OFS Raman Fiber Lasers and VLMA Amplifiers

EPIC Online Technology Meeting – Medical Lasers

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At the Forefront of Optical Fiber Technology

Heritage Spanning A Century

1880

Alexander Graham Bell invents the photophone.

1900s

AT&T acquires the assets of **American Bell.**

AT&T breakup.

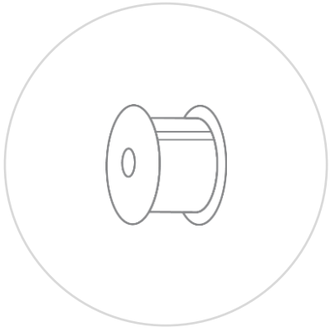
Lucent Technologies, a spin-off of Bell Labs and AT&T's manufacturing operations, is created.

2001

Furukawa Electric Company acquires Lucent's optical fiber business.

OFS is created.

Extensive Product Portfolio Serving Customers Worldwide

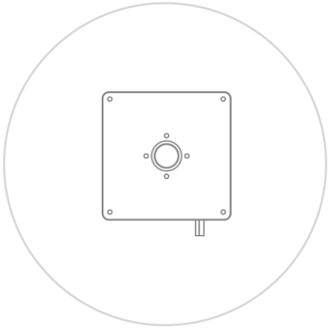


Optical Fiber

Fiber Optic Cables

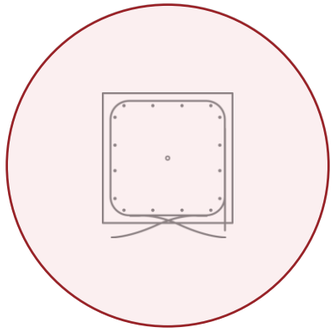
Optical Components

Optical Connectivity



Modules

Fusion Splicers



Fiber Laser Components and Amplifiers

The TrueMode™ Yb laser cavity

TrueMode™ Yb Cavity

TrueMode Cavity – Kilowatt Yb fiber laser optical modules with industrial performance

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TrueMode Cavity – Kilowatt Yb fiber laser optical modules with industrial performance

OFS optical modules

- OFS does not make turn-key laser systems.
- Optical module includes all fiber components and packaging for thermal management but no pump diodes or control electronics.
- Designed for our customers to rapidly develop novel laser solutions while taking advantage of OFS fiber and fiber laser expertise.

Moving to new wavelengths to enable new applications

TrueMode™ Yb Cavity

Cascaded Raman Resonator

- Cascaded Raman Resonator provides nonlinear frequency shifting

Moving to new wavelengths to enable new applications

TrueMode™ Yb Cavity

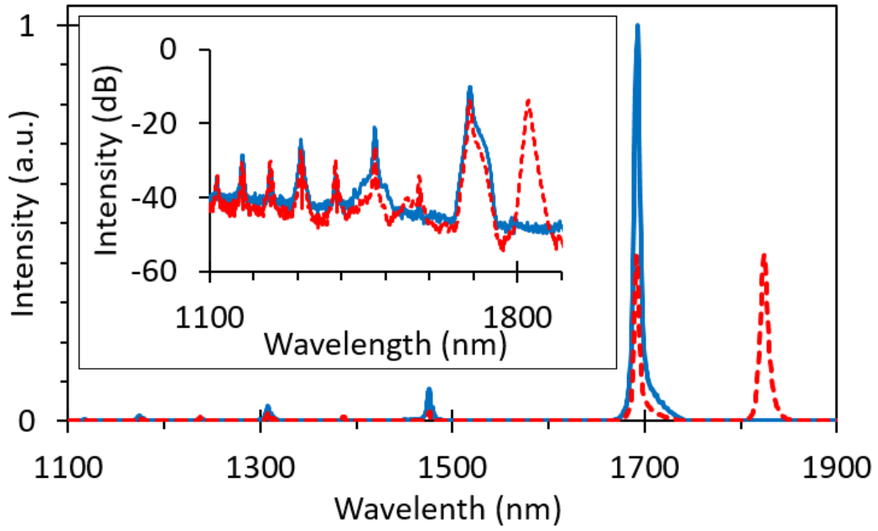
Cascaded Raman Resonator

Raman Laser Cavity

- Cascaded Raman Resonator provides nonlinear frequency shifting
- Raman laser = Yb cavity + CRR
- Applications
  - Medical lasers
  - High brightness laser pump source
  - Test and measurement
  - Sodium guide star
  - Frequency conversion

