High Power Fiber Laser System for Polarization of ^{3}He Gas

RAYTUM PHOTONICS

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Traditional Diode Laser for Polarization Application

Most of lasers used for ^3He gas polarization are 795 nm diode laser either with fiber pigtailed or free space output beam. Issues with high power diode laser is:

1. Terrible beam quality.

2. In-direct pumping. The 795 nm laser first polarizes the Rb vapor and then polarized K vapor. Efficiency is low.

3. For fiber coupled diode laser, the laser beam polarization is random and need complicated optics system to reshape the polarization.

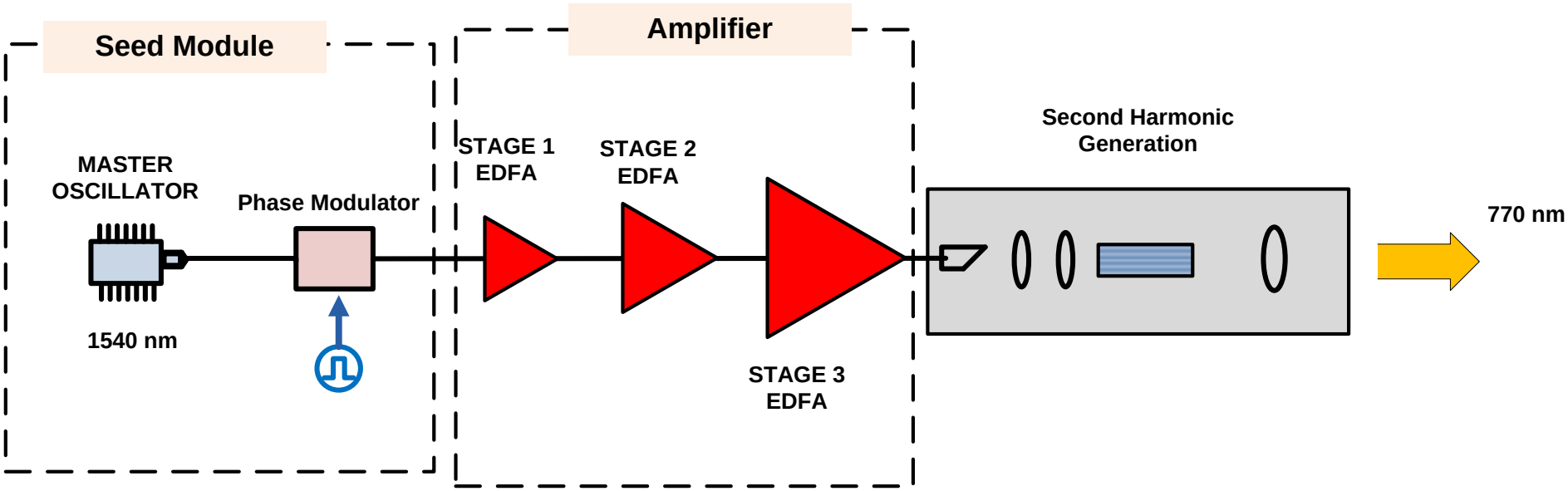
Advantages of Fiber Laser System

- **Single Spatial Mode output with $M^2 < 1.2$**
- **Linear polarization output**
- **Lasing wavelength at 770 nm, directly pumping K vapor, potentially improve the polarization rate of ^3He gas.**
- **Lasing spectral width is tunable from MHz to nm.**

Phase II Specification

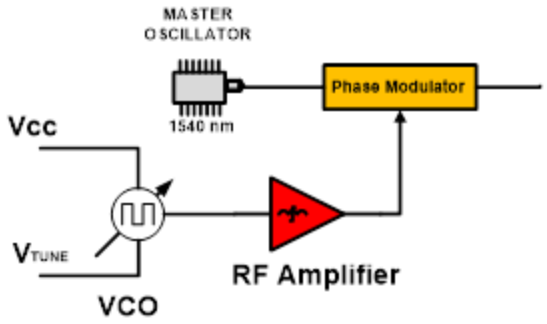
Parameter	Specification	Additional Comments
Output Power	100 W at 1540 nm > 50 W at 770 nm	Output power at 770 nm might be higher if higher efficiency is achieved
Wavelength (nominal)	1540 nm (Fundamental) 770 nm (SHG)	Tunable
Linewidth Tuning	MHz to 0.2 nm	
Wavelength Tuning	> 1 nm	Sufficiant for the K vapor pumping and can be locked to the absorption line
Output Polarization	Linear/Circular	
Thermal Management	Water Cooling	
Lifetime	> 8,000 hours	The laser module is hermetically sealed
Package Size	1,300 in^3	This is a rough estimate

