Novel Optical Fibers for Telecommunications and High-Power Laser Applications

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Abstract: This paper reviews our recent work on multi-element-fiber (MEF) technology for space-division-multiplexed transmission systems and progress towards the mode area scaling using multi-trench-fiber (MTF) design for high power applications.
Keywords [Optical Fiber, SDM, High power fiber laser, Cladding-pump amplifier]

1. Introduction

Telecommunication and high power fiber lasers have been highly focused areas of optical fiber research due to their substantial commercial scope. Exponential growth in data traffic has generated significant interest from the research community to implement space-division-multiplexing (SDM) in optical fibers [1]. Currently, the approaches to implement SDM in optical fibers have been mainly multicore fiber (MCF) or few-mode fiber (FMF) [1]. Both these approaches have shown significant potential, however, there are still limitations to these approaches, such as development of specialized multiplexing/de-multiplexing components which prevent them from practical implementation [2]. This paper reviews a novel approach of implementing SDM through multi-element-fiber (MEF), which has the potential to overcome the current limitations faced by the MCF and FMF.

In high power fiber lasers, the current challenge is to increase the effective area (A_{eff}) of the fundamental mode in fiber while ensuring a good beam quality for single-mode operation. Increasing the A_{eff} can reduce the intensity of the optical field, and thus increase the thresholds for nonlinear effects. Several fiber designs have been proposed for mode area scaling [3]. However, most of these designs are not suitable for mass production due to complex fabrication processes involved. This paper reviews the development of a novel multi-trench fiber (MTF) [4-5]. MTF has shown significant potential for mode area scaling with an additional advantage of relatively simple fabrication due to its cylindrical symmetry.

2. Multi-element Fiber (MEF)

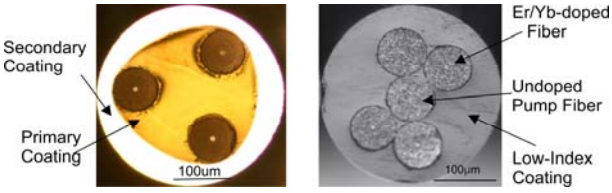

Fig.1 Image of a)passive 3-MEF, and b) active 5-MEF

In MEF, multiple fibers are drawn together in a common coating. This enables implementation of SDM in optical fibers with ultra-low crosstalk between spatial channels. This approach has been applied to develop transmission fibers as well as both core and cladding pumped amplifiers [6-9]. The transmission fiber and the cladding-pump amplifier have been tested in a SDM transmission system with an aggregate data rate of 1120Gbits/sec. Fig.1 shows the microscope images of a passive 3-element MEF and a cladding pumped 5-element Er-Yb-doped MEF.

3. Multi-Trench Fiber (MTF)

The MTF structure has a core surrounded by periodic rings of low and high refractive index in the cladding. Fig.2 shows the refractive index profile of the fabricated 30µm core MTF and its cross-section image. Numerical simulations show that MTF can achieve an A_{eff} as large as 10,500µm^2 at wavelength around 1 um in a rod-type configuration [4]. On the other hand, MTF can achieve A_{eff} ~ 800µm^2 in a bend configuration [5]. MTF offers very high suppression of higher order modes (HOMs) and can be fabricated using conventional low-loss fiber manufacturing technique, such as MCVD [10].

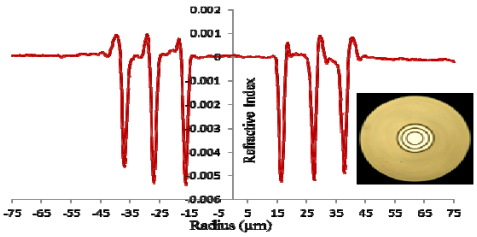

Fig.2 Refractive Index Profile of fabricated MTF. Inset shows the microscope image of fiber end.

4. References

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