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THREE DIMENSIONAL IMAGING AT 10 KM USING A DIODE PUMPED SOLID STATE LADAR

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INTRODUCTION

The Laser Radar Research Facility at Wright Laboratory is involved in the research and development of laser radar for three dimensional imaging applications. Since 1985 their efforts have focused on both direct diode LADAR and diode pumped solid state LADAR. Early work was directed at obtaining laser radars that would operate at ranges up to 2 km. In the last year it has become possible to consider even longer ranges, a consideration made possible by recent advances in solid state laser technology. This paper discusses recent advances in diode pumped solid state lasers that provide the opportunity to obtain three dimensional laser radar imagery at a range of 10 km. In addition, the results of a 10 km imaging test will be presented.

BACKGROUND

Efforts at the Laser Radar Research Facility focus on technologies that can be inserted into LADAR systems to improve their overall performance. The technologies being investigated for the long range three dimensional imaging application include high power diodes, various host materials, coupling techniques and cavity configurations. The overall goal is to develop a diode pumped solid state (DPSS) laser radar system with a high frame rate, long range, and good resolution for accurate three dimensional imaging. The initial goals for this LADAR system are shown below in Table 1.

Peak Power	30 KW
Pulse Repetition Frequency	40 KHz
Pulse Width	8-10 nsec
Mode	TEM_{00}

Table 1 Initial Design Goals for DPSS Laser

Recent advances in semiconductor diode laser research have yielded higher power diode pumps. Additionally, more efficient cavity designs for diode pumped solid state lasers are continuously being developed. These advances point the way to higher power LADAR systems. By incorporating some of these technological advances into our LADAR design we have been able to achieve all but one of the goals shown in Table 1 using a DPSS laser. One of the challenges remaining is keeping the power up at high pulse repetition frequencies.

The higher powers obviously improve the range performance and is what led us to the 10 km imaging demonstration. Indirectly, however, it also improves the weather performance (a significant deterrent to laser systems). The more power a given laser has the more weather it will be able to penetrate.

DISCUSSION

Continuous wave diode laser arrays for pumping are available commercially in the 10 to 20 watt range. The challenge is coupling a number of these diodes into the active medium without damaging the medium due to thermal loading. At the Laser Radar Research Facility several materials and cavity configurations have been investigated to determine the optimum configuration and pump power. The materials experimented with include Nd:YAG, Nd:YLF, and Nd:YVO_4.

Our initial research efforts produced an end pumped Nd:YVO_4 LADAR imaging system. This system is a fully functional flight capable imaging LADAR. The laser in this system used a 10 watt pump and demonstrated peak energies exceeding 100 μJ, pulse repetition frequencies above 30 kHz, and pulse widths less than 20 ns. This system produced high resolution three dimensional laser radar images at ranges exceeding 2 km.

Figures 1 and 2 illustrate the performance of Nd:YVO_4 at high pulse repetition frequencies. The curves show performance for both 10 and 15 watt diode pumps. This does demonstrate the high PRF goal however, the peak power at these high PRFs does not reach the desired goal. Note also in Figure 2 that the pulse width exceeds our desired goal at the high PRF.

Figure 1. Nd:YVO4 Q-Switched Laser, PRF vs Pulse Energy [1]

