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INTEGRATED PHOTONIC CIRCUITS TAILORED FOR SPACE APPLICATIONS

Abstract

Photonics is envisioned to revolutionize spacecraft engineering by replacing or enhancing traditional electronic methods in critical areas like digital and RF telecom payloads, sensors and lidars. In particular, it promises to improve space systems performance by reducing the onboard devices' size, weight, and power consumption. In this framework, Photonic Integrated Circuits (PICs) are emerging as pivotal solutions in space applications, offering an unmatched degree of stability, miniaturization and integration of multiple optical elements to enable complex functions analogous to electronic integrated circuits. Moreover, the additional feature of reconfiguring the device transfer function further enhances the capabilities of these devices, allowing the realization of multiple experiments on the same hardware.

Among different PICs fabrication platforms, femtosecond laser writing (FLW) on a transparent glass substrate is versatile and reliable for integrated optical devices. FLW is a mask-less approach enabling rapid prototyping of PICs while also unlocking 3D design capabilities with low optical and coupling losses with off-the-shelf optical components. Programmability in femtosecond-laser-written integrated circuits is commonly achieved through thermal phase shifters with the integration of thermal isolation structures to reduce power dissipation and thermal cross-talk.

We propose new thermal isolation structures with a novel thermal phase shifters fabrication approach. By machining the sample with a femtosecond laser, we remove the glass volume around the waveguides, thus completely isolating them from the bulk substrate. This vacuum-compatible solution allows the employment of shallower isolation structures, effectively halving the fabrication time while maintaining the isolation characteristics of deep isolation trenches. Alongside a state-of-the-art curvature radius, the phase shifters paired with these isolation trenches offer a compact footprint allowing for an optical length reduction of approximately 20% with respect to the current standard for this platform while reducing the total production time, keeping low parasitic series resistance and no notable increase in power dissipation or thermal cross-talk. These outcomes enable a significant leap in layout complexity and pave the way for low power-budget femtosecond-laser-written photonic circuits.