System Schematic



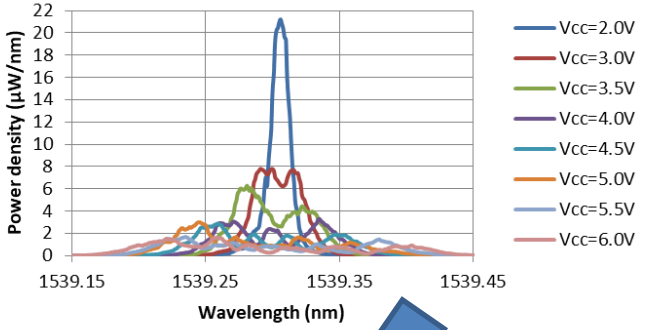
Spectral Width Tuning

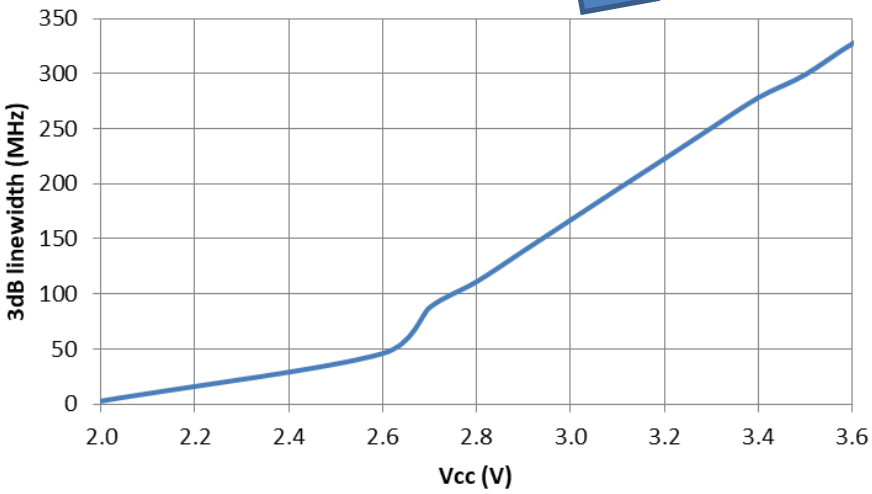
1 MHz, 40 mW

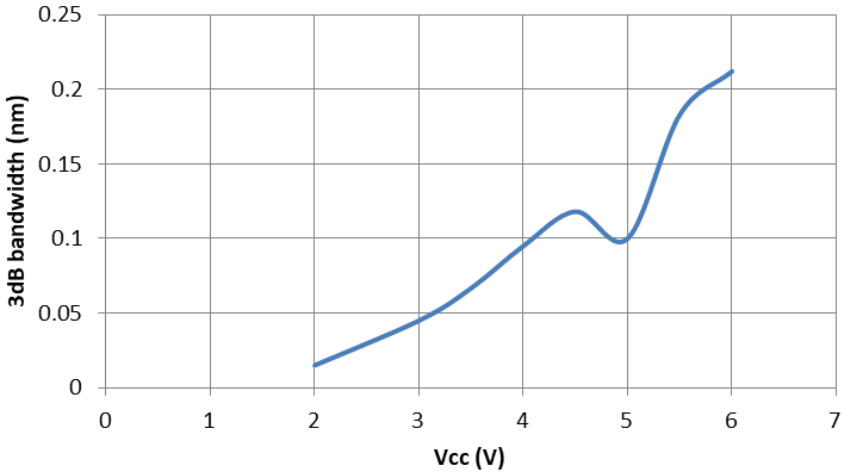


F-P Interferometer Trace

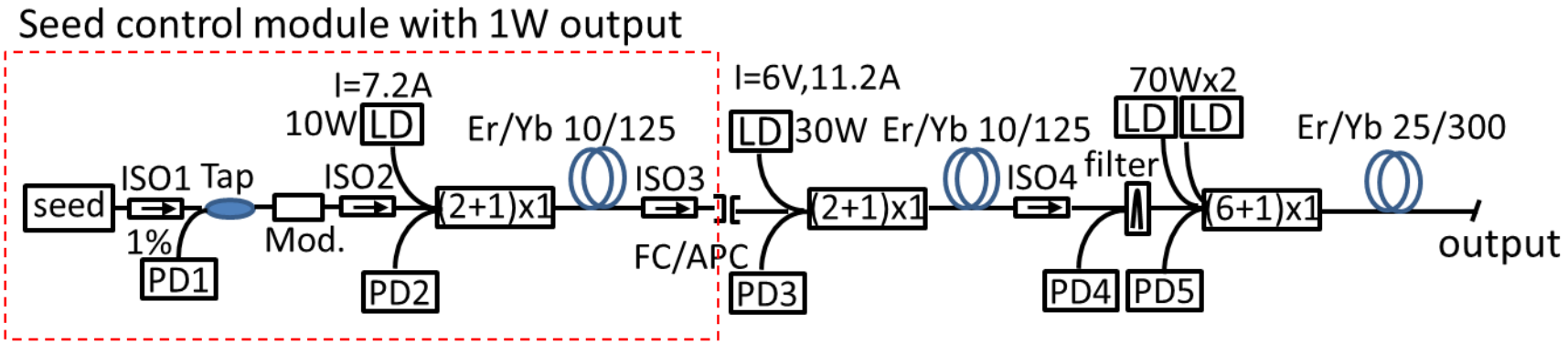
