UNIVERSITY OF HULL

The laser group at the University of Hull has a long history dating back to the earliest days of gas lasers in the UK. During the 1970's, research concentrated on pulsed gas lasers, particularly CO_2 based devices. The 1980's saw a move into the development of excimer lasers and, in turn, the study of laser-material interactions. Our light-matter interaction research now ranges from the millimetre length scale to the nanometre regime.

We are organised into two groupings: the Lasers and Light-Matter Interactions group is primarily concerned with understanding the physics of light interaction with matter and how this knowledge can be applied to real-world applications; these are often micromachining based. The Nano-Photonics group has particular interest in how small scale structures affect light.

We are based within the Physics subject area of the School of Mathematical and Physical Sciences. Our facilities include a suite of eleven laser laboratories that house systems with wavelengths in the range of vacuum ultraviolet (157nm) to 11micron and pulse durations from continuous wave to 120fs. These are augmented by an optical parametric oscillator and white light picosecond source.

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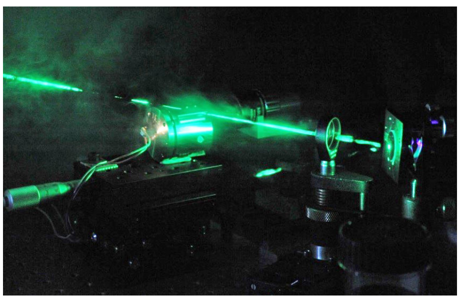
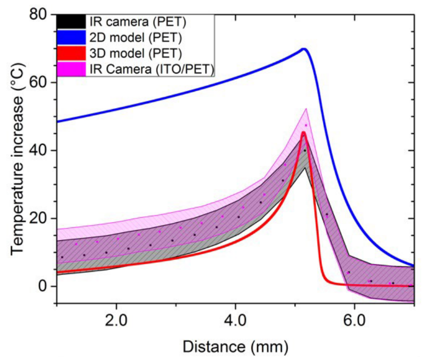
NANO PHOTONICS

The nanophotonics group in Hull (Drs. Adawi and Bouillard) uses a wide range of CW and pulsed lasers to explore light-matter interactions at the nanoscale using far field nano-spectroscopy techniques such as fluorescence-lifetime imaging microscopy (FLIM) and Fourier plane imaging as well as surface enhanced Raman scattering (SERS). Our research aims to develop novel nanophotonic systems for single molecule sensing, nanolight sources, energy transfer and novel biosensing nanoprobes.



FLEXIBLE ELECTRONICS

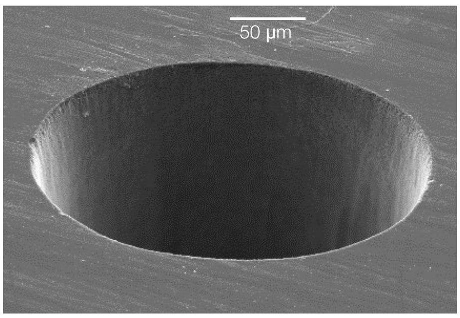
Drs. Snelling and Walton have been funded by the EU through the H2020 scheme to explore laser sintering of indium free inks to produce transparent conducting tracks for displays and photovoltaics. Here, we are collaborating with TWI, who are the coordinators, as well as partners in Germany, the UK and Spain (https://infinity-h2020.eu/). The need for low temperature processing has led us to model the interactions and verify these calculations with thermal imaging. To-date, we have achieved a dramatic reduction in resistivity of the laser irradiated inks relative to their as-deposited characteristics.



Calculations of laser-induced temperature rise.

GLASS PROCESSING AND FREE-FORM OPTICS

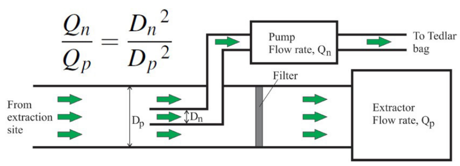
Glasses are difficult to laser process due to their low absorption in the visible wavelength range and their brittle behaviour. Intrinsic absorption can be utilised if the wavelength is short enough and we have demonstrated high quality etching using the 157 nm molecular fluorine laser. Absorption can also be induced through non-linear processes with ultrashort laser pulses in the femtosecond to picosecond regime. Our goals are to produce optical quality surfaces that have a high degree of height fidelity. Current modelling predicts the final stress-strain state of glasses irradiated with long pulses (up to millisecond) and we plan to extend these studies into the short and ultrashort pulse regimes. A new project is just beginning funded by The Leverhulme Trust to explore the fabrication of free-form optics. This is a collaboration between Dr Howard Snelling (Hull), Prof Sir Michael Berry (Bristol) and Prof David Jesson (Cardiff).

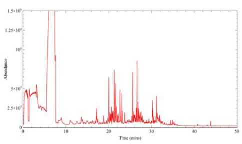


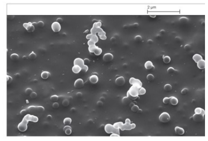
Crack-free femtosecond laser trepanning of a hole in glass

LASER INTERACTIONS WITH COMPOSITE MATERIALS

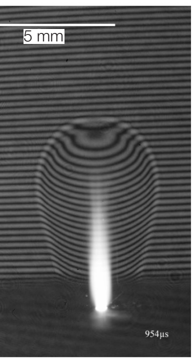
Composite materials are ever more prevalent and I am sure that the readers of the AILU magazine would agree that the integration of laser technology into the manufacturing process is something to be encouraged. We have two main goals in our laser-interaction studies. These are the application of short laser pulses to minimise the heat affected zone, and exploration of fume produced during processing. Laser generated fume is not often studied and we have developed techniques for characterising both particle and gas phase products. Fast (nanosecond) photography can track the movement of debris and isokinetic gas sampling combined with mass spectroscopy is used to identify vapour.







Isokinetic gas sampling of laser-produced fume with the corresponding mass spectrum and captured particles.



High-speed interferometry (left) of the evolution of gas from a laser irradiated composite and nanosecond shadowgraphy (right) of ejected carbon fibres.

OPTICAL SENSOR NETWORKS

Composite materials have a major application in the off-shore wind industry. We are part of an EPSRC funded Prosperity Partnership that is exploring various aspects of the turbine construction (University of Sheffield, Durham University, University of Hull). At Hull, we are incorporating fibre optic sensors into these large composite structures to enable a "digital twin" to be recorded during manufacture and service.