Integrated disruptive componentS for 2µm fibre Lasers **ISLA**

2 µm Sub-Picosecond Fiber Lasers

Advantages:

2 - microns wavelength offers

- eye-safety
- potentially higher pulse energy and average power in single mode fiber compared to 1 µm.
- better performance with a variety of materials due to higher absorption at 2 µm; clear plastics, certain thin-films, Silicon processing

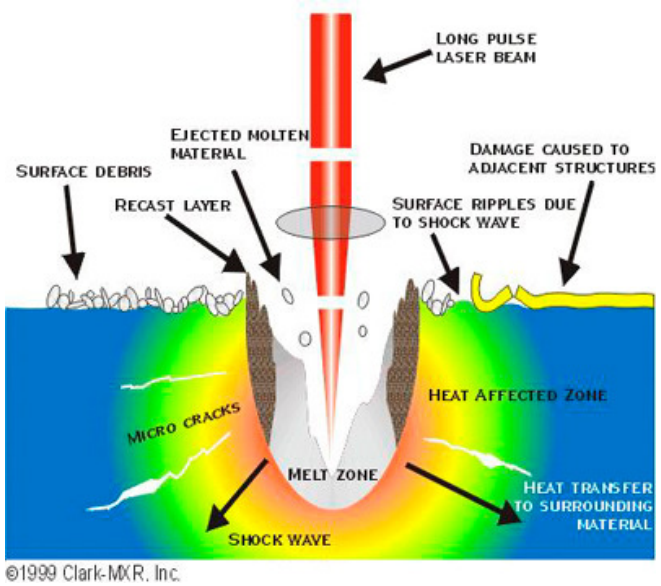
Polymer	Thickness (mm)	Wavelength (nm)	Absorption at Rt (%)
PMMA (acrylic) Transcolors	3.2	1540	10-13
PMMA (acrylic) Transcolors	3.2	1940	50-55
Polycarbonate Makrolon®	3	1540	10-12
Polycarbonate Makrolon®	3	1940	44-50
Polypropylene	1.2	1540	10
Polypropylene	1.2	1940	31

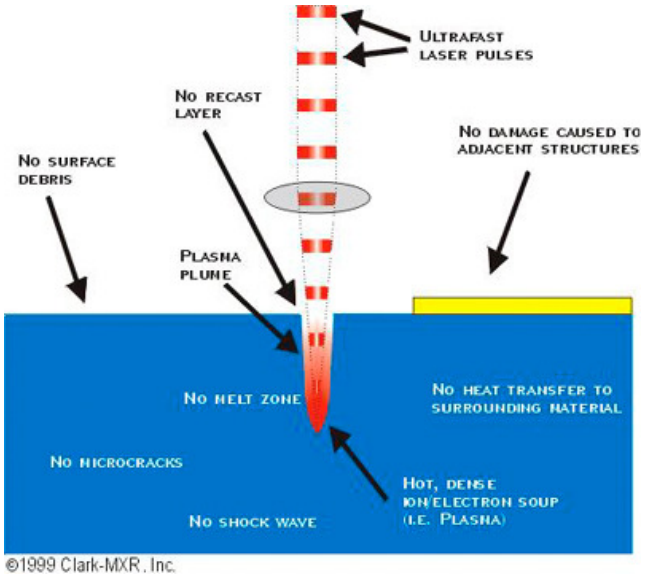
IPG photonics application note

Substantial process advantages compared to nanosecond pulses for micromachining

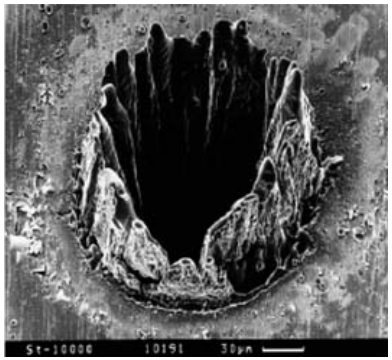
- smaller heat-affected zone (less than 1 micron typical)
- less micro-cracking
- less recast
- cutting through hard or brittle materials
- selectively removing mixed material layers
- substantially faster speed / productivity for precise processes
- higher quality ↔ higher speed ↔ (lower cost)

