Micromachined Multimode Interference Device in Flat-fiber

S. Ambran, C. Holmes, J.C. Gates, A.S. Webb, P.G.R. Smith, J.K. Sahu
Optoelectronics Research Centre (ORC), University of Southampton, United Kingdom.
sa4g09@orc.soton.ac.uk

A novel flat-fiber platform is presented for fabricating integrated optical multimode interference (MMI) devices. Fabrication is achieved by modifying a standard optical fiber drawing process and applying a micromachining technique. The fabricated structure consists of an MMI region within the flat-fiber that is defined by micromachined trenches, illustrated in Figure 1(a). A 1x3 splitter has been demonstrated, with a spatial output mode that be tuned by placing refractive index oils within the micromachined trenches.

MMI devices have been demonstrated in different planar platforms such as silicon-on-insulator and silica-on-silicon. However, many of these materials are potentially expensive, high loss or have a complex fabrication process. The desire to have a fiber-like platform, capable of supporting multiple waveguides in a planar format, led us to develop a novel silica optical flat-fiber technology. This allows us to overcome the limitations of existing planar technologies by offering a low cost, low loss substrate with fiber-like flexibility, long lengths and the ability to make integrated devices. The flat-fiber substrate is fabricated using standard silica fiber fabrication but differs by collapsing the preform during the fiber drawing stage by using a vacuum. The trenches of the device were diced using an ultra-precision micromachining technique.

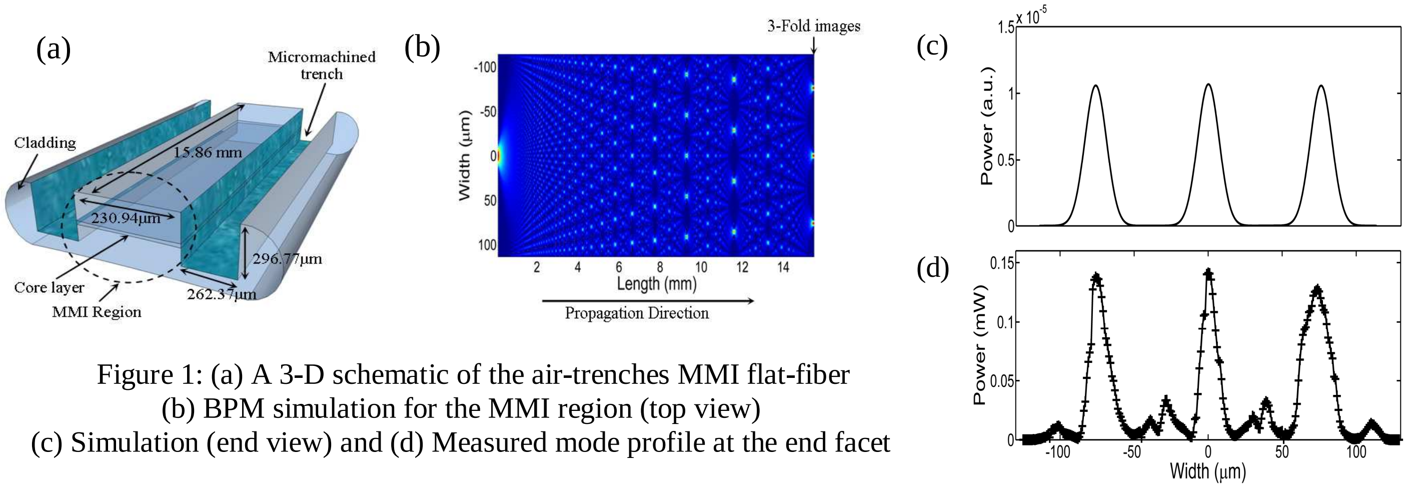

Figure 1: (a) A 3-D schematic of the air-trenches MMI flat-fiber
(b) BPM simulation for the MMI region (top view)
(c) Simulation (end view) and (d) Measured mode profile at the end facet

A Fast-Fourier Transform Beam Propagation Method (FFT-BPM) was used in order to understand the propagation of light in the MMI device, as depicted in Figure 1(b) for 1635 nm wavelength. Figure 1(c) and (d) respectively show the simulation and the measured three-fold image intensity peaks at the output facet. The experimentally measured data was obtained by scanning a SMF-28 fiber across the output facet and thus the simulation has been convoluted with a Gaussian profile representing the SMF-28 fiber accordingly. The insertion loss of the device was ~2.9 dB and is attributed to the roughness of the MMI machined surface and output modal mismatch. As well as defining the MMI's boundaries, the use of trenches allows us to tune the image formed in the MMI. By replacing the air in the trenches with the refractive index oils, the effective width of the MMI region is altered due to the Goos-Hänchen effect. This results in a change of the MMI image and also the mode profile at the output facet. Employing this effect the device can be used as a microfluidic refractive index sensor or be tuned for specific modal control. We will present design optimization for achieving maximum refractive index tunability including the integration of such MMI components with Direct UV-Writing (DUW) waveguides for increased device sophistication.