100W Mode-Locked Green Laser for GaAs Photoemission Guns

Jihong Geng, PhD

Principle Investigator

AdValue Photonics, Inc

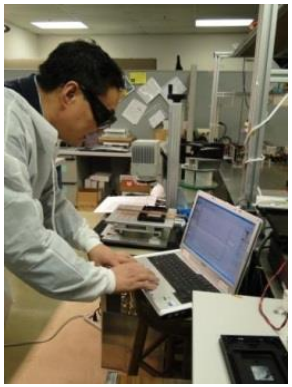
DoE Grant Number: DE-SC0011215

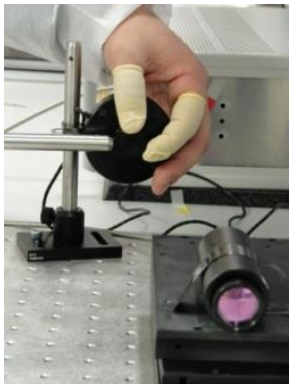
Agenda

- Company Information
- Motivation & Addressed Problems
- Our Solutions
- Phase II Tasks
- Accomplishments to Date
- Plans in Year 2
- Questions

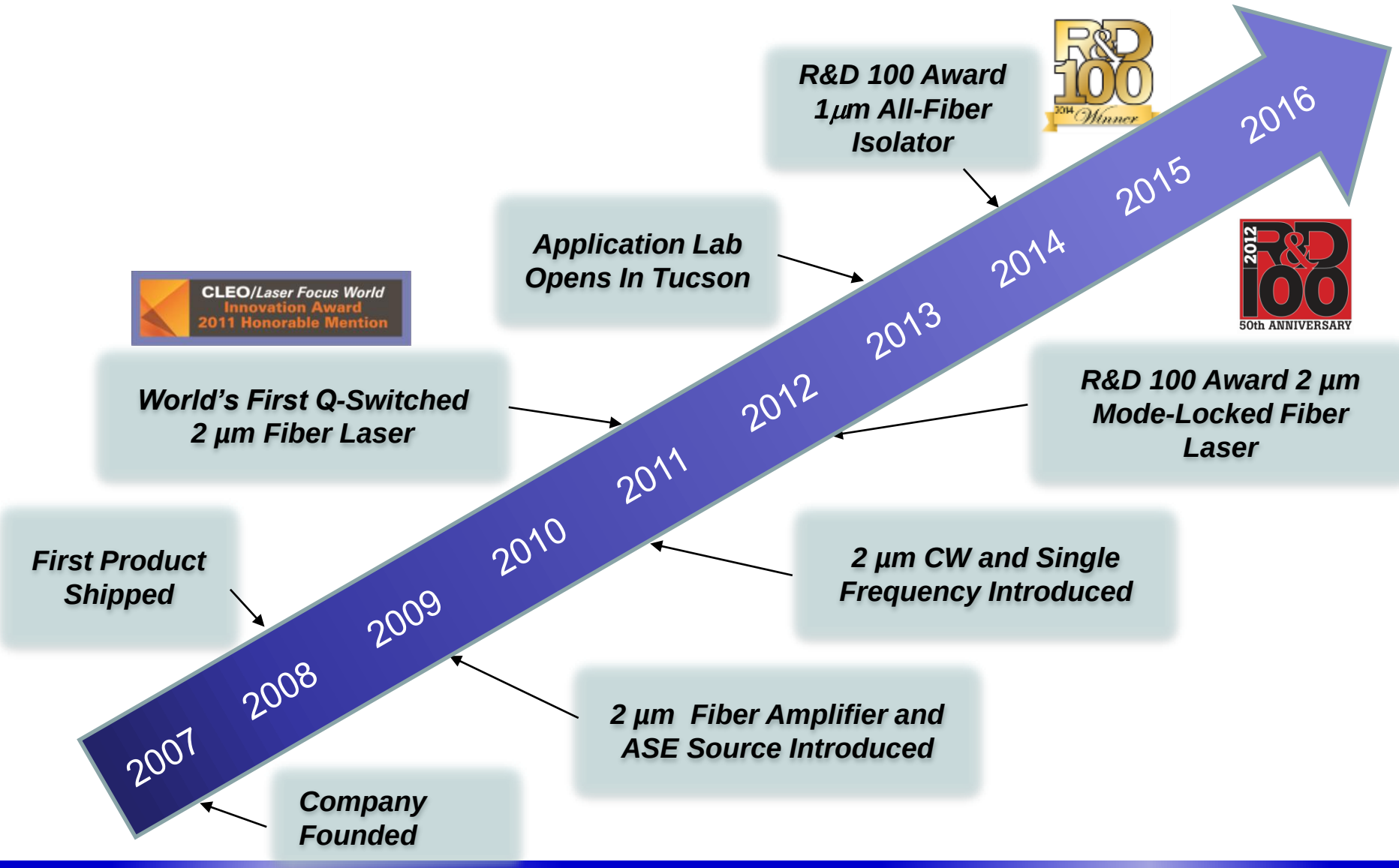
Company Background

- *Founded in 2007*
- *Located in the Optics Valley – Tucson, AZ*
- *Consistent Profitable Growth*
- *Outstanding Technical Team (10+ PhD)*
- *Innovative and Award Winning Products*
- *Dedicated Application Lab*
- *Glass and Fiber Fabrication Facility*
- *Building World Class Operational Capability*





Company Key Milestones

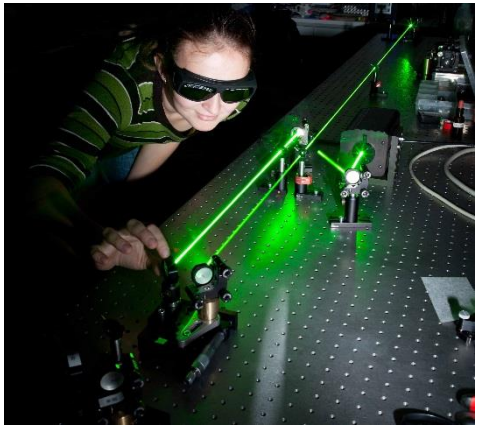


Product at glance

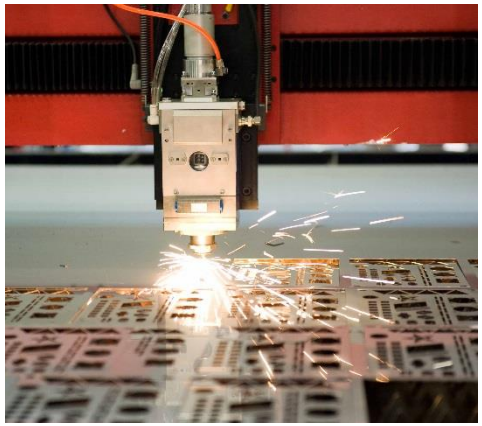
Rare-Earth Doped Specialty Glasses and Fibers

