Session VIII. Airborne LIDAR

N91-24143

Status of 2 Micron Laser Technology Program
Mark Storm, NASA Langley

STX
ST SYSTEMS CORPORATION
28 RESEARCH DRIVE, HAMPTON, VIRGINIA 23666 • (804) 865-3274

October 17, 1990

Status of 2 Micron Laser Technology Program

Mark Storm*, ST Systems Corporation (STX)
28 Research Drive
Hampton, Virginia 23666

This paper describes the status of 2 micron lasers for windshear detection. Theoretical atmospheric and instrument system studies by Russell Tang and Rowland Bowles have demonstrated that the 2.1 micron Ho:YAG lasers can effectively measure windspeeds in both wet and dry conditions with accuracies of 1 m/sec. Two microns laser transmitter technology looks very promising in the near future but several technical questions remain. Ho:YAG laser would be small compact and efficient requiring little or no maintenance. Since the Ho:YAG laser is diode laser pumped and has no moving part, the lifetime of this laser should be directly related to the diode laser lifetimes which can perform in excess of 10,000 hours. Ho:YAG efficiencies of 3-12% are expected but laser demonstrations confirming the ability to Q-switch this laser are required. Coherent laser operation has been demonstrated for both CW and Q-switched lasers.

Status of 2-Micron Laser Technology Program

Presented to the:

Third Combined Manufacturers' and Technologists'
Airborne Wind Shear Review Meeting, Hampton, Va.

October 17, 1990

Mark E. Storm
STX/NASA Langley

OUTLINE

1.0 Introduction
- -Requirements for Coherent Lidar
- -Laser approach

2.0 Single-Frequency Ho:Tm:YAG
- -Laser performance
- -Frequency Tuning
- -Heterodyne detection

3.0 2-micron laser issues:
- -Efficiency Considerations
- -Crystal Spectroscopy

4.0 Injection Seeding Experiment
- -Coherent Technology Results

5.0 Summary and Prospects for a Windshear Transmitter.

Laser Requirements for a Windshear Transmitter

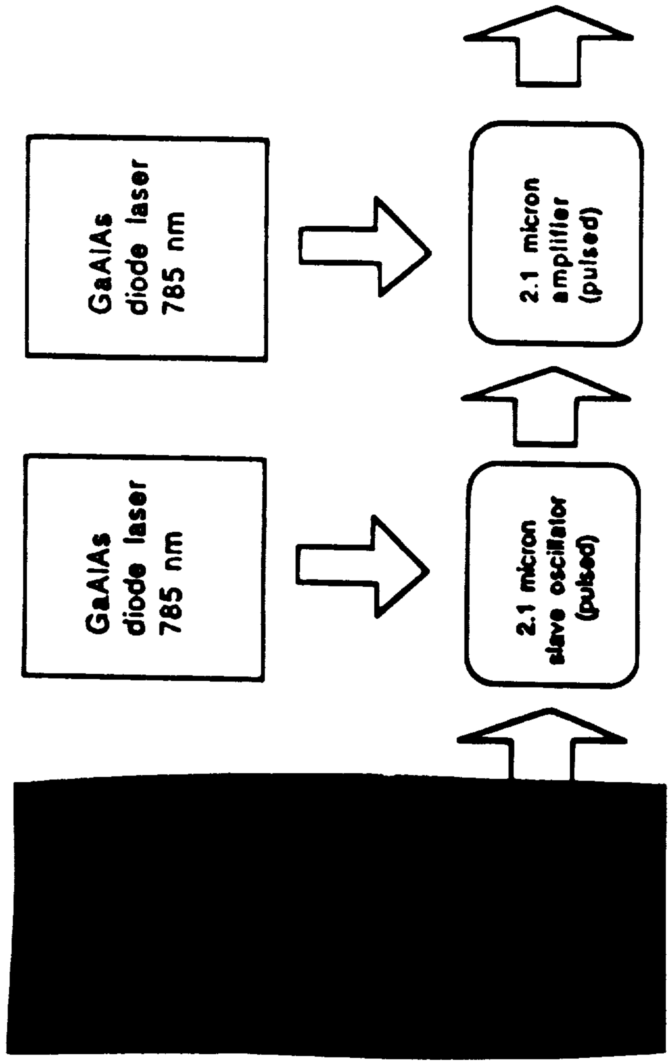
Single-Frequency, Q-switched

Laser energy: 5-10 mJ

Repetition rate: 150-300 Hz

Laser Bandwidth: 1.0 MHz

Compact, Efficient, Reliable- 200+ hours of maintenence free operation.