Advantages – Long pulses vs. Ultrafast pulses





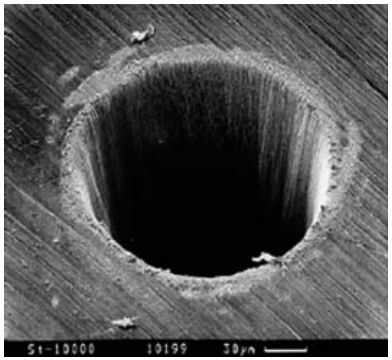
Nanosecond



Chichkov et al, 1996

Oxford Laser C. Bansal; 2012

Sub - Picosecond



Chichkov et al, 1996

Sub - ps Laser pulses increase quality of micro-ablation processes

Applications:

Micromachining

- Micromachining of clear plastics,
- Certain thin-films
- Silicon processing

Spectroscopy, Metrology

- Seed sources
- Time-resolved (pump-probe) measurements
- Frequency combs
- SCG pumps (SCG for mid-IR)
- LIDAR sources
- Eye-safe remote sensing, standoff sensing

Sources for high-harmonic generation

- OPO, OPA seed and pump sources

Medical

- Ophthalmology
- Hair removal

Challenges:

- Mode locked Laser development
  - Self- starting of robust modelocking
  - Dispersion management

- Limited availablility of 2 µm components → ISLA project
  - Mode locking devices
  - Fibers
  - High brightness pump sources
  - Tap couplers, pump/signal combiners, circulators,…
  - AOM, pump diodes,..

- Diagnostics for ultrashort pulses is costly and limited available for 2 µm wavelength:
  - Optical spectrum analyzer
  - Autocorrelator
  - Beam profiler cameras

Commercially available systems:

AdValue Photonics
Innovative & Reliable

2 Micron High Power Mode-Locked Fiber Laser (AP-ML2)

- Introduced at PW 2015
- Operating wavelength: 1.95±0.05 µm
- Pulse width: 800 fs (with external pulse compressor)
- Max. pulse energy: 10 µJ
- Max. average power: 3 W
- Output polarization: Random
- Beam quality, M^2 : <1.3

Proprietary multicomponent glass allows for high doping concentrations, short absorption lengths → suppression of nonlinear effects.

