N93-14845

Two Micron Laser Development for Atmospheric Remote Sensing at NASA Langley Research Center

Philip Brockman, NASA Langley Research Center

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Fourth Combined Manufacturers' and Technologists' Airborne Wind Shear Review Meeting
April 14-16, 1992

EYE SAFETY
REVISION OF INFRARED MPE

CURRENT ANSI STANDARD

λ	PULSE LENGTH (t)	MPE	LAWS
1.4 to 1000 μm	1 ns to 100 ns	10^{-2} J/cm²	
	100 ns to 10 s	$0.56\ t^{1/4}$ J/cm²	0.015 J/cm² (2.1 μm, 600 ns) 0.023 J/cm² (9.1 μm, 3 μs)
1.54 μm	1 ns to 1 μs	1.0 J/cm2	

REVISED ANSI STANDARD

λ	PULSE LENGTH (t)	MPE	LAWS
1.4 to 1.8 μm	1 ns to 10 s	1.0 J/cm²	
1.8 to 2.6 μm	1 ns to 1 ms	0.1 J/cm²	0.1 J/cm² (2.1 μm, 600 ns)*
1.8 to 2.6 μm	1 ms to 10 s	$0.56\ t^{1/4}$ J/cm²	
2.6 μm to 1 mm	1 ns to 100 ns	0.01 J/cm²	
2.6 μm to 1 mm	100 ns to 10 s	$0.56\ t^{1/4}$ J/cm²	0.023 J/cm² (9.1 μm, 3 μs)

*NOTE, MPE AT 2.1 μm INCREASED BY FACTOR OF 6

FOR 20-JOULE TRANSMITTER PULSE, 2-MICRON FLUX IS 1/133 OF NEW ANSI STANDARD AND 9-MICRON FLUX IS 1/575 OF NEW ANSI STANDARD.

