High power Adaptable Laser beams for materials prOcessing

HALO project newsletter #1

April 2013

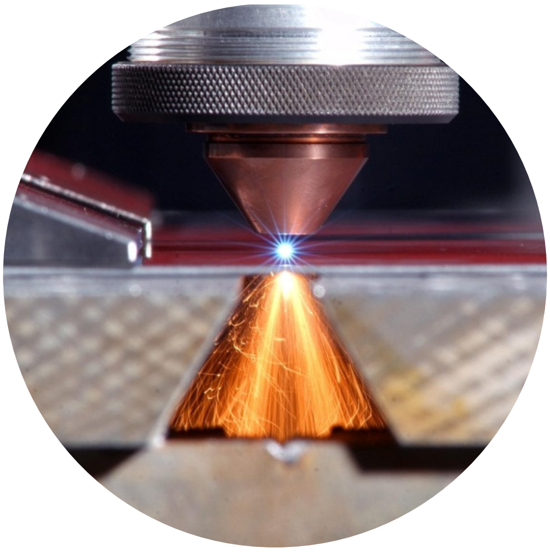
Welcome to the first HALO project newsletter!

HALO is a collaborative research project supported by the European Commission through its Seventh Framework Programme (FP7). The project will develop technology for the next generation of adaptable materials processing lasers. It brings together large laser manufacturers with key European component suppliers, academic and research organisations and end users of industrial laser systems. Over a three year period, the project will tackle a wide range of laser technology for processing several important materials, including sheet metal, ceramics and glass.

The project will investigate the simulation of cutting processes, develop new components, experiment with novel laser configurations and exciting processing techniques. More information can be found on the project website (www.halo-project.,eu), including an overview presentation and background info.

In this newsletter:

- *ILT presents its meta-modelling and high speed videography to provide high quality input data*
- *ORC reports on some remarkable new laser designs applied to hollow beam 2 µm sources*
- *Synova explains its unique liquid jet process for cutting brittle materials.*



HALO is supported by the European Commission through the Seventh Framework Programme (FP7), project number 314410.

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Image courtesy of Fraunhofer ILT

The project is keen to establish potential exploitation routes for the technology which is being developed. The HALO members would be very interested to discuss the project with interested parties, particularly potential end-users. If you have any questions or would like to suggest new applications or technology related to the project, please contact Tim Durrant or Bruce Napier on the emails given above. The website will be updated with new material throughout the project, so check back, or sign up for the RSS feed for news updates!

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SEVENTH FRAMEWORK PROGRAMME

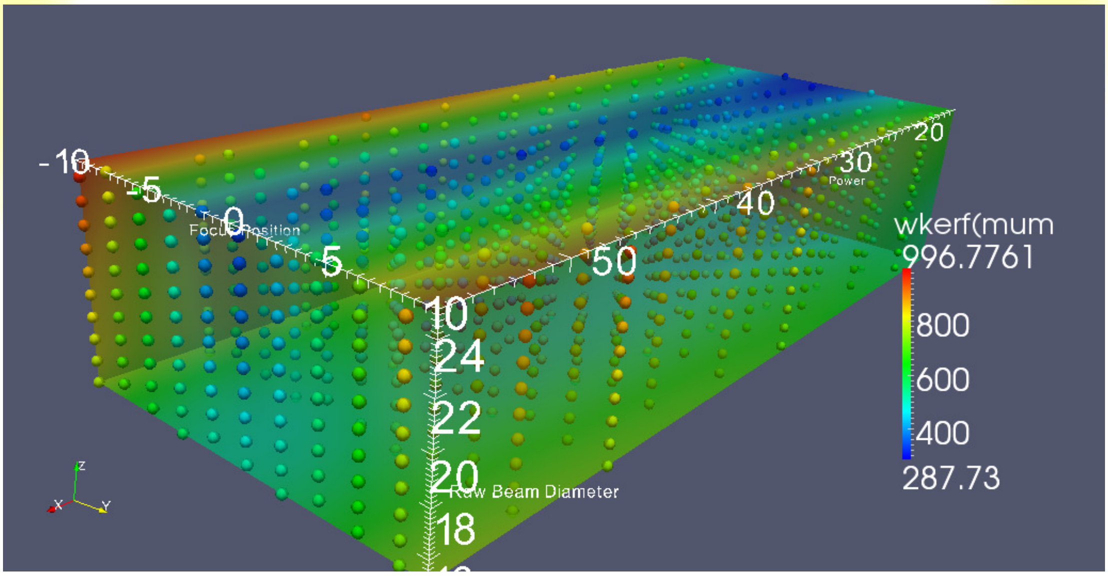
Improving laser materials processing efficiency using metamodelling