genia photonics

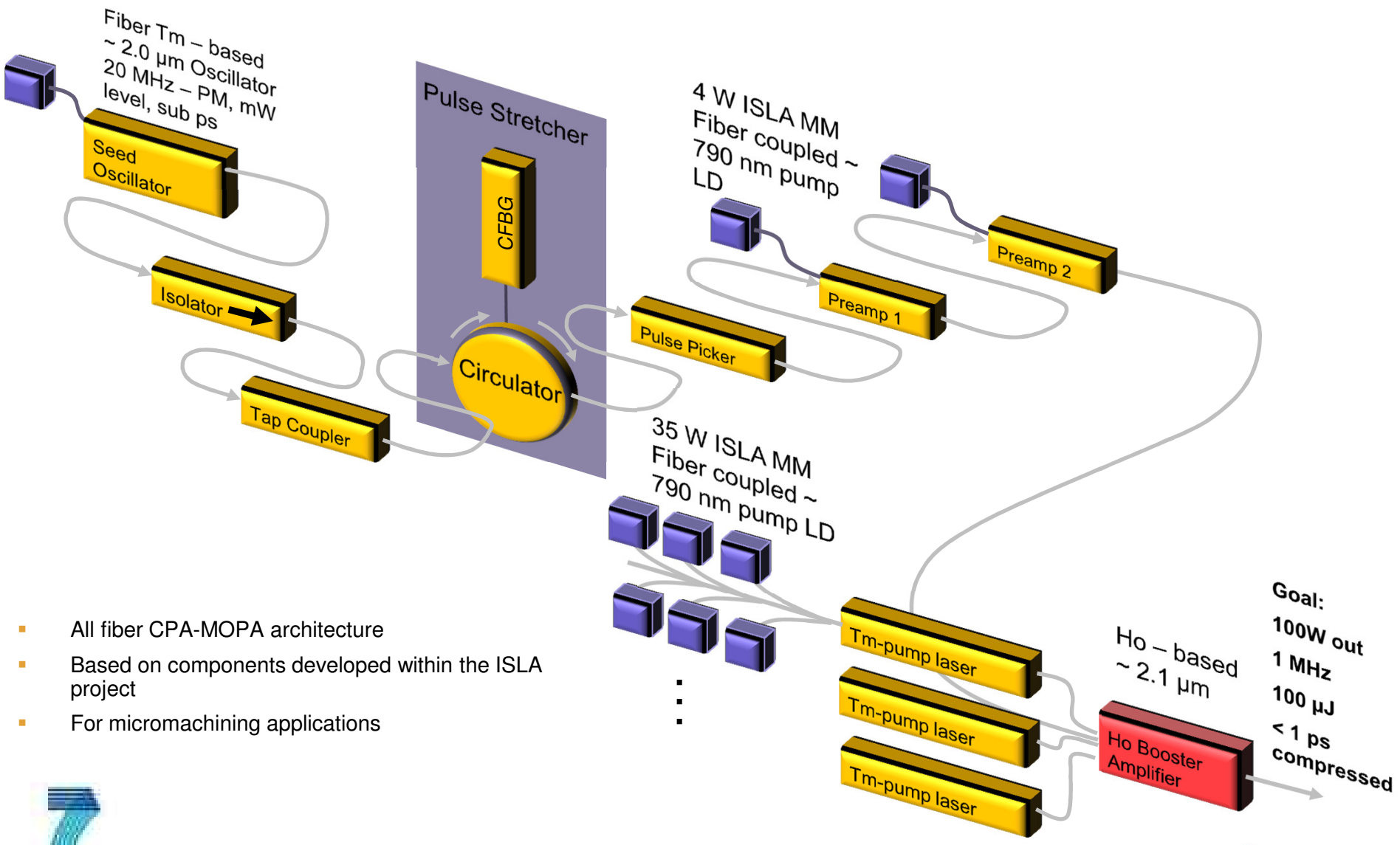
Parameters	Units	TLA-1950-050
General Laser Parameters		
- Central Wavelength	nm	1950
- Wavelength Range	nm	1900-2000
- Tuning Step Size	nm	< 0.01
- Output Average Power	mW	1000
Pulse Train		
- Repetition Rate	MHz	10-120
- Pulse Width	ps	85 +/- 15 ps
Laser Pulse		
- Maximum Peak Power	W	1000
- Form Factor	M^2	< 1.2
- Polarization Extinction Ratio	dB	> 15

