



Heriot Watt University

Solid State Lasers and Nonlinear Optics Theme Ultrafast Optics Group

Institution	Heriot-Watt University
Group name	Ultrafast Optics Group
Website	http://www.ultrafast.hw.ac.uk
Principal Contact	Prof. Derryck Reid
Email	d.t.reid@hw.ac.uk
Telephone	+44 (0) 131 451 3652

Impact Statement	
<p>The Ultrafast Optics Group has worked closely with industry for several years, receiving industrial cash sponsorship (estimated at >£1M) from AWE, Renishaw, Coherent Scotland, DCG Systems, Selex Galileo, BAE Systems, NPL and Rofin, with in-kind support from many other companies.</p> <p>An example of the group’s impact on industrial practice is our work in two-photon microscopy and stimulation of semiconductor integrated circuits, which has led to a substantial project funded by DCG Systems to develop an instrument using two-photon excitation for fault diagnosis in integrated circuits. Reid’s former PhD student, Keith Serrels was hired by the sponsoring company to progress the work, embodying the impact in terms of knowledge-transfer.</p> <p>Active development of laser and OPO frequency-comb sources is ongoing in collaboration with other companies, and NPL has now adopted in its comb systems a metrology scheme developed by a jointly supervised EngD student, giving a real improvement in the noise of their comb systems.</p>	

Patents	
Year Filed	Description
2010	US patent application 12-970000 (“Optical Apparatus”), covering a method for obtaining high-energy pulses from a femtosecond optical parametric oscillator
2010	PCT application number PCT/GB2010/001047 (“Optical Apparatus”) , covering a method for obtaining high-energy pulses from a femtosecond optical parametric oscillator
1998	US Patent 6195167 (“Autocorrelation of ultrashort electromagnetic



	pulses”) - Licensed to <i>Elliot Scientific Ltd</i> (lapsed 2007; patent held by the University of St Andrews)
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Technical Capability	Near- to Mid-IR Femtosecond Frequency Combs
We have expertise in repetition-rate and carrier-envelope-offset frequency locking of femtosecond Ti:sapphire lasers and optical parametric oscillators, with durations to 30 fs, repetition frequencies to 500 MHz and wavelengths from 500 - 3000 nm.	

Technical Capability	High-Energy Femtosecond Optical Parametric Oscillators
Using a patent-protected energy scaling approach we have demonstrated 0.65- μ J pulses at 1.5 μ m from a cavity-dumped femtosecond optical parametric oscillator. Systems like this have the potential for laser waveguide inscription in mid-infrared materials.	

Technical Capability	Nonlinear Microscopy of Integrated Circuits
Using infrared femtosecond lasers we are able to carry out two-photon OBIC and one-photon confocal backside imaging of silicon integrated circuits.	

Technical Capability	Infrared Optical Coherence Tomography
In previous work we have implemented OCT from 1.0 - 2.0 μ m using a femtosecond-laser supercontinuum.	

Technical Capability	Broadband Mid-IR Fourier-Transform Spectroscopy
We have achieved 1-cm ⁻¹ resolution spectra in the 3 μ m - 4 μ m region by using broadband (200 nm) mid-infrared pulses	

Technical Capability	Er-/Yb-Fibre Lasers and Amplifiers
We have expertise in femtosecond Er:fibre and Yb:fibre lasers and amplifiers.	

Technical Capability	Yb:KYW lasers
We have expertise in femtosecond Yb:KYW lasers with average powers from 100 mW to several Watts.	



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Solid State Lasers and Nonlinear Optics Theme Extreme Light Group

Institution	Heriot-Watt University
Group name	Extreme Light Group
Website	http://extremelight.eps.hw.ac.uk
Principal Contact	Dr. Daniele Faccio
Email	d.faccio@hw.ac.uk
Telephone	+44 (0) 131 451 3645

Impact Statement	
<p>The Extreme Light Group has just recently been started at Heriot-Watt and is still in the development stage. The group's expertise is the area of nonlinear optics and light-matter interaction. Research is mainly concentrated on how light interacts with matter at high intensities, on how the interaction may be tailored by choosing or tailoring the light properties and on novel applications at the boundary between different disciplines, e.g. quantum optics and general relativity.</p>	

Technical Capability	Frequency conversion from the Extreme-UV to the MIR
<p>We have expertise in perturbative and non-perturbative (or extreme) nonlinear optics with applications to laser light frequency conversion covering the whole electromagnetic spectrum from the Extreme-UV/soft X-ray region to the mid-infrared.</p>	

Technical Capability	Ultrashort laser pulse filaments
<p>We have a decade's experience in the field of ultrashort laser pulse filaments and super-continuum generation.</p>	

Technical Capability	Geometry applied to optics
<p>We have developed over the past years models of General Relativity applied to optics. Specific interest in the formation of the analogues of event horizons has led to the detection of Hawking radiation and the discovery of novel photon amplification schemes.</p>	



Technical Capability	Transient Stimulated Raman conversion
Combining knowledge of filaments and pulse shaping, in previous work we have shown up to 75% stimulated Raman conversion efficiency using 10-20 femtosecond pulses, i.e. in the transient regime which is typically limited to sub-1% efficiencies.	

Technical Capability	Space-time laser pulse characterization
We have developed a series of techniques for measuring the space-time intensity profile, intensity and phase and propagation velocity of complex ultrashort laser pulses.	