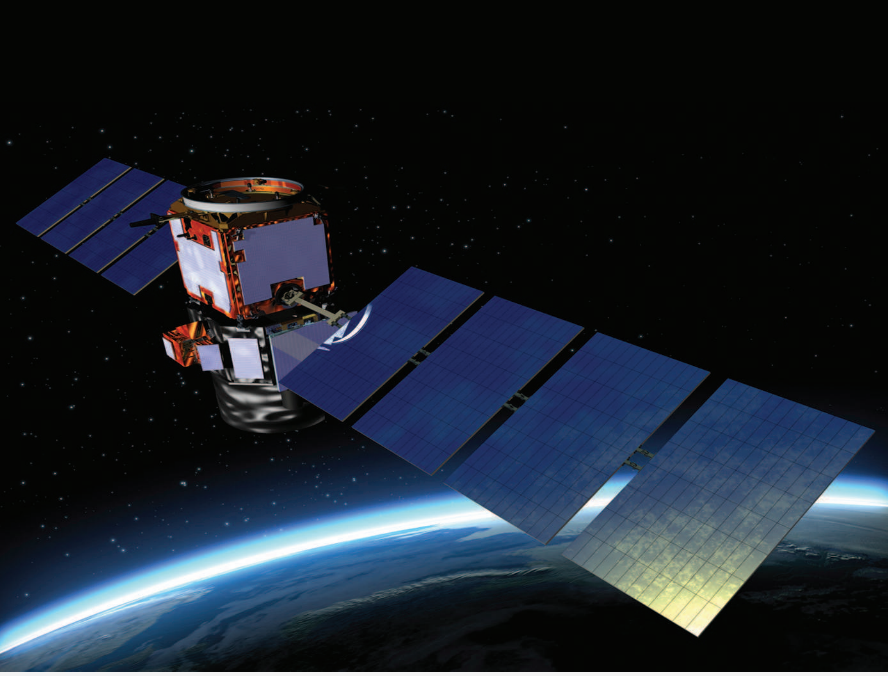


National Aeronautics and Space Administration

Optics

Thin-Film Evaporative Cooling for Side-Pumped Lasers

Highly efficient and uniform cooling for improved monochromaticity and optical efficiency

NASA's Langley Research Center has developed a highly efficient way to cool solid state crystal lasers. This patent pending thin-film evaporative cooling technique offers higher optical efficiencies and monochromatic quality than traditional conductive cooling techniques. NASA has developed this technology for use in side-pumped 2.0-micron laser systems used in light detection and ranging (LIDAR) instruments. This thin-film cooling design concept also has broad utility for diode-pumped solid state laser systems, especially those with high heat flux or challenging packaging requirements.

BENEFITS

- Continuous, highly effective cooling of solid state laser crystals, preventing thermally induced damage and stress
- Lower solid state laser temperatures, resulting in increased laser optical efficiencies
- Uniform angular cooling of the laser, allowing improved monochromatic output
- Useful for a wide variety of diode-pumped solid state lasers (DPSSL)

APPLICATIONS

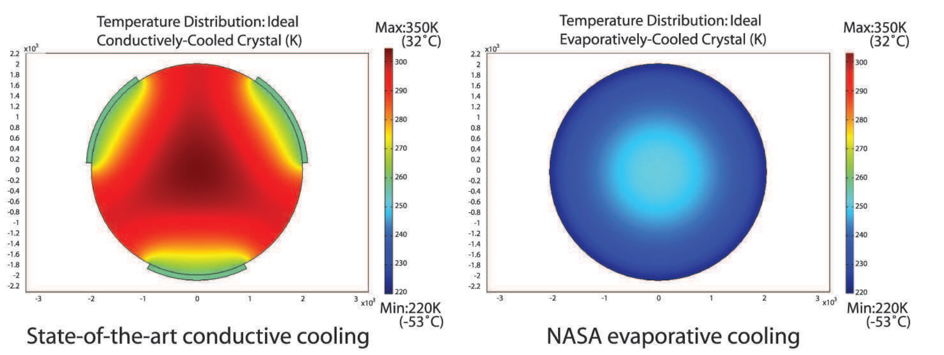
- Aerospace - advanced LIDAR systems for earth sciences and weather satellites
- Industrial - DPSSL material processing - welding, cutting, marking
- Test and measurement - spectroscopy

technology solution

THE TECHNOLOGY

The novel NASA technology was developed to improve upon current water- and ammonia-based conductive cooling systems for optically pumped solid state laser crystals. NASA is developing 2.0-micron LIDAR lasers, which employ solid state laser crystal rods that are optically pumped from the sides using diode lasers positioned around the circumference of the crystal. Optically pumping the crystal creates a high heat flux within the crystal. Current conductive cooling of these pumped crystal lasers is inadequate to uniformly address the generated heat flux, which can result in poor optical performance and even thermal damage to the crystal. Water cooling can uniformly cool the laser crystal but provides only room-temperature cooling, which results in poor optical output efficiencies in the laser. Ammonia-based coolants offer a much lower cooling temperature but do not provide uniform cooling throughout the laser crystals, which results in uneven cooling within the crystal. This lack of uniform cooling results in reduced monochromatic output of the laser light. In addition, water and ammonia cooling approaches add packaging complexity.

The NASA patent-pending design includes a transparent cylindrical housing that surrounds the solid state crystal rod, creating an annular gap along the length of the rod (Figure 1). A suitable, common cooling fluid is injected into the gap so that the coolant liquid wets the rods surface in a thin film layer. This thin film is critical to ensure that the cooling fluid does not boil, but instead undergoes a controlled evaporative phase change from liquid to gas. With sufficient space between the thin film cooling layer and the transparent housing, the coolant can continuously evaporate into the space without boiling and provide highly efficient cooling along the length of the rod and across its radial profile. The resulting cooling is more uniform and efficient than conductive cooling approaches, and the DPSSL packaging is simplified. Modeling the effects of evaporative cooling (as shown below) indicates that the NASA technique is significantly more uniform and enables higher optical output than traditional cooling methods.



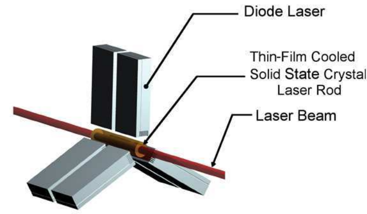


FIGURE 1 - Modeled thermal profile of solid state crystal laser

PUBLICATIONS

Patent No: 7,760,778

More Information

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