WINDSHEAR TRANSMITTER

ORIGINAL PAGE IS
OF POOR QUALITY

RESEARCH GOAL:

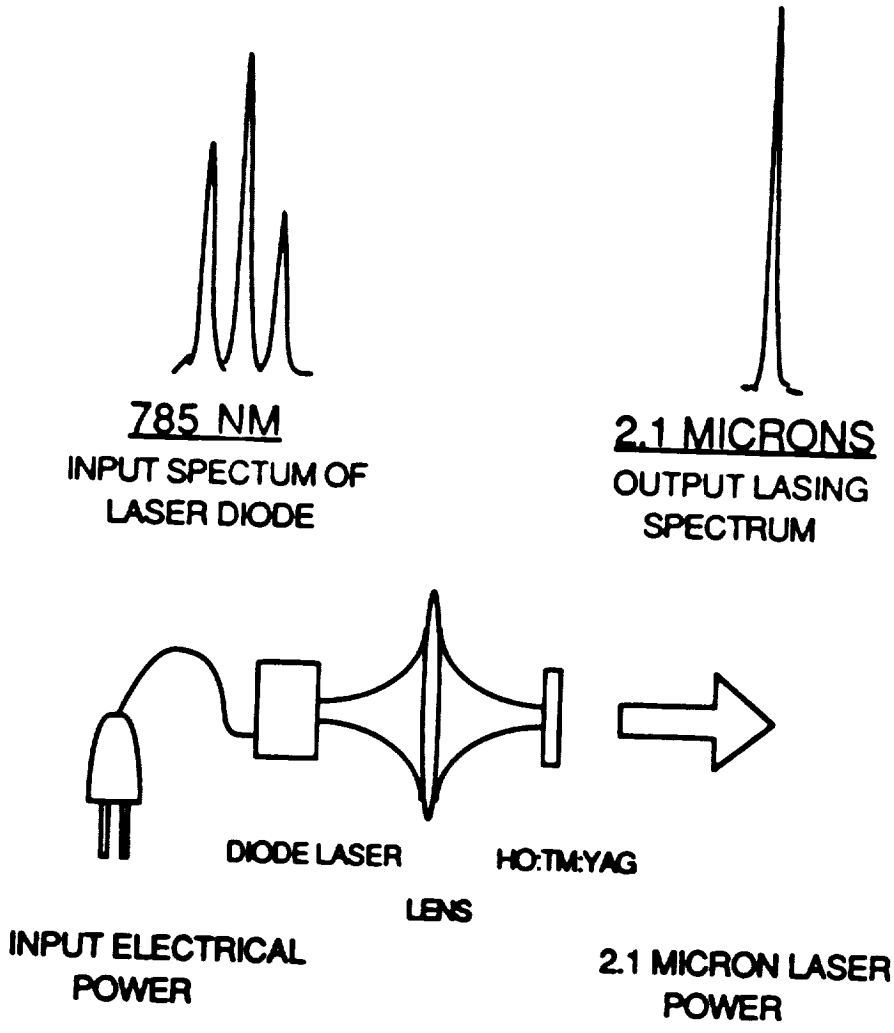
SINGLE-MODE LASER FOR INJECTION LOCKING
OF Q-SWITCHED, 2-MICRON LASER.

APPROACH:

FABRY-PEROT
PLANO-PLANO
DIODE-LASER PUMPED

ACHIEVEMENTS:

- SINGLE-MODE LASING OF HO:TM:YAG
- 10 mW optical power at 2.091microns
- 68% slope efficiency, QE.= 1.8, 4% optical-optical
- 31 GHz [4.5 Angstroms] Temperature Tuning
- Demonstrated Heterodyne Detection



SINGLE-FREQUENCY HO:TM:YAG LASER

SINGLE FREQUENCY HO:TM:YAG

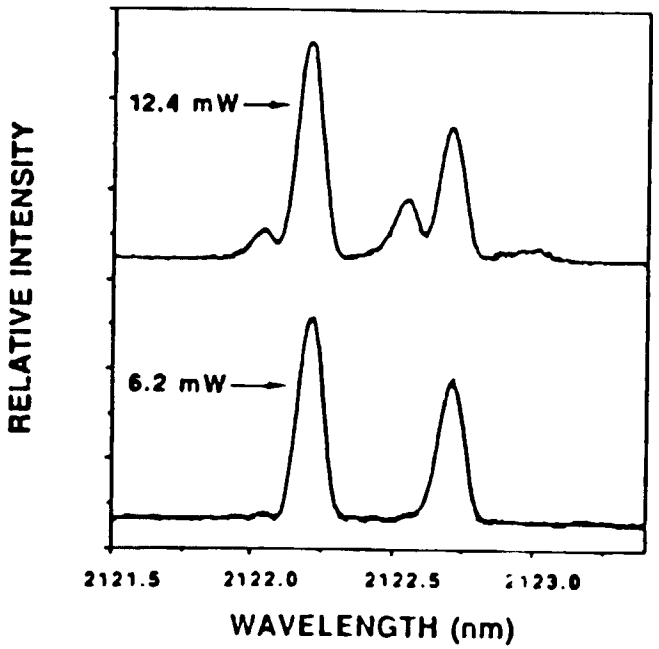


Fig. 1. Multimode lasing spectra of 2.5-mm thick Planoconvex Ho:Tm:YAG at two different laser output powers.

