Extending the wavelength coverage of Laser Quantum's **taccor** range

Abstract

Many in scientific research benefit from the high repetition rate afforded by the 1 GHz range of taccor lasers. Here, we look at how these high repetition rate lasers can be used to achieve wavelengths from 250 nm to 3850 nm.

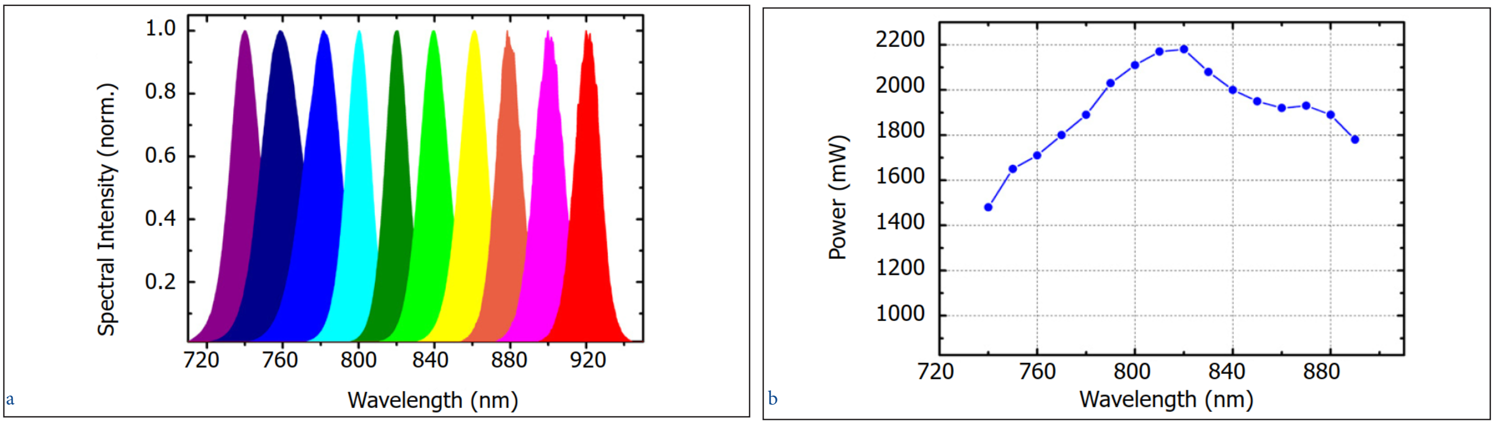

Figure 1:
Output spectra and typical power curve from **taccor tune 10**

Laser Quantum's **taccor** family of femtosecond lasers offers repetition rates in the range from 500 MHz to 10 GHz and is a unique product in the market. Based on Ti:sapphire as gain medium, the **taccor** lasers deliver pulse durations below 15 fs at output powers of up to 2 W. However, their wavelength has classically been limited to the interval between 740 nm and 930 nm, mostly determined by the gain material characteristics. While there are many applications in this spectral range uniquely benefitting from the GHz repetition rates offered by the **taccor** (frequency comb generation, astro-combs, asynchronous optical sampling, THz time-domain spectroscopy, nonlinear microscopy, quantum optics, dual-comb spectroscopy, OCT and many others), Laser Quantum has often been faced with the question of whether the wavelength range of this successful product could be extended. Laser Quantum has teamed up with Angewandte Physik und Elektronik (APE), a highly renowned manufacturer of nonlinear frequency conversion instrumentation, to explore second and third harmonic generation (SHG, THG) and optical parametric oscillators (OPOs) driven by the **taccor** in order to extend the availability of femtosecond light at GHz repetition rates to the blue/ultraviolet and the near-infrared (NIR) to mid-infrared (MIR) wavelength range. An extension of the wavelength range to the blue and UV is of interest for applications such as quantum optics, picosecond ultrasound based metrology and mapping of multilayer structures or photoemission spectroscopy. In quantum optics, the low pulse energy but high event rate can enhance the statistics of relevant events detected around 800 nm.

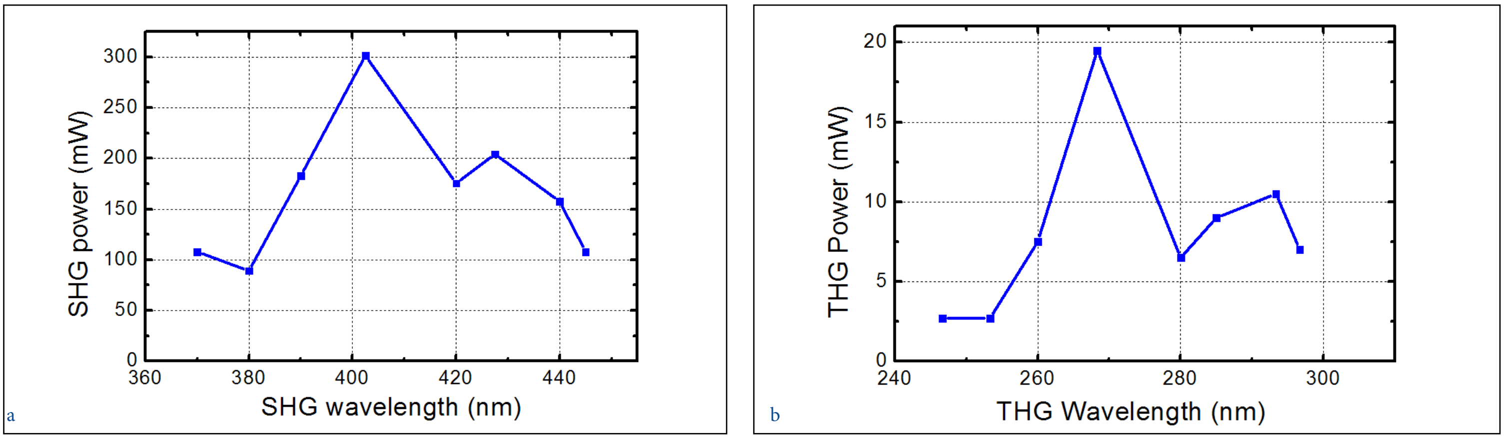

Figure 2:
Output power of APE HarmoniXX unit in second-harmonic generation (SHG, left panel) and third-harmonic generation (THG, right panel) modes pumped by the Laser Quantum **taccor tune 10**

