picoEmerald FT

Tunable
Two-Color
ps Light Source

Microscopy & Spectroscopy

picoEmerald FT
Two-Colors in One Box

Microscopy and Spectroscopy with a Tunable Two-Color Source

Best in class Coherent Raman light source that is as easy to use as a femtosecond two-photon excitation laser. Tuning speed: 1.5 s for a random tuning step, up to 100x faster than previous generation picoEmerald S.

Highly improved signal-to-noise ratio mainly due to the reduction of the laser repetition rate leads to 10x faster image acquisition compared to picoEmerald S.
Shot noise limited performance of the Pump beam (>5 MHz, 10 mW).

In a single box, picoEmerald provides fully automated, temporally and spatially overlapping picosecond pulse trains: 1032 nm from the laser oscillator and the OPO Signal beam. Tuning now down to 210 cm^{-1} to access low frequency vibrational bands.

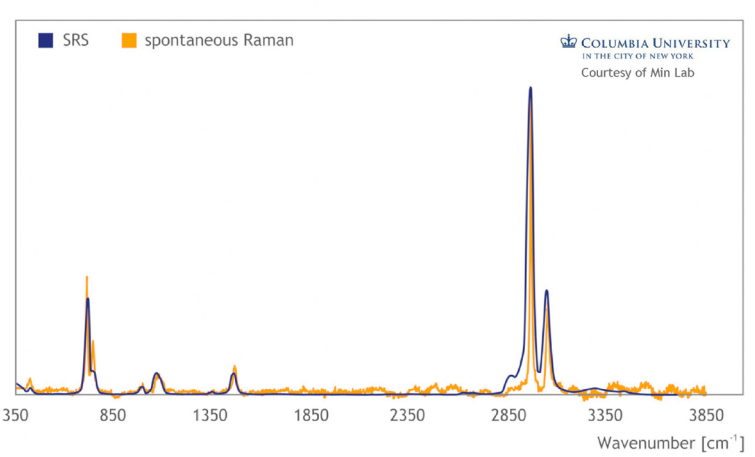
- Two-color turnkey system ideal for stimulated Raman microscopy up to video rate speed
- Perfect temporal and spatial overlap of exit beams
- Tunable between 660 nm ... 2340 nm
- 210 cm^{-1} ... 5450 cm^{-1} energy difference
- 2 ps pulses with 10 cm^{-1} spectral width
- Fully automated and computer controlled
- Shot noise limited -> Extremely low noise compared to all-fiber laser systems
- Compatible with commercial microscopes and homebuilt setups
- Active and passive stabilization, ideal for long-term experiments

picoEmerald FT
SRS Application

Stimulated Raman Scattering Microscopy (SRS)

SRS microscopy is enabled by the picoEmerald system in combination with APE's integrated EOM (Electro-Optic Modulator). SRS microscopy provides nearly background free imaging contrast. It also allows easy spectroscopic identification of the sample fingerprint region based on Raman spectral databases. Very short integration times allow imaging at video rates.

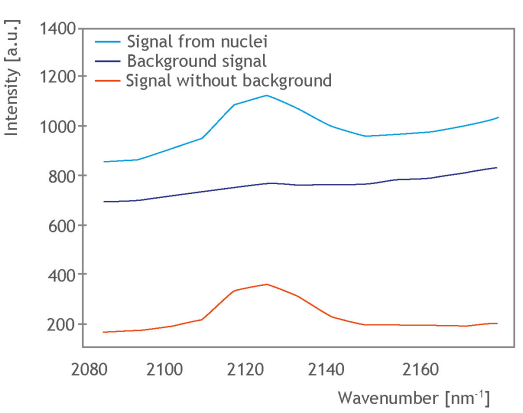
Measurement of Real Raman Spectra



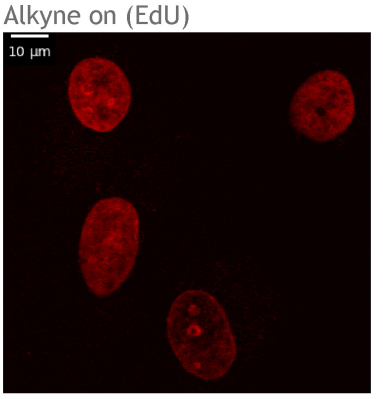
Comparison of Raman and SRS spectra of DMSO recorded with the picoEmerald FT. Only background subtraction and linear intensity scaling of the Raman spectrum was done to overlay the spectra.