Product Market

The Premier Manufacturer of 2μm Fiber Lasers and Amplifiers



Scientific



Materials Processing

Medical

Motivation

DoE needs

DoE Customer: Thomas Jefferson National Lab

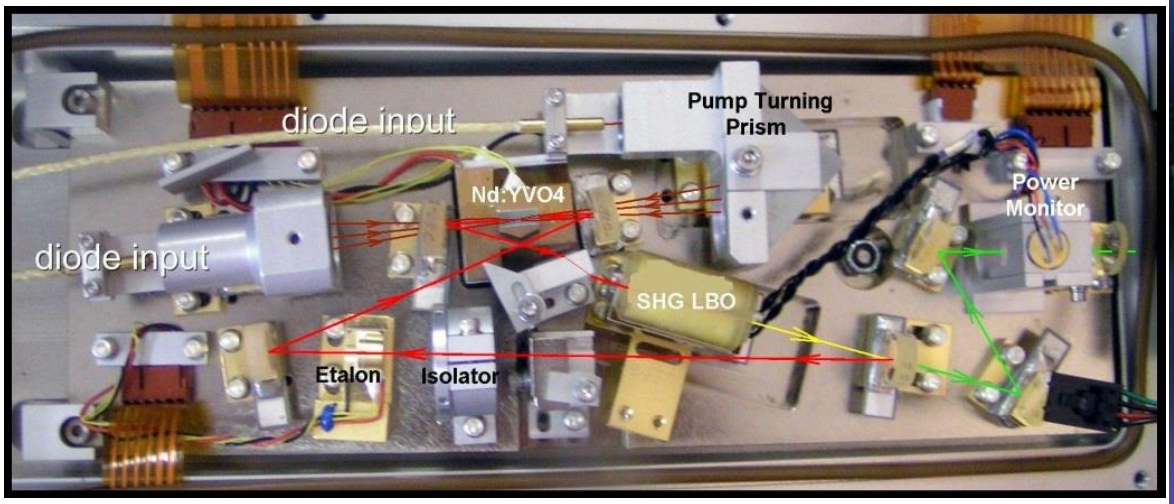
Advanced accelerator development requires a >100W mode-locked green laser, which can be phase-synchronized to GHz RF signal for the application of GaAs photoemission guns.

Commercial applications

- Material processing
- Other scientific applications

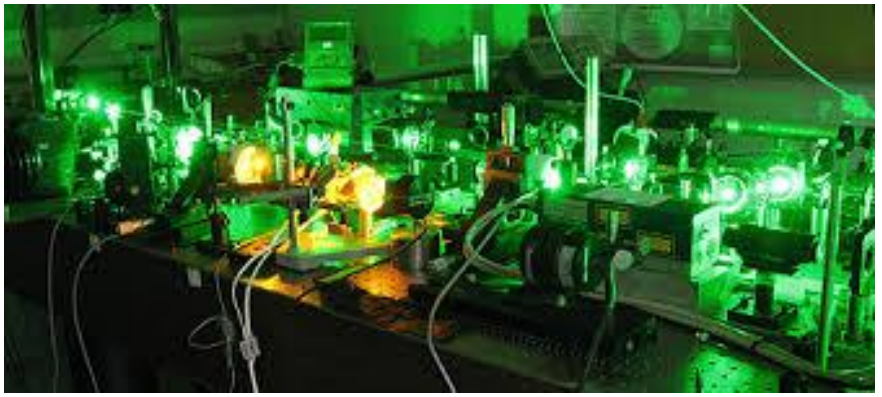
Problems

Solid-State Laser Approach

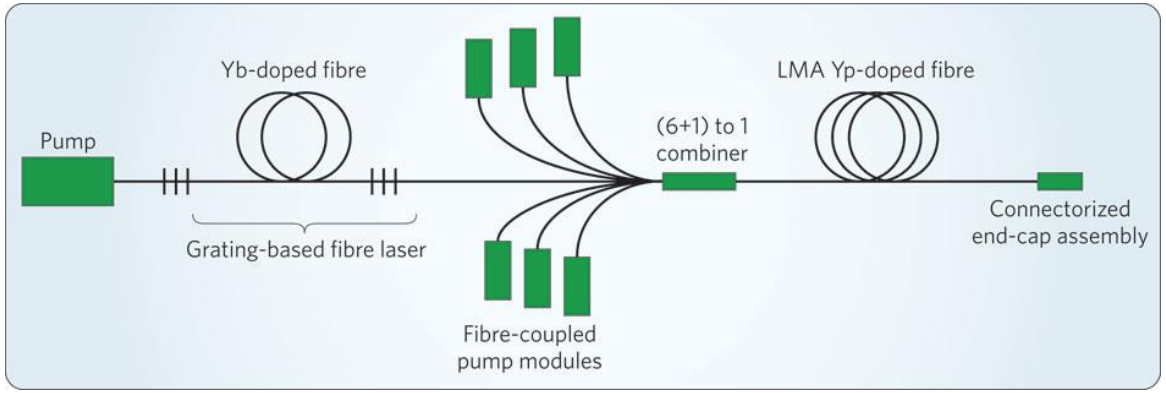


Solid-state laser cavity

- Many bulk components
- Complicated alignment
- Mechanical sensitivity
- Thermal deformation



Fiber Laser Approach



Fiber laser cavity

☺ Monolithic structure – robustness, compactness, reliability
☺ Well-defined waveguide – excellent beam quality
☺ Well-managed heat – high average power capability
▼ Long fiber length – nonlinear optical effect, peak power limit
▼ Small fiber core – nonlinear optical effect, peak power limit

Our Approach

High-efficiency high-gain gain fiber

Flexible Fiber Design

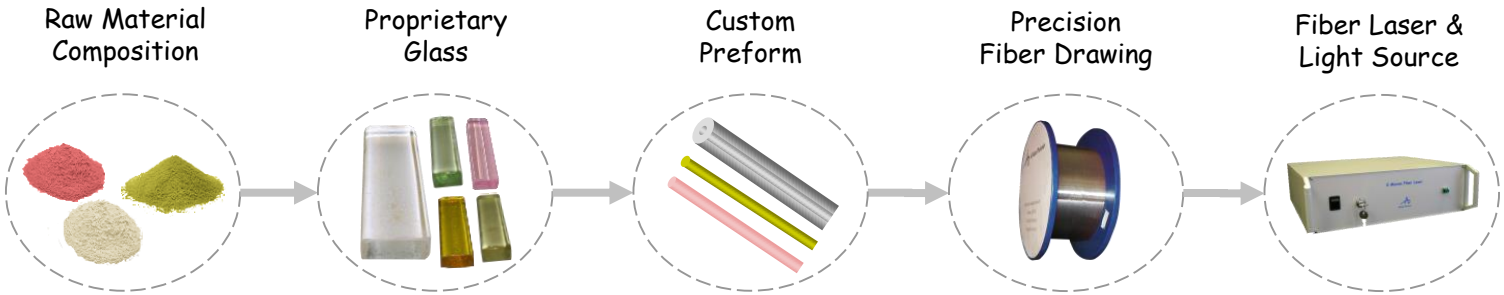
- Higher Doping Concentrations
- Short Gain Fiber Length
- Custom Core Sizes
- Minimized Intra-Cavity Nonlinearities

Enables

Innovative Solutions

- Shorter Pulse Width
- Higher Pulse Energy
- Higher Peak Power
- Higher Average Power