Fraunhofer ILT

The cutting of any material using a laser is a highly complex process. Dozens of inter-dependent variables must be considered which can exhibit a dramatic, unexpected and non-linear influence on the process. To make matters worse, the situation changes every instant throughout the cutting process. Reflected light from constantly evolving surfaces form dynamic interference patterns and plasmas form and flow; all in the presence of evaporated and ejected material which interact with the incident radiation. Predicting the resulting maelstrom and modelling the process under study requires powerful mathematical techniques.

Meta-modelling is a method used to study such complex multi-dimension relationships. By considering the process at the appropriate level of abstraction, the variables may be represented as “pure“ mathematical functions, often without any physical meaning. However, in the mathematical model this permits links to be established between many parameters and criteria quickly and efficiently. Using graphical user interfaces, these can be explored rapidly in a visual format, allowing multi-criterion optimisation and sensitivity analysis.

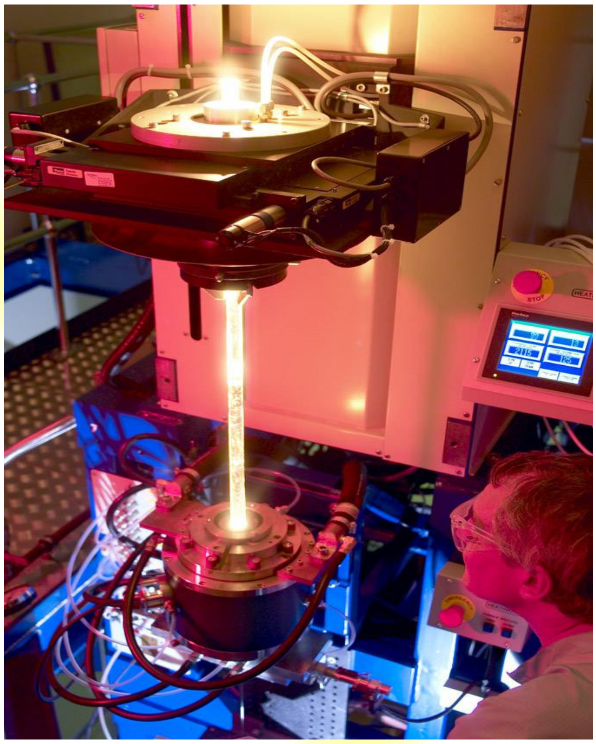
This technique allows the combination of individual cutting simulation runs into a comprehensive overview which may be represented as a process map of the laser cutting process. Study of the metamodel allows allows engineers to understand and improve the real processes. It allows a direct comparison with experimental data and prediction of the cutting result in seconds.



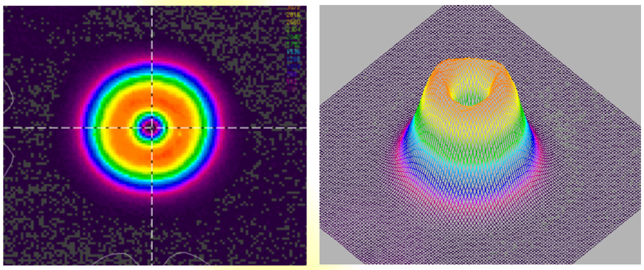
Visualization of a metamodel set-up for HALO: a 3-dimensional cube in parameter space of laser metal cutting. In this case the three dimensions represented are: 1) Laser power (in 100 W), 2) Focus position (in mm), and 3) Raw beam diameter (in mm). The visualised criterion in this colour representation is the cutting kerf width in microns. The spheres show the original data sets, for which cutting simulations have been executed; the continuous, semi-transparent cube shows the metamodel generated from these data points. [Image courtesy of Fraunhofer ILT.]