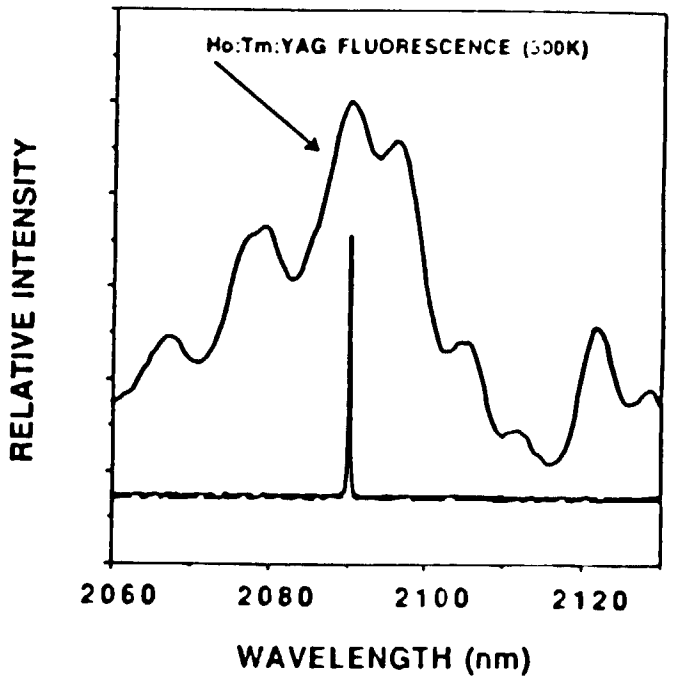
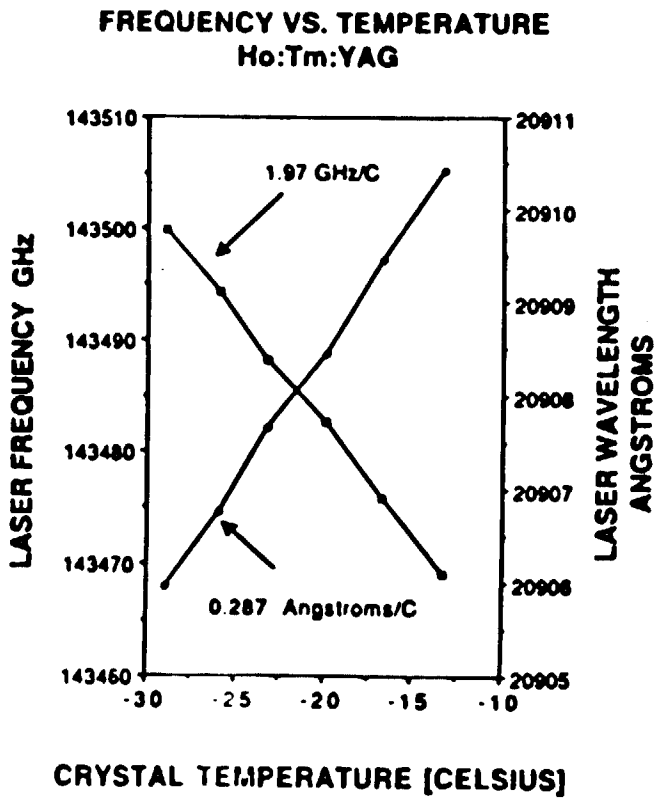


Fig. 2. Fluorescence spectra and single-longitudinal-mode lasing spectrum of a 1-mm thick Ho:Tm:YAG.

