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14. ABSTRACT

Equipment listed in the report was purchased under the Department of Defense University Research Instrumentation Program (DURIP)

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diode laser spectroscopy

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Final Technical Report

Next-Generation Diode Lasers for Wavelength-Multiplexed Propulsion Sensors

AFOSR Grant F49620-01-1-0229

Prepared for

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

For the Period

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Submitted by

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Next-Generation Diode Lasers for Wavelength-Multiplexed Propulsion Sensors

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EQUIPMENT ACQUIRED

Table 1 lists the equipment purchased by the DURIP Grant, Next-Generation Diode Lasers for Wavelength-Multiplexed Propulsion Sensors, AFOSR Grant F49620-01-1-0229 and matching funds from Stanford University Cost Sharing Accounts. This contract initially coverd the period 03/15/01 to 03/14/02, but was extended to end on 09/14/02.

RESEARCH SUMMARY

The application of laser-based diagnostics to reacting flows has enabled extraordinary advances in our understanding of advanced propulsion concepts and engine design during the past two decades. Modern propulsion facilities are now commonly equipped with laser-based test equipment for flow visualization, spray characterization, and planar laser-induced fluorescence measurements of temperature, fuel mixing, and combustion intermediate species.

The development of inexpensive, rugged, solid-state laser sources by the telecommunications industry has led to a new revolution in practical and portable sensors for high-speed reacting flows. Simultaneous multi-parameter measurements using diode laser-based sensors now offer prospects for real-time combustion control. This equipment grant provides equipment to enable research to develop the next generation of diode laser sensors, which we envision will use diode lasers with wavelengths that are outside the telecommunications bands to enable detection of important combustion species such as: CO, NO, and hydrocarbon fuels.

This equipment grant was focused on three areas: novel new quantum cascade lasers operating in the mid-infrared, addition of fuel-measurement channels to an existing wavelength-multiplexed near-infrared diode laser sensor, and novel high-speed wavelength-tuning techniques to enable more robust near-infrared measurements in harsh environments. The equipment list in Table 1 shows the distribution of expenses in the three focus areas.

This new equipment will expand the range of our current studies, as previous experiments in our laboratory were unable to measure propane fuel or NO. Using this equipment, researchers at Stanford will be able to investigate the background spectroscopy needed to develop and apply such sensors to combustion and propulsion flows. We have already chosen scanned- and fixed-wavelength strategies for propane detection and recently completed a proof-of-concept demonstration of a diode laser sensor for propane filling of laboratory combustors (including a pulse detonation engine) using equipment provided by this grant. The new lasers for NO have arrived and initial spectroscopic and flame demonstration measurements are underway. The new CW Nd:YAG has been used to repetitively and rapidly heat a standard DFB laser for fast wavelength scanning applications.

TABLE 1: Next-Generation Diode Lasers for Wavelength-Multiplexed Propulsion Sensors

Item	*Supplier*	*Cost ($)*
Quantum Cascade Laser Sensor		
Lasers for NO detection near 5.2 μm, plus pulser, housing, and temperature controler	Alpes Laser	34,153
High Modulation Frequency Laser Mount, with TC cooler and collimation optic	PSI Corp	8,660
Multipass cell for sensitive detection of optical absorption	Scienza, Inc	7,048
Multi-Channel Diode Laser Sensor		
Temperature controlled laser mounts for 6 laser sensor	ILX Lightwave	9,156
Current and temperature controller for multi-channel laser sensor	ILX Lightwave	11,638
Diode lasers custom made at 1.68μm to detect propane fuel	Laser Components	10,914
High-Speed Wavelength Tuning		
High-power, CW Nd:YAG for rapid diode laser tuning	Coherent	53,630
High-speed pulsed power supply for rapid modulation of diode lasers	Agilent	6,260
Retrofit pulsed laser	Lambda Physics	26,129
Miscellaneous optics	Thorlabs, Iolon, etc	212
TOTAL		**$167,800**