PolarOnyx Laser

2 Micron High Power Mode-Locked Fiber Laser (AP-ML2)

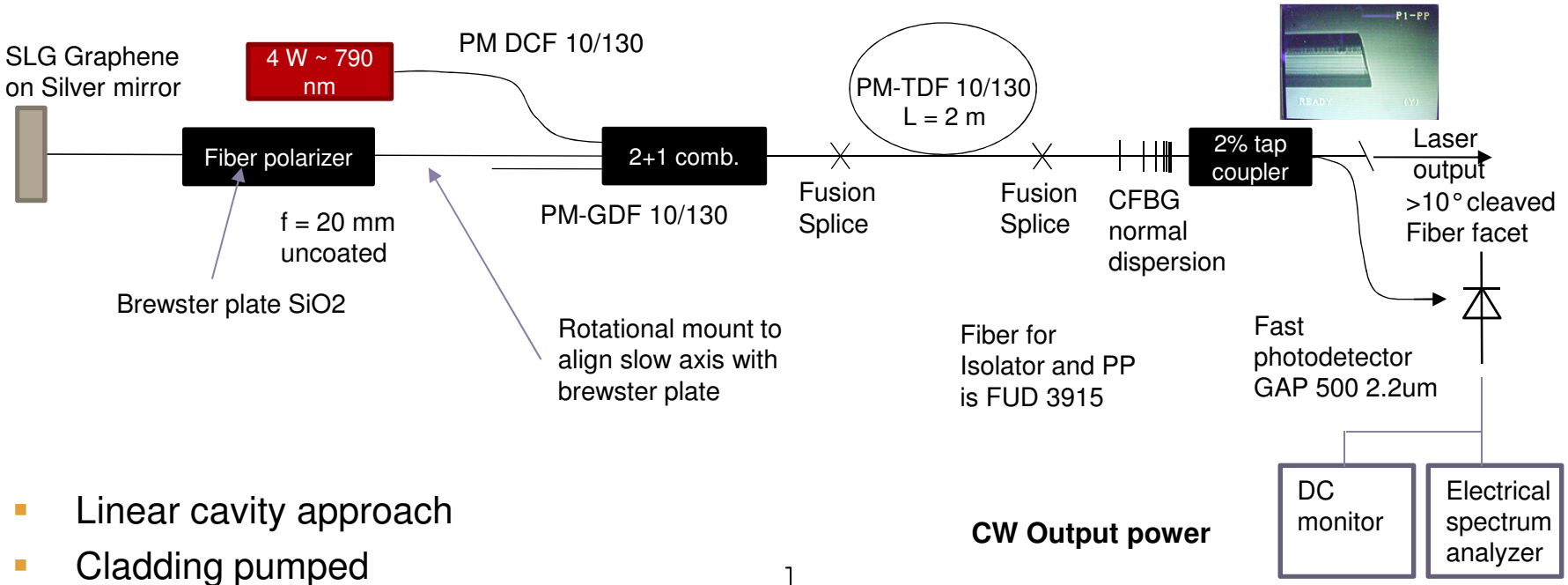
- Operating wavelength: 1950 nm – 2050 nm
- Pulse width: 150 fs - 500 fs (with external pulse compressor)
- Pulse energy: 16nJ
- Max. average power: 5W
- Output polarization: Random
- Beam quality, M^2 : <1.3

ISLA 2-µm sub-ps Tm - Ho Laser System

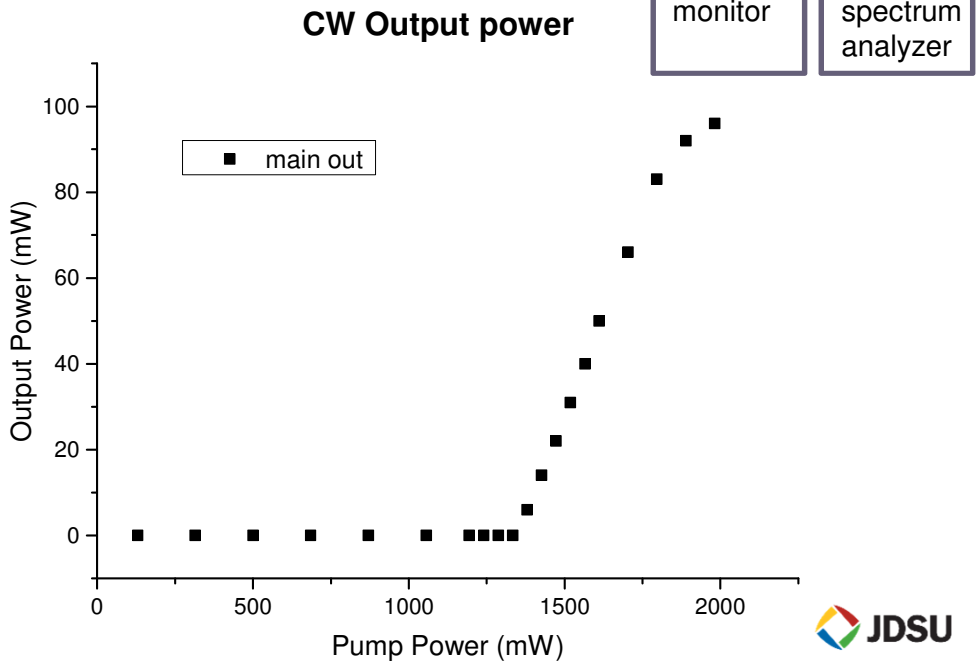


- All fiber CPA-MOPA architecture
- Based on components developed within the ISLA project
- For micromachining applications

