Deep tissue imaging using 920 nm fiber lasers

*TOPTICA introduces the new FemtoFiber ultra 920, the latest member of their successful femtosecond fiber laser family. The novel and unique concept of the laser provides <100 fs pulses that are spectrally centered at 920 nm. The system is able to deliver more than 1 Watt in average power for deep tissue microscopy, corresponding to pulse energies of 18 nJ at 80 MHz repetition rate. The combination of the patented SESAM mode-locked ring oscillator design and TOPTICA's expertise in developing and producing industrial grade laser systems, makes the FemtoFiber ultra 920 an easy to operate and maintenance free system, optimized for 2-photon fluorescence excitation of GFP (**G**reen **F**luorescent **P**rotein).*

Keywords: femtosecond lasers, ultrafast lasers, fiber lasers, neuroscience, laser synchronization, microscopy, spectroscopy, GFP

Introduction

Multiphoton microscopy has become the key technology to image biological samples at the cellular level. Due to the low-energy photons involved and the confinement of the multiphoton signal to the focus of the laser, the technology is ideally suited for high-resolution, deep-tissue imaging with minimized photo damage.

Whereas many time-resolved or nonlinear spectroscopy and microscopy techniques have used titanium-sapphire lasers in the past, recent advancements in laser technology have made fiber lasers equal alternatives. Fiber laser technology provides unmatched flexibility and modularity, combined with robust and reliable operation. Using a master oscillator power amplifier concept, several fiber amplifiers can be optically synchronized to only one mode-locked fiber oscillator. This results in synchronized, phase-stable pulses trains which can be independently tailored with respect to wavelength, power, pulse duration, and repetition rate.

Nowadays, commercial fiber lasers reliably generate pulses with durations well below 100 fs, excellent beam quality and outstanding stability between consecutive pulses. In combination with TOPTICAs patented passive SESAM mode-lock technology, these fiber lasers feature an extremely low intensity noise making them the ideal choice for time-resolved and nonlinear spectroscopy and microscopy.

System description

TOPTICA has an excellent record in industrial grade production of fiber lasers designed for reliable operation around the clock. The new laser centered at 920 nm perfectly fits into the already established portfolio of high power ultrafast fiber lasers at 780 nm and 1050 nm.

The new FemtoFiber ultra 920 reaches an average power of more than 1 W at 80 MHz repetition rate, which is a record-breaking achievement in conjunction with the short pulses of <100 fs at the same time. The pulses are generated using a SESAM mode-locked ring-type Erbium-based fiber oscillator, followed by a patent-pending high-power fiber amplifier. For reaching highest reliability levels, only polarization maintaining fibers are used.

The FemtoFiber ultra 920 comes with a compact laser head with a footprint of 23 x 15.5 cm^2. The laser head is designed to ensure minimum heat dissipation to its environment providing highest stability with respect to beam pointing. The laser system comes with an 19"-type standard rack (3 units height) control and supply unit, which is connected via a detachable fiber and electronic lines of 2 meters length. No water-cooling is required, convection cooling of the control/supply unit is sufficient for stable operation of the system. In addition to manual operation, the laser system can also be controlled remotely via Ethernet or USB. A simple graphics interface enables user friendly access to all laser parameters.

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The FemtoFiber ultra 920 is the ultimate solution for applications in non-linear microscopy like two-photon excitation of fluorescent proteins or second-harmonic generation based contrast mechanisms. With an emission wavelength of 920 nm the laser closes the gap between the FemtoFiber ultra 780 and the FemtoFiber ultra 1050 and ideally matches the green and yellow fluorescent protein markers (GFP, YFP) commonly used e.g. in neurosciences and other laser-related biophotonic disciplines.