OSA Trace



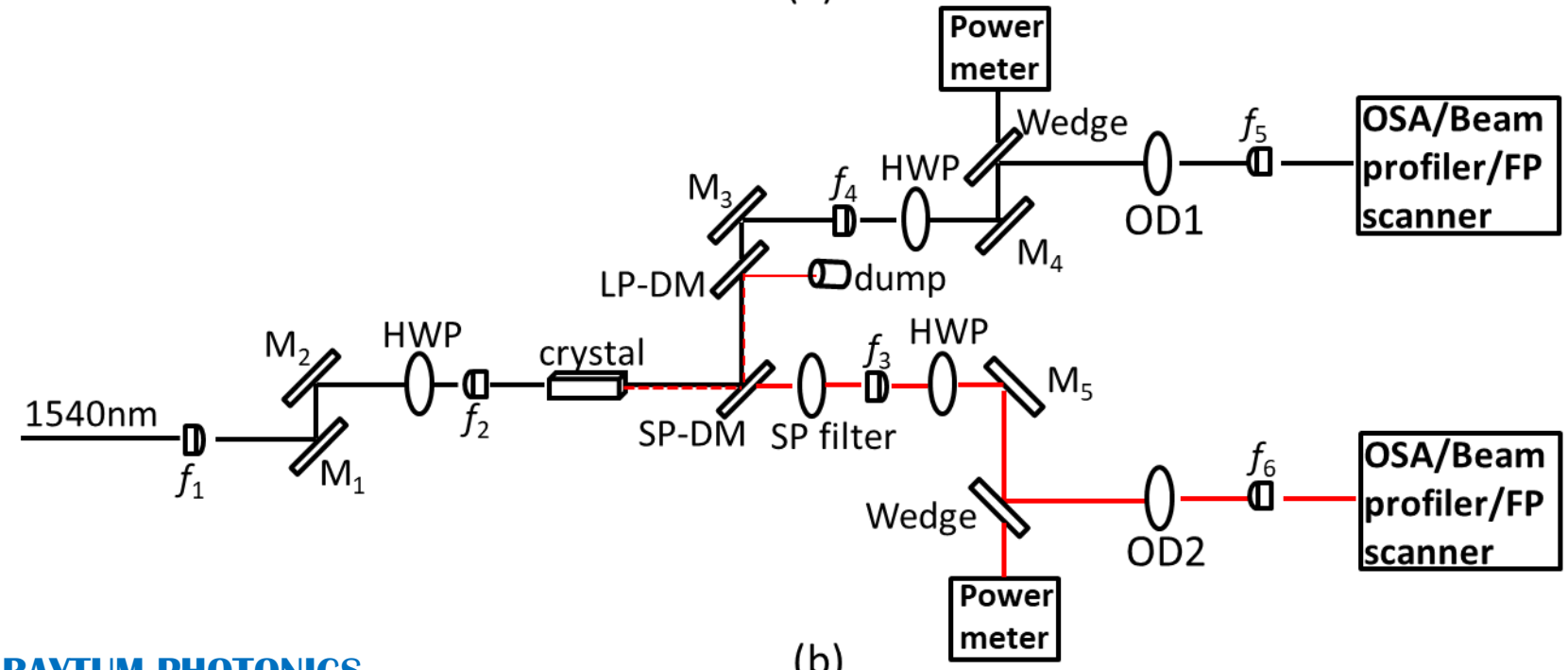




System Structure

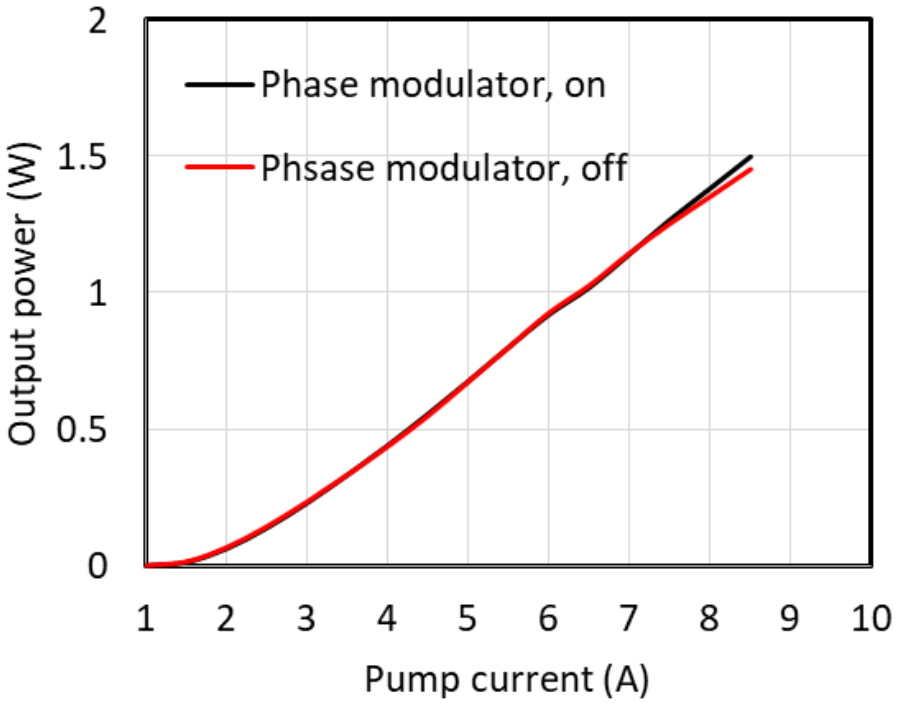


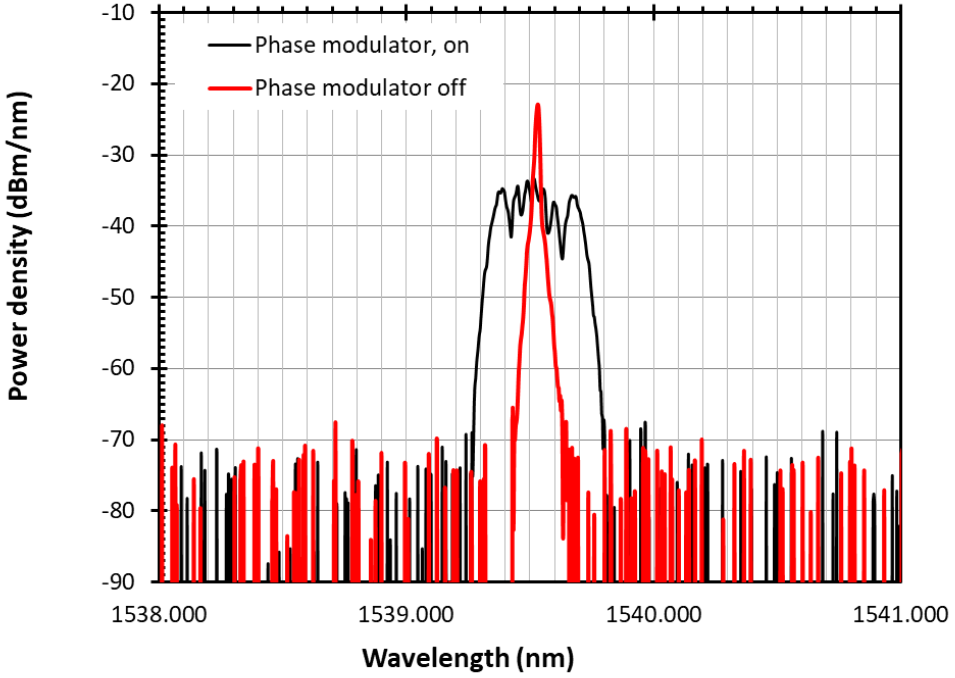
(a)



(b)

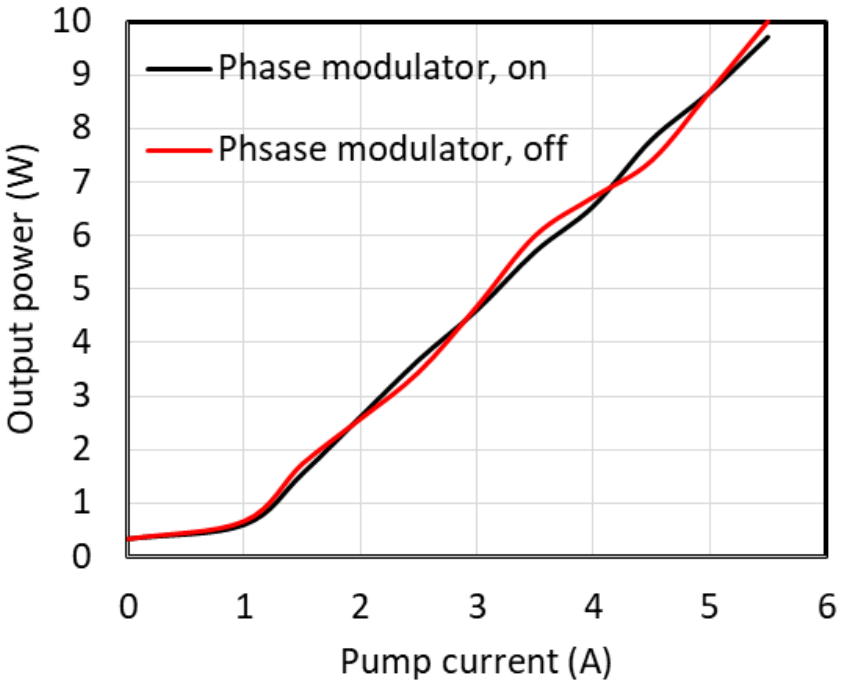
Performance of First Stage Fiber Amplifier

