High Q Laser - Press Release

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High Q Laser presents the picoEMERALD

A turnkey, single-box, solid-state-laser-based light source for coherent anti-Stokes Raman scattering (CARS) microscopy

As CARS microscopy has migrated from physics labs into life-science labs, the demand for an easy-to-use, turnkey light source has increased. In response, High Q Laser and APE joined forces to develop a remote-controlled, truly hands-free single-box CARS light source—" picoEMERALD"—which provides two tunable ultrafast-laser pulse trains from a single beam exit.

The picoEMERALD is a combined ps laser and optical parametrical oscillator single box system. It supplies three fully automated temporally and spatially overlapping ultrafast pulse trains: 1064 nm out of the laser oscillator itself, from 690 to 990 nm (signal range) and 1150 to 2300 nm (idler range) from the OPO, respectively. The controller inside the OPO takes care of the power stability and wavelength tuning; the pump and Stokes beams are tailored to be sent into the microscope. The microscope user needs only to decide which mode to work in: signal and idler or signal and 1064 nm, and how much laser power to be applied.

In the first mode, the signal and idler leave the OPO resonator perfectly overlapped in space and time, allowing greater penetration depth due to red shifted excitation beams with a tuning range from 1350 to greater than 10,000 cm^{-1}. In the second mode, the OPO signal is mixed with the 1064 nm pulses from the pump laser with a tuning range of 650 to greater than 5000 cm^{-1}, which is the setup preferred by most researchers so far. The picosecond oscillator is based on a misalignment-stability-optimized resonator with only one active laser stage. In addition, the resonator can be actively stabilized for maintaining optimum power over the system lifetime.

With the *pico*Emerald researchers in biology, medical and other life sciences get an easy to use light source for CARS microscopy. As a next step microscope manufacturers will integrate the *pico*Emerald into their confocal microscope systems and offer complete CARS imaging systems to life science users.

At first glance, the technology inside the OPO appears the same in comparison to the older EMERALD laser, with temperature-tuned noncritical phase-matched lithium triborate as a gain medium and a Lyot filter for wavelength fine-tuning. But the fact that the size of the overall system, including the pump laser and the beam shaping, is only 70% of the previous OPO shows the dramatic reduction in size, with a new cavity design optimized by finite-element methods for maximum passive stability and machined into a single block of aluminum. Any remaining drift is compensated by actively stabilizing control elements such as cavity length and mirror tilt; everything is controlled via PC or microscope software, with no mirrors exposed for manual tweaking.

Unlike previous systems, in which the user had to adjust the pulse overlap in space and time, this is done inside the laser. Sensors for the overlap do a check for a first alignment. The time overlap is measured at the exit of the OPO, and may be slightly different from the overlap at the sample side due to dispersion of the microscope. The initial delay will be good enough to generate CARS signals; it can then be electronically optimized for maximum brightness. The 1064 nm beam and the signal/idler beam can be attenuated to the desired power level. This power level is monitored and is kept constant over time to allow measurement periods as long as overnight.

The vibrational excitation modes of the molecules excited by CARS microscopy typically have a bandwidth on the order of 10 cm-1. This corresponds to a pulse duration of around 2 ps for transform-limited pulses; shorter pulses than this decrease the spectral resolution, while much

longer pulses decrease the effectiveness of the CARS four-wave-mixing process. The picoEMERALD delivers 7 ps at 1064 nm and 5 to 6 ps from the OPO to balance these requirements almost ideally.

Image: picoEMERALD, a combined ps laser (picoTRAIN™) and optical parametrical oscillator single box system.

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For more than 10 years HIGH Q LASER has been a leading supplier of diode pumped pico- and femtosecond all-solid-state oscillators and amplifiers based on Direct Diode Pumping and Semiconductor Saturable Absorber Mode Locking.

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