Raw Materials → Laser Systems

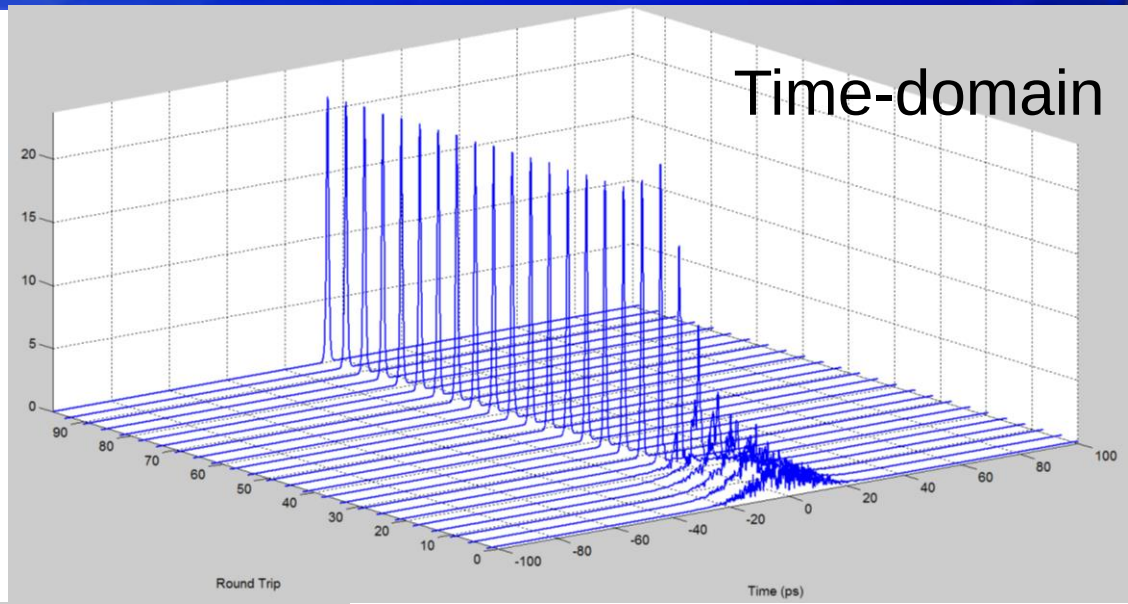


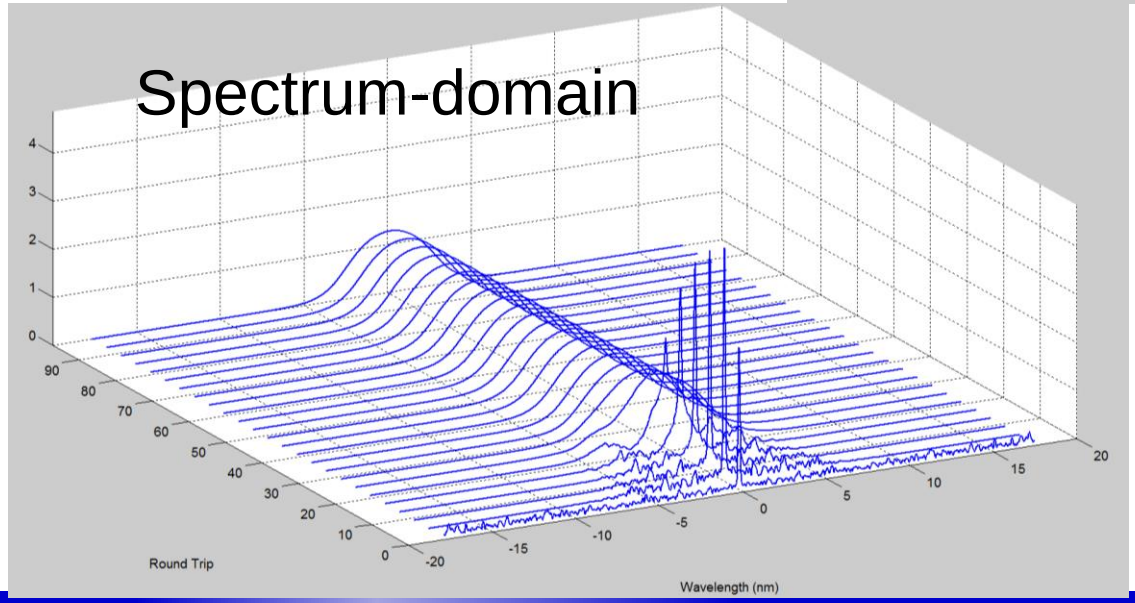
Phase II Tasks

- Develop a robust mode-locked Yb-doped fiber laser oscillator
- Model the pulse evolution in high-power Yb-doped laser system
- Design and fabricate Yb-doped silicate fibers for amplifiers
- Phase locking of a mode-locked fiber laser to an external GHz signal
- Design and build a fiber amplifier chain with 200W average output
- Characterize the noise from high-power mode-locked fiber amplifiers
- Demonstrate a 100W mode-locked green laser system
- Build a prototype unit

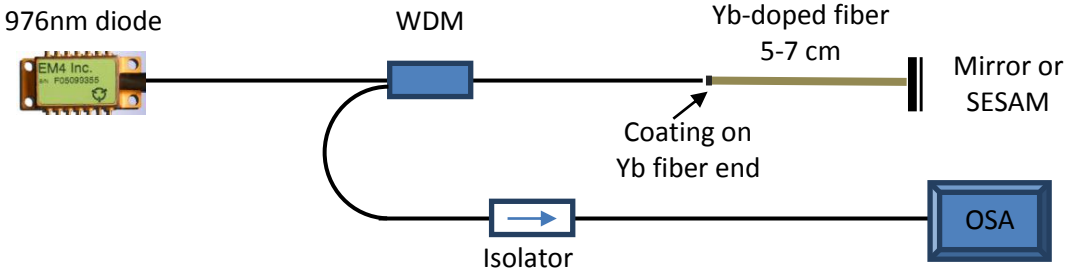
Simulation

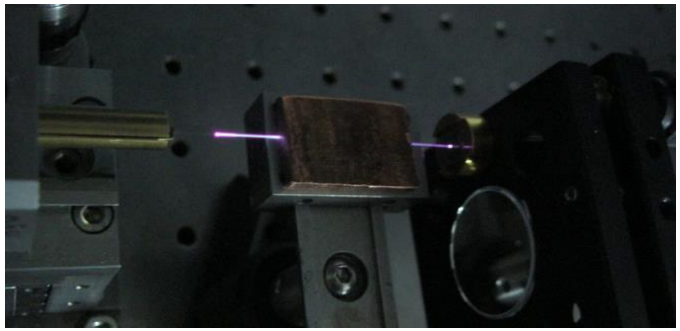
Pulse buildup in a mode-locked Yb fiber laser