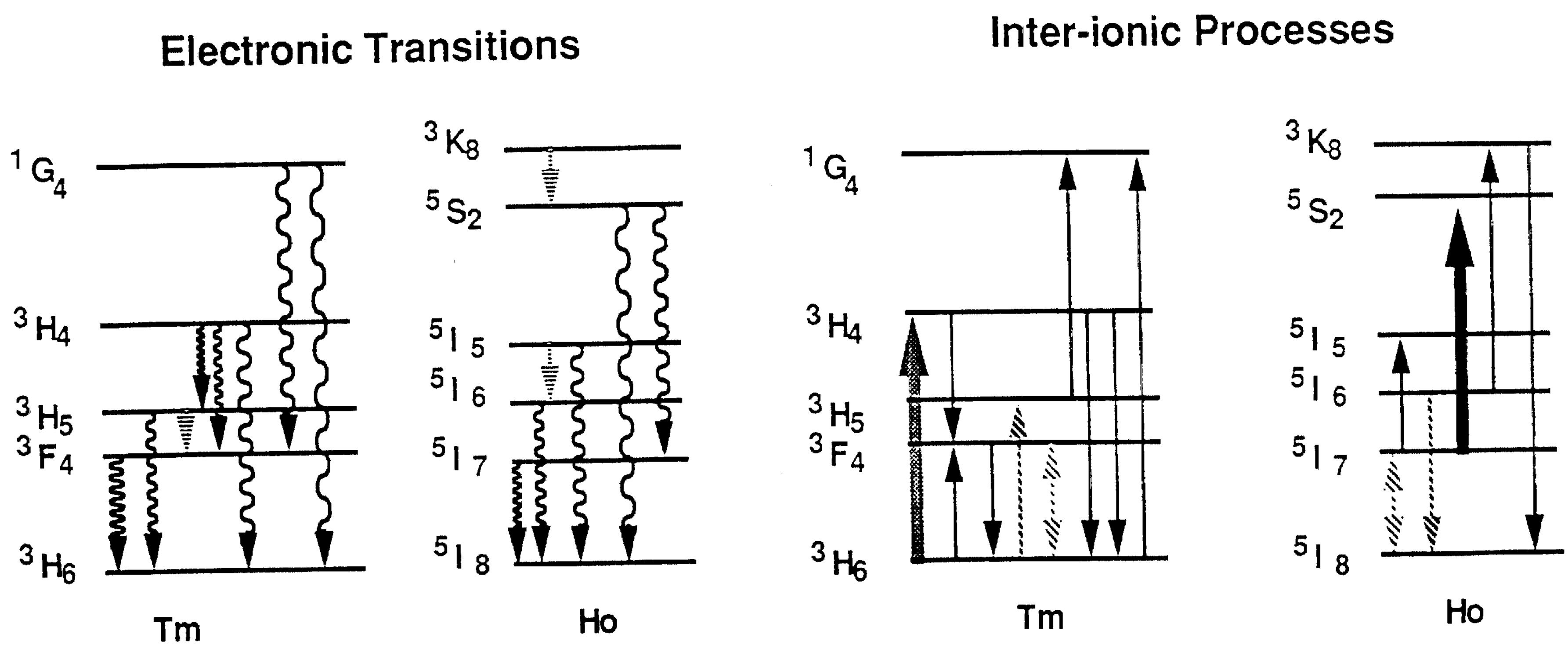
Tm:Ho DYNAMICS CHARACTERIZATION

- Spectroscopy
  - absorption
  - emission
  - time / temperature dependent
- Laser Experiments
  - laser pumped
  - flashlamp pumped
  - reduced temperature
- Modeling
  - resonators
  - thermal
  - quantum mechanical
  - energy transfer dynamics

Q.M. MODEL CALCULATION

- Energy levels
- Electric and magnetic dipole transition probabilities
- Lifetimes
- Branching ratios
- Absorption spectra
- Emission spectra

Tm - Ho Energy Transfer Processes Being Considered



Radiative

Non radiative

Processes connected to upper levels are newly added to model

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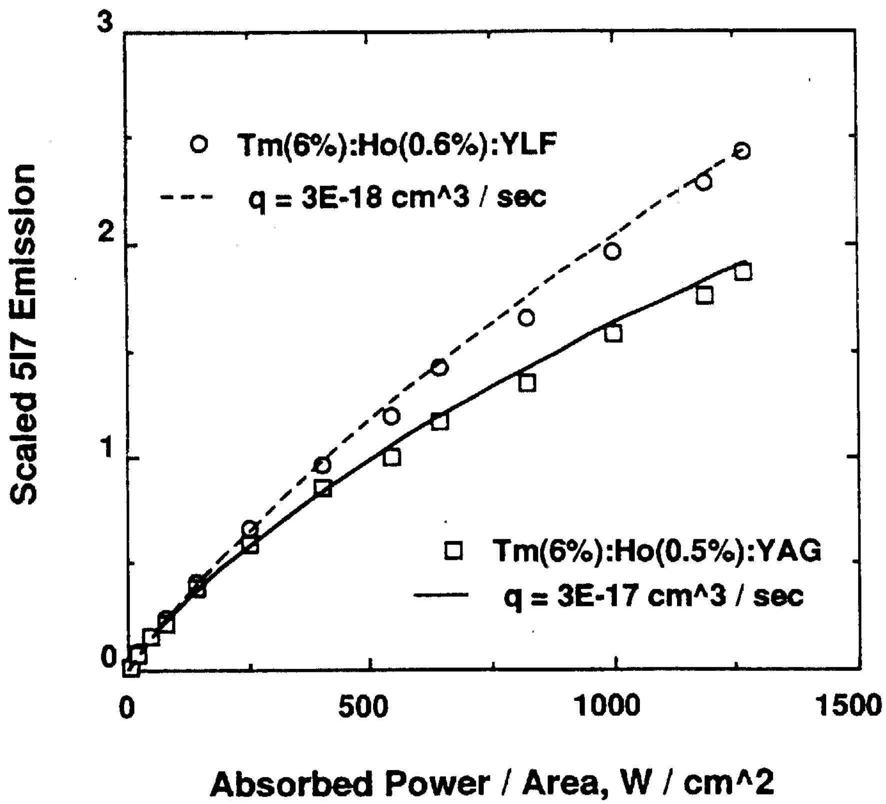
Upconversion from the 5I7 Manifold Can Limit the Maximum Stored Energy



- CW diode excitation simplifies analysis
- Upconversion rate an order of magnitude less in YLF
- At higher pump fluences must include effects of ground state depletion

