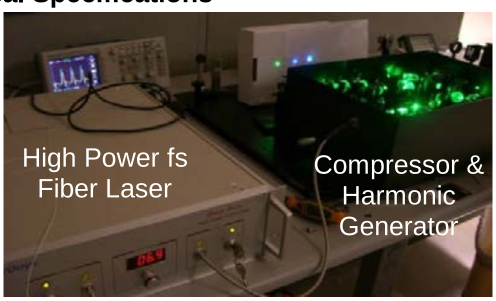
# Femtosecond Fiber Lasers based Biomedical Solution

**Overview**

Femtosecond (fs) fiber lasers are growing in popularity over conventional solid state lasers. A turn-key fs laser solution offers unprecedented features of compactness, low maintenance, and low power consumption. At PolarOnyx, our mission is to provide customers with the highest quality, cutting edge fiber laser products and support. As the leader in high power fiber lasers, we have developed a biomedical solution for our customers working on nonlinear bio-imaging, spectroscopy, cell dissection, nano surgery, confocal microscopy, and more.

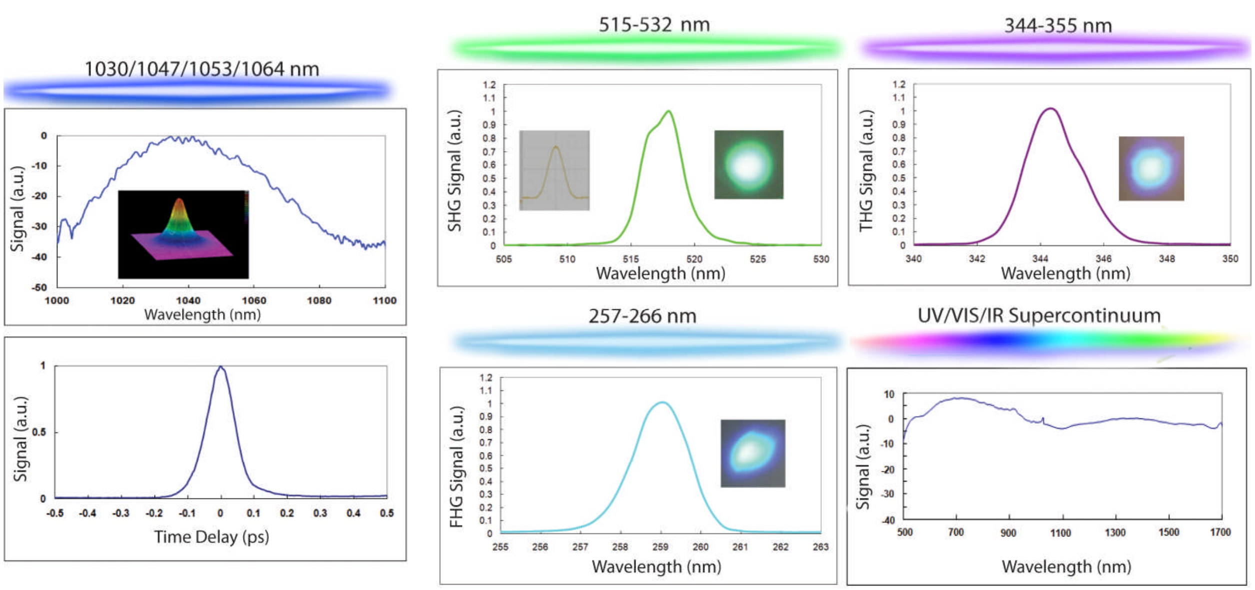
This system relieves biomedical researchers and engineers of the expensive and cumbersome usage of different lasers and instead provides an all-inclusive laser source solution. It includes a high power 1 micron fs fiber laser (average power at 1 W or 5 W), second harmonic (green), third harmonic (UV), and forth harmonic generation (deep UV), as well as various types of supercontinuum (UV/VIS/IR) sources, generated by coupling output pulses into a nonlinear fiber, such as a photonic crystal fiber (PCF).

**Technical Specifications**





Biomedical solution set-up and performance (SHG, THG, FHG, and supercontinuum)




Spectrum performance, pulse width, and beam quality of the biomedical solution laser

Two versions of the fs fiber laser based biomedical solution are available. One is based on our standard 1 W fs fiber laser, the ***Uranus*** Series, with >1 W average power, pulse repetition rate 30-100 MHz, pulse width <200 fs and SHG of >200 mW, THG of >10 mW, and FHG of >50 mW. The pulse widths of these harmonic generations are comparable to fundamental pulses.

