Multi-trench Fiber for high power laser applications

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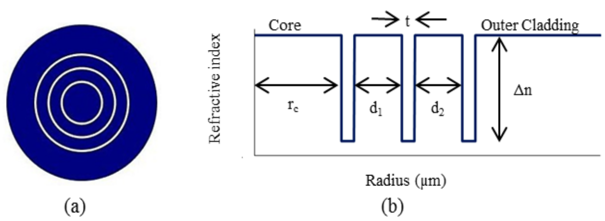
Abstract: Optical fibers have realized their immense potential for high power applications in the last decade. However, non-linearity still remains a challenge for power scaling for fiber lasers [1]. A large effective area of the fundamental mode of the optical fiber can increase the threshold of the non-linear effects [2]. However, simply increasing the core size leads to multi-mode operation and hence deteriorates the beam quality. Several novel optical fiber designs have been proposed to offer a large effective area of optical fibers such as Low NA Step index fibers, Photonic Crystal Fibers, Bragg Fibers, etc., while still maintaining single mode operation.

Recently, we proposed a novel multi-trench fiber (MTF) design for large effective mode area, as shown by a cross-section schematic and a refractive index profile design in Fig. 1. [3]. This fiber design offers advantages of relatively easy fabrication, splicing, and cleaving. Numerical simulations reveal that the MTF fiber geometry can provide single-mode operation with a core diameter as high as 100µm with an effective area of ~ 10,000µm^2 in a rod-type configuration and ~800µm^2 in a bend configuration. A 30µm diameter core MTF has been fabricated and the cross-section and measured refractive index profile is shown in Fig. 2. S^2 measurement shows ~50dB suppression of higher order modes (HOM) in a one meter length of fiber. Also, an ytterbium-doped single-trench-fiber laser (slope efficiency ~85%) with a 20µm diameter core has been experimentally demonstrated with very high suppression of HOM (~32dB), which was also verified by S^2 measurement. The refractive index profile, plot of laser slope efficiency, an output beam profile and a laser output spectrum are shown in Fig. 3.



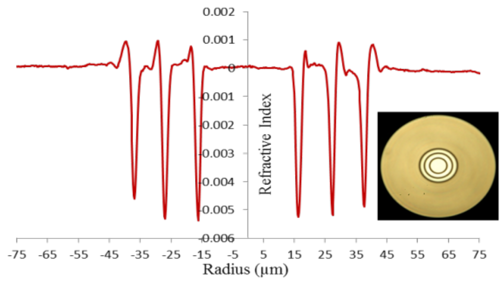


Fig. 1 Fig. 2

Fig. 1. (a) Schematic cross-section of the proposed fiber structure. (b) Refractive index profile of the proposed optical fiber. Fig. 2 Shows the refractive index profile of the fabricated MTF. Inset shows the microscope image of the cleaved end of the fiber.

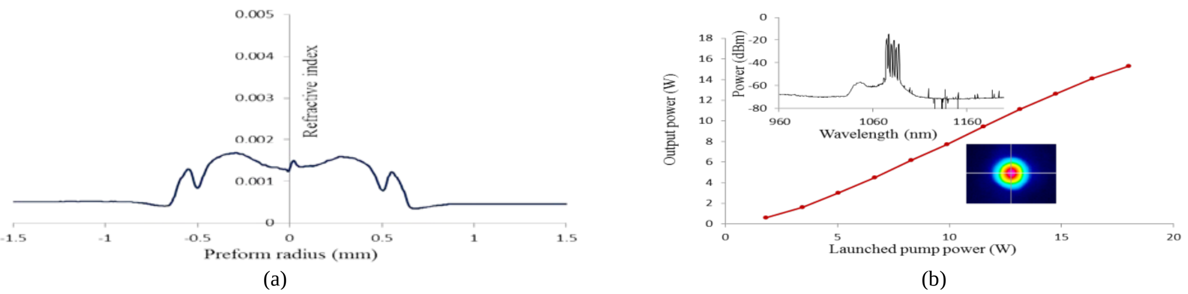


Fig. 3 (a). Refractive index profile of the fabricated Yb^{3+} and Al^{3+} doped preform. (b) Measured slope efficiency of the fabricated fiber. Inset image shows the output beam profile and inset graph shows the measured spectrum of the output beam.

References:

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