Program Title: "Efficient in-band diode-pumped Q-switched SSL for methane detection"
Contract No.: NNX13CG05C
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Identification and Significance of Innovation: Growing interest in precise measurements of methane concentration and distribution in the Earth's atmosphere is stimulating efforts to develop LIDAR systems in the spectral region of 1.65 μm utilizing Path Differential Absorption techniques. The key element of such systems is a tunable high energy optical source with good beam properties operating in the vicinity of a methane absorption line. During this SBIR program, we developed a novel laser source meeting these system needs using in-band pumping Q-switched solid state lasers (SSLs) based on Er-doped active media as a optical source. The in-band pumping of SSLs allows for shifting a significant portion of the system thermal load from the gain medium to the pump diodes, thus greatly reducing gain medium thermal distortions deleterious to SSL power scaling with high beam quality.

Technical Objectives and Work Plan: The high-level goal of this program was to develop a tunable Q-switched SSL operating at 1651 nm which provides >1 mJ pulse energy at 2 kHz repetition rate. Two major objectives were defined: (1) developing an efficient and robust gain block for SSL laser with in band diode pumping, and (2) developing an effective injection-seeded Q-switch SSL at 1651 nm.

Technical Accomplishments: In framework of this SBIR program, we developed an injection-seeded Q-switched SSL for methane detection. Our program deliverables included a tunable Q-switched SSL and pumping system. During this program, we developed a robust gain block with in-band laser diode pumping and optimized properties for the active media. Building on this gain block, we developed a high-performance injection-seeded Q-switched SSL at 1651nm providing >1 mJ at 2000 Hz repetition rate. Our program results demonstrated the ability of this new laser source to meet the following performance attributes: (i) >350 μJ pulse energy at 10 kHz repetition rate (>1.5 mJ at 2 kHz); (ii) excellent beam quality with $M^2 \sim 1.03$ at high pulse energy operation; (iii) tuning by external seed in the wavelength range from 1650 nm to 1651 nm; and (iv) the potential for extending the tuning range to longer wavelengths of at least 1651.4 nm.

NASA Applications: The high-pulse-energy solid state laser (SSL) with Er-doped active media developed in this program will be crucial for LIDAR instruments intended for the measurement of methane in the Earth's atmosphere. This laser technology will also potentially provide new capabilities for measurements of other atmospheric constituents and the surface topography of the Earth and other planetary bodies anticipated for numerous NASA mission programs. This laser will serve as an ideal source for LIDAR systems in the wavelength range near 1.65 μm and for active remote sensing optical instruments in general.

Non-NASA Commercial Applications: In commercial markets, there are a number of potential applications that will benefit from high-energy pulsed Er-doped SSLs. The detection of methane and other hydrocarbon gases is of critical importance in the energy industry, and the laser source developed for NASA systems will have direct relevance for related commercial requirements. As with NASA remote sensing applications, there are commercial applications for improved high energy SSLs in various types of LIDAR systems for measuring atmospheric properties such as wind and weather patterns, air pollution, and general trace gas analysis. High pulse energy laser sources are key elements of all range-finding and LADAR systems and critically impact end system performance. The SSL laser technology developed in this program will serve broad applications in the bio-medical arena, with examples such as nerve stimulation and dentistry.