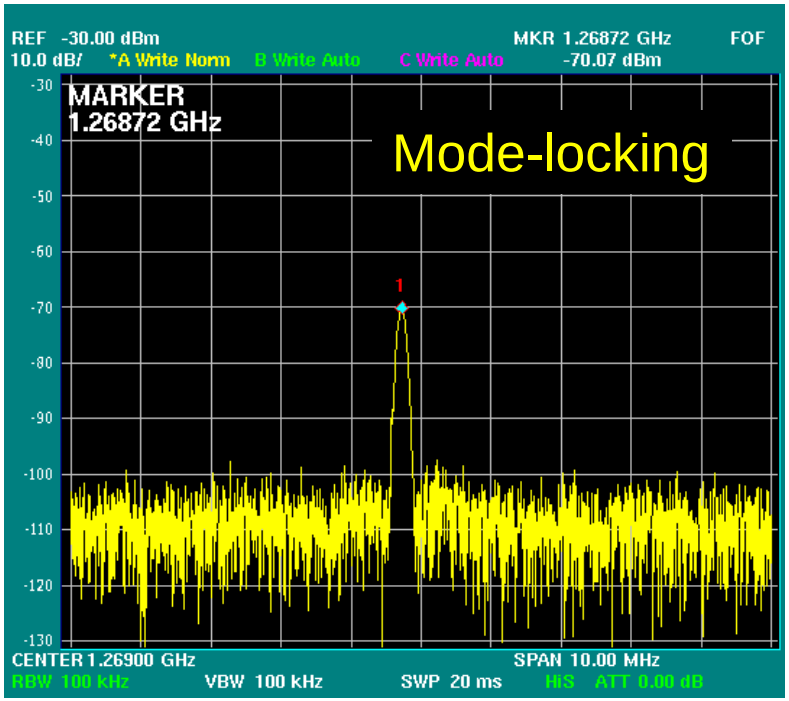


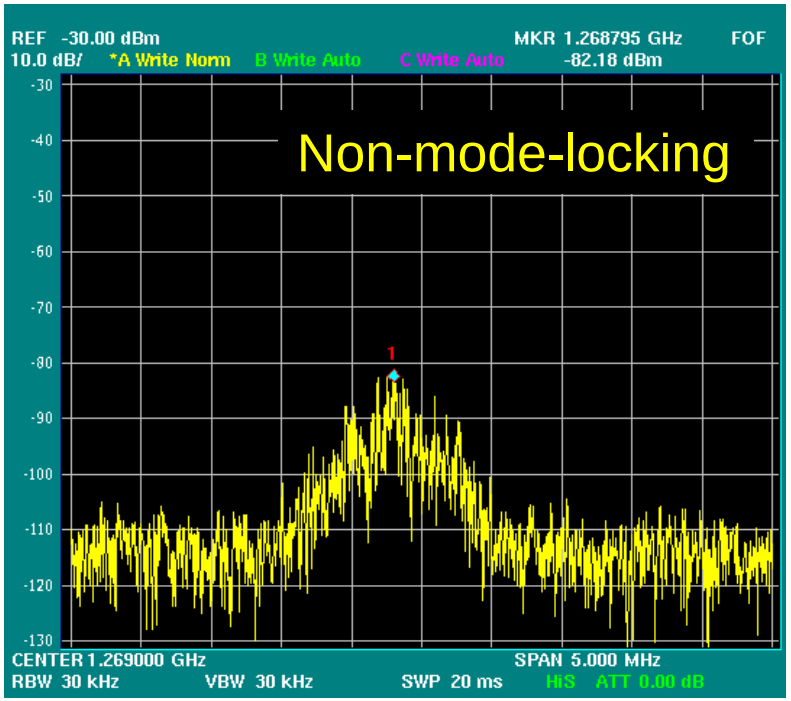


GHz mode-locking

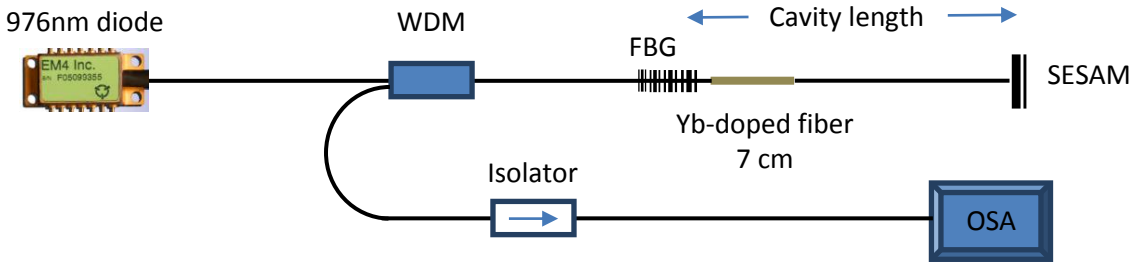


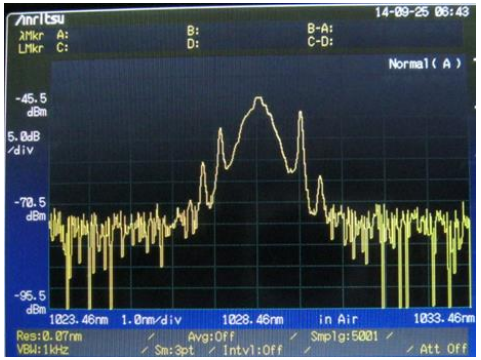


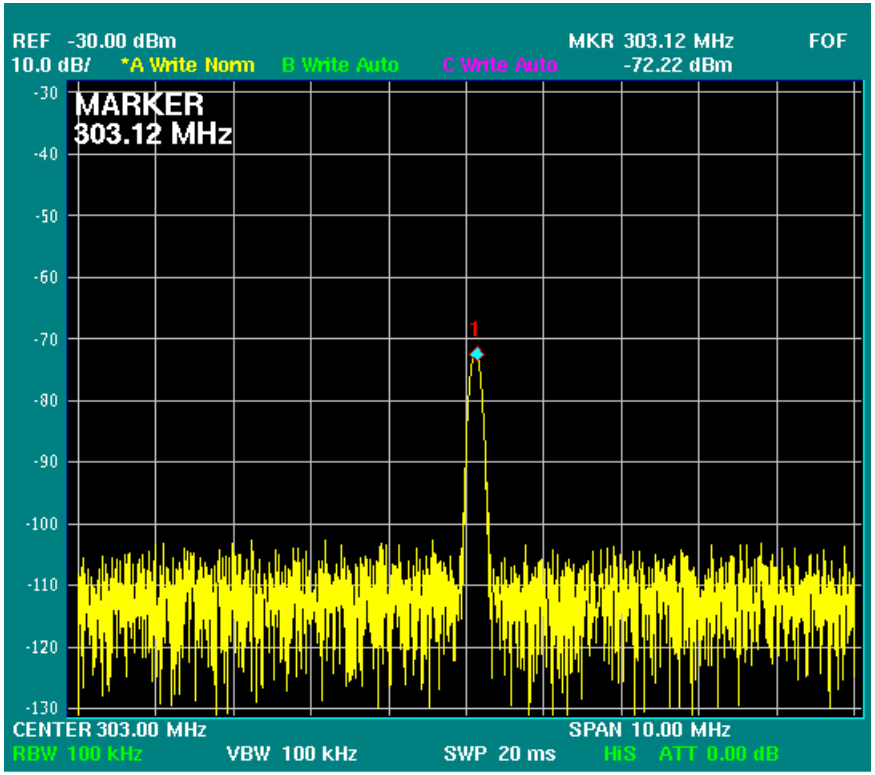


