High power Adaptable Laser beams for materials processing

HALO

Project overview presentation

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

www.halo-project.eu
Materials processing with lasers

- Laser technology is already well established in manufacturing
- Materials processing with lasers covers many techniques
  - Cutting and bending
  - Welding and joining
  - Marking and engraving
  - Surface patterning and processing
- The next generation of lasers offers key manufacturing technology for the “Factory of the Future”
  - Faster, cheaper, better processes!
- HALO will improve
  - Efficiency, adaptability and sustainability of manufacturing systems
  - Integration into business processes.
• Industrial laser market has shown robust growth for thirty years
  • Double-digit annual growth
  • Strong rebound from global crash in 2008/9

• Europe
  • Makes up almost one third of the world market (2012)
    - Industrial lasers ~1.5 M€*
    - Industrial laser systems (integrated tools based on lasers) ~5.5 M€*
  • Is a power base for laser system manufacture and development

• HALO will help to maintain Europe’s leading role in industrial laser technology.
The next generation of materials processing lasers will have adaptable beams to optimise efficiency.

HALO will investigate:

- Adaptable beam profiles
  - Gaussian
  - Top hat
  - Ring modes

- Modelling of laser cutting processes
  - Beam & pulse propagation
  - Absorption
  - Ablation

- Novel cutting processes
  - Brittle materials
  - Sheet metal cutting
  - Liquid jet cutting.
Consortium

Components

Coordinator
- G&H (Torquay)

Laser technology development
- ORC Southampton
- Fraunhofer ILT
- Lulea University

Industrial end users
- Synova
- Laser Expertise
- Trumpf Laser
- Trumpf Werkzeugmaschinen

Admin & management
- Vivid Components
Meta-modelling

- Mathematical model of complex multi-dimension relationships
  - “Pure” mathematical functions
  - Often without any physical meaning
- Links many parameters and criteria quickly and efficiently
  - Fast visual exploration
  - Multi-criterion optimisation
  - Sensitivity analysis
  - Machine integration/ control/ set-up
  - Direct comparison with experimental data.

Images courtesy of Fraunhofer ILT

→ Parameters = Model Input
→ Explorable quantitative 8-dimensional Cutting Process Map
→ Design Tool Metamodel → Solution in Design Space.
Beam forming

- Beam shape has a large influence on cutting efficiency
- Optimum shape depends on precise process details
  - Dozens of variables
  - Highly sensitive optimisation
  - Non-intuitive!
- HALO will
  - Develop adaptable lasers to optimise beam shape to the process
  - Identify ideal beam parameters