Hybrid fibre-bulk solid-state lasers with adaptable output beams for laser processing of materials

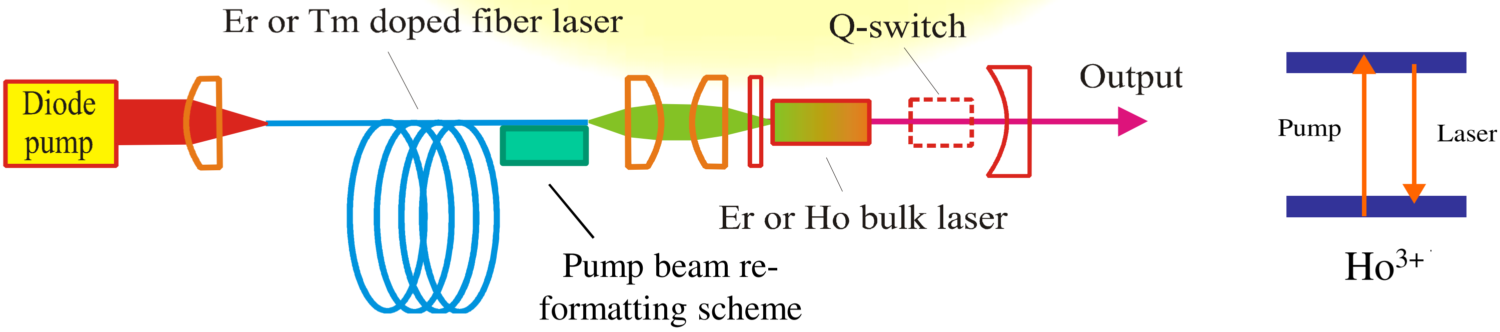
Tailoring of the output beams from high power lasers to achieve more effective and higher quality processing of materials such as metals, glasses and plastics is area of activity that is gathering pace. In most situations, modification of beam shape and polarisation is achieved using external beam shaping and polarisation controlling components. This can be challenging as the components must be able to withstand very high powers without damage and ideally without compromising on brightness and depth of focus.



Research at the Optoelectronics Research Centre (University of Southampton) is investigating an alternative strategy for producing the desired beam profiles without the need for external beam shaping optics. The approach is based on the use of a hybrid (fibre-laser-pumped bulk solid-state) laser concept in which the pump beam from a high power thulium-doped fibre laser operating at ~1.9 µm is re-shaped using specially designed optical fibres to allow the direct excitation of the desired laser transverse modes in a holmium-doped crystal laser operating at ~ 2.1 µm. This laser architecture offers the potential for scaling to very high output power in both continuous-wave and high-peak-power pulsed modes of operation. The work will target doughnut (annular) and top-hat like beam profiles, which have been shown to offer significant advantages for laser cutting in terms of power, speed and cut quality. A further important feature of this approach is that it allows 'real-time' modification of the laser beam profile when operating at high powers. Work on the development of the high-power thulium-doped fibre pump laser, fibre-based pump re-shaping scheme and the holmium-doped crystal laser is underway at the ORC.