PM Seed Oscillator

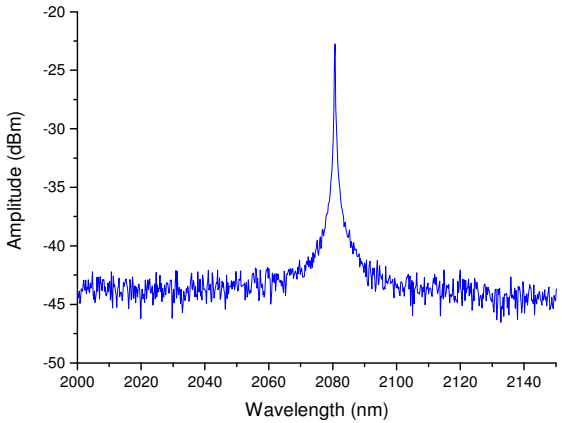


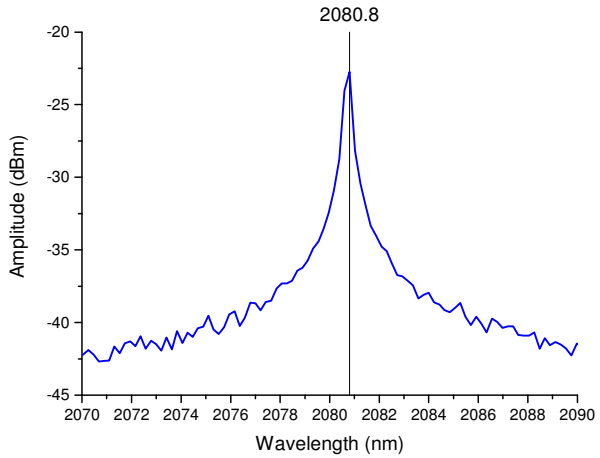
- Linear cavity approach
- Cladding pumped
- 2080 nm emission wavelength
- In fiber Polarizer
- CFBG for dispersion compensation and output coupling
- Resonator length: ~ 5 m
- PRF: 20 MHz

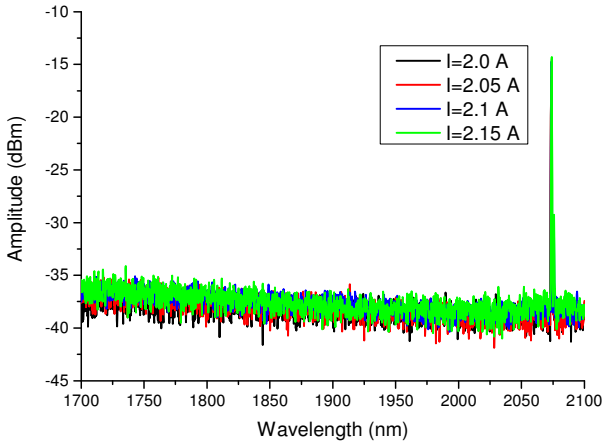


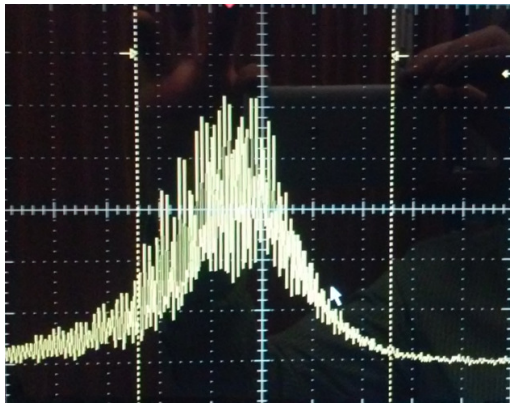
Demolaser III – cw Optical Spectrum Measurement