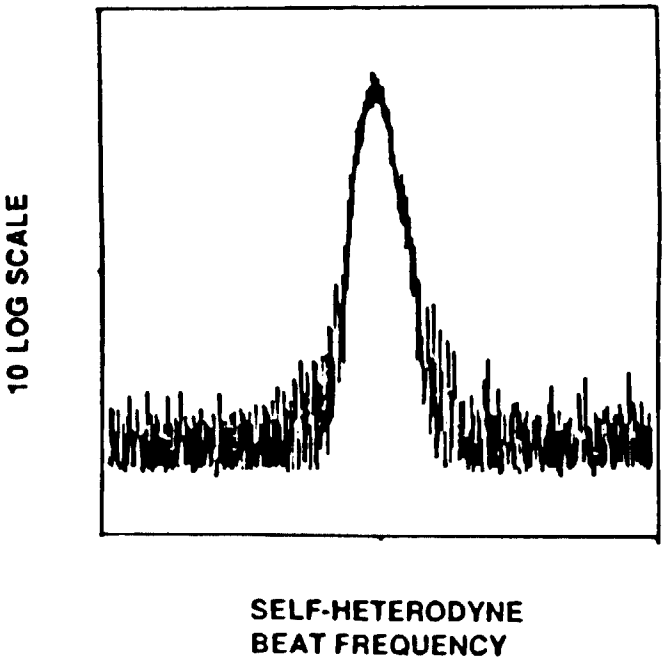
MULTIMODE LASING

SINGLE MODE LASING

SINGLE FREQUENCY HO:TM:YAG

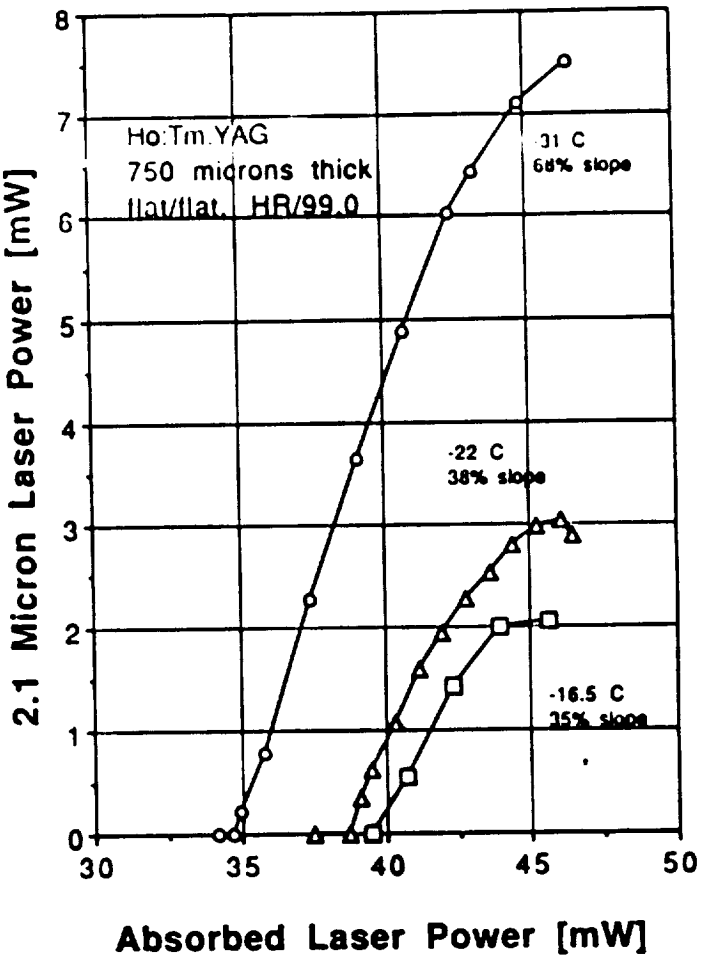


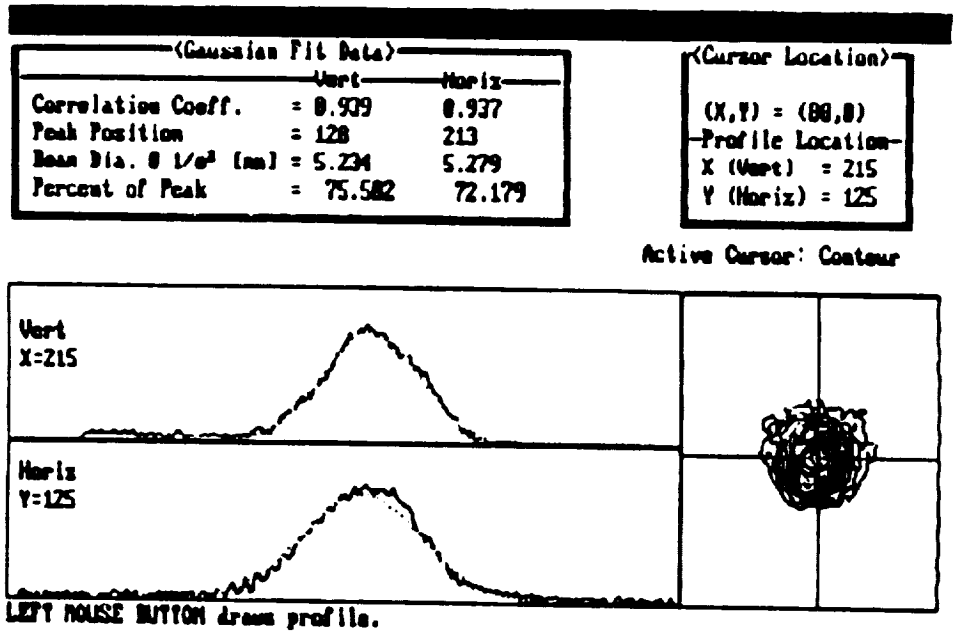
TEMPERATURE TUNING



HETERODYNE SIGNAL

Single-Frequency Laser Power





SINGLE-MODE SPACIAL PROFILE : TEMoo

ORIGINAL PAGE IS
OF POOR QUALITY

NO

NASA
National Aeronautics and
Space Administration

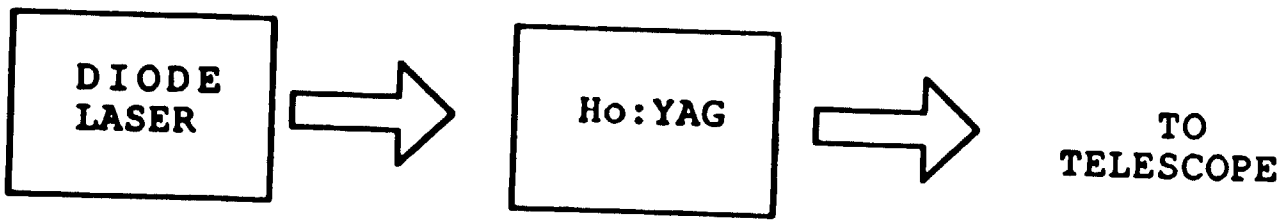
NASA
National Aeronautics and Space Administration

2 MICRON LASER EFFICIENCY

$$\eta_{laser} = \eta_{diode\ laser}\ \eta_{absorption}\ \eta_{energy\ transfer}\ \eta_{Q\text{-}switch\ optical\ extraction}$$