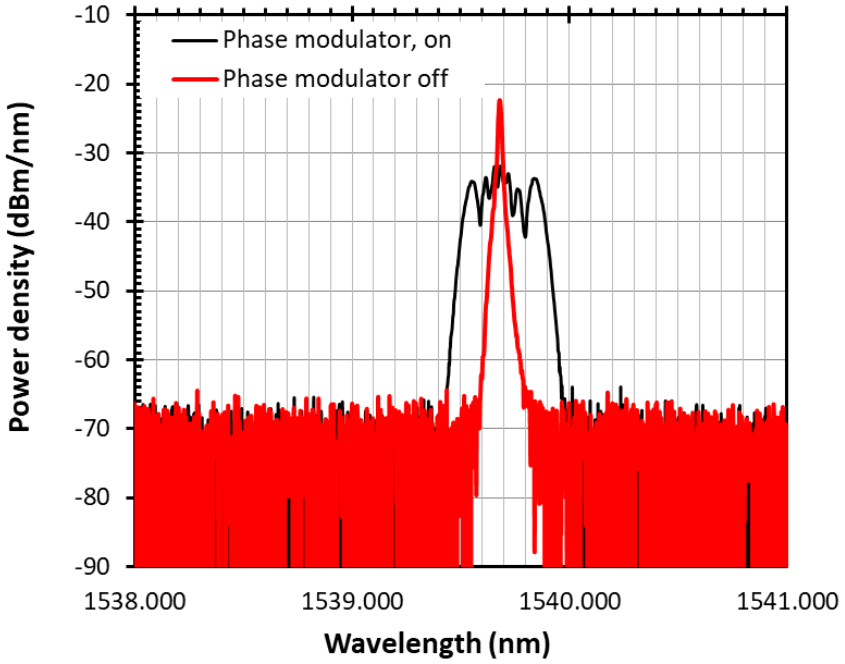




Max output power out of first stage is more than 1.5W with signal/noise contrast ratio of more than 40 dB

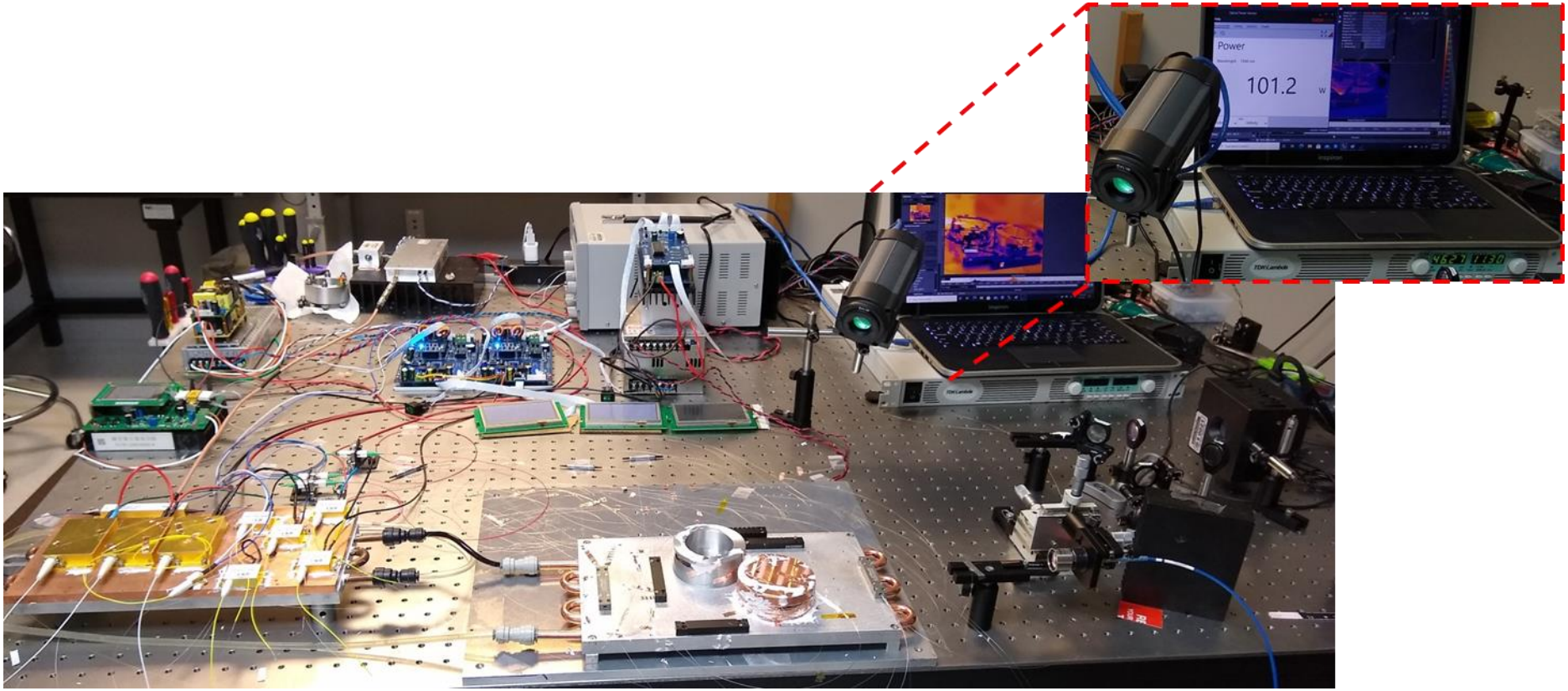
Performance of Second Stage Fiber Amplifier



