Novel Ultrafast Laser Inscribed Multi-Pass Waveguides for Reduced Bend Losses

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Efficient and spatially compact photonic circuits are desirable for optical communications and quantum computing applications. The index contrast and mode-field confinement govern the minimum radius of waveguide curvature without incurring bending losses, which in turn, dictate the space required for intra-device routing. Ultrafast Laser Inscribed (ULI) waveguides are typically limited to index contrasts on the order of optical fibres. While this allows for low loss fibre coupling, the comparatively large size of optical fibres imposes a physical limit on integration density. Hence, the ability to confine the mode more tightly would enable ULI circuits to act as low loss, high connection-density interconnects between novel Spatial Division Multiplexing (SDM) fibres and silicon photonics. In this work, we demonstrate a novel multi-pass ULI waveguide in boro-aluminosilicate glass (Corning Eagle XG) for 1550 nm operation. Two physically distinct modification methods are successively applied to increase the index contrast. A conventional waveguide is inscribed with a high pulse repetition rate (5.1 MHz) followed by a second inscription pass, with a low pulse repetition rate (150 kHz). The result is a high index, composite waveguide morphology, with improved mode-field confinement, resulting in mode-field diameter on the order of 5 μm, half that of a standard telecommunication fibre. This approach increases baseline propagation loss by approximately 0.5 dB cm-1, as a result, standard high repetition waveguides are more efficient for bend radii on the order of 15 mm or larger. However, the benefit of the multi-pass approach increases dramatically for tighter bends. For a bend of radius 8 mm, for example, the high repetition waveguide experiences bend loss of 7.7 dB cm^{-1}, compared to 2.7 dB cm^{-1} for the multi-pass waveguide.

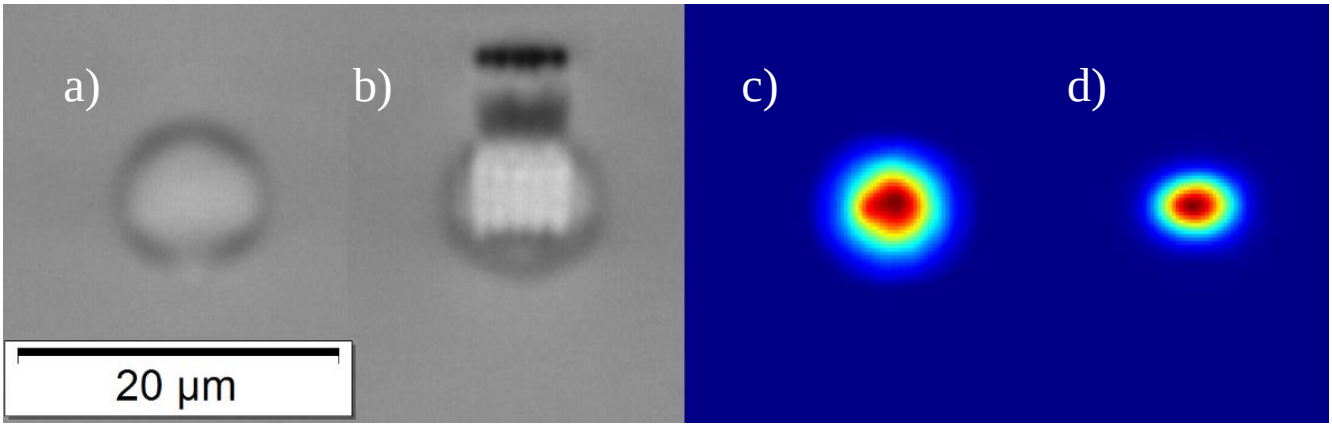

Figure 1 a) High pulse repetition waveguide. b) High repetition waveguide with low repetition multi-pass modification. c) Original guided mode. d) Multi-pass guided mode