26B3

ALL SOLID-STATE LASER SYSTEM FOR AIRBORNE WATER VAPOR CONCENTRATION MEASUREMENTS IN THE STRATOSPHERE USING THE DIAL TECHNIQUE IN THE NEAR INFRARED

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Introduction

Recent measurements have demonstrated the potential of airborne lidar systems for the determination of two dimensional distribution of water vapor with high spatial resolution (Ehret et al, 1993). It is well known, water vapor has strong influence on the evolution of weather and climate. Moist processes in the troposphere play a mayor role in the climate system by regulating atmospheric circulation and temperature as well as the availability of sunshine and water surface. Even in very dry regions in the lower stratosphere, water vapor influences the formation of Polar Stratospheric Clouds (PSCs) and is strongly involved in cloud micro physics and air chemistry processes.

Stratospheric water vapor can be measured with the differential absorption lidar technique applied in the near infrared at 935 nm. However, the determination of water vapor concentration requires the utilisation of a pulsed laser transmitter possessing specific centre wavelengths for the on- and off- line measurements. Additionally, a very small nearly transform limited laser bandwidth, frequency stable output over the DIAL measurement period, and a very high spectral purity are laser parameters necessary to minimize errors in the calculation of water vapor content. A small volume, lightweight, robust and efficient package possessing minimal electrical requirements and a long service- free lifetime are further attributes for such a laser system especially for airborne applications. In this presentation a specific design based on the master-slave laser technique (Fig. 1) which has been developed to meet this demands will be described. We note that the whole DIAL system will have polarization sensitive detection, too and thus will be capable of distinguishing between aerosols and PSCs in the stratosphere.

Laser Systems

The pulsed slave laser of the DIAL laser shown in Fig. 2 is based on Titanium doped Sapphire and is constructed in a ring format. When the ring laser oscillates unidirectionally then spatial hole burning will be eliminated and the oscillator will be defacto single longitudinal mode. The frequency at which the slave laser oscillates is provided by injection seeding of the master laser. The pulse width of the slave laser which is a function of the slave resonator length as well as the pump energy above threshold, since this slave is operated in a gain switched regime, will determine the bandwidth of the slave. To achieve the required spectral purity of the slave pulse may require coarse bandwidth limiting devices in the slave resonator.

The master laser could be one of several possibilities, but at the moment the only material which cover the wavelength ranges that we require is also Titanium Sapphire. This cw laser must be pumped by a diode pumped frequency doubled Nd:YAG laser with sufficient power to produce output at the seed wavelength which happens to be the operation wavelength. The availability of a suitable pump laser and a reduction in the size of the cw oscillator are the barriers to adopting this laser as the master laser. Another vital point to be solved is the speed and repeatability of tuning of the cw laser with its subsequent frequency locking, if one laser is used, or the adoption of two lasers.

The whole laser system is proposed with two master lasers where the outputs of both are combined on a polarizing beamsplitter, if the respective polarizations of the on- and off-line measurements are not important. Two separate pump heads are used to gain switch the slave resonator, with a timing separation which is adjustable to the particular application.

Reference

G. Ehret, C. Kiemle, W. Renger, and G. Simmet, "Airborne remote sensing of tropospheric water vapor with a near-infrared differential absorption lidar system", App. Opt. Vol. 32, No. 24, 4534-4551 (1993)

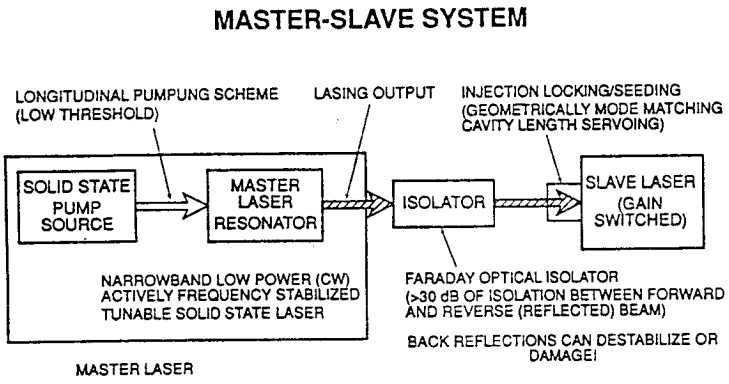

Fig. 1 Master-Slave system

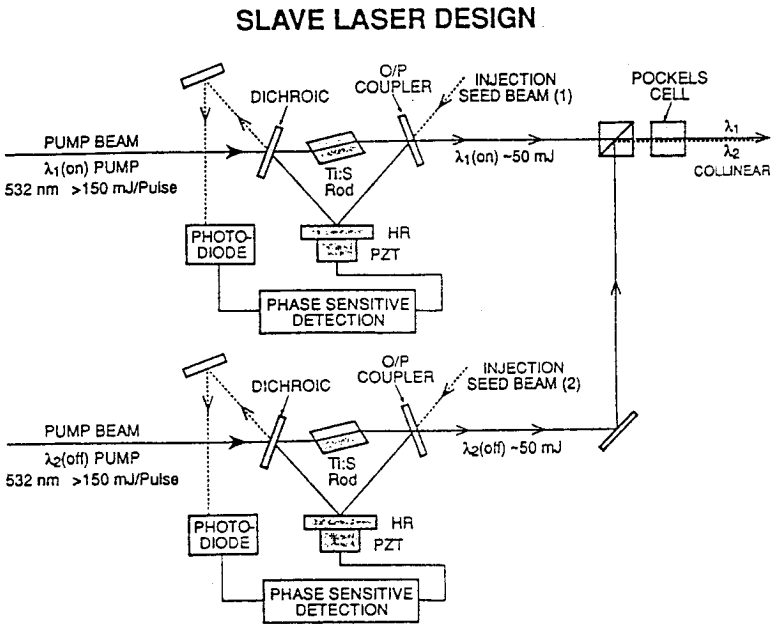

Fig. 2 DIAL laser system