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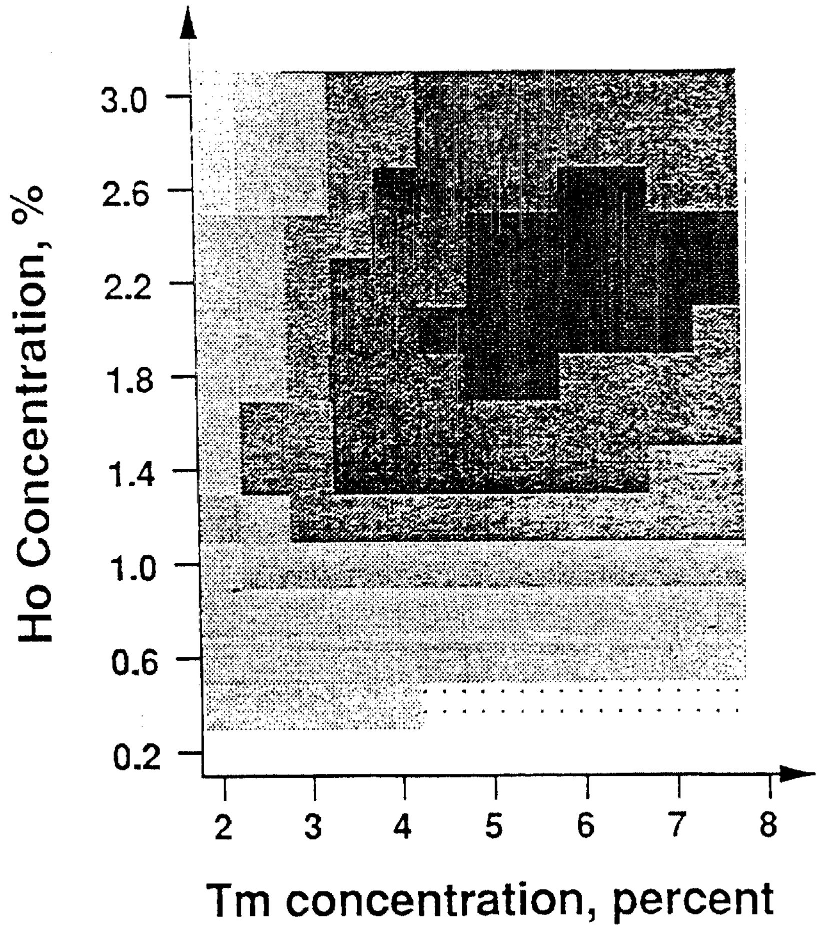
Maximum Energy Extraction Efficiency Can Be Optimized for the Disk Amplifier

Oscillator Radius = 0.1 cm

Pump Energy = 1.2 J



Room Temperature Maximum Energy Extraction Efficiency

9	> 4.0
8	0.36 - 0.40
7	0.32 - 0.36
6	0.28 - 0.32
5	0.24 - 0.28
4	0.20 - 0.24
3	0.16 - 0.20
2	0.12 - 0.16
1	0.08 - 0.12
0	< 0.08