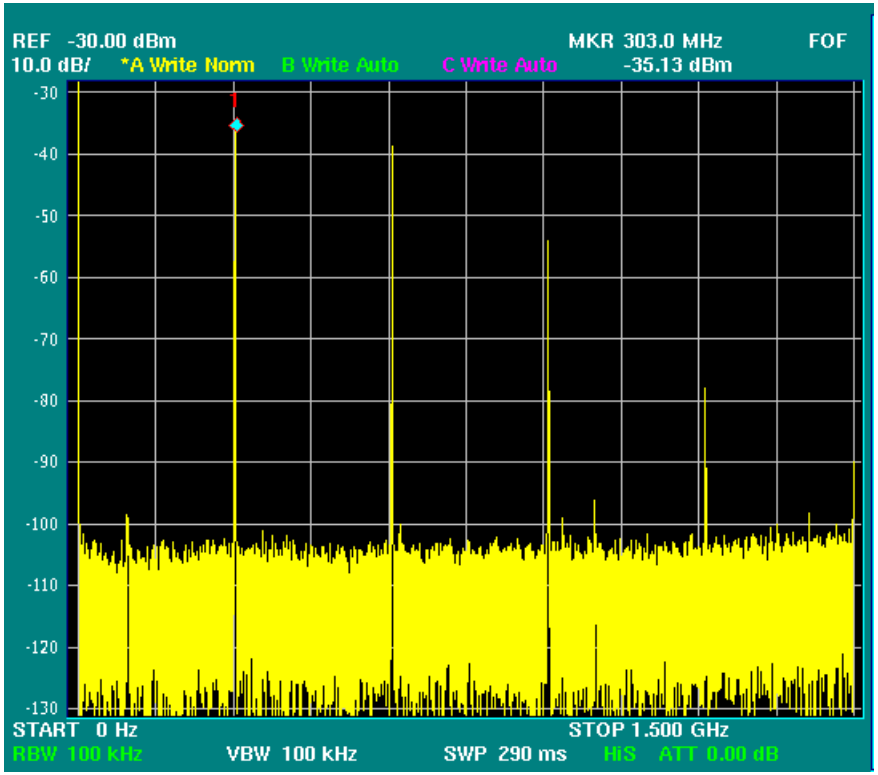


300 MHz mode-locking



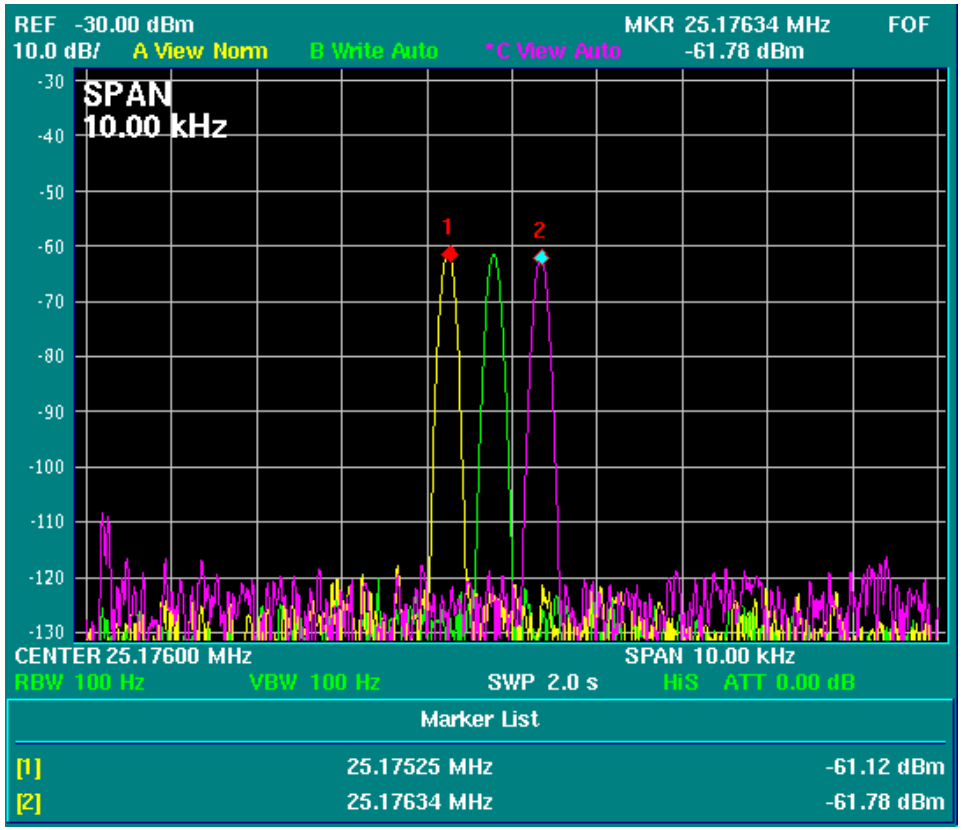


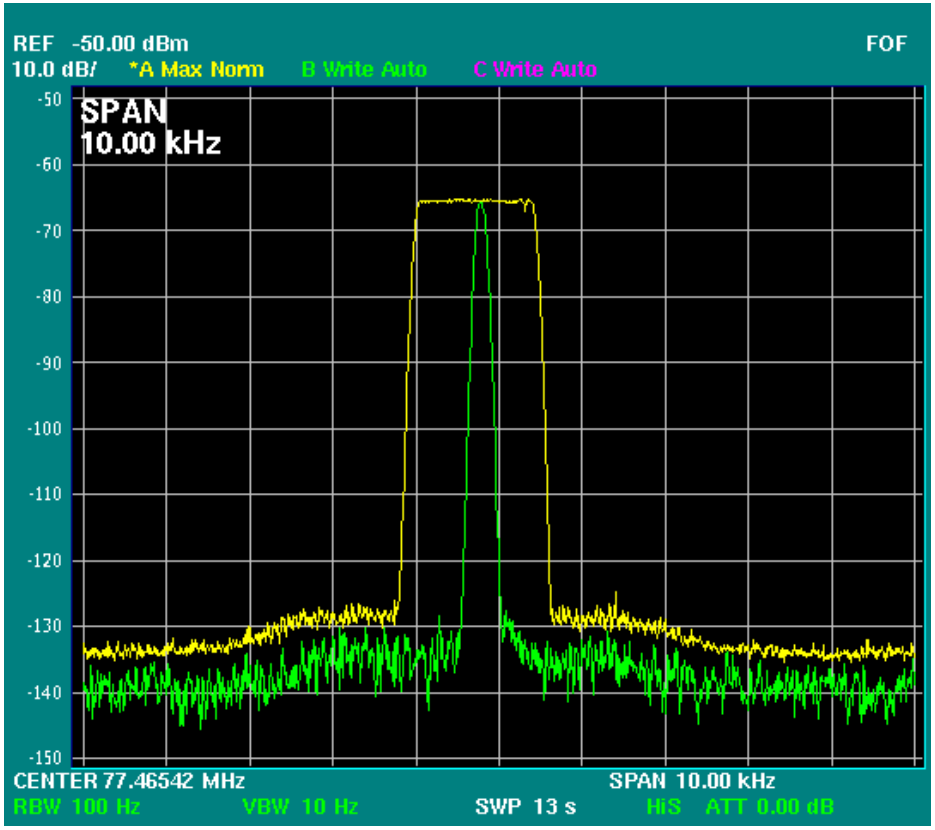




Tuning for phase locking

Mode-locking rep rate tuning for phase locking

