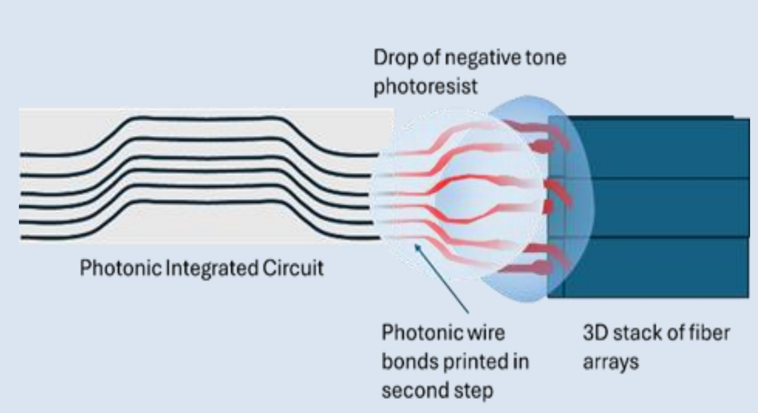

Fig.2.Three-dimensional stack of Fiber Array Unit to a planar row of photonic waveguides.

TECHNICAL CHALLENGES

1. Demonstration of process technology of photonic wire bonding with low coupling losses
2. Scalability issues related to laser direct writing being a serial processing technique
3. Correct in situ identification of the start and the end point of the photonic wire bond
4. Prototype demonstration connecting a 3D stack of fibers to 2D planar waveguides.

PRIOR ART

Single mode fiber to photonic chip alignment is typically done through either passive or active mode of alignment [1]. A fiber attachment solution combining the mass production capability of passive alignment and minimum coupling loss of active alignment is required for a radical improvement in fiber to waveguide connection technology. Intermediate features on glass substrates or waveguides manufactured through ultrafast laser-ablation enables accurate positioning of fiber guide pins for self-alignment [2], [3]. These bridge structures or optical chiplets have been envisioned to be detachable so that each photonic module can be tested before committing to the package [4], [5]. However, this requires the processing of a separate glass substrate increasing the overall cost and complexity of the systems. On the other hand, two photon polymerization(2PP) based laser direct writing to bond the fiber facet to the waveguide in situ has been demonstrated to be one of the promising ways towards solving these issues. [6], [7]. Moreover, 2PP method being a volumetric 3D printing method can also nicely lend itself for direct writing of 3D waveguides for attachment between 3D stacked fibers and 2D planar waveguides. Thus, 2PP based laser direct writing can, on one hand, result in a better fiber to waveguide connectivity combining the benefits of both active and passive alignment and at the same time allow the bonding of 3D stacked fibers to 2D planar photonic waveguides.

Comparison of Proposed vs. Previous R&D:

	Previous R&D	Proposed work
Fiber Array Unit	Single planar array of Fiber	Two layers of Fiber stacked on top of each other
Photonic Wire Bond (PWB) density	40/mm	80/mm
Fabrication time per PWB	30s	30s or better

INDUSTRY INTEREST AND PARTNERSHIPS

MixxTech has shown a broad interest in working in ultrafast laser writing as a part of this SRA.

References

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