Applications:

- SHG imaging and microscopy
- Multiphoton excitation
- Advanced microscopy techniques
- Neuroscience
- Semiconductor inspection

Key Features:

- SESAM mode-locked ring fiber oscillator
- Patented and patent pending laser oscillator and amplifier design (US 8,457,164)
- Unique approach with <100 fs pulses at >1 W
- Polarization maintaining fibers only
- “Cold" and Compact laser head design
- Compact and detachable laser head for straight-forward OEM integration
- Air-cooled system
- Excellent price-performance point
- 24 VDC power supply
- < 150 W power consumption

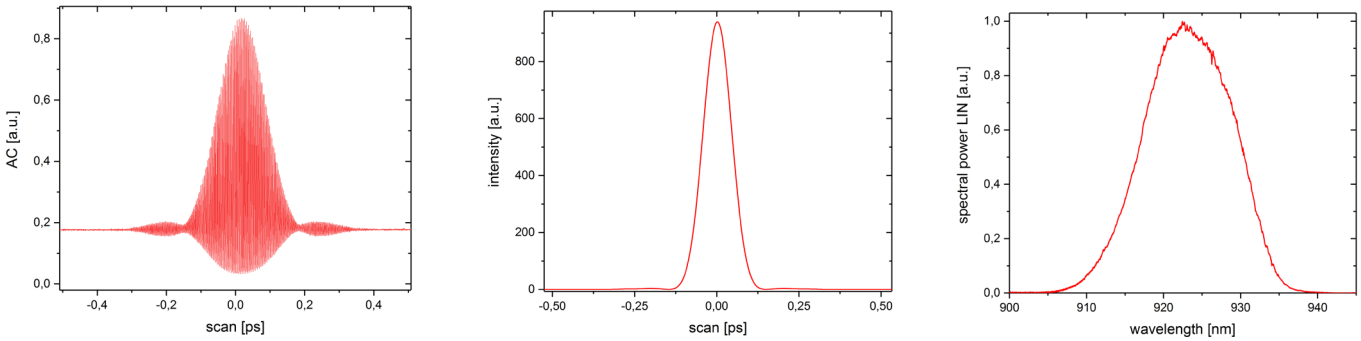

Figure 1: Test results of the new FemtoFiber ultra 920. Autocorrelation trace and retrieved pulse shape of the FemtoFiber ultra 920 feature <100 fs pulses with 99% of the laser power within the main pulse. The emission spectrum is centered at ~920 nm with a bandwidth of ~15 nm and emission spectrum.

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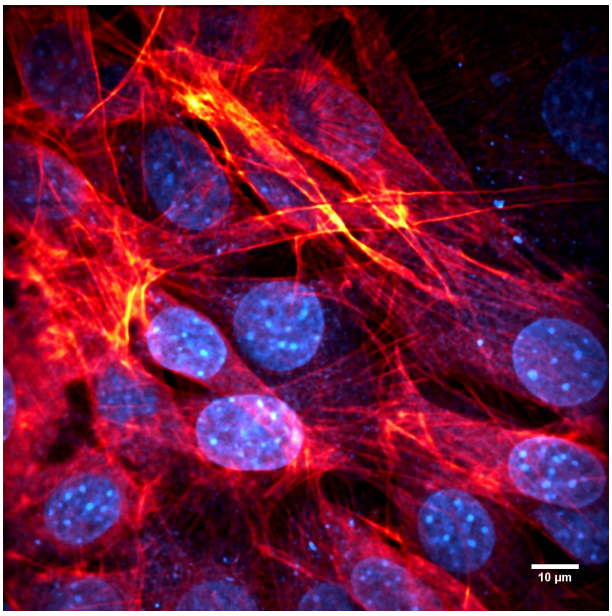

Figure 2: Image of the new FemtoFiber ultra 920 featuring a 19" rack mount unit-based laser controller with a compact and detachable laser head for straightforward OEM integration. The laser system is the perfect choice for two-photon excitation of fluorescent proteins and is engineered for reliable operation around the clock. In a first demonstration experiment the research group of Prof. Thomas Hellerer at the University of Applied Sciences in Munich used the FemtoFiber ultra 920 to record high-resolution images of Fibroblast labeled with iFluor594.

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