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Structured glass for low power actuation of thermal phase shifters

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Femtosecond laser micromachining (FLM) is a versatile technique that allows cost-effective and rapid fabrication of 3D photonic integrated circuits providing devices for various applications, ranging from lab-on-a-chip to quantum interferometry. Up to date, the possibility to reconfigure the operations performed by these circuits mainly relies on thermal phase shifters. However, the actuation of an integrated microheater requires several hundreds of milliwatts (around 600 mW) to induce a 2π phase shift in FLM devices operating at telecom wavelength, thus preventing the integration of more than a few microheaters on the same chip. Therefore, we devised a new FLM fabrication process, based on water-assisted-laser-ablation, able to reduce the power dissipation for a given phase shift of more than one order of magnitude, with no compromise either on the compactness or on the passive optical performance of the circuit. We realized Mach-Zehnder interferometers encompassing high-quality optical waveguides in aluminum borosilicate glass (0.29 dB/cm propagation losses and 0.27 dB/facet coupling losses at 1550 nm) and two different types of thermally insulating microstructures. In particular, isolation trenches on the sides of the heated photon path and bridge waveguides, structures in which the glass is ablated also under the optical path. As a result, interferometers featuring trenches show a reconfiguration period of 57 mW, whilst bridge waveguide ensures a reduction of the power dissipation required to induce a 2π phase shift down to 37 mW. In the end, we performed the same experimental measurements in a vacuum environment, demonstrating a further reduction in the required power dissipation when air is removed from the ablated regions. The advantages of structured devices are also underlined by performing thermal crosstalk measurements. These results will lead to an increase of the devices complexity attainable with FLM technology, opening new scenarios both in classical and quantum information applications.

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