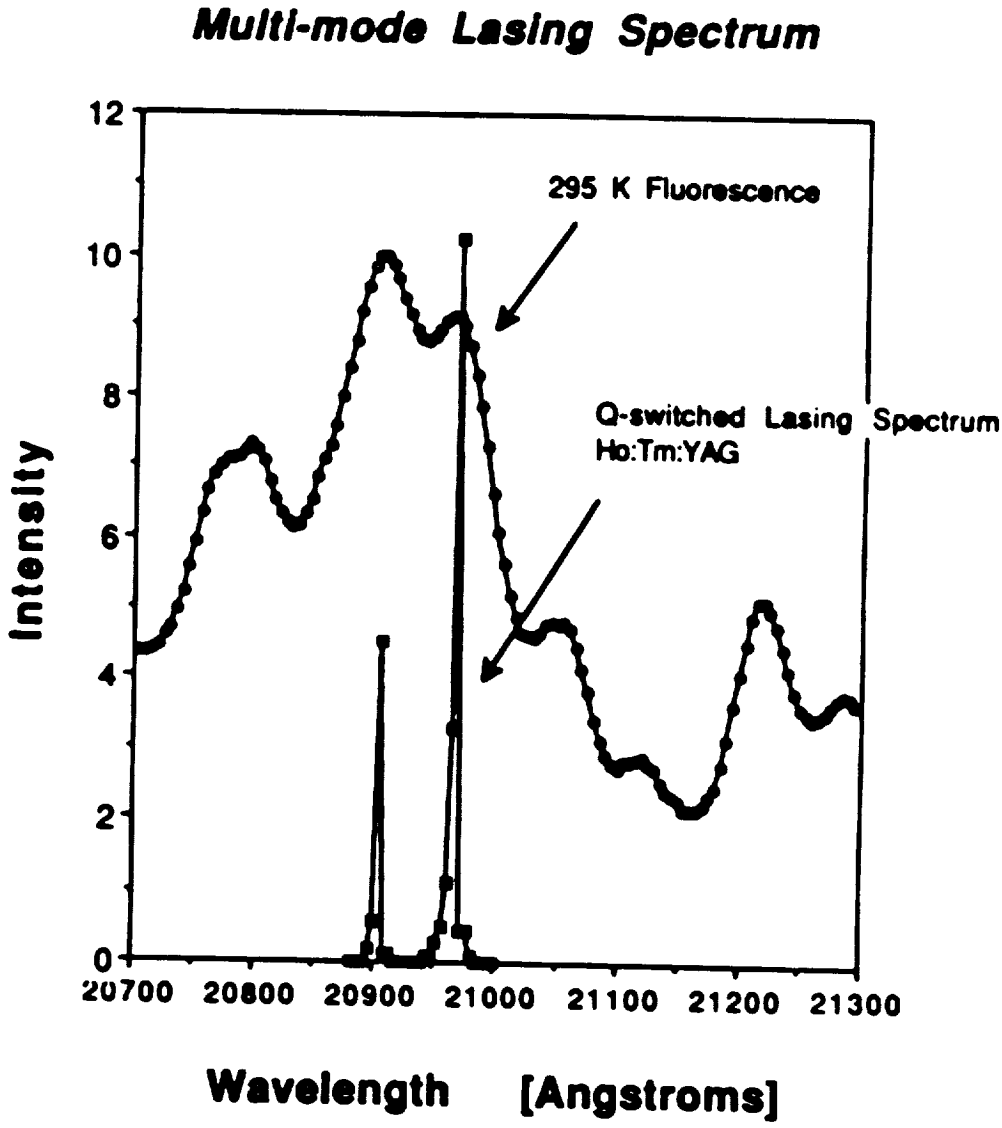
SPECTROSCOPIC

LASING DYNAMICS

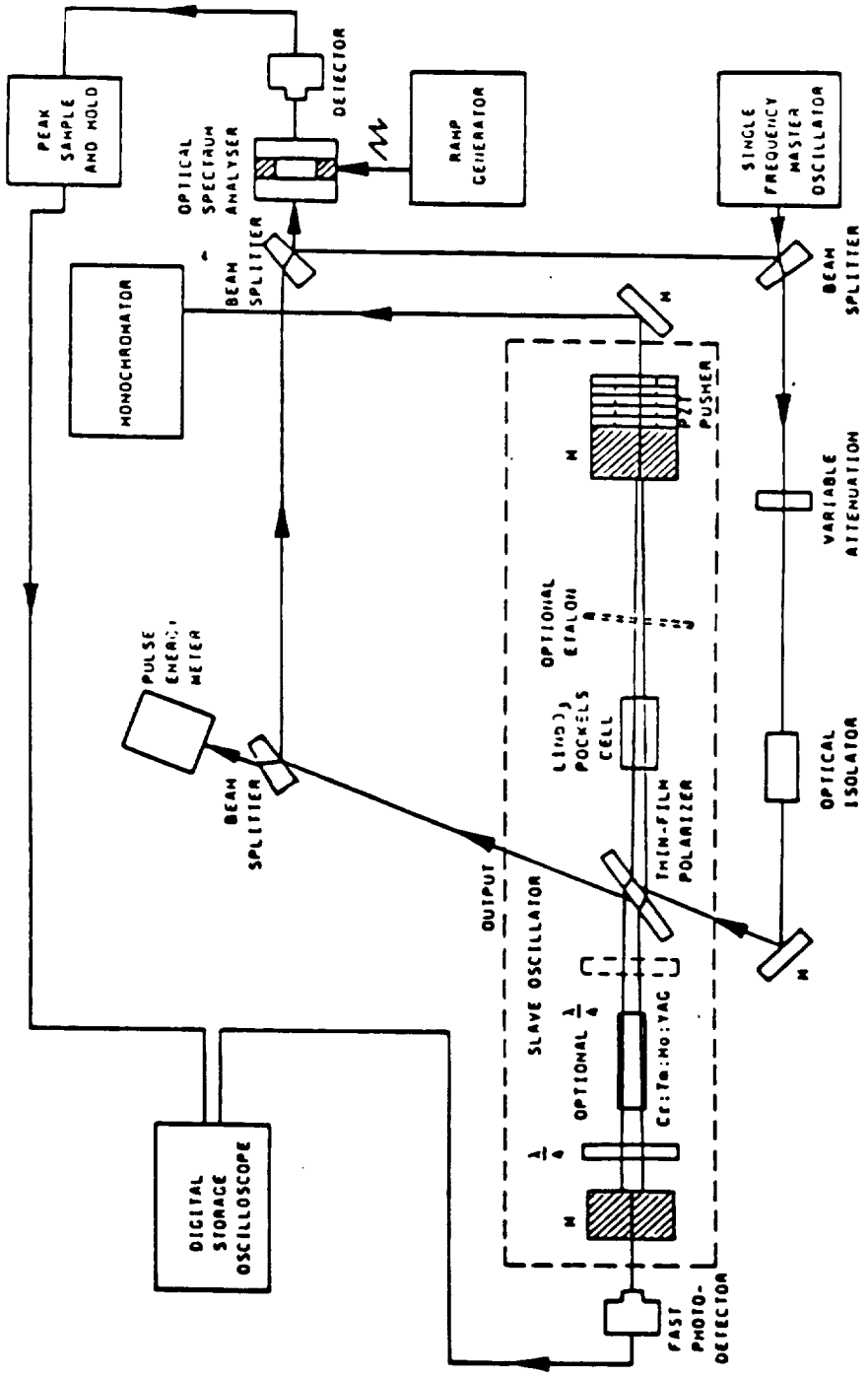


2-micron Laser Efficiency

	Present	Projected
Diode Laser	.50	.50
Optical Coupling	.80	.90
Absorption Effic.	.50	.65
Energy Transfer	.95	.95
Optical Extraction	.30	.60
Q-switching	.55	.80
Total Efficiency	.03	.13