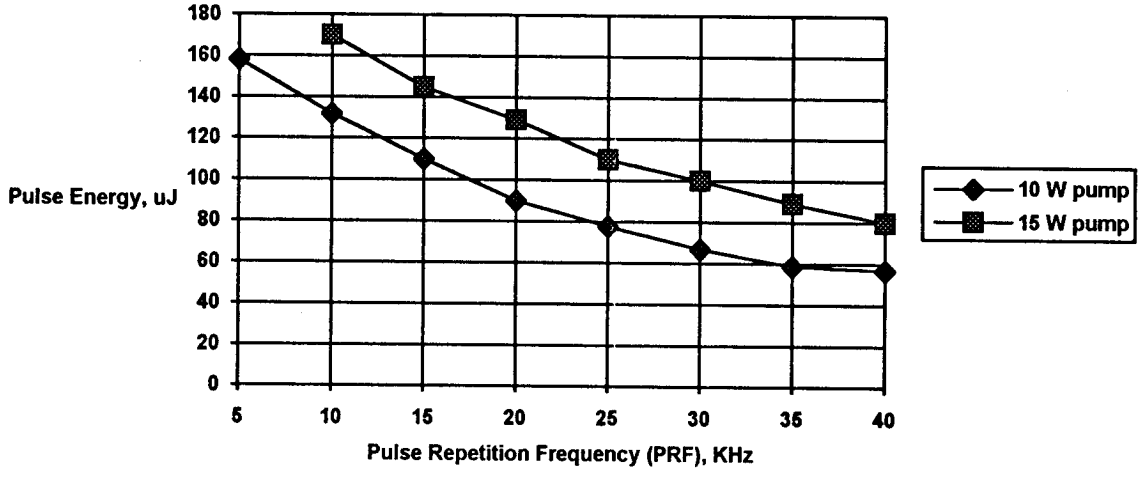
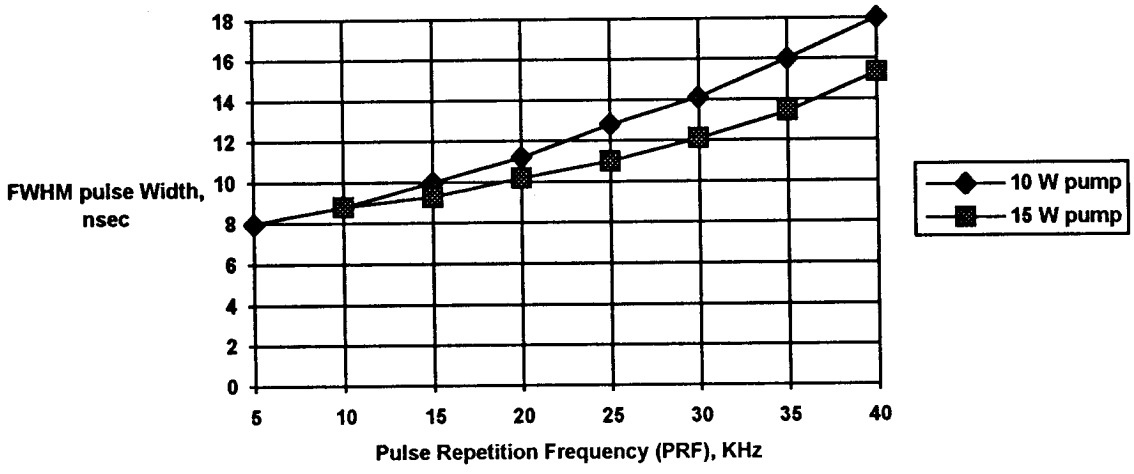


Figure 2. Nd:YVO4 Q-Switched Laser, PRF vs Pulse Width Data [1]



More recently pulse energies of 500 mJ have been obtained using a diode pumped Nd:YLF in a tightly folded resonator (TFR) cavity design [1]. This pulse energy has made possible a long range imaging capability for a DPSS system. Our long range imaging goal was to demonstrate a 10 km imaging capability using the TFR design. To achieve this goal we divided our efforts into two phases. The first phase was to demonstrate the 10 km imaging capability using a Nd:YLF TFR laser commercially available from Spectra Physics. This laser was integrated into a breadboard imaging LADAR system and tested on a 300 foot tower. During this test a variety of targets were imaged at ranges between 2 and 10 km. Images collected during this test will be presented at the conference. The second phase of the test is to develop and integrate a high power laser into the flight worthy imaging LADAR system discussed previously. This system will then be tested to demonstrate a 10 km three dimensional imaging capability in a captive flight test.

[1] Hutchinson, S.B. et. all "Advances of 3-10 watt Average Power Diode Pumped Lasers", Proceedings from O/E Aerospace Sensing, 12 April 93, Oralndo FL