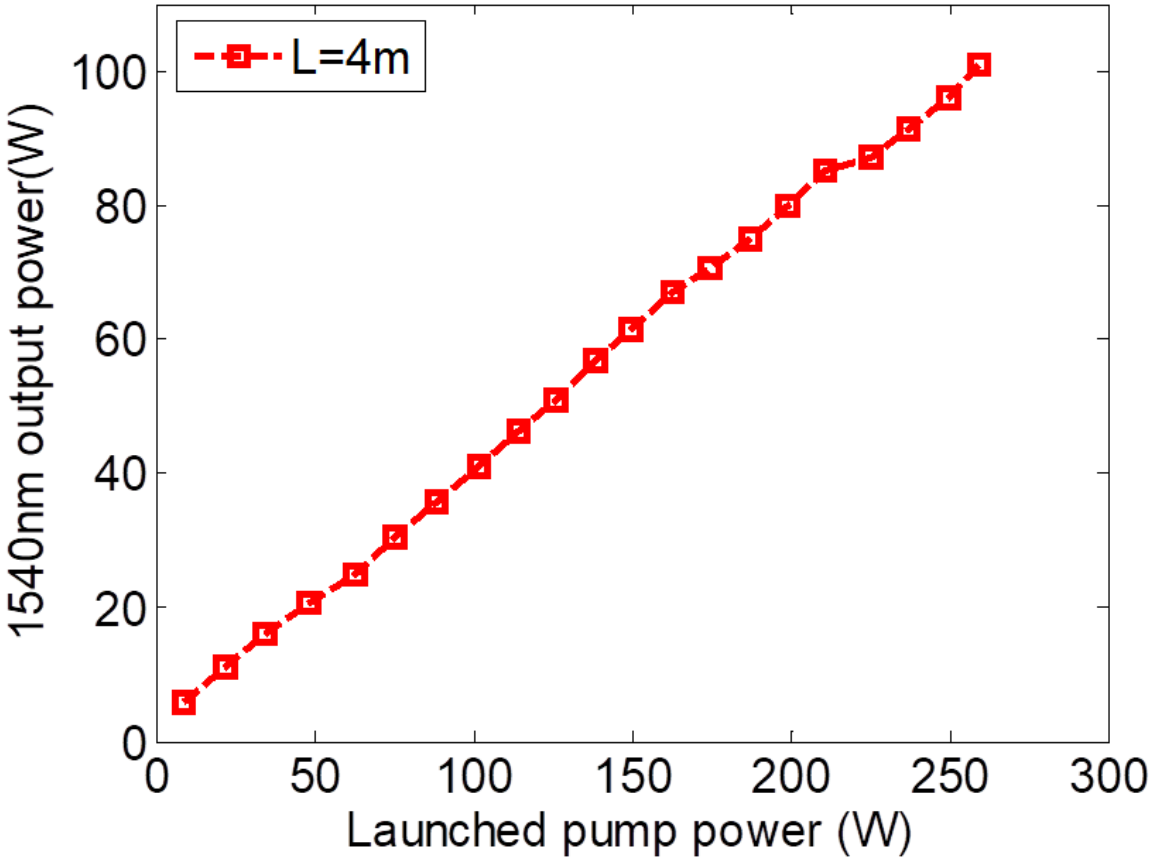


Max output power out of first stage is about 10W with signal/noise contrast ratio of more than 35 dB

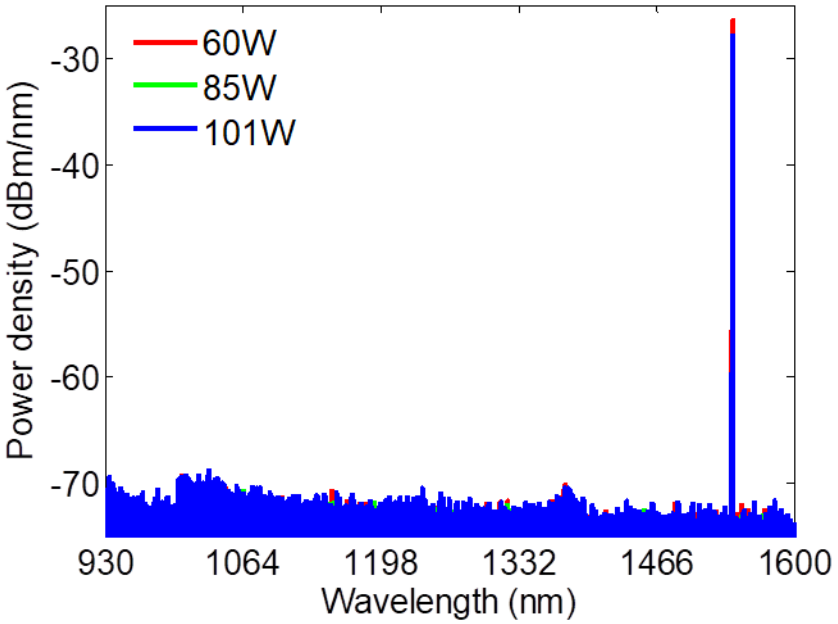
Final Stage Amplifier



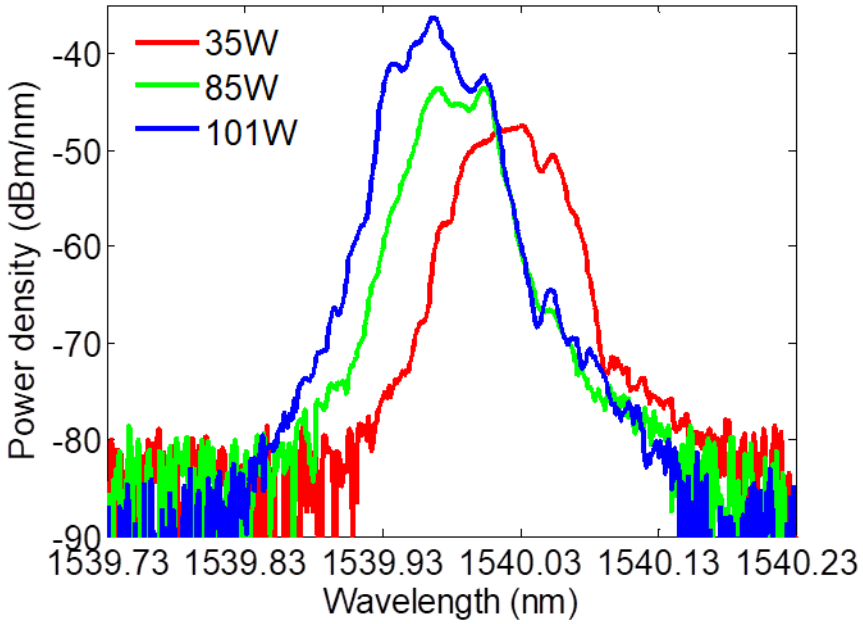
Performance of Final Stage of Amplifier



Output Spectrum (Forward)