Raman Labels – Alkine Detection (EdU)

HeLa cells incubated in 100 µM EdU

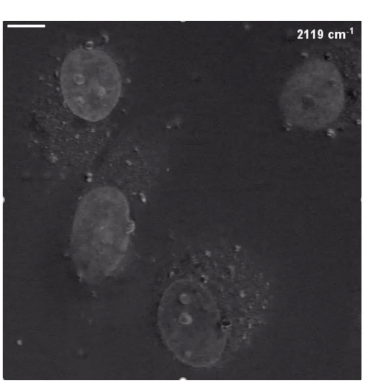


Alkyne on (EdU)



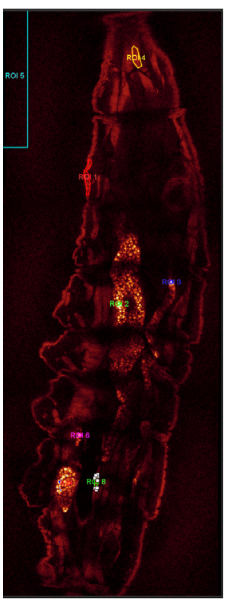
Differential image
2123 - 2083 cm^{-1}

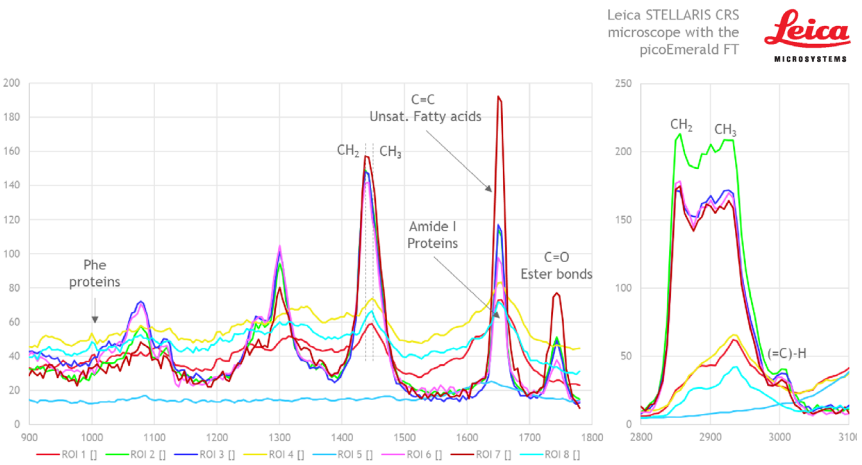
Columbia University
in the City of New York
Courtesy of Min Lab



picoEmerald FT
SRS Application

Fast Spectroscopic SRS Imaging of Hatched Drosophila Larvae





ROI 1: Protein-rich membrane
ROI 2, 3, 6, 7: Lipid structures - spectra resemble triolein (tricayl glyceride of oleic acid)
ROI 4: protein-rich region
ROI 5: PBS embedding medium
ROI8: protein-rich structure

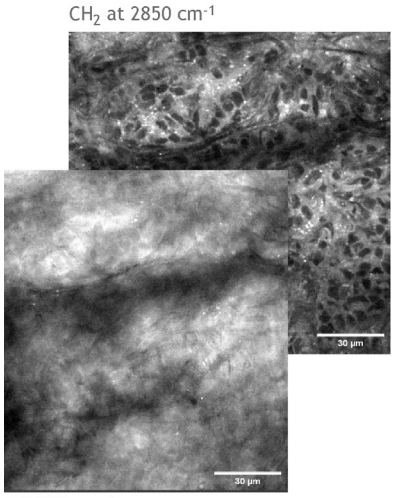
Stimulated Raman Histology on Human Brain – Glioblastoma Tumor

Measured by Youssef Ahmad

LIGHTCORE technologies

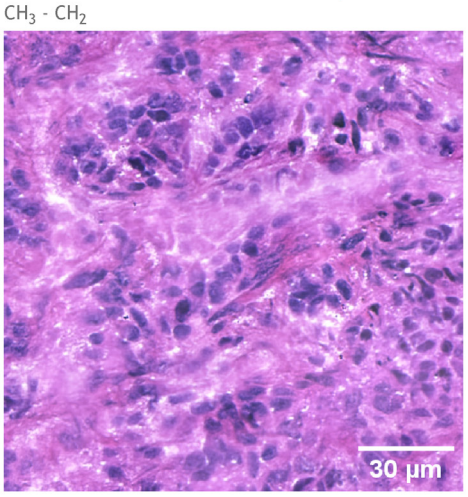
INSTITUT FRESNEL

CH_2 at 2850 cm^{-1}



@ 2940 cm^{-1}

CH_3 - CH_2



Automatic false colour annotation through deep learning algorithm;
Virtual histology image

