Upgrade to the Ultrafast Spectroscopy Laboratory

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Introduction

As part of the recent infrastructure funding, the existing regenerative amplifier laser and an OPA in the Ultrafast Spectroscopy Laboratory (USL) have been replaced. The aging homebuilt OPA systems are now replaced with commercial devices and a new nanosecond laser has replaced the AOT/Q-Peak system which was on loan from the ULTRA project.

Regenerative Amplifier

Upgrades to the pump lasers over the past five years meant that the existing YLF pump lasers and Titanium:Sapphire oscillator did not need to be replaced at this time. A new regenerative amplifier, Newport Spectra-Physics Spitfire Pro was installed in March this year (Figure 1). As with the previous Spitfire, the laser can operate in either picosecond or femtosecond mode. This allows the continuation of the science programme of the USL, providing 5 mJ, 800 nm, 1.4 ps or 120 fs pulses at 1 kHz. Improvements to the design of the cavity include thermoelectric Peltier cooling of the Ti:Sapphire rods in the regenerative and linear amplifier stages, minimizing thermal lensing effects so higher pump energies can be used; separation of the stretcher and compressor grating mounts, the ability to compensate higher order effects in the compressor; the use of a single Pockels cell in the cavity reducing losses; improved throughput in compressor ~70% and ease of conversion from fs to ps mode.

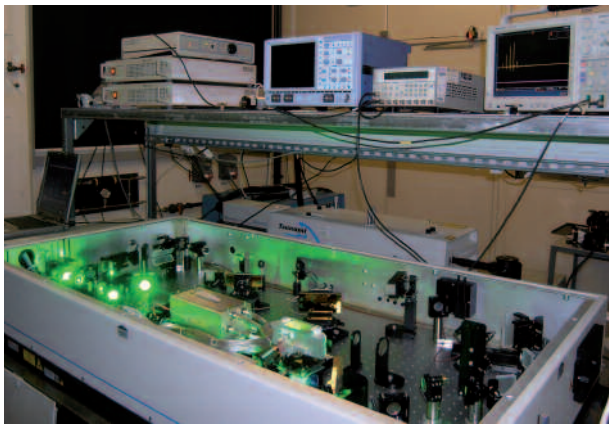

Figure 1. New Spitfire Pro regenerative amplifier in USL.

The shorter pulse width in femtosecond mode, and significantly improved beam profile (Figure 2) will benefit particularly PIRATE and transient absorption experiments as this should allow for generation of more stable white light continuum beam, used to seed the MIR OPAs and to generate a broadband probe pulse respectively.

TOPAS Systems

The old OPAs of in-house design used to generate the tunable pump and probe pulses for the TR^3 and PIRATE experiments were also identified as a significant risk to the continued operation of the USL, so TOPAS-400 and TOPAS-C optical parametric amplifiers from Light Conversions were also purchased at this time. Operating in ps and fs mode respectively, both systems may be tuned from the near infrared (2.6 μm) to the visible (480 nm) with significant increases in output energy over a much larger spectral range than previously possible (see Figure 3).

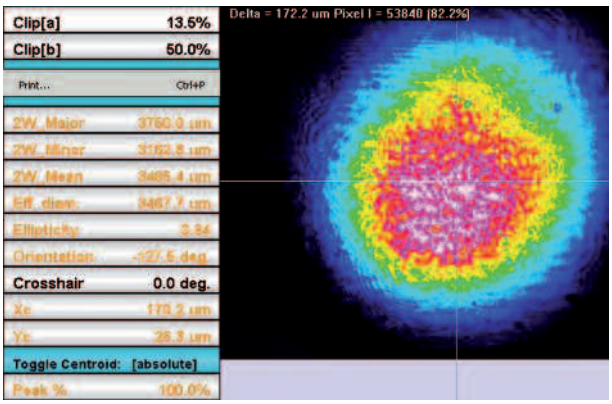

Figure 2. Beam profile of Spitfire Pro in fs mode of operation.

The increase in the energy of the regenerative amplifier from 1 mJ in fs mode to 5 mJ (and from 2.5 mJ to 5 mJ in ps mode) means that sufficient energy is available to continue to use the in-house OPAs in parallel with the TOPAS systems either as an additional pump beam for pump-dump-probe experiments or as a fully tunable pump for TR^3 experiments.

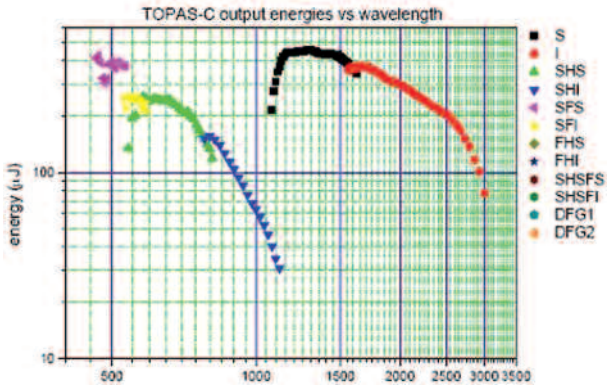

Figure 3. Tuning curve of TOPAS-C pumped with 2.5 mJ output from Spitfire Pro in femtosecond mode. [2]

Nanosecond Laser

One of the difficulties in the PIRATE science programme was always in relating the data recorded at RAL with that collected on ns-TRIR (time resolved infra red) apparatus elsewhere. An electro-optically Q-switched Nd:YVO_4 laser was incorporated into the laboratory to address this problem, allowing measurements to be carried out on ps-µs timescales[1]. This laser has been upgraded to 5 W and 10 kHz operation as part of the ULTRA programme and has been incorporated into that laboratory. A replacement ns laser, with improved specifications (see Table 1) AOT-YVO-25QSPHP/MOPA was installed in February 2007 to allow experiments in the ns to ms regime to continue.

Wavelength (nm)	Power at 25 kHz (mW)	Power at 1 kHz (mW)
1064	898	68
532	410	38
355	175	24
266	68	12

Table 1. Output power of AOT-YVO-25QSPHP/MOPA measured with an oscillator diode current of 3.2 A and an amplifier diode current of 3.2 A.

Summary

Large capital investment in the equipment has revitalized the USL. The improved stability, reliability of the operation of the regenerative amplifier will have immediate impact on the delivery of the existing programme. The increase in the output energy of the regenerative amplifier also opens up new experimental possibilities – techniques such as 2D-IR, hole-burning spectroscopy, stimulated Raman spectroscopy may now be developed – securing the future science programme of the laboratory.

References

1. M. Towrie, A. Gabrielsson, P. Matousek, A. W. Parker, A.-M. Blanco-Rodriguez, A. Vlček, *Appl. Spectrosc,* **59**, 467-473 (2005).
2. Reproduced with permission from Light Conversions.