High power, single-mode fiber laser with operating wavelength from 1 µm to > 1.8 µm

Example : 100 W Raman fiber lasers at 1700 nm



Raman laser with 100 W at 1692 nm

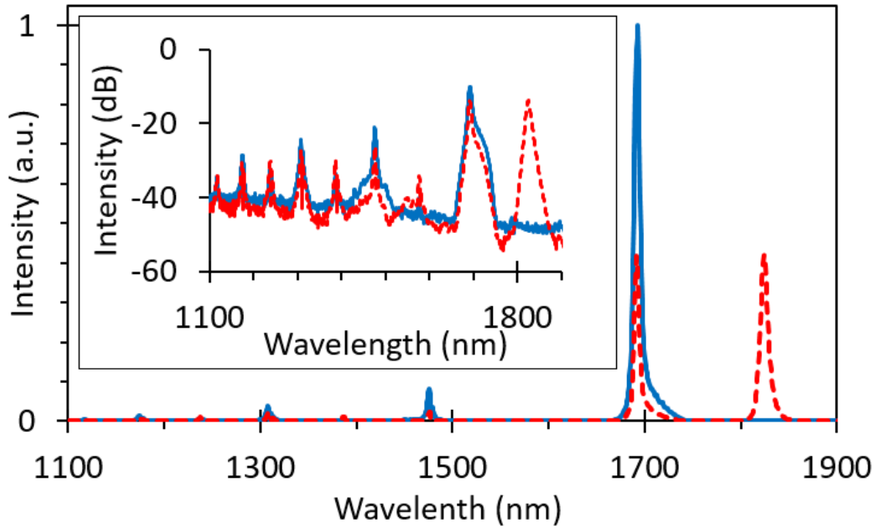
1700 nm wavelength range is difficult for rare-earth doped fiber such as thulium but is interesting for emerging medical and other applications.

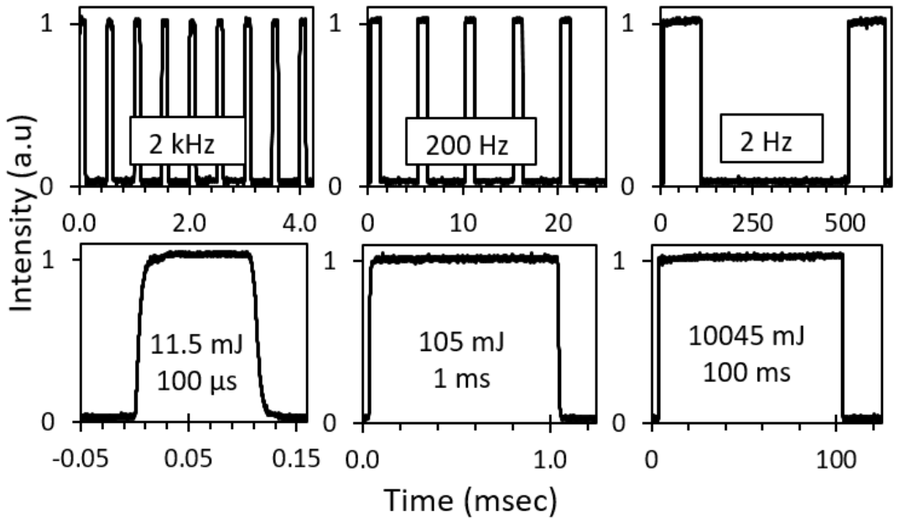
Blue curve – Spectrum using OFS Proprietary Raman filter fiber
Red curve – Spectrum using conventional Raman fiber

OFS Proprietary Raman filter fiber enables high power, high spectral purity at target wavelength.