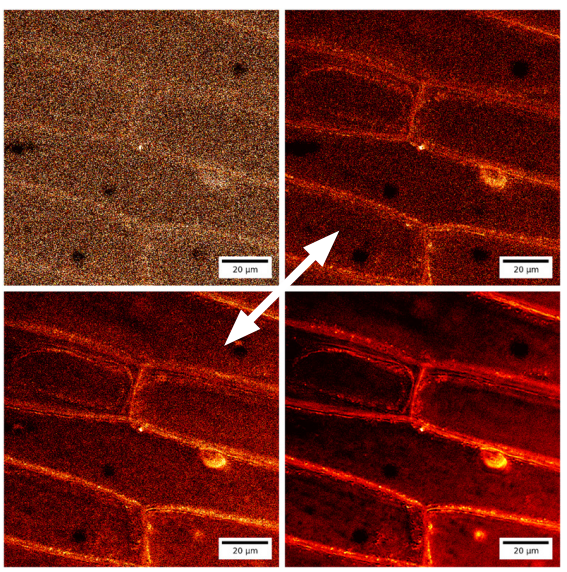
picoEmerald FT
Application

SRS Microscopy

Onion imaged at 880 cm^{-1}. Measurements with the picoEmerald FT (40 MHz, 20 MHz modulation frequency) are compared to those of the previous model, the picoEmerald S (80 MHz, 20 MHz modulation frequency). The microscopy images where taken for 2 µs and 20 µs pixel dwell time under identical conditions. It can be seen, that the picoEmerald FT yields a 10x faster acquisition speed, compared to the previous picoEmerald S.

picoEmerald S

80 MHz
20 mW Pump
9 mW Stokes



picoEmerald FT

40 MHz
20 mW Pump
9 mW Stokes

2 µs 20 µs

Microscope Compatibility

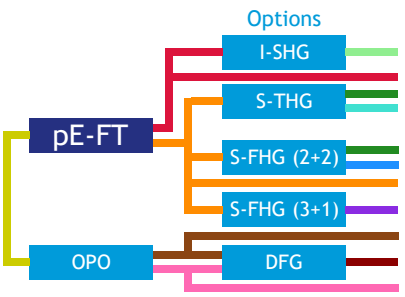
- Leica Stellaris and SP Series
- Lightcore BondXplorer
- Nikon Eclipse Ti2- Platform
- Thorlabs Multiphoton
- Zeiss LSM-Series
- Horiba
- Evident (Olympus) FV-Series
- Home-built setups

Application Examples

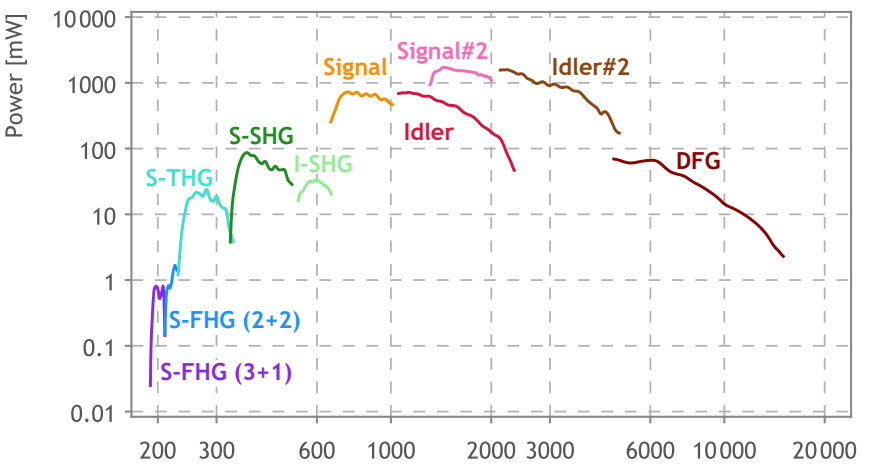
- SRS (Stimulated Raman Scattering) Microscopy
- CARS (Coherent Anti-Stokes Raman Scattering) Microscopy
- SRP (Stimulated Raman Photothermal) Microscopy
- Second Harmonics Imaging (SHG)
- Two-Photon Excitation Fluorescence Microscopy
- FLIM (Fluorescence Lifetime Imaging Microscopy)
- FRET (Fluorescence Resonance Energy Transfer)
- SEHRS (Surface Enhanced Hyper Raman Spectroscopy)

