High energy, narrow linewidth 1572nm ErYb-fiber based MOPA for a multi-aperture CO_2 trace-gas laser space transmitter

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There is significant interest in narrow linewidth 1572nm laser transmitters for atmospheric CO_2 remote sensing. NASA is maturing the technology readiness of a high energy 1572.3nm laser transmitter to TRL-6. NASA has successfully demonstrated the 1572nm fiber laser approach to a CO_2 lidar system in an airborne platform. A higher energy version of the transmitter is required for a space-based satellite measurement system with global coverage. The transmitter needs to provide 2.5mJ pulse energy, 20W average power and near transform limited linewidth (1--100MHz). The operational power level includes a desired 20% power derating. Spatial resolution of the LIDAR system can tolerate pulse widths less than ~1.0µsec which specifies peak power requirement over ~2.5kW.

Erbium doped fiber amplifier (EDFA) technology is well suited for supporting amplification at 1572.3nm, and is built with highly reliable optical components, some of which have 20 years of reliability heritage from the commercial telecommunications industry. However, stimulated Brillouin scattering (SBS) in fiber amplifiers is a major obstacle for achieving >0.2kW peak output power with narrow linewidth. In order to reduce the peak power requirements of the EDFA, a multi-aperture laser transmitter architecture is envisioned with each aperture outputting near diffraction limited beam quality (M^2<1.5). Multi-aperture architecture increases reliability of the system with the possibility of redundant apertures, at the some expense to the system size, weight and complexity. An optimum number of apertures is envisioned to be 4-8 apertures.

Fibertek has been developing a cladding pumped erbium-ytterbium (ErYb) based 1572.3nm power amplifier for demonstrating the technology readiness of the laser transmitter. An ErYb based power amplifier using highly efficient and reliable 976nm multimode pumps is the most reliable EDFA technology for achieving the needed high average powers. Maximum reported peak powers to date have been limited to 0.2kW for narrow linewidth operation (<10MHz), due to the high core NA and substantial fiber lengths needed for cladding pumping. Here, a cladding pumped polarization maintaining (PM) ErYb fiber based power amplifier optimized for high energy and high efficiency operation at 1572.3nm is presented. The power amplifier is seeded with a 4-10µJ transmitter that employs precise linewidth, pulse shaping and polarization control, which are required for optimal SBS suppression. Using COTS PM ErYb fiber, the power amplifier has been demonstrated to achieved 0.44kW peak power (440µJ pulse energy) and 3.3W average power with transform limited linewidth (<10MHz). A 50% increase in pulse energy has been demonstrated when the linewidth is increased to 100MHz and when pulse width is increased from 1µsec to 1.5µsec while keeping transform limited linewidth. Optical-optical efficiency is 11-14%.

A custom double clad ErYb LMA fiber has been designed and fabricated with slightly larger core and smaller clad sizes which is expected to support x2 the energies produced by the

COTS LMA fibers. The fiber is fabricated with recently developed highly efficient ErYb core doping concentrations. This includes a higher Er-doping levels which is expected to be especially favorable for efficient 1572nm amplification. Presentation will include measured performance of the novel ErYb fiber. Taking advantage of linewidth, pulse width, and novel ErYb fiber design, cladding pumped ErYb technology is expected to be able to support ~0.8mJ/pulse and present a reliable EDFA technology for the atmospheric CO_2 LIDAR transmitter.