Raman fiber lasers at other wavelengths

- Pulsed current drive to Raman laser pump diode enables high-energy, long pulse operation of the Raman laser
- Pulses are free of relaxation oscillations or overshoot
- Spectrum is virtually identical to CW operation
- Enables:
  - Synchronous pumping of low-rep-rate pulsed lasers
  - Medical applications





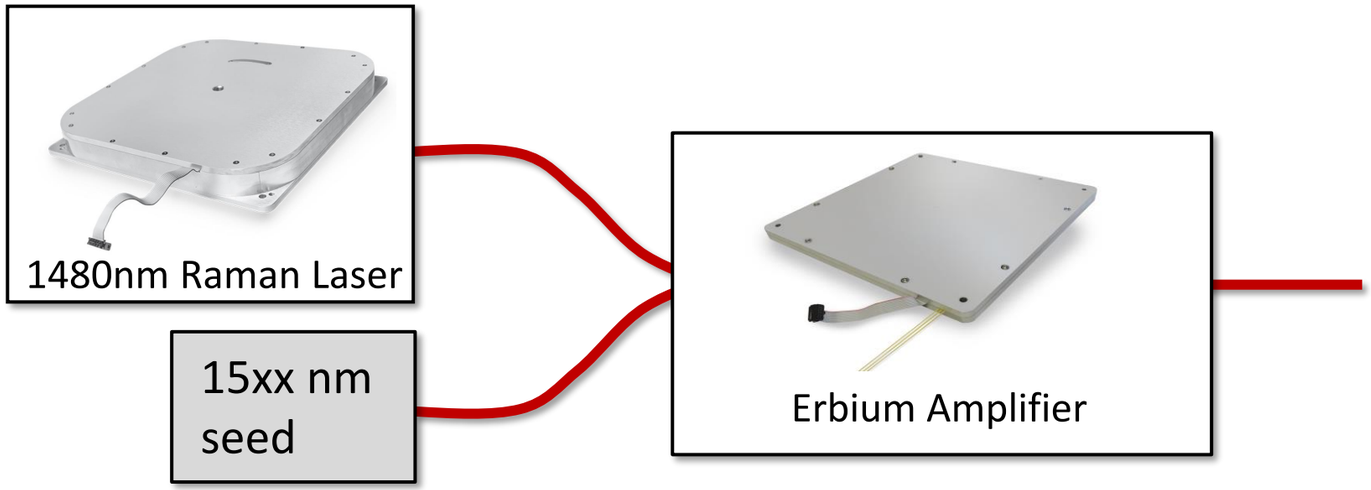
Compact, OEM Raman cavities

3 and 10 W, Raman fiber laser cavities : Single mode output over wide wavelength range in a compact form-factor

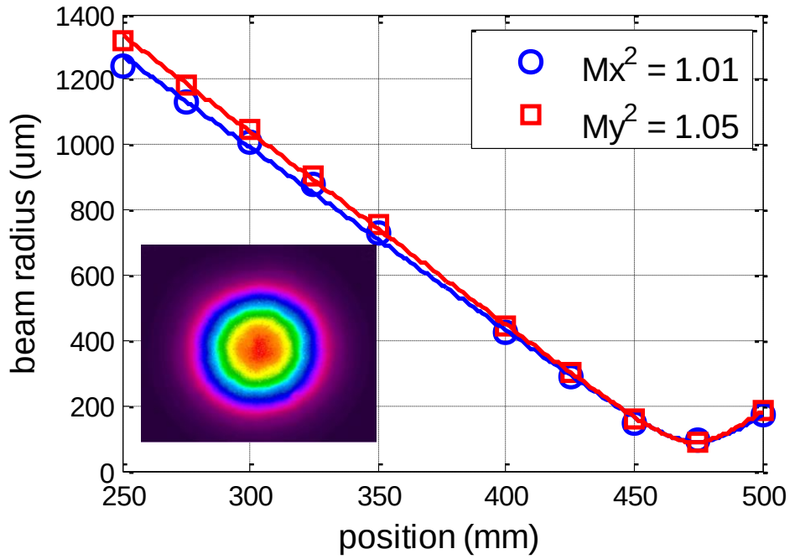
Applications:

- Fiber laser pumping
- EDFA pump
- Telecom – distributed amplification
- Test and Measurement
- Medical lasers