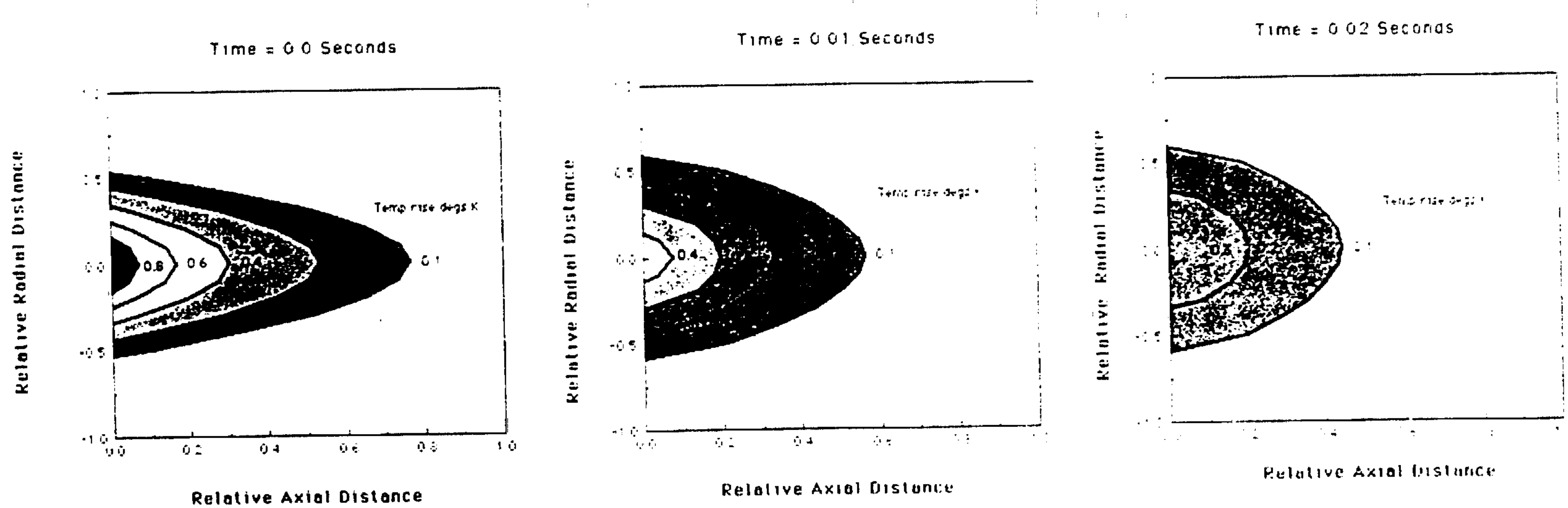
At fixed Ho concentration, efficiency rolls off due to diminished Tm-Ho transfer

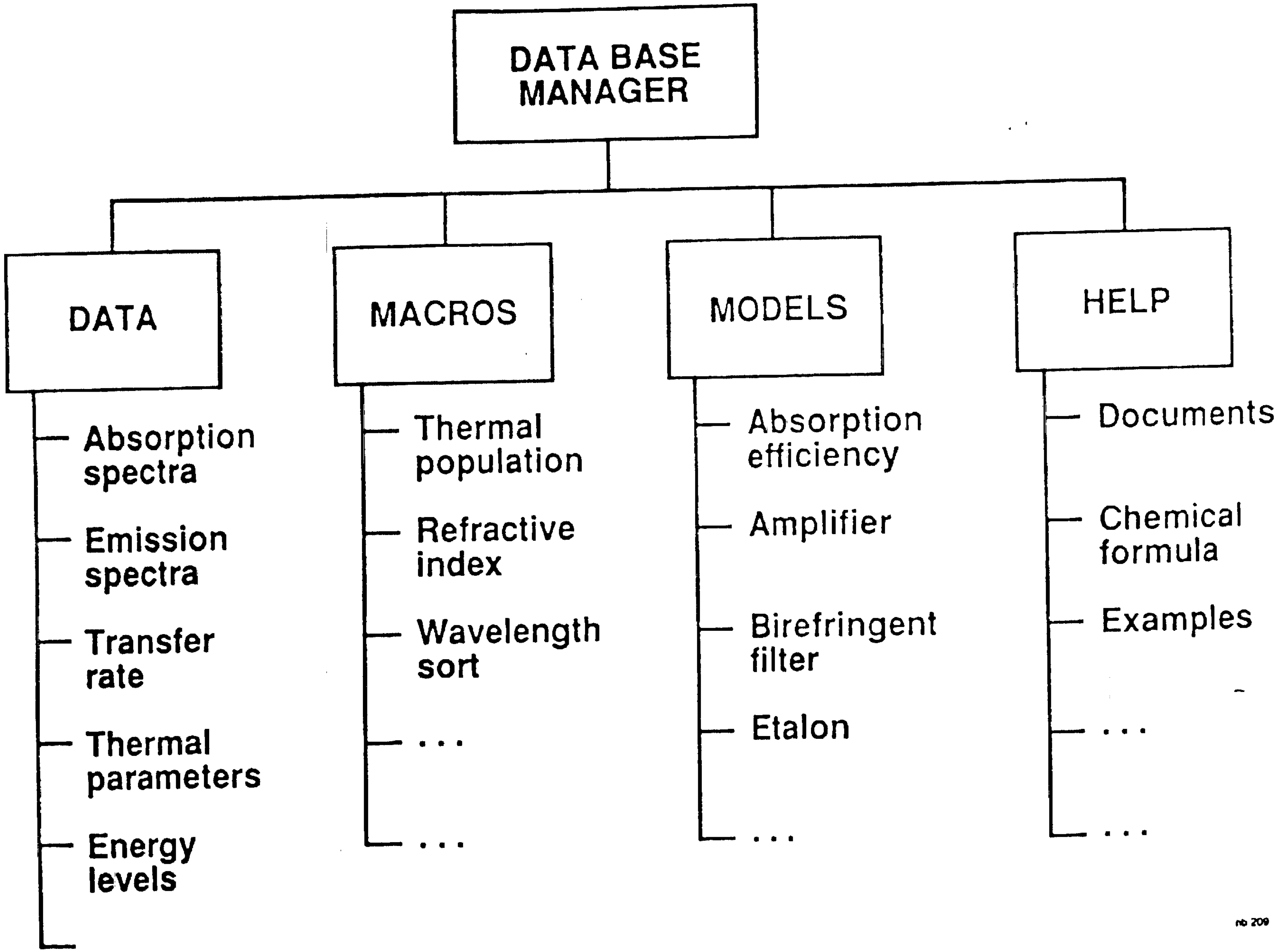
At fixed Tm concentration, efficiency rolls off due to ground state absorption