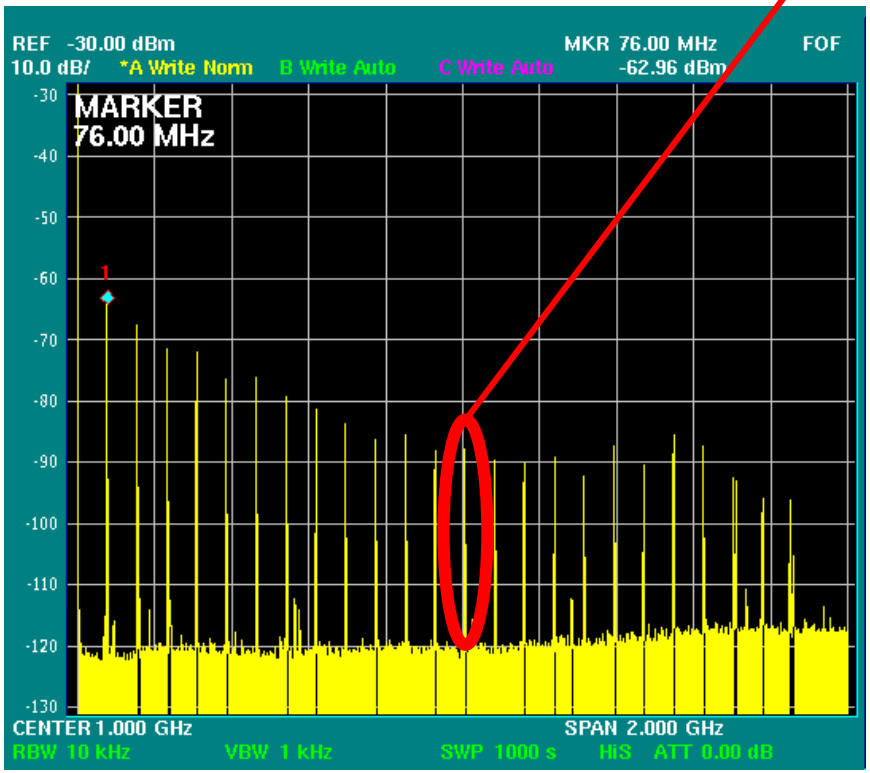


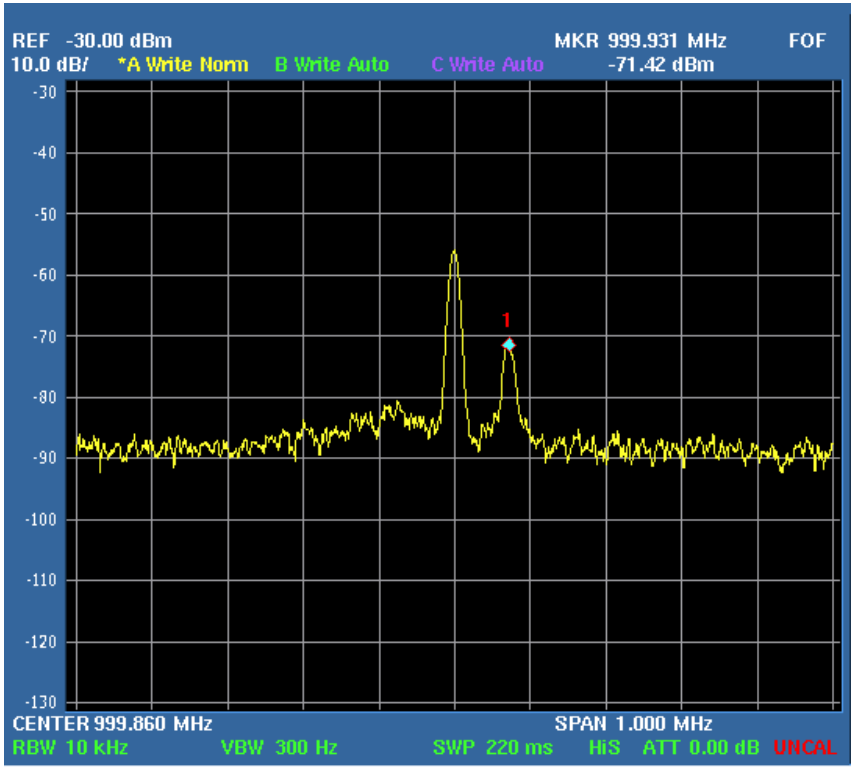


Phase synchronization

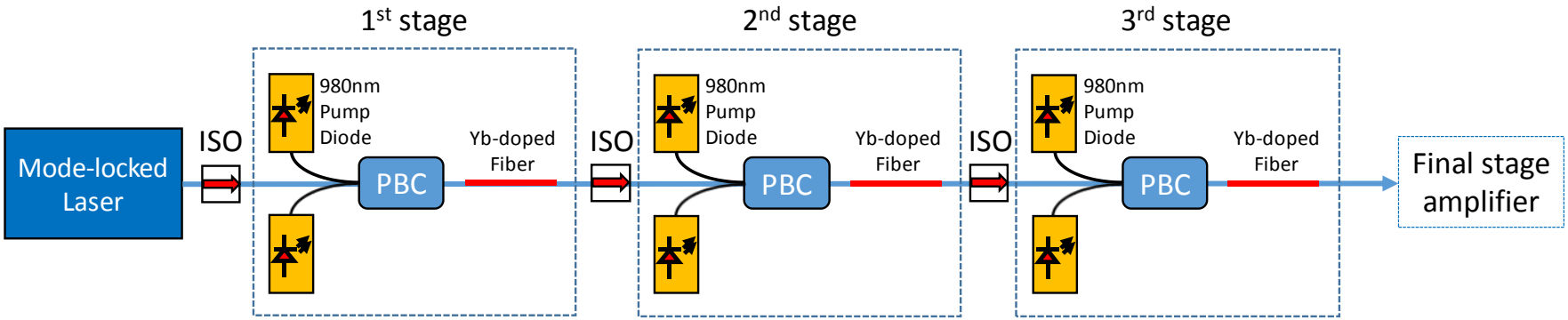
Harmonic tone heterodyning with 1GHz RF signal

