Additive- CMOS Compatible Fabrication of 3D Photonic Circuits for Integrating Multi-Chip and Multi-Material Platforms

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Combining the strength of multiple photonic and electronics concepts in one hybrid and multi-chip platform is a promising solution for the diversification of chips for specific computing tasks to boost performance. We demonstrated flash-TPP, a novel CMOS compatible lithographic methodology that enables ultra-fast fabrication of high-performance 3D photonic circuits based on additive fabrication via one- (OPP) and two-photon polymerization (TPP) combined with direct-laser writing (DLW). We obtain a refractive index contrast between core and cladding in the order of 10^{-3}, enabling single-mode propagation over large (6 mm) distances, and with only 1.3 dB/mm (0.26 dB) propagation (injection) losses. We introduce the first steps towards the realization of a new approach merging semiconductor (GaAs) quantum dot (QD) micro-lasers and polymer-based 3D photonics circuits printed via flash-TPP. Conceptually, the 3D waveguides are interfaced on top of vertically emitting QD micropillar arrays. This results in the optical coupling of the QD emission of the micro-cavities into the 3D waveguides, yielding very high emission collection efficiency into the waveguides at cryogenic temperatures (4 K), with coupling losses of only 1.1 dB. Similarly, we demonstrate further CMOS compatibility by merging our 3D printing technology with silicon-on-insulator (SOI) platforms. We successfully couple light from high-performance 2D planar SiN waveguides into 3D waveguides via out-of-plane total internal reflection couplers, all in a monolithic and single fabrication procedure. Preliminary optical characterization of such integrated devices shows good performance in terms of optical losses. Merging 3D waveguides with CMOS technology in a single hardware system represents a crucial step for promising applications in advanced photonic information processing. With this, we lay a promising foundation for scalable integration of hybrid photonic and electronic platforms.