Heat Propagation in a Laser Rod

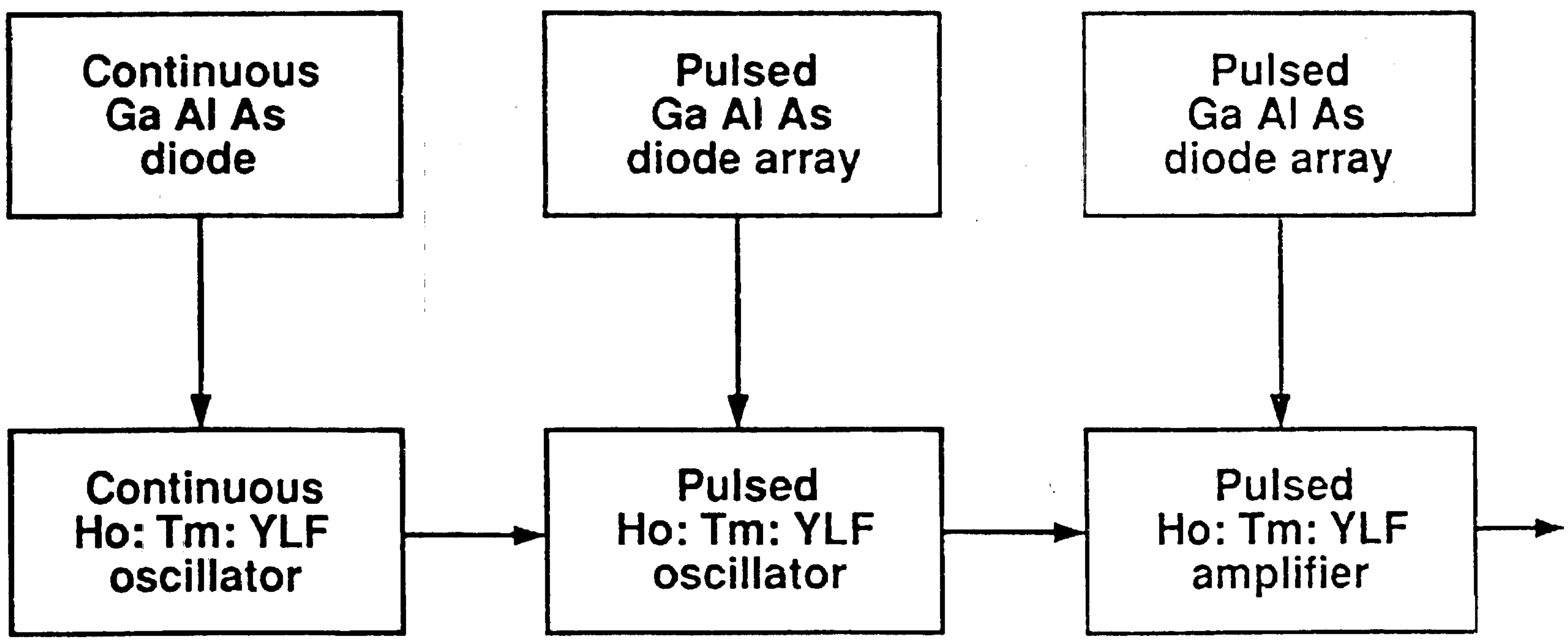
End-pumped Single Pulse

Gaussian Cross Section




DATA BASE MANAGER
DATA
Absorption spectra
Emission spectra
Transfer rate
Thermal parameters
Energy levels
MACROS
Thermal population
Refractive index
Wavelength sort
. . .
. . .
MODELS
Absorption efficiency
Amplifier
Birefringent filter
Etalon
. . .
HELP
Documents
Chemical formula
Examples
. . .
. . .