Whitepaper

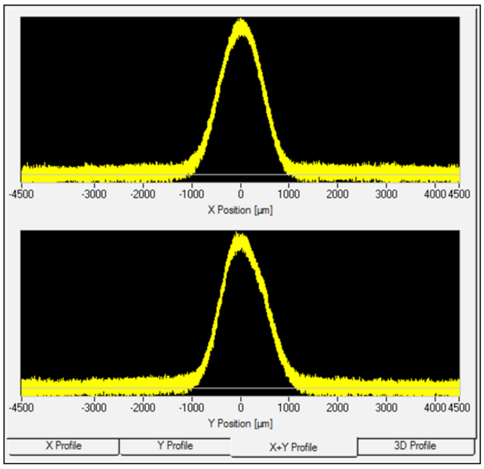

Figure 3:
Sagittal and tangential intensity profile of the SHG output from the HarmoniXX unit at 400nm

In metrology, the short wavelength pulses offer a higher depth resolution and for photoelectron generation it can be essential to have low charge electron clouds (minimizing expansion via Coulomb repulsion) but GHz repetition rates again allowing better experimental statistics. Extension to the near-infrared (NIR) and mid-infrared (MIR) ranges is of interest to reach the spectroscopic fingerprint region for many samples in analytic applications or for sensing applications such as LIDAR. Fig. 1 shows a series of output spectra as emitted by the **taccor tune 10** and a curve showing an output power typically at the level of 2 W across most of the tuning range.

This laser has been used to drive the APE HarmoniXX nonlinear conversion unit with results as shown in Fig. 2a. For our choice of the SHG parameters (crystal length, focusing) we have made a compromise between phase-matching bandwidth and conversion efficiency. The second-harmonic generation (SHG) output power of the system optimized for maximum operation bandwidth varies between 80 mW at the spectral wings and 320 mW near 800 nm wavelength while the bandwidth of the SHG varies between 3 nm and 7 nm. Custom versions focusing on greater bandwidth or high power at a given wavelength are possible.

Fig. 2b also shows the third-harmonic generation results using the same laser with a maximum output power of 25 mW achieved at 267 nm. Again, this result has been achieved in a configuration optimized for operation across the **taccor tune** tuning range but could be optimized for a specific wavelength with possible relative conversion efficiency gains of 15-40%.

Importantly, the near-Gaussian beam quality for both SHG and THG output is maintained at M^2 values around 1.5 with little astigmatism as illustrated in Fig. 3.

In order to access the NIR and MIR APE have developed a 1 GHz version of their successful OPO-X product. The **taccor** GHz OPO-X is a fully automated, synchronously pumped optical parametric oscillator that provides femtosecond pulses tunable in the near-infrared spectral region with GHz repetition rates. It features an integrated spectrometer and power sensors to facilitate active stabilization and remote control via a software interface. Fig. 4 shows a typical tuning curve when pumped by 2 W of power from the **taccor tune** at 800 nm. The **taccor** GHz OPO-X delivers an uncompressed pulse duration of typically 200 fs. External compression to the bandwidth limit near 130 fs is optional with a prism compressor. The **taccor** GHz OPO-X exhibits an excellent beam quality with M^2 values below 1.2. Further optional extensions permit access to the idler output, extending the wavelength range to between 1750 nm and 3850 nm, and to the signal SHG with access to the visible range between 505 nm and 740 nm. Both options provide up to 200 mW of average power.

In summary, Laser Quantum and APE have teamed up to give scientists almost continuous access to more than a decade of wavelength coverage between 250 nm to 3850 nm at a uniquely high repetition rate of 1 GHz. Those applications requiring a large mode spacing, high mode power, high event rate or low-pulse energy at high average power can now benefit from this exciting development.

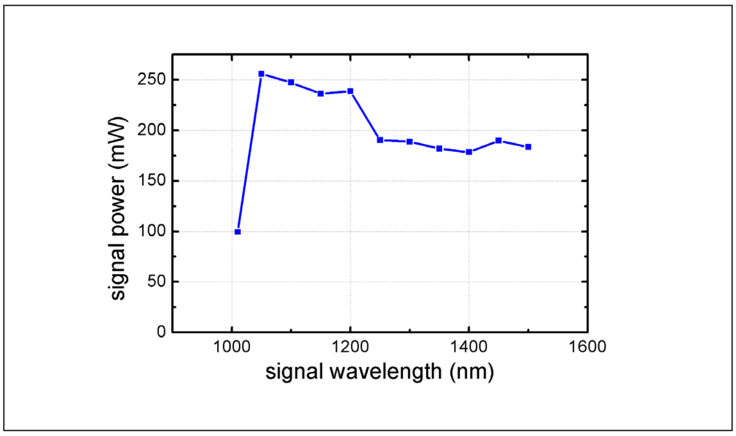

Figure 4:
Typical tuning curve of the GHz OPO-X when pumped by 2W of power from a **taccor power 10**

Figure 5:
Image of the GHz OPO-X

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