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Enabling next Generation Photonic Integration and Packing by Augmenting 3D Nano-Print Technology

The global Photonic Integrated Circuit market is an emerging, fast-growing billion-dollar market embracing a wide range of applications from optical communications and signal processing to industrial metrology, sensing, and quantum applications. Yet, packaging and assembly of photonic systems consisting of discrete chips still represent a major technical and commercial challenge. The majority of costs associated with silicon photonic device production is driven by the packaging process – in particular, during the tedious process of precisely aligning chips, both with each other and with the optical fibers that relay their photonic signals. The technologies that can facilitate this process are evolving rapidly, but more progress will be needed to keep pace with the rising generation of photonic integrated circuit based systems.

Vanguard Automation's mission is to advance photonic integration and packaging at manufacturing scale augmenting two-photon polymerization. Two-photon polymerization, also referred to as additive nano fabrication or 3D nano-print technology, allows equipping single mode micro-optical components with coupling elements.

The Photonic Wire Bonding (PWB) approach enables flexible hybrid integration of best-in-class known-good devices with high density in a fully automated fabrication process. Pre-aligned chips are connected with 3D-printed freeform waveguides. The technique lends itself to both rapid prototyping of small batch sizes as well as large-scale production. 3D-nanoprinting of micro-lenses and mirrors lends itself to both die and wafer-level fabrication. The approach features low coupling losses by precise mode matching of optical components with widely different mode-profiles. Moreover, with expanded beams the alignment tolerances can be relaxed, which simplifies optical system assembly. Micro-mirrors give additional design freedom and allow combining vertically and horizontally emitting components in compact assemblies.

Both approaches, Photonic Wire Bonds [1] and micro-optical lenses [2] have demonstrated coupling losses around 1 dB, reliability during telcordia-like thermal stress tests, high-power resistance, and ability to operate within cryogenic conditions [3].

We will give an overview of Vanguard Automation's unique process technology, including machines and software for building integrated optical systems with in-situ 3D-printed Photonic Wire Bonds as well as micro-optical lenses.

References

[1] Blaicher, M., et. al., **Hybrid multi-chip assembly of optical communication engines by in situ 3D nano-lithography**, *Light: Science & Applications* **9, Article number: 71 (2020)**Authors, Journal, Issue (Year) page
[2] Dietrich, P-I, et al., **In situ 3D nanoprinting of free-form coupling elements for hybrid photonic integration**, *Nature Photonics* **12, 241--247 (2018)**
[3] Darcie, A., et al.: SiEPICfab: the Canadian silicon photonics rapid-prototyping foundry for integrated optics and quantum computing Proceedings Volume 11691, Silicon Photonics XVI; 116910C (2021)