Heterogeneous integration for silicon photonics based on micro-transfer printing

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Abstract *Micro-transfer printing is an enabling technology to heterogeneously integrate thin-film components onto silicon photonics wafers. This tutorial will cover the basics of micro-transfer printing as well as demonstrations such as GaAs and InP opto-electronic device integration, LiNbO3 modulator integration and electronic IC integration. ©2025 The Author(s)*

Introduction

Next-generation silicon photonic integrated circuits will need heterogeneous integration to cater high-volume applications such as ultra-high speed optical transceivers, photonic interposers, LiDARs, etc. While silicon photonics leverages CMOS fabrication infrastructure to enable scalable, low-cost photonic IC fabrication, often the methods for heterogeneous integration are less scalable, not versatile and have a large NRE. Micro-transfer printing [1], a technology under license from X-Celeprint Ltd., is a technology that combines the advantages of established integration approaches such as flip-chip (separating the silicon photonics process flow from the non-native device process flow, possibility to pre-test, back-end integration) and wafer-bonding (high-thoughput integration, low coupling losses), while at the same time being very versatile.

Micro-transfer printing technology

Micro-transfer printing, relies on the transfer of thin-film, released components from a source substrate (III-V wafer, LiNbO3 wafer, SOI electronics wafer,…) to a target wafer (i.e. a silicon photonics wafer) using a structured PDMS stamp.

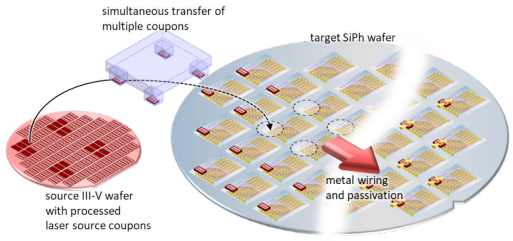

Fig. 1: Micro-transfer printing schematics

This technology allows for the parallel integration of non-native components onto a silicon photonics target wafer, that has cavities defined in the back-end of line stack to accommodate these components and interface them with the silicon or silicon nitride waveguide circuit.

Integration demonstrations

The technology can be used to heterogeneously integrate III-V opto-electronic components (e.g. InP SOAs & photodiodes, GaAs SOAs, VCSELs & photodiodes) as well as LiNbO3 phase shifters and electronic integrated circuits onto a silicon photonics wafer. A few examples are shown below.

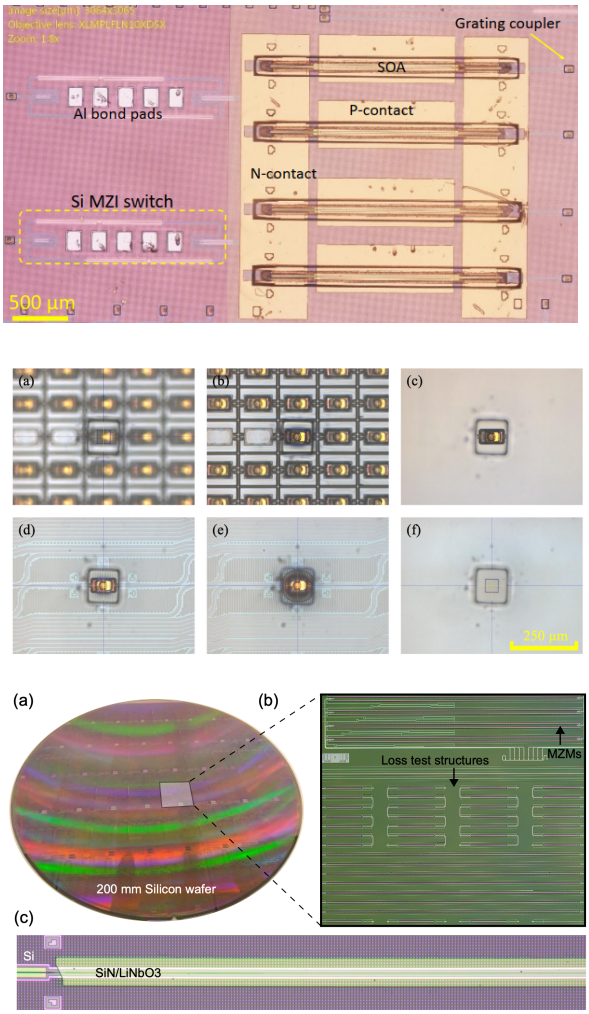

Fig. 2: Demonstrations showcasing the versatility of micro-transfer printing; (top) InP SOA integration on silicon photonics; (middle) GaAs VCSEL integration on SiN photonics; (down) LiNbO3 integration on Si/SiN photonics

Conclusions

Micro-transfer printing stands out as a scalable

and versatile heterogeneous integration approach for silicon photonics. Work on demonstrating high integration yield and reliability of the resulting components is ongoing.

[1] G. Roelkens et al. “Present and future of micro-transfer printing for heterogeneous photonic integrated circuits," *APL Photonics*, vol. 9, 010901, 2024, DOI: 10.1063/5.0181099