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HIGHLY-EFFICIENT HIGH POWER ALL-FIBER EYE-SAFE LASERS AND POLARISATION MAINTAINING kW-LEVEL 1μm AMPLIFIERS.

Adrian Carter, Gavin Frith, John Edgecumbe, Bryce Samson, Julia Farroni and Kanishka Tankala.

Nufern, 7 Airport Park Road, East Granby, CT 06026 USA

Email: acarter@nufern.com

Abstract: We demonstrate a novel large core diameter fiber design which facilitates the use of conventional mode selection techniques to achieve high output power, robustly single-mode laser operation in the 1.55 and 2.0μm eyesafe spectral regions. We also present recent progress in scaling the output power of narrow spectral linewidth all-fiber amplifiers into the kW domain.

1. INTRODUCTION

In this presentation we introduce the fundamental design considerations that need to be addressed when manufacturing active fibers suitable for use in monolithic fiber based lasers and amplifiers. We will discuss the various operating wavelength choices and will present a number of recent advances in the manufacture of highly efficient, large-mode area (LMA) fibers for operation in the eye-safe spectral regions of 1.55 and 2.0μm. The recent availability of these LMA doped fibers has fuelled a recent explosion in power scaling at these wavelengths, similar to that already witnessed at 1.06μm.

2. EXPERIMENT AND RESULTS

The inherent difficulties associated with manufacturing fibers containing the relatively high lanthanide ion dopant concentrations required for high optical-efficiency whilst maintaining a low core NA has meant that the development of LMA fibers has largely been restricted to ytterbium fibers for use at around 1.06μm. In spite of the numerous advantages, a significant drawback of the Yb based system is the relatively high sensitivity of the human eye to such wavelengths. Consequently for certain applications, such as ranging, pollution monitoring, clear-air turbulence analysis and free-space communications, operating in the "eye-safe" 1.55 or 2.0μm region is preferred.

2.1. Erbium/ytterbium-codoped fiber

We have found that by incorporating a pedestal feature between the core and cladding of a conventional polarization maintaining (PM) Er/Yb double clad fiber it is possible to create an LMA-like structure and thereby increase the non-linear threshold and achieve the pulse energies, peak powers, efficiency and beam quality suitable for many "eye-safe" coherent monitoring systems.

2.2 Thulium-doped fiber devices

Achieving efficient operation from 790nm-pumped Tm-doped fibers at wavelengths shorter than 1.95μm requires careful attention to fibre and device design. Similarly lasing at wavelengths beyond 2.08μm involves overcoming the reduced gain and intrinsic optical losses of the host silica. We present a highly efficient MOPA producing 70W at 1.908μm with 53% slope efficiency from the PA stage. We also demonstrate that highly efficient operation is possible at lasing wavelengths lasing as high as 2.13μm.

2.3 Narrow linewidth kW-domain amplifiers

All-fiber amplifiers with single mode beam quality, linearly-polarized output and compatibility with narrow linewidth seed sources represent a promising technology as building blocks for power scaling to the 100kW level through various coherent and spectral beam combining schemes [1,2]. We demonstrate a monolithic fiber amplifier that delivers an output power of 860W (pump limited) at ~85% slope efficiency and a PM-LMA monolithic fiber amplifier that delivers 750W output power with single mode beam quality and excellent PER. We characterize the system with seed sources of ~0.4nm spectral width and see no signs of spectral broadening or SRS from the fiber amplifier at these power levels.

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