picoEmerald FT
UV to MIR Generation

Example Configuration for UV-MIR Generation



Typical Tuning Curve



Wavelength extension options

The picoEmerald FT's wavelength coverage can be extended from 190 nm to 16 µm. All generated pulses are intrinsically synchronized with each other, conserving the pulse characteristics of the picoEmerald FT with 2 ps pulse length and 10 cm^{-1} bandwidth.

The wavelength extension towards the UV/VIS range can be achieved using the picoEmerald FT in combination with our HarmoniXX devices.

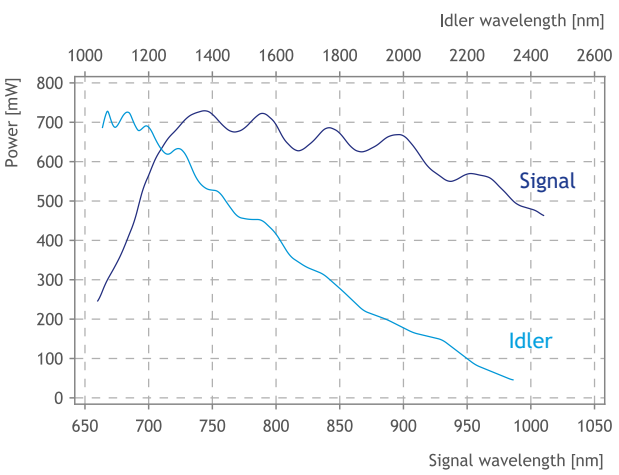
Extension to the infrared range is based on a Levante IR OPO pumped through the optional 1 µm output of the picoEmerald FT. The Levante IR OPO enables independent wavelength tuning from 1300 nm up to 4.8 µm, independent of the picoEmerald FT. MIR light generation up to 16 µm is possible through DFG generation (HarmoniXX DFG).

picoEmerald FT
Specifications

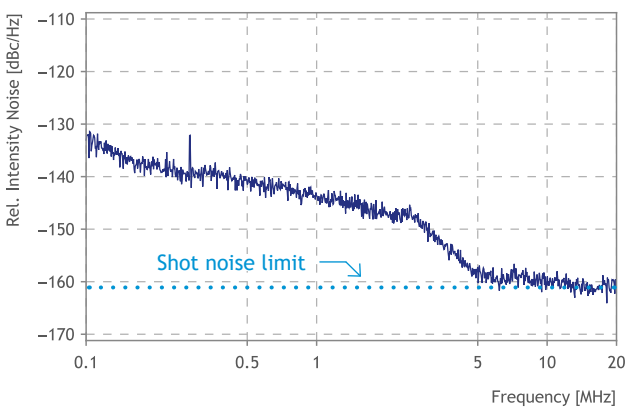
Main Parameters

Type of Source	Automated picosecond (narrow-band) tunable light source
Wavelength 1 1032 nm beam*	1032 nm (± 1.5) nm
Wavelength 2 OPO Signal	660 nm ... 1010 nm
Wavelength 3 OPO Idler*	1055 nm ... 2340 nm
Power 1 1032 nm beam*	>700 mW unmodulated >350 mW modulated at 20 MHz (customized versions on request)
Power 2 OPO Signal	>600 mW at 800 nm
Power 3 OPO Idler*	>400 mW at 1250 nm
Δv OPO Signal - 1032 nm beam*	210 cm^{-1} ... 5450 cm^{-1}
Pulse Width	2 ps
Repetition Rate	40 MHz
Spectral Bandwidth Signal, 1032 nm beam	10 cm^{-1}
Beam Diagnostics	Integrated spectrometer for Signal wavelength and bandwidth Integrated sensors for 1032 nm and Signal beam of power, position and temporal overlap
Pointing Stability	<100 µrad per 100 nm
M^2	<1.2 (OPO Signal), typ. 1.2 (1032 nm beam)
Polarization	Linear; Horizontal >100:1
Beam Divergence**	0.8 (± 0.2) mrad (at 800 nm and 1032 nm)
Beam Diameter at 2 m after exit**	3.0 (± 0.5) mm at 800 nm; 3.2 (± 0.5) mm at 1032 nm

picoEmerald FT – typical output power



picoEmerald FT – Relative Intensity Noise (RIN)
measured at 800 nm with 10 mW – engineering data



