# ONE MICRON LASER TECHNOLOGY ADVANCEMENTS AT GSFC

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In recent years, lasers have proven themselves to be invaluable to a variety of remote sensing applications. LIDAR techniques have been used to measure atmospheric aerosols and a variety of trace species, profile winds, and develop high resolution topographical maps. Often it would be of great advantage to make these measurements from an orbiting satellite. Unfortunately, the space environment is a challenging one for the high power lasers that would enable many LIDAR missions. Optical mounts must maintain precision alignment during and after launch. Outgassing materials in the vacuum of space lead to contamination of laser optics. Electronic components and optical materials must survive the space environment, including a vacuum atmosphere, thermal cycling, and radiation exposure. Laser designs must be lightweight, compact, and energy efficient. Many LIDAR applications require frequency conversion systems that have never been designed or tested for use in space. For the last seven or eight years the National Aeronautical and Space Administration (NASA) has undertaken a program specifically directed at addressing the durability and long term reliability issues that face space-borne lasers (The Laser Risk Reduction Program-LRRP).

When the LRRP was first being proposed, a survey of desired spacebased LIDAR missions was conducted. It was determined that there were six categories of measurements of high priority to earth science: coherent wind detection, noncoherent wind detection, coherent detection of river/ocean surface currents, altimetry/bathymetry, and range resolved measurements of ozone and carbondioxide using the differential absorption technique. It was decided that all six of these measurements could be enabled by the development of two primary laser systems operating at 1.0 micron and 2.0 micron. These would then be combined with a limited number of frequency conversion methods. **The effort was shared between NASA Goddard Space Flight Center in Greenbelt, Maryland, and NASA Langley Research Center in Hampton, Virginia with Goddard concentrating on 1 micron lasers and Langley on 2 micron.**

The fundamental goal is to develop knowledge about building space qualified lasers. To achieve this, we designed, and built testbed lasers which were then be subjected to rigorous environmental testing required for space qualification. Although future LIDAR missions may not use the exact architectures produced under this program, we have developed the baseline knowledge of how to design and build successful spaceborne laser systems. For both laser systems under development it was decided to target 1.0 Joule/pulse output energy. Some of the desired measurements require substantially less energy per pulse, but may require high repetition rates. Rather than spread resources too thin it was decided to focus on the high energy per pulse system, which was regarded as the more challenging problem to solve.

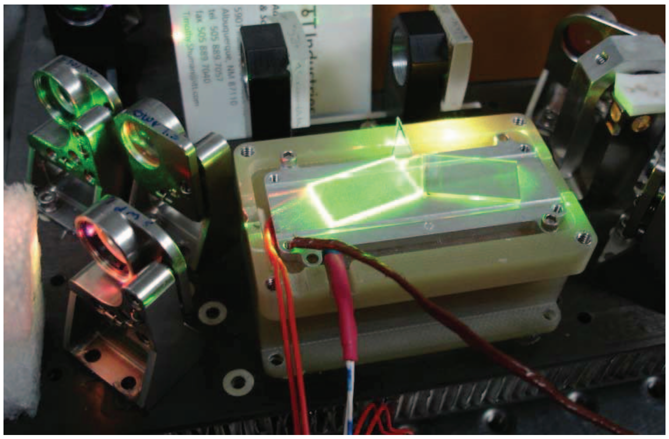

**Figure 1. This OPO developed under the LRRP converts 1.0 micron light to 1.55 microns suitable for CO2 measurement.**

A number of issues were already known to be major factors in the reliability of space based lasers. Many of these issues center around reliability of materials or manufactured products. Others are related to processes and handling during the build, test, and integration of instruments.

One of the most important reliability efforts was the evaluation of high power laser diode arrays used as the laser pump source. Since the 1.0 and 2.0 micron lasers each require different pump wavelengths and are designed to operate under substantially different conditions, both GSFC and LaRC set up diode test and evaluation facilities.

Contamination is another of the leading concerns related to space flight lasers. This is because the resulting damage is so catastrophic and widespread. Under the LRRP we conducted a number of tests to evaluate contamination potential of commonly used laser materials. The goal was to develop a database of laser induced damage thresholds for as many relevant compounds as possible

This paper is an overview of these issues plus more facing space-borne lasers, the goals that Goddard has been pursuing to address them, and some of our more significant achievements over the course of the LRRP.

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