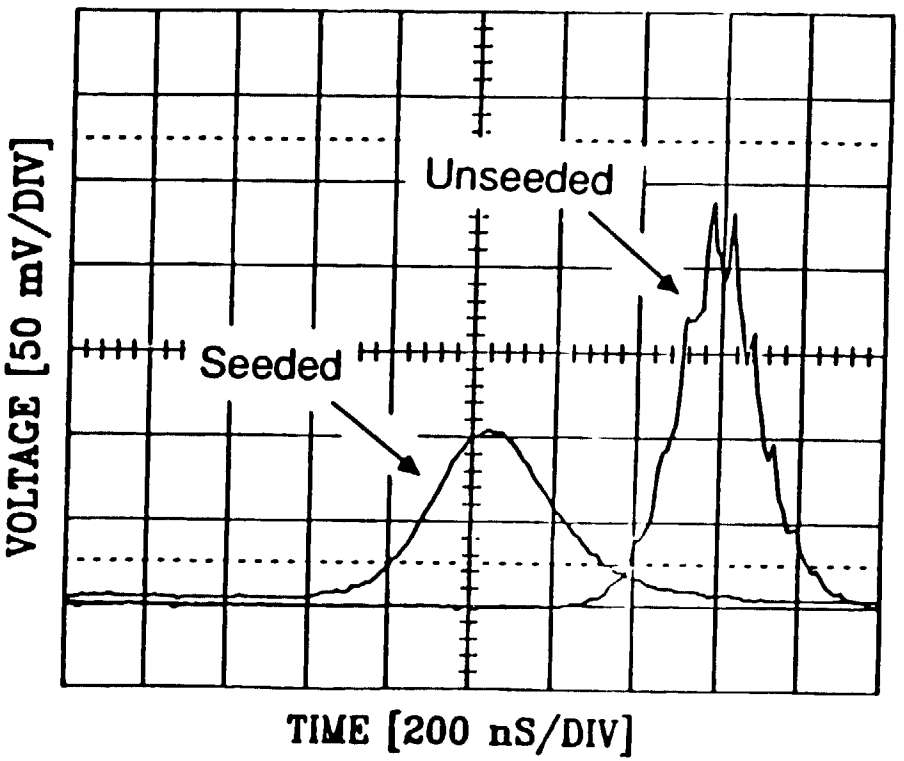

Multi-mode Lasing Spectrum
295 K Fluorescence
Q-switched Lasing Spectrum
Ho:Tm:YAG
Intensity
12
10
8
6
4
2
0
20700
20800
20900
21000
21100
21200
21300
Wavelength [Angstroms]

Coherent Technology Inc.



Injection Locked , Q-switched , 2-micron Laser

Coherent Technology Inc.



2-Micron Accomplishments for Coherent Transmitter

-CW, single-frequency demonstrated.
Storm, Kane

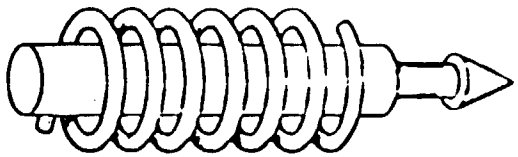
-Pulsed, single frequency demonstrated in flashlamp-pumped, injection control experiment.
Henderson

-Heterodyne detection demonstrated in self-heterodyne experiment.
Storm

Future Demonstrations Necessary for Windshear Laser

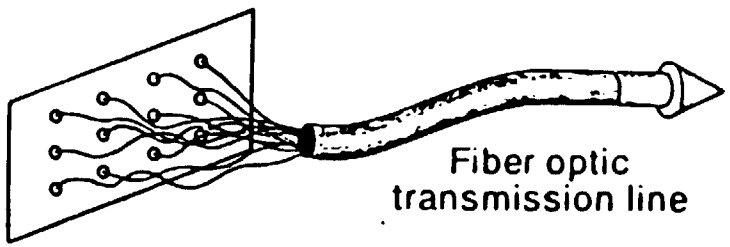
-Efficient energy scaling to 10 mJ level for Q-switched operation.
-Diode laser pumped
-100 Hz min. rep. rate