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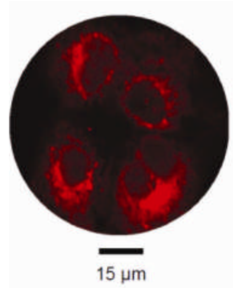
The other version is based on our standard 5 W fs fiber laser, also in the ***Uranus*** Series, with average power >5 W, pulse repetition rate 30-100 MHz, pulse width <300 fs, SHG of >1 W, THG of >50 mW, and FHG of >300 mW. A supercontinuum (SC) coupling stage can be additionally included for customers to couple light directly into various nonlinear fibers, such as PCFs, designed for different wavelengths (for example, 1030 nm or 515 nm).

**Biomedical Applications**

The biomedical solution allows researchers and engineers to access multiple wavelengths for various applications. Applications include:

- Multi-photon microscopy and endoscopy
- Confocal microscopy
- Time-resolved spectroscopy and microscopy
- Coherent Anti-Stokes Raman spectroscopy and microscopy
- Cellular, molecular, and micro imaging and biopsy
- Optical Coherence Tomography (OCT)
- Tissue and cellular imaging, welding, and ablation
- Neural imaging and surgery
- Portable biomedical instrumentation for disease diagnosis/treatment

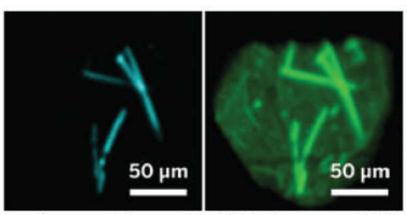


Cultured Cells

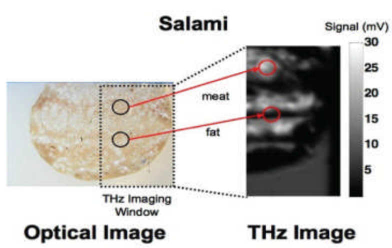
**Noted Past and Present Applications**

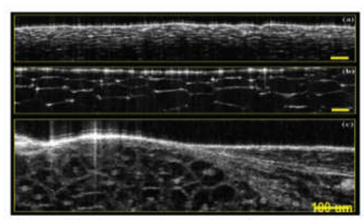
Professor Ji-Xin Cheng (Purdue University) and Professor Jay Sharping (University of California, Merced) achieved multimodal coherent anti-Stokes Raman scattering (CARS) imaging with PolarOnyx's fs fiber laser based optical parametric oscillator (FOPO). Professor Garth J. Simpson and coworkers at Purdue University used our laser's second harmonic generation (SHG) to effectively image protein crystals. Professor Norbert F.Scherer (University of Chicago), Professor William E. Moerner (Stanford University), Dr. Siavash Yazdanfar (GE Global Research), Professor Shou Tang (University of British Columbia), Professor Xingde Li (Johns Hopkins University), Professor Zhongping Chen and Professor Bruce J. Tromberg (University of California, Irvine, Beckman Laser Institute), implemented PolarOnyx's fs fiber lasers to study two and three-photon imaging, fluorescence imaging, and OCT for various types of bio-samples (tissues, cells, single molecules, etc.).

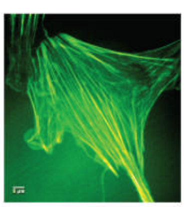
Furthermore, Professor Elliott Brown (Wright State University) is exploring fs fiber laser pumped TeraHertz (THz) imaging and Professor Eric Mazur (Harvard University) and Professor Sanjay Kumar (University of California, Berkeley) are studying cellular ablation and nano surgery.

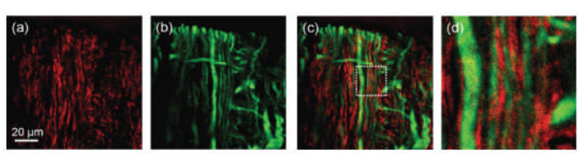


Protein crystal imaged by SHG microscopy (left) and a conventional fluorescence image (right).

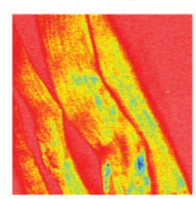




(a) in vitro bovine bone, (b) Onion skin, (c) in vivo tadpole (OCT Images)


Multiphoton fluorescence image of a Muntjac skin



Multimodal CARS/TPEF imaging of rat spinal cord (a) CARS image of myelin sheath. (b) TPEF image of axons. (c) Overlaid CARS and TPEF images. (d) Magnified segment of the overlaid images.


Second harmonic imaging of rat tail tendon

**The future of ultrafast fiber lasers is beyond our imagination. The possibilities are endless.**