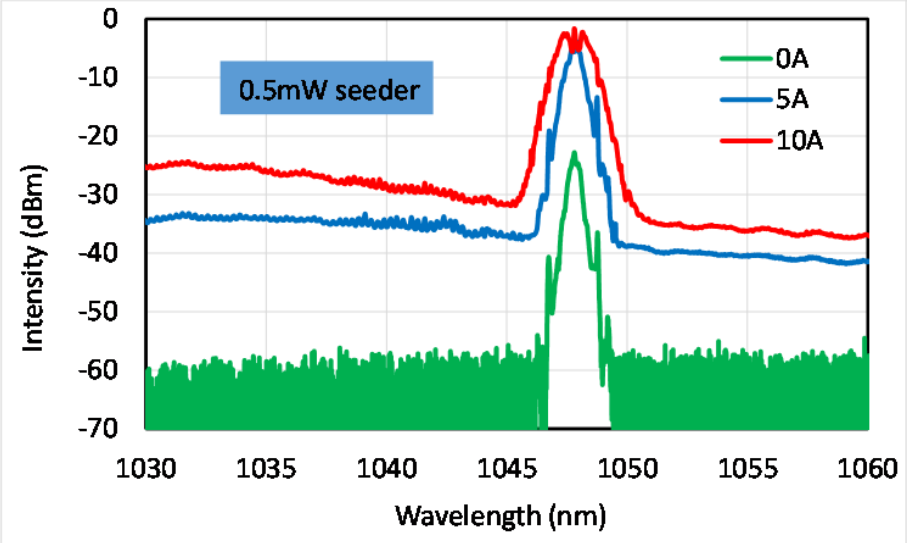
1GHz signal → ⊗ → Heterodyne beating

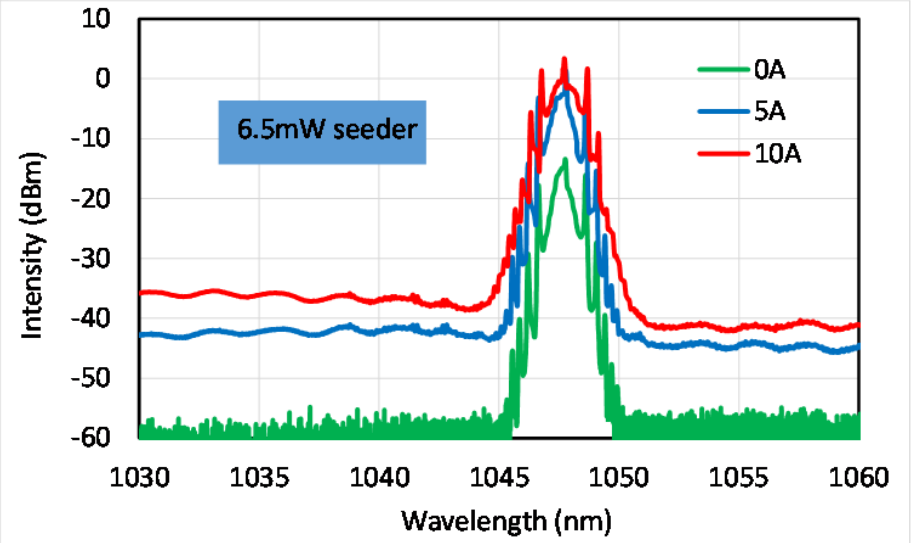




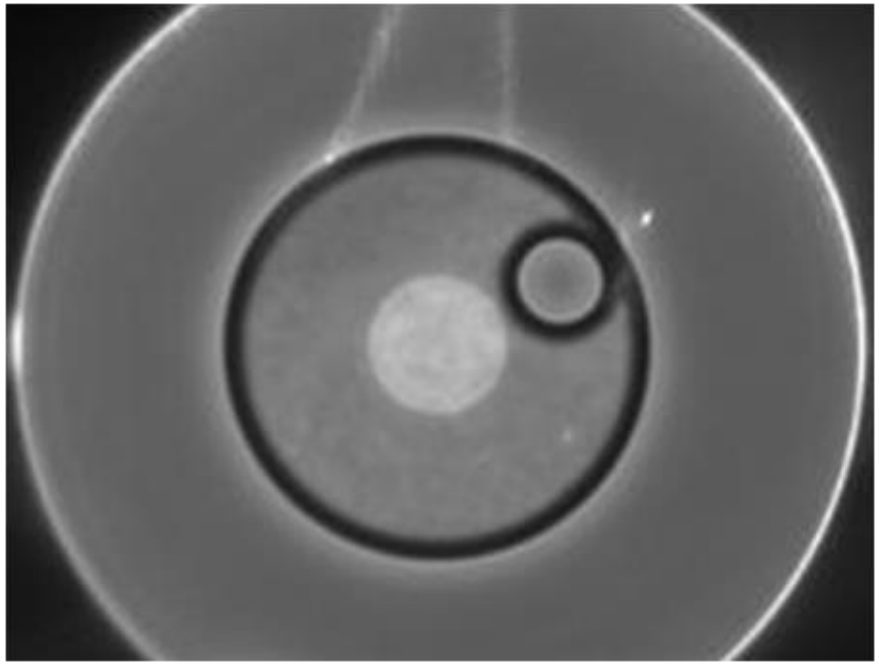
Fiber amplifier chain



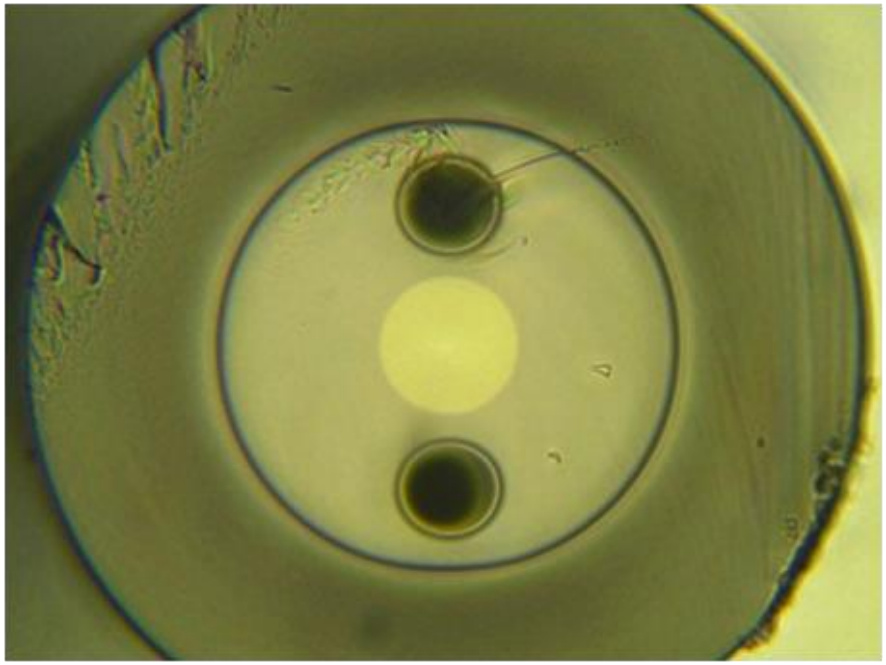




Double-cladding Yb-doped large-mode-area fibers



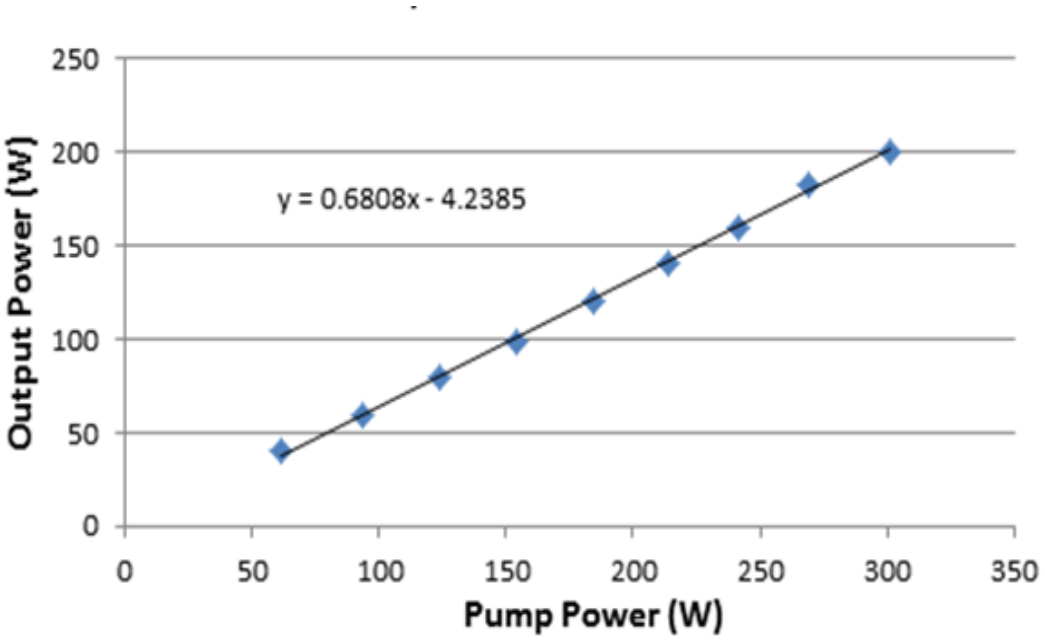
Non-PM

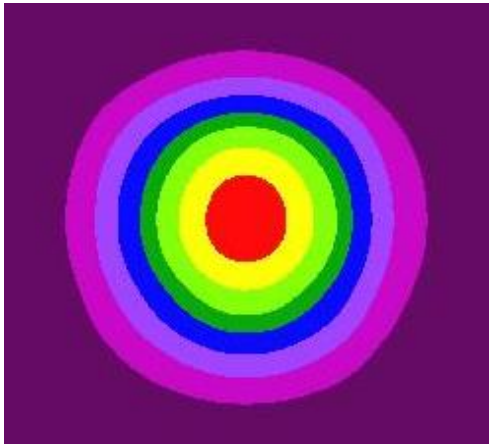


