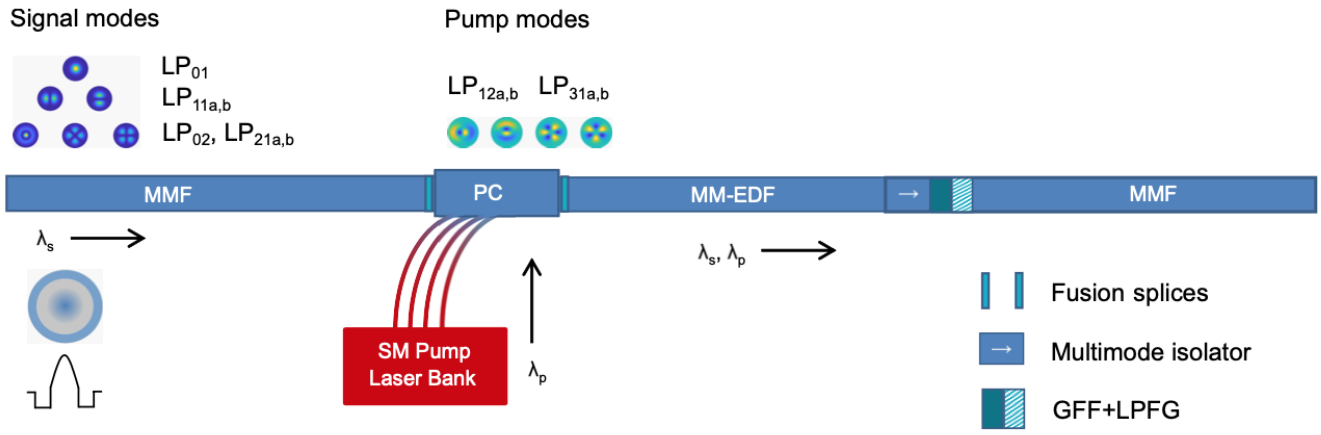
Docket #: S22-482

Efficient, Integrated Multimode Amplifiers for Scalable Spatially Multiplexed Long-haul Optical Fiber Transmission

Researchers in The Optical Communications Group at Stanford have developed an efficient, integrated multimode optical amplifier for scalable, spatially multiplexed long-haul optical fiber transmission. Cost effective and power efficient Space Division Multiplexing (SDM) scaling and integration in long-haul optical communications systems is key in supporting future demands of today's digital society. The Optical Communications Group designed multimode erbium-doped fiber amplifier (MM-EDFA) for six spatial modes (12 spatial and polarization modes) includes a graded-index (GI) multimode fiber amplifier with optimized ring erbium doping profile, length, and pump mode powers. A cascade of wavelength- and mode-selective couplers efficiently couples four pump diodes to four pump modes, while passing signal modes with minimal loss. This design uses fewer pump laser diodes per signal with lower cost, complexity, and power consumption than parallel SMF-based systems. It can deliver high-performance multimode amplification with acceptable levels of noise figure and mode-dependent gain, which may provide a path for economical, efficient scaling of SDM long-haul systems.



Integrated Multimode Amplifier Design Concept Schematic
(Image courtesy of Optical Communications Group)

Stage of Development – Proof of Concept
Research continues to extend the design to support more modes for multimode or multicore fibers.

Applications

- Long Haul Optical Network & Networking – in particular, multimode amplifier subsystems for spatially multiplexed long-haul submarine optical fiber communication systems.

Advantages

- Lower pump power consumption, with power conversion efficiency comparable to state-of-the-art single-mode optical amplifiers.
- Lower cost / complexity
  - Fewer pump laser diodes and pump couplers per spatial mode.
  - Fewer transmission fiber pairs compared to equivalent single-mode systems.
- High-performance multimode amplification, with levels of noise figure and mode-dependent gain low enough to be acceptable in long-haul systems.

Publications

- Srinivas, H., Krutko, O., & Kahn, J. M. (2023). Efficient Integrated Multimode Amplifiers for Scalable Long-Haul SDM Transmission. *Journal of Lightwave Technology*.

Patents

- Published Application: 20240195138

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