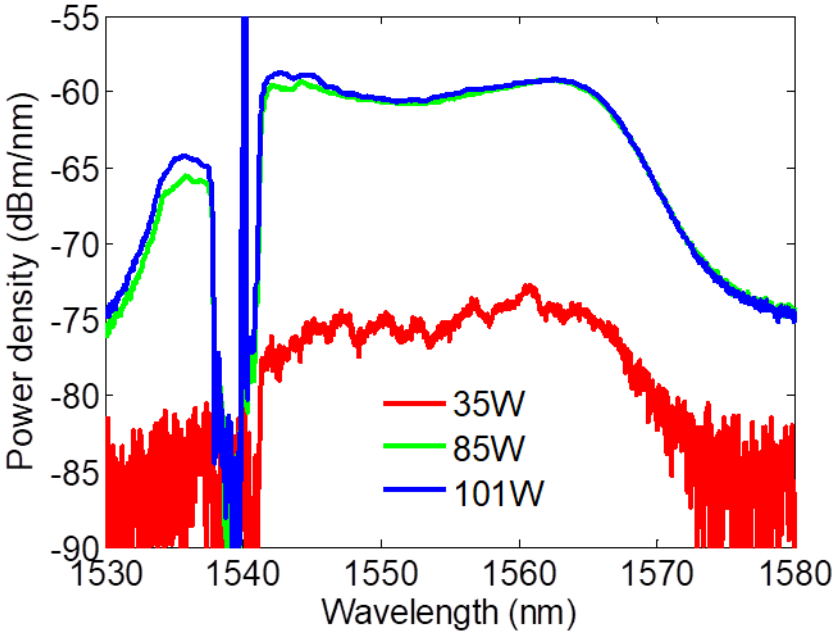


(a) 670nm span, 0.2nm resolution

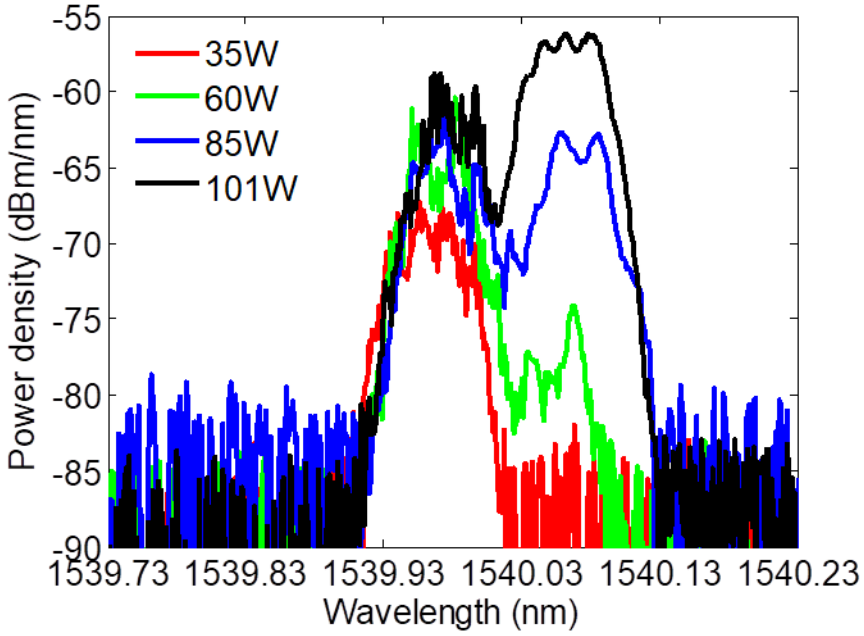


(b) 0.5nm span, 0.01nm resolution

Output Spectrum (Backward)