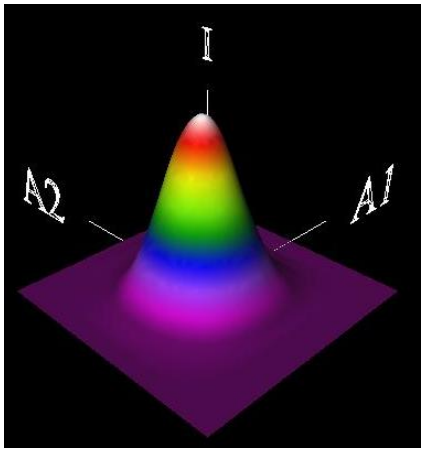
PM

200W power amplifier

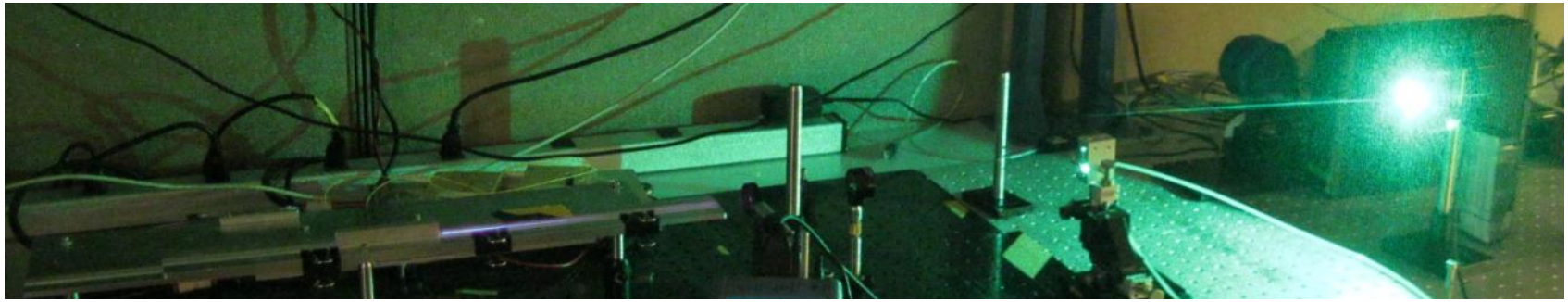
Output power from a Yb-doped fiber power amplifier at 1030nm

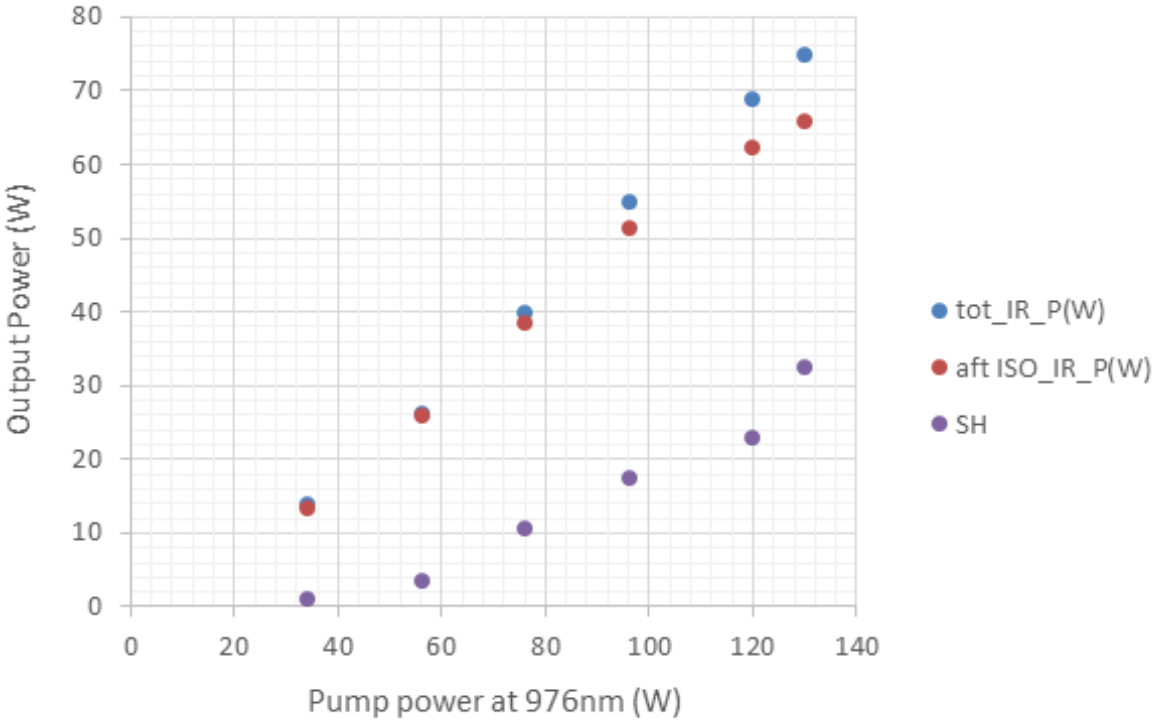






Frequency doubling





Plans in Year 2

- Optimize the design for a robust laser oscillator
- Demonstration of phase synchronization to GHz RF signal
- Prototype the laser unit

Thank you

Questions?