LASER DIODE PUMPED REMOTE SENSING DEVELOPMENT



Cr doped flashlamp pumped laser

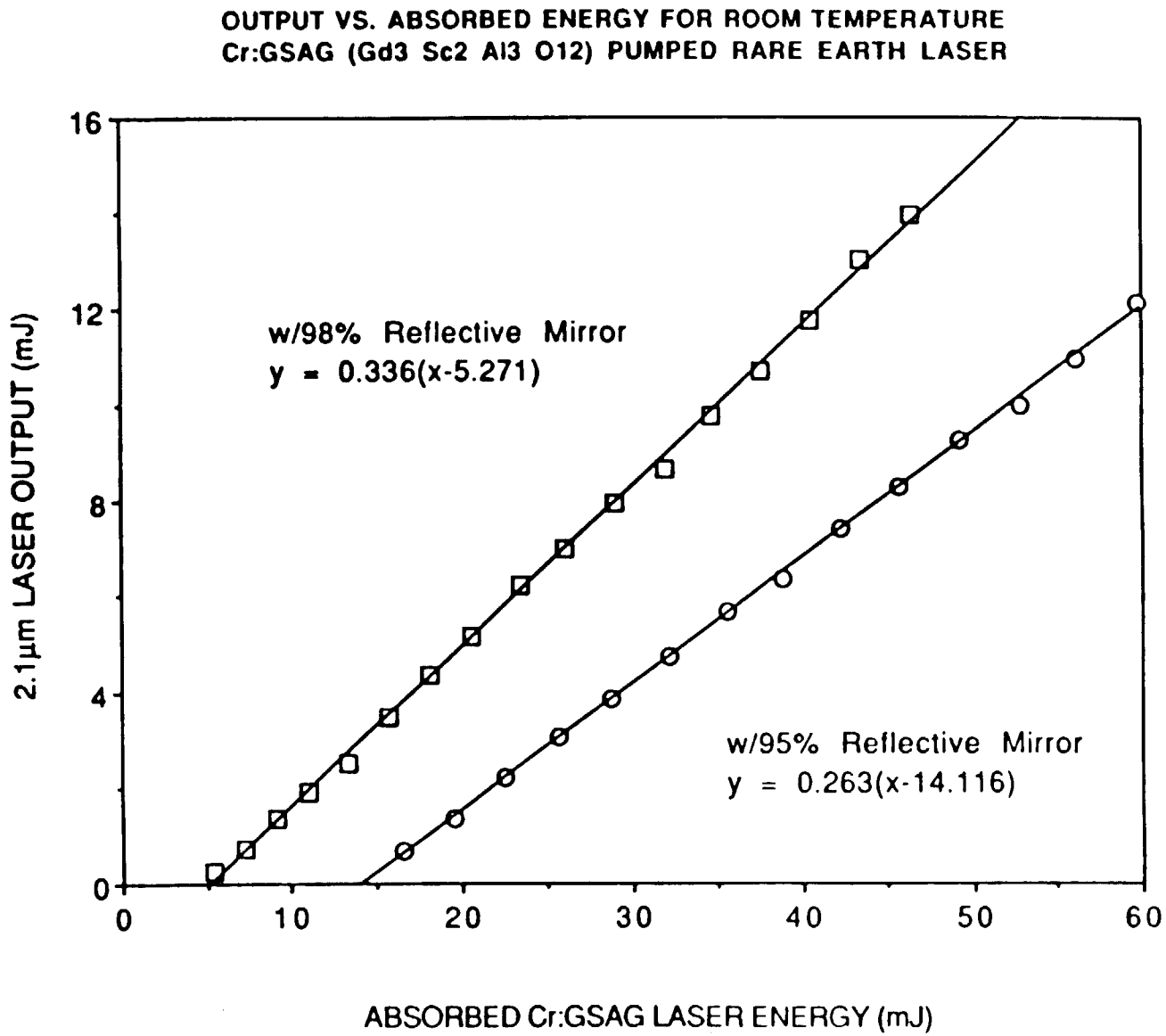
Tm:Ho laser



Fiber optic transmission line

Laser diode array bank

Rare earth eye - safe laser


OUTPUT VS. ABSORBED ENERGY FOR ROOM TEMPERATURE
Cr:GSAG (Gd3 Sc2 Al3 O12) PUMPED RARE EARTH LASER
2.1µm LASER OUTPUT (mJ)
16
12
8
4
0
0
10
20
30
40
50
60
w/98% Reflective Mirror
y = 0.336(x-5.271)
w/95% Reflective Mirror
y = 0.263(x-14.116)
ABSORBED Cr:GSAG LASER ENERGY (mJ)