VLMA-Er Amplifiers : High performance, low nonlinearity pulse lasers

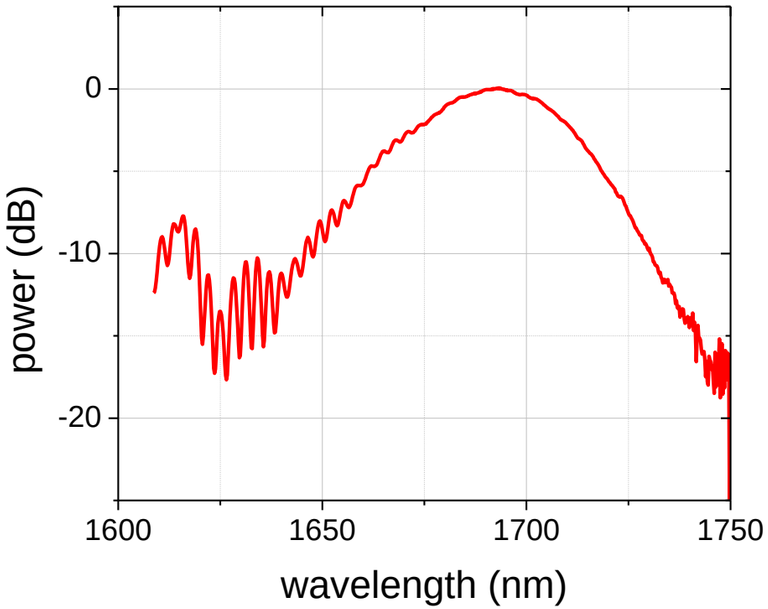


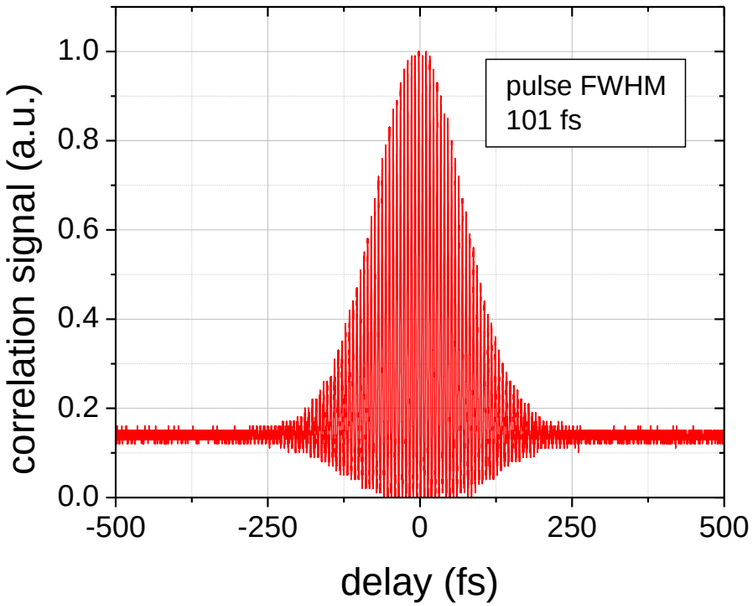
- **V**ery-**L**arge-**M**ode **A**rea (VLMA) fiber
  - Core diameter ~ 50 μm core diameter
  - Over 100 W average output power
  - Polarization maintaining



Very large core enables high pulse energy amplification while maintaining diffraction limited output

High energy pulse amplification in a VLMA-Er fiber





- 20 nJ
- 100 femotseconds
- 200 kW peak power
- 1690 nm

Example : Femtosecond pulse amplification in VLMA-Er amplifier

- Wavelength tunable, high energy, femtosecond pulses via soliton generation
- Femtosecond pulses without need for chirp compensation.
- High polarization extinction
- Diffraction limited

VLMA amplifier – suitable for high energy pulse amplification from femtoseconds to microseconds

Conclusions

What we offer

- Raman modules : High power, CW, single mode output from 1 micron to 1.8 microns
- Very-Large-Mode Area Er amplifiers for high average power, high peak power handling capabilities at eye-safe wavelengths opening up new applications.
- Optical modules that allows for rapid prototyping of systems.

What we are looking for

- Partners with
  - Unique requirements for lasers in medical applications.
  - Who need high power at novel wavelengths typically unavailable from rare-earth doped fibers
- Laser and system integrators who can benefit from the optical modules that OFS builds.