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Development of Solid-State Laser Radars at 1 and 2 μm

Kin Pui Chan and Dennis K. Killinger
University of South Florida
Department of Physics
Tampa, FL 33620
U. S. A.

Abstract: We review some of our recent work regarding the development of a 1 μm Nd:YAG coherent Doppler lidar and a 2 μm Ho direct-detection lidar/DIAL. Experimental results of the 1 and 2 μm lidar measurements and the atmospheric turbulence effect on the performance of these short wavelength lidars will be presented.

I. Introduction

In recent years, there has been significant progress in the development of compact and tunable solid-state lasers at 1-3 μm. These solid-state laser sources are being actively investigated for the use as efficient and long-lived optical sources in a wide variety of laser remote sensing applications. We have recently developed a 1 μm Nd:YAG coherent Doppler lidar and a direct-detection 2.1 μm Ho lidar/DIAL in order to study the potential usage of such solid-state lasers for atmospheric and distributed target lidar measurements. In this paper, we review some of our recent work regarding these two lidar systems.

II. 1 GHz Bandwidth Nd:YAG Coherent Doppler Lidar

Our short pulse (8 ns) 1 μm Nd:YAG coherent Doppler lidar[1] used a single frequency, injection seeded, Q-switched Nd:YAG laser as transmitter and a tunable, single frequency cw Nd:YAG laser as local oscillator. This 1 GHz bandwidth coherent lidar has been developed for 1 m range-resolved Doppler measurements of high velocity (1 km/s) aerosols or distributed targets. We have also employed this lidar system to study the atmospheric turbulence effect on heterodyne lidar detection, and measured that for a 1 μm coherent lidar operating near the ground, atmospheric turbulence-induced signal coherence loss may significantly reduce the heterodyne lidar detection efficiency. This reduction, however, can be improved by using a 2-dimensional multi-element heterodyne detector array, as predicted in our Monte carlo computer simulation,[3] and experimentally demonstrated in our recent lidar measurements.[4]

III. Eye-Safe 2.1 μm Ho Atmospheric Lidar/DIAL

We have also studied the use of a 2.1 μm Ho laser for lidar/DIAL measurements. The Ho laser is considered to be potentially well suited for these remote sensing applications, since it is eye-safe (wavelength > 1.4 μm), offers wide tunability, and can be pumped by laser diodes. In our Ho lidar measurement using a 20 mJ/pulse, Q-switched Ho:YSGG laser, we demonstrated that the Ho lidar has the potential to measure aerosol backscatter profiles out to a range of several kilometers.[5] Recently, we have tuned the wavelength of the Q-switched Ho laser over a 80 nm spectral range, through the use of intracavity etalons in the laser cavity, and applied this tunable 2.1 μm Ho laser for simultaneous range-resolved measurements of atmospheric water vapor and aerosol backscatterd profiles.[6]

References:

1. K. P. Chan and D. K. Killinger, "Short pulse coherent Doppler Nd:YAG lidar," Opt. Engr. 30, 49-54 (1991).
2. K. P. Chan, D. K. Killinger, and N. Sugimoto, "Heterodyne Doppler 1 μm lidar measurement of reduced effective telescope aperture due to atmospheric turbulence,"Appl. Opt. 30 (April 20,1991).
3. N. Sugimoto, K. P. Chan, and D. K. Killinger, "Optimal heterodyne detector array size for 1 μm coherent lidar propagation through atmospheric turbulence," Appl. Opt. 30 (April 20,1991).
4. K. P. Chan and D. K. Killinger, "Enhanced Detection of atmospheric turbulence distorted 1 μm coherent lidar returns using a 2-D heterodyne detector array," submitted to Opt. Lett.(1991).
5. N. Sugimoto, N. Sims, K. P. Chan, and D. K. Killinger, "Eye-safe 2.1 μm Ho lidar for measuring atmospheric density profiles," Opt. Lett. 15, 302-304 (1990).
6. S. Cha, K. P. Chan, and D. K. Killinger, "Tunable 2.1 μm Ho lidar for simultaneous range-resolved measurements of atmospheric water vapor and aerosol backscatter profiles," to be published in Appl. Opt. (1991).