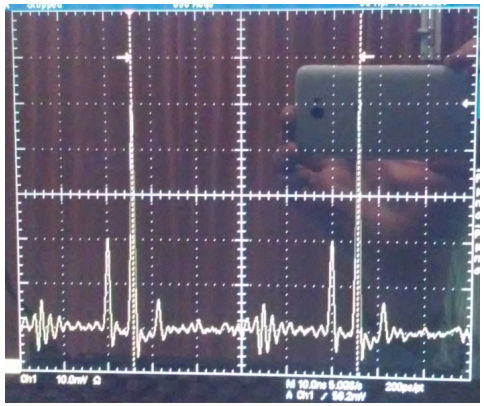
- Emission wavelength: 2081 nm
- No parasitic laser emission at shorter wavelength has been observed
- Stable linearly polarized output







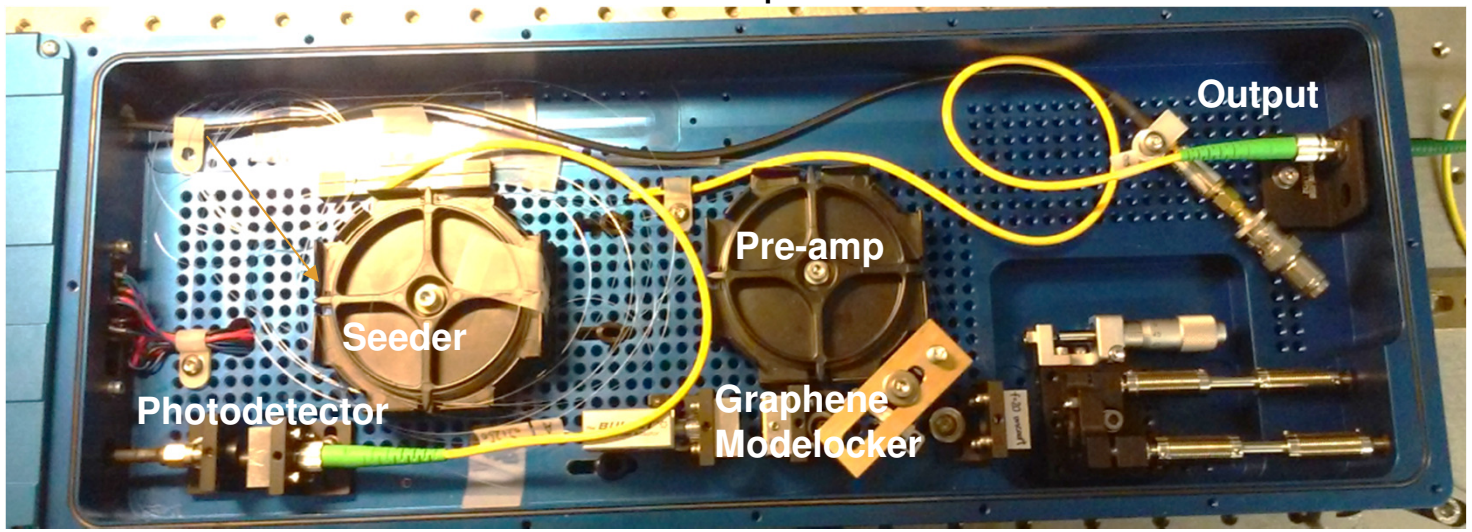




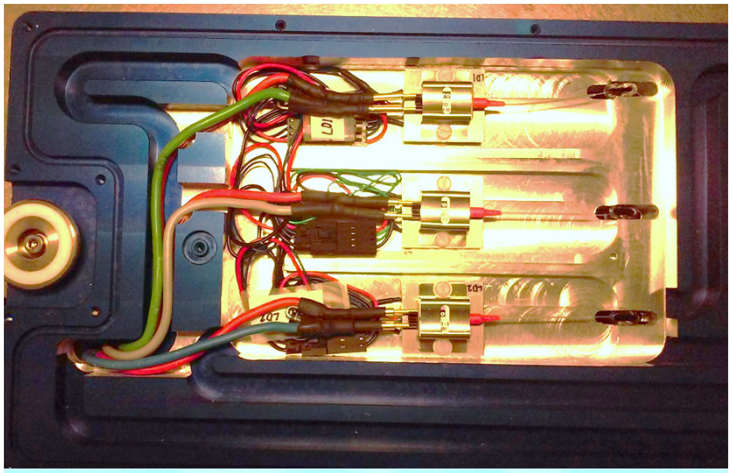
Seed Oscillator and Preamp Experimental Setup

- Rugged industrial Housing
- All fiber components
- Linearly Polarized

Top Side containing oscillator, Preamp and AOM

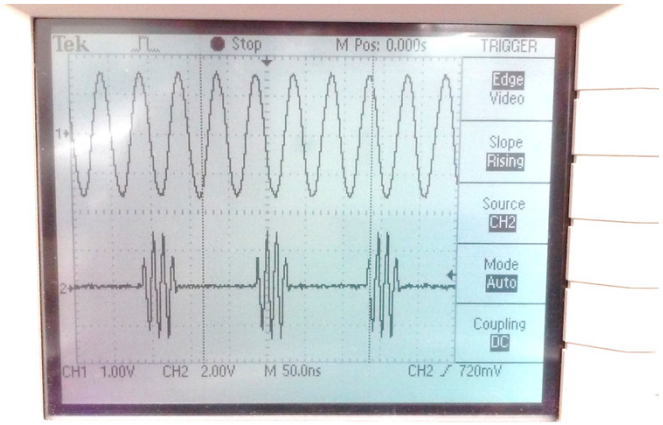


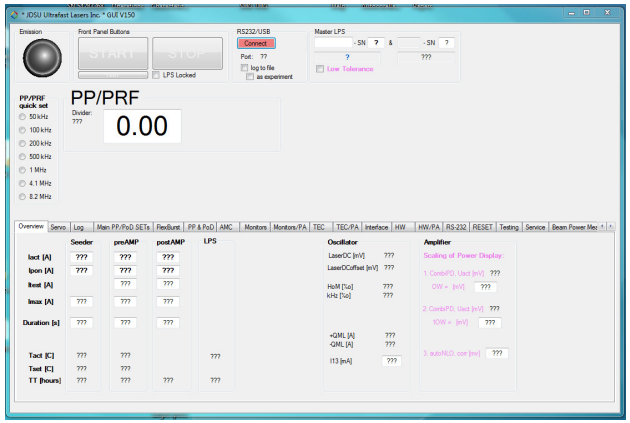
Bottom Side containing Pump diodes



Industrial Laser Control Unit

- Turnkey industrial grade control unit
- Specifications:
  - 19” Rack mount
  - 3 x TEC/NTC driver 3 A
  - 3 x Laser diode driver 6 A
  - 1 x AOM driver
  - 1 x fast photodiode 2.2 um
  - Average power photo detector(s)
  - Optional water cooling
  - GUI –USB





Summary and Outlook

- 2 microns offer eye-safety, potentially higher pulse energy and average power,
- Better performance with plastics and certain thin-films that absorb better at 2 micron
- Sub-ps seed oscillator is currently being developed beyond the ISLA project, utilizing components from ISLA partners

Outlook:

Due to advantages such as better perfomance in plastic machining and potentially higher pulse energies, ultrafast fiber lasers at 2 um are an emerging technology with creditable market demand.

Demolaser III – Tm doped Fiber

Tm double clad fiber:

- Nufern PM – TDF – 10/130
- Core: 10 um
- Cladding 130 um
- Core NA: 0.15
- Mode field diameter 11.5 um @ 2.1um
- Single mode cutoff wavelength: 1.95 um
- 793 nm cladding absorption: 4.5 – 5 dB/m
- Dispersion @ 2.1 um: 45 ps/km nm