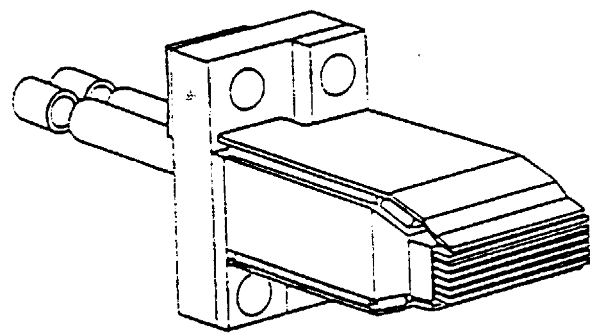
INJECTION LOCKED OSCILLATOR-AMPLIFIER SYSTEM PROVIDES SINGLE FREQUENCY SOLID STATE LASER

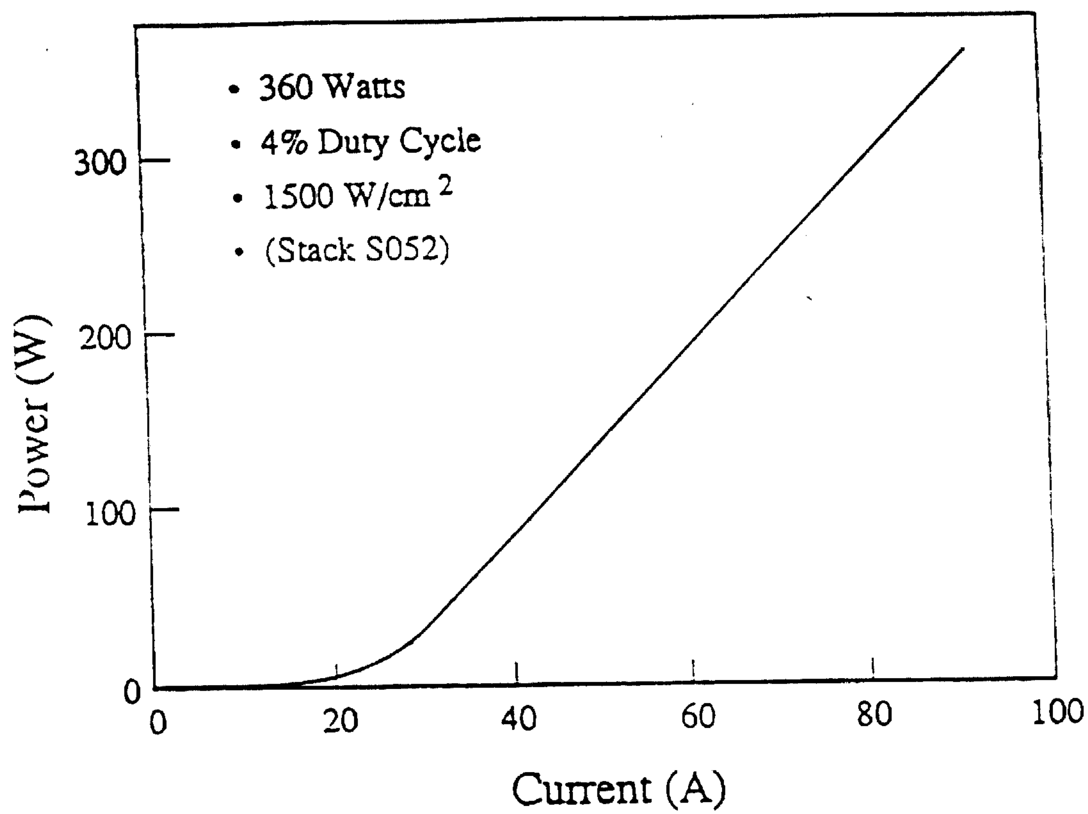


- Seed laser
  - *single frequency demonstrated*
  - *10 mW demonstrated*
- Power oscillator
  - *1.0 μsec pulselength at 30 mJ*
  - *diode pumped laser head fabricated*
- Amplifier
  - *Ho and Tm concentration optimized*
  - *disk configuration selected*
- Supporting activities
  - *Cr: Be Al_2O_4 pumped Ho: Tm: YLF*
  - *spectroscopy*
  - *quantum mechanical model*