*The picoEmerald FT is a modular platform. 1032 nm output, EOM and Idler output are optionally available.
**Beam parameters optimized to generate foci with same size and z-position for Pump and Stokes.

picoEmerald FT
Specifications

Software

Software	Graphical User interface (GUI) for Windows PC
Remote Control	Ethernet TCP/IP / Serial RS232

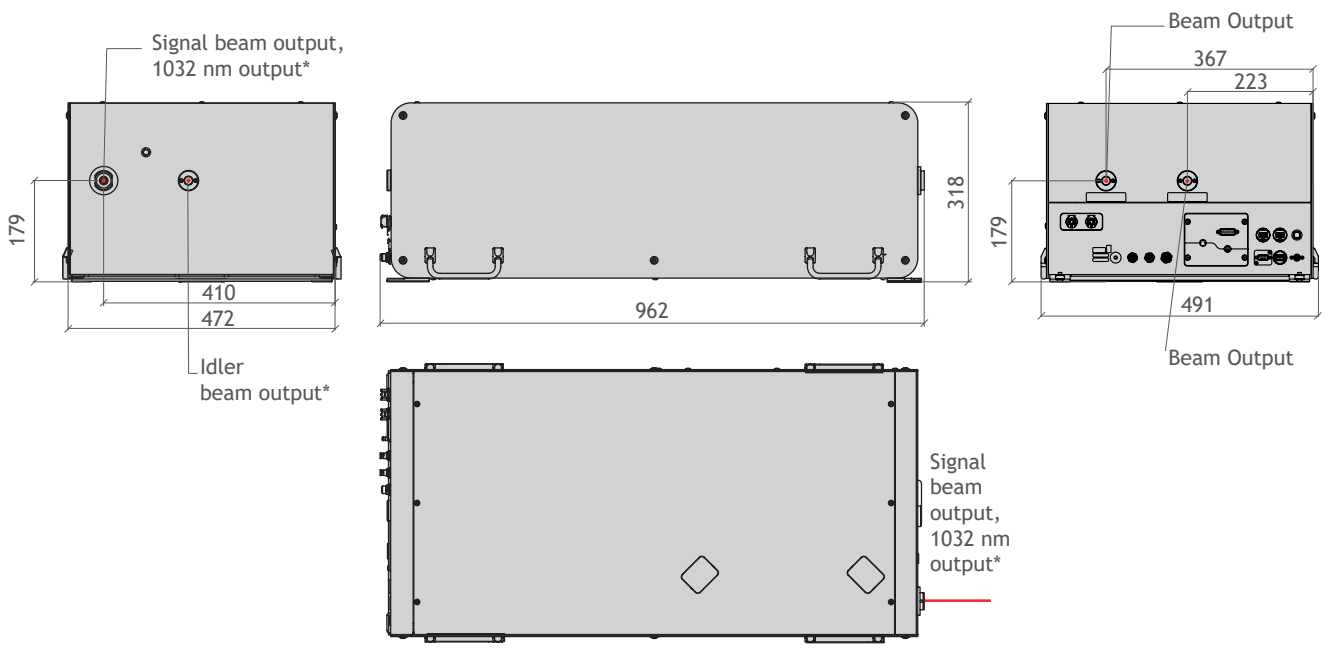
EOM Modulator*

Stokes Modulation	EOM with 20 MHz modulation frequency, exactly half of the repetition rate, built into picoEmerald

Dimensions, Power Consumption, Environment

Dimension	picoEmerald: 962 mm x 318 mm x 472 mm, 104 kg (see drawing for details) Laser Control Unit: 19 inch (4 U), 11 kg Chiller: 197 mm x 330 mm x 279 mm, 10 kg
Power	100 V ... 240 V, 50 Hz ... 60 Hz, max. 450 W (setup without Chiller) 100 V ... 240 V, 50 Hz ... 60 Hz, max. 600 W (Chiller)
Environmental Conditions	ambient temperature and humidity during operation / standby: +18 ... +25°C, temperature fluctuation: <1°C recommended, humidity: <60%

All dimensions in mm



*The picoEmerald FT is a modular platform.
1032 nm output, EOM and Idler output are optionally available.

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