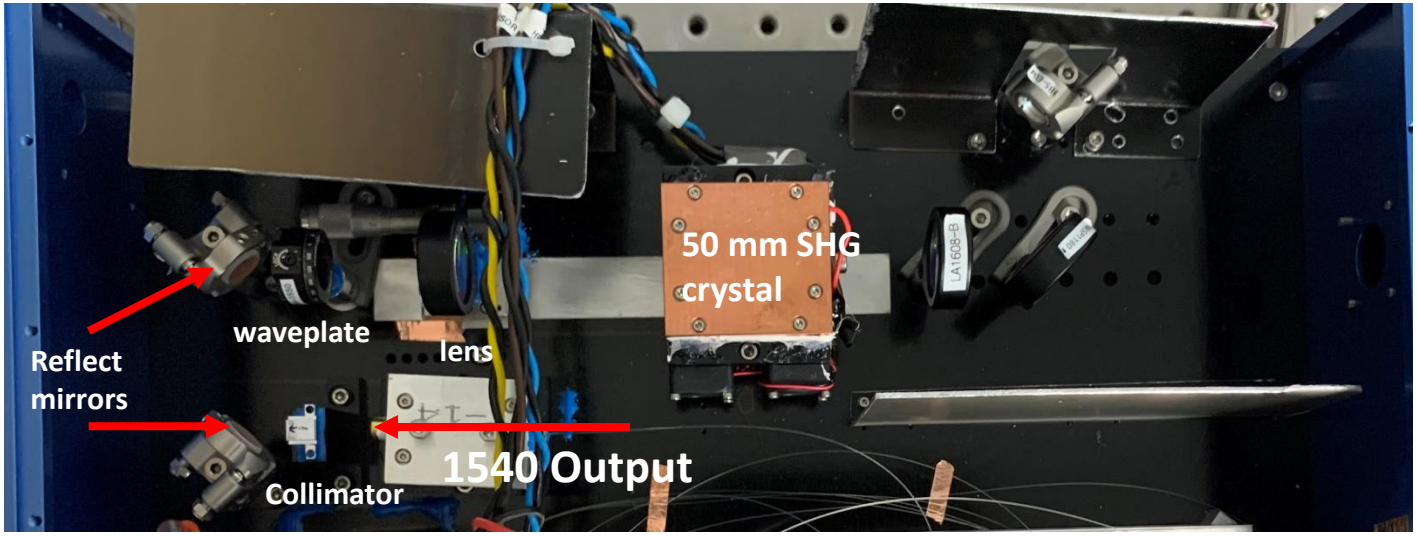


(a) 50nm span, 0.1nm resolution

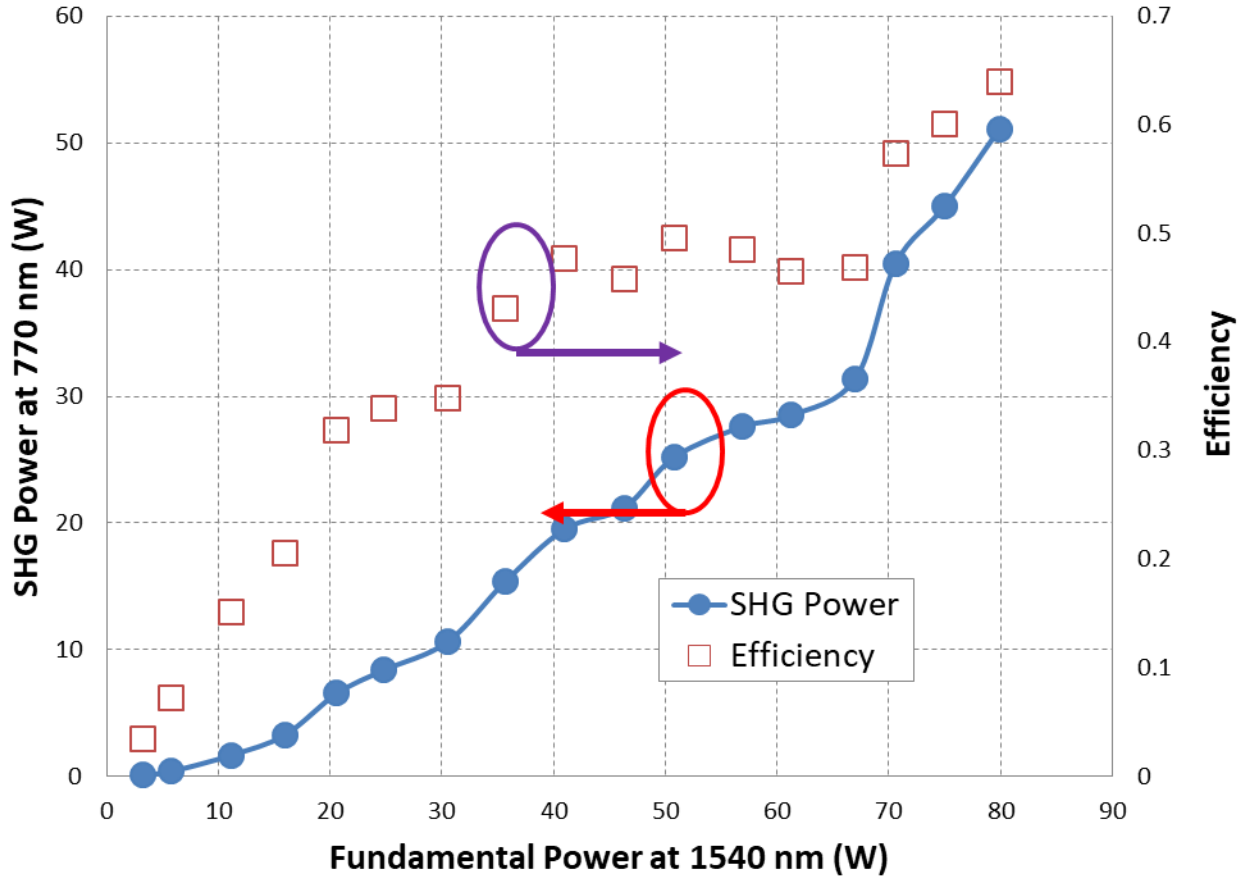


(b) 0.5nm span, 0.01nm resolution

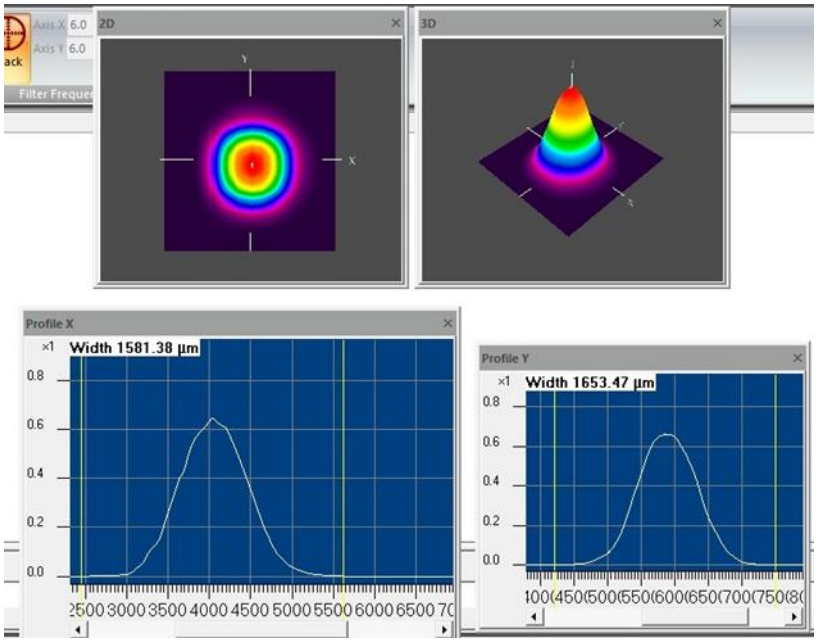
Second Harmonic Generation

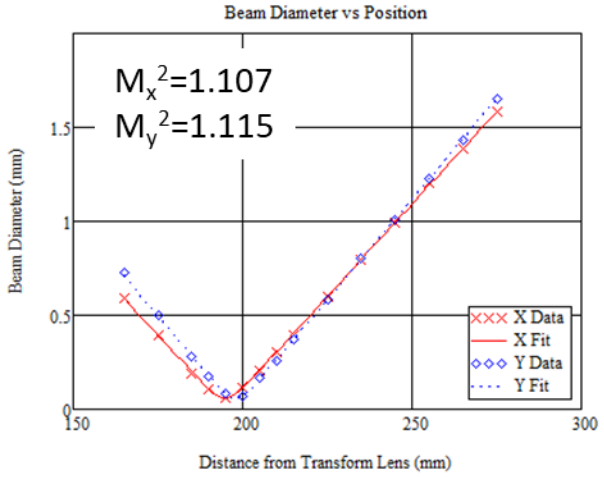


SHG Performance



Output Beam Quality





Transform lens, f_t = 200·mm
Wavelength, λ = 770·nm

$data_{ave} := d\_ave(data)$

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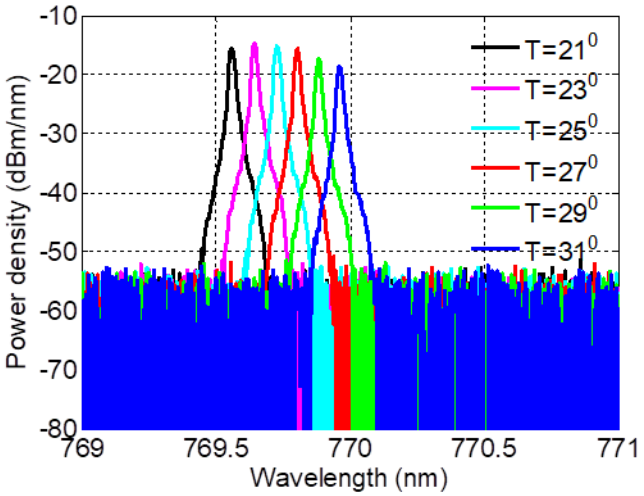
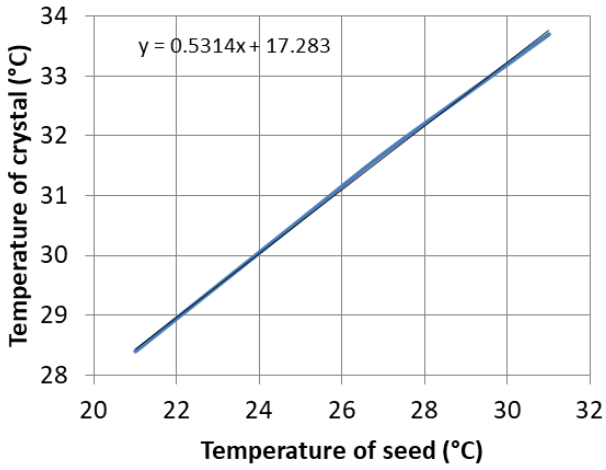
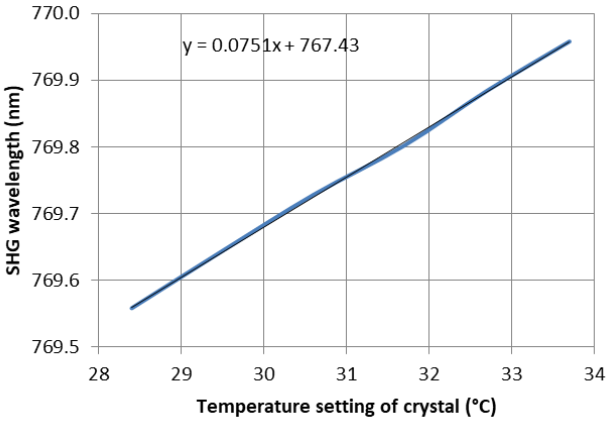
Wavelength Tuning of 770nm Output







Wavelength tuning of 770nm output is realized by tuning both seed and SHG crystal temperatures simultaneously.