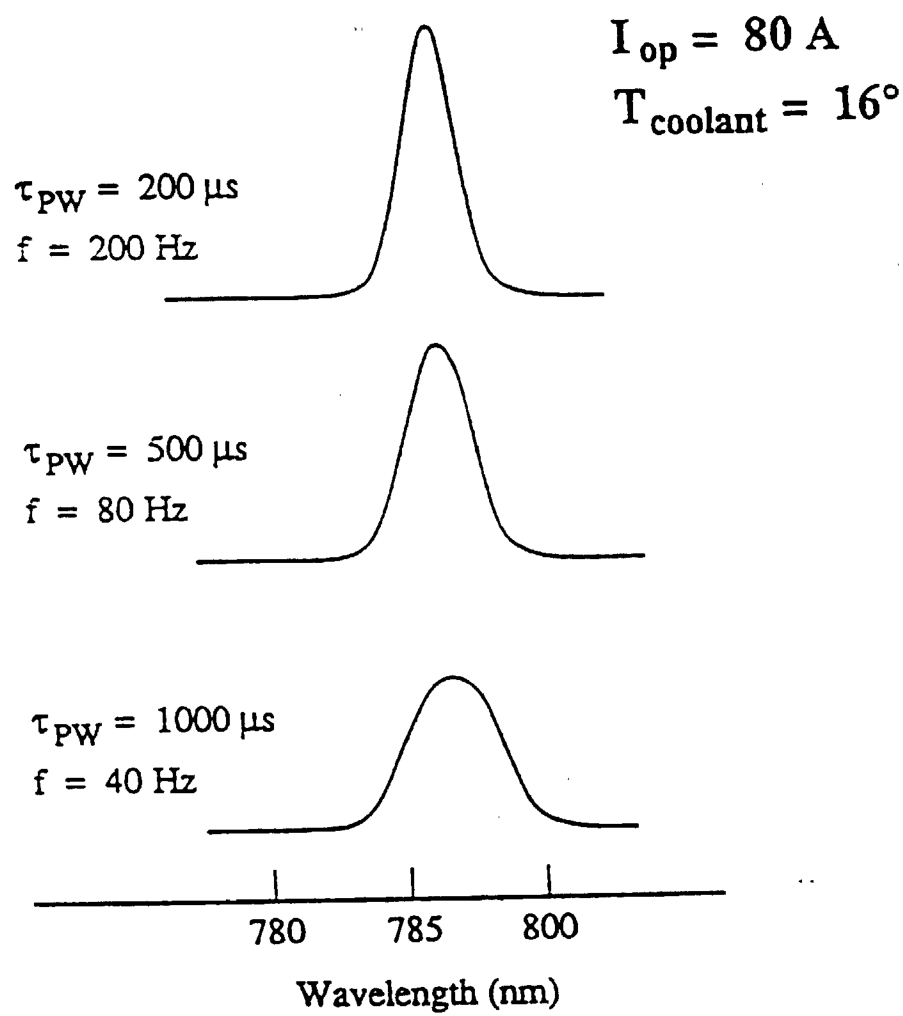
nb 366

4% Duty Cycle
0.4 mm Pitch (6) Bar Array
on 0.5 cm x 1 cm Cooler





• 360 Watts
• 4% Duty Cycle
• 1500 W/cm 2
• (Stack S052)
Power (W)
0
100
200
300
0
20
40
60
80
100
Current (A)



I_{op} = 80 A
$T_{coolant}$ = 16°
τ_{PW} = 200 µs
f = 200 Hz
τ_{PW} = 500 µs
f = 80 Hz
τ_{PW} = 1000 µs
f = 40 Hz
780
785
800
Wavelength (nm)