# Few-Mode Erbium Doped Fiber Amplifier for Space Division Multiplexing based Optical Communication System

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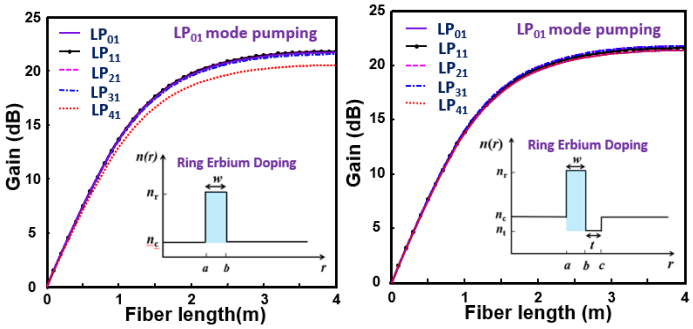
Statement of the Problem: Few mode fiber (FMF) based space division multiplexing (SDM) technology is the providential solution of capacity crunch issue [1]. To enable simultaneous amplification of different signal mode groups of FMF, it is needed to design a few-mode erbium doped fiber amplifier (FMEDFA). In course of designing FMEDFA, the real challenge is to equalize the gains of different mode groups (i.e. zero differential modal gain (DMG)) without any mode coupling.

Methodology & Theoretical Orientation: We design a trench-assisted ring-core FMEDFA. The simultaneous amplification of eighteen modes (including degeneracy and polarization) has been studied using this fiber. Transfer matrix method has been used for mode profile calculation [2]. Gains and DMGs of modes of FMEDFA have been calculated by solving coupled-mode equations of signal, pump and amplified spontaneous emission (ASE) through Runge-Kutta method [3]. DMG among the signal mode groups can be minimized by reducing the difference in pump's overlaps with different signal modes. One more factor should also be considered that sufficient effective-index spacing between signal mode groups is necessary to avoid mode coupling due to macro-bending. This can be achieved by optimizing the refractive index profile of fiber along with erbium doping profile and pumping scheme.

Findings: Ring core design of FMEDFA confines most of the power of signal mode groups in ring core and thus, reduces the difference between the pump's overlaps with different signal mode groups and aids to minimize the DMG. Further, on inserting a layer of trench just after ring core, a significant reduction of DMG from 1.32 dB (in absence of trench) to 0.45 dB (in presence of trench) is obtained along with slight increase in effective-index spacing.




Figs: 1. Gains versus fiber length in absence of trench 2. Gains versus fiber length in the presence of trench.

Conclusion & Significance: The proposed trench-assisted ring core FMEDFA, for SDM system, enables the simultaneous amplification of eighteen signal modes of $LP_{01}$, $LP_{11}$, $LP_{21}$, $LP_{31}$ and $LP_{41}$ mode groups with the gain excursion of about 1 dB.

## Recent Publications

1. **A. Gaur** and V. Rastogi "Design and Analysis of Annulus Core Few Mode EDFA for Modal Gain Equalization" IEEE Photon. Technol. Lett. 28, 1057-1060, 2016.
2. **A. Gaur** and V. Rastogi, "Design and Analysis of High-Power Segmented-Core Trench-Assisted Yb-free Erbium Doped Fiber Amplifier" Opt. Laser Technol. 95, 46-50, 2017.
3. V. Rastogi, **A. Gaur**, P. Aschieri, and B. Dussardier, "Mode group specific amplification length in an asymmetric LPG assisted few-mode EDFA" Opt. Commun., vol. 382, pp. 13-17, 2017.
4. **A. Gaur**, G. Kumar, and V. Rastogi, "Dual-core few mode EDFA for amplification of 20 modes" Opt. Quant. Electron.50, 66(1)-66(2), 2018.
5. **A. Gaur** and V. Rastogi, "Modal gain equalization of 18 modes using a single-trench ring-core EDFA" J. Opt. Soc. Am. B35, 2211-2216, 2018.

Biography

Ankita Gaur has her expertise in the designing of few-mode erbium doped fiber amplifiers. She has designed the fiber amplifiers for space division multiplexing based optical communication system and high power applications. She has completed her post-graduation and Ph.D. degrees from Indian Institute of Technology Roorkee, India. Currently, she is working as Assistant Professor in M. L. V. Textile &Engineering College, Bhilwara, India.

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## References:

1. D. J. Richardson et al., Nat. Photonics 7, 354–362 (2013).
2.K. Morishita, IEEE Trans. Microw. Theory Tech. 29, 348–352 (1981).
3.N. Bai et al., Opt. Express 19, 16601–16611 (2011).