Broadening of 770nm output spectral width (I)

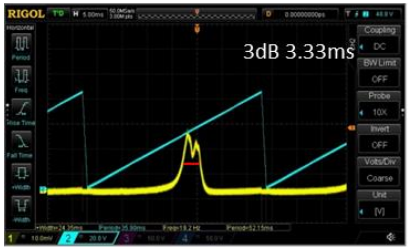
Measured with Fabry-Perot interferometer (resolution < 1MHz) when the spectral width is within 10s of MHz

(a) V_{cc}=2.0V

(b) V_{cc}=2.6V

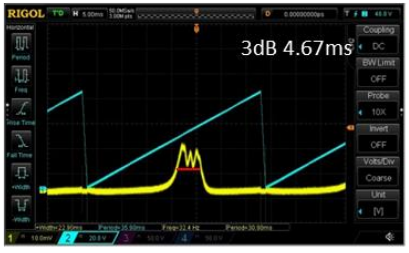
(c) V_{cc}=2.7V

(d) V_{cc}=2.8V



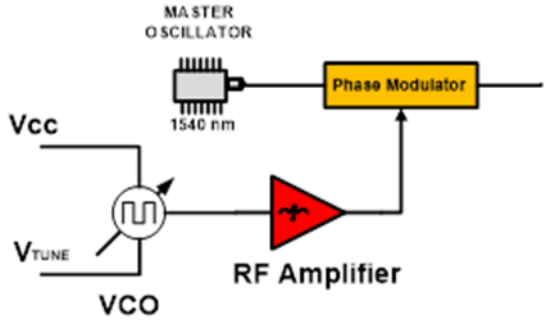
(e) V_{cc}=2.9V

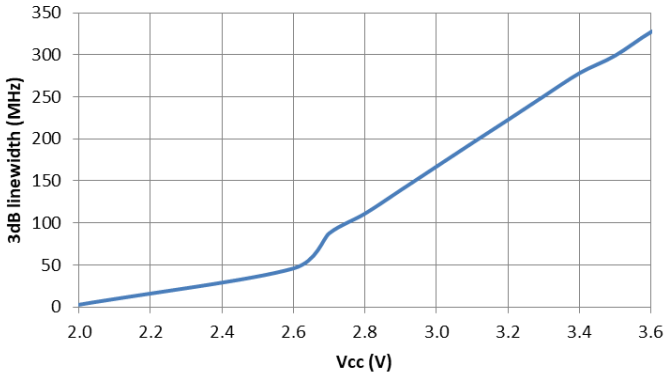
(f) V_{cc}=3.0V



(g) V_{cc}=3.1V

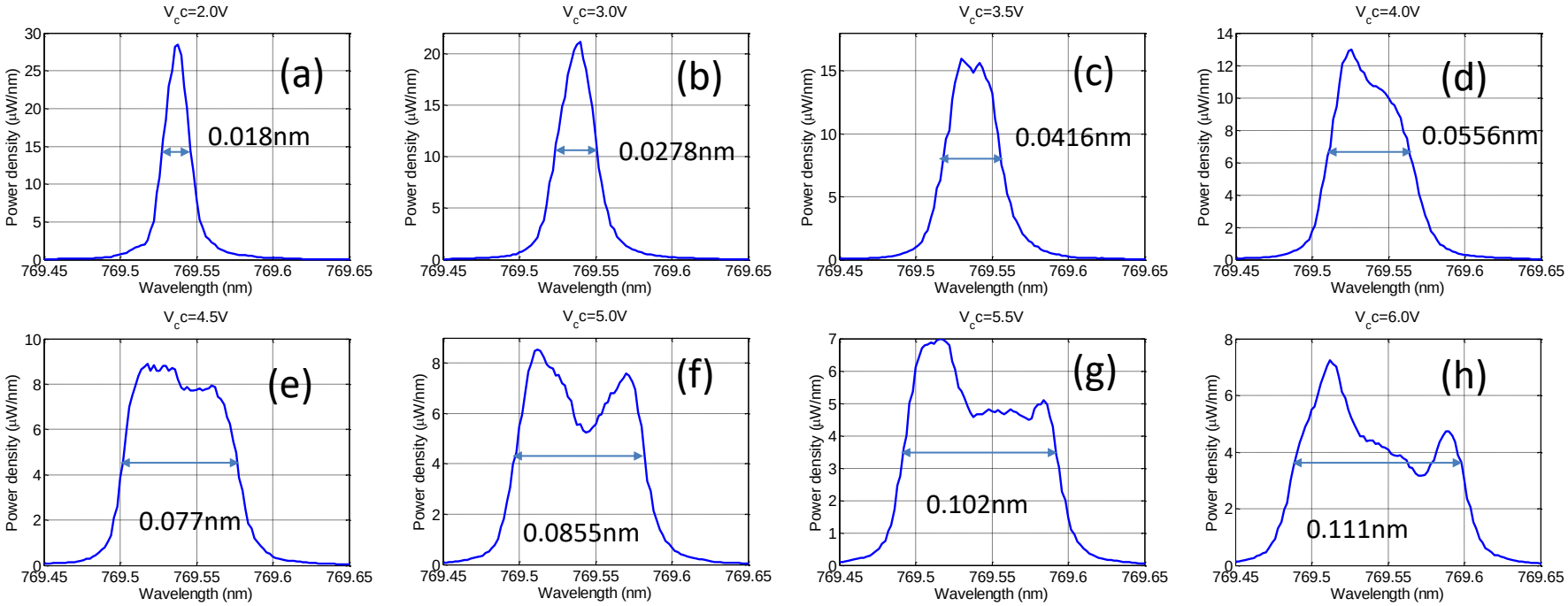
(h) V_{cc}=3.2V

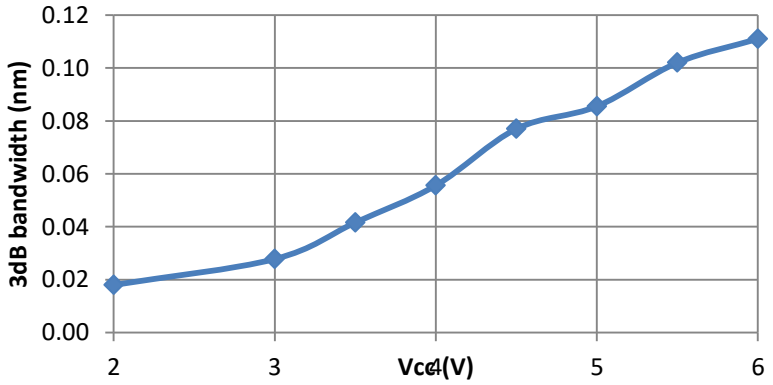




Broadening of 770nm output spectral width (II)

Measured with Optical Spectral Analyzer (resolution 0.01 nm) when the spectral width is more than GHz





Prototype to Be Delivered

Main Power Enclosure

Laser Head Module

Thank you!