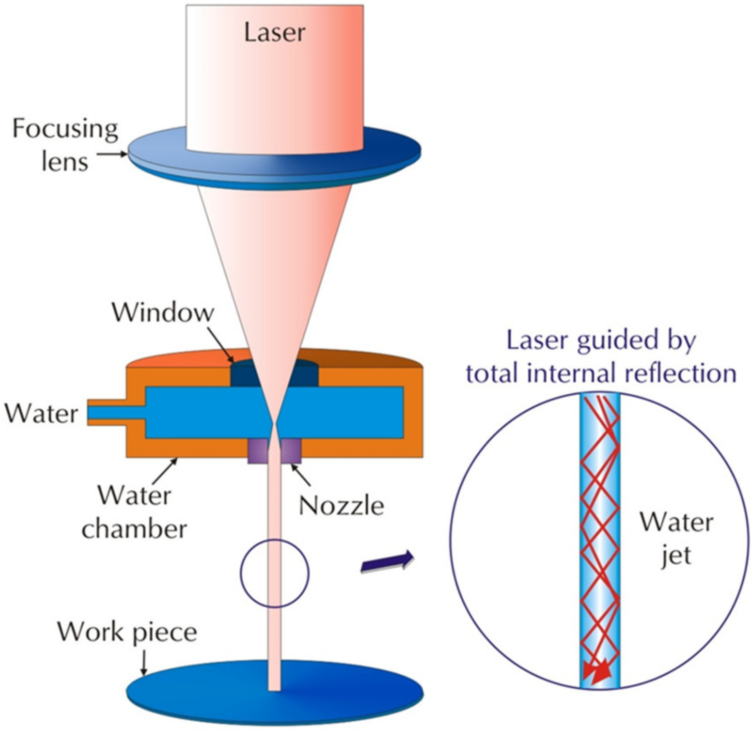


"Doughnut" mode beam profile



Schematic of the ORC hybrid laser architecture. [Images on this page courtesy of ORC Southampton.]

Liquid jet laser cutting: Microjet®
A revolution in micro-machining



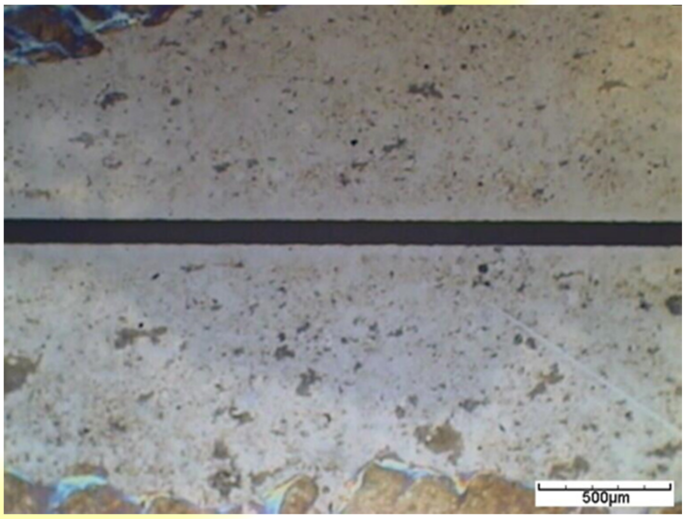
Schematic showing the Synova Laser Microjet ® technique

The conventional focused laser beam working distance is limited to a few millimeters by beam divergence, resulting in material damage to a heat-affected zone and contamination from molten material which is not expelled.

Laser MicroJet® technology employs a laser beam which is completely reflected at the air-water interface, and the beam can be guided over a distance of up to 10 cm. The water jet cools the substrate while removing the molten material from the cut and avoiding contamination. The low pressure stream of water generates virtually no force on the work piece, allowing trouble-free processing of very fine materials.

Within HALO, Synova will develop its proprietary liquid jet cutting technology which combines the advantages of both water and laser cutting in one operation. Using the difference in the refractive indices of air and water, the technology behind Laser MicroJet® creates a laser beam that is completely reflected at the air-water interface.

The laser light is contained within the water jet as a parallel beam, similar in principle to an optical fibre. This containment is maintained through and beyond the work piece, facilitating accurate cutting of porous or layered materials, with minimal thermal and structural distortion, leaving a fine cut edge. Its advantages outweigh both high-pressure water jet cutting and conventional laser cutting.



High quality sapphire scribing to a depth of 140 μm has been demonstrated using a 532 nm pulsed laser. [Image courtesy of Synova.]

Within the HALO project, Synova has performed tests on sapphire wafers with different types of laser. It has worked closely with Fraunhofer ILT to develop a metamodel (see page 2) for the liquid jet laser technique, which is now complete and being used to optimise the cutting process. The project has shown that Laser Microjet® is indeed capable of scribing sapphire. To date good quality scribing to a depth of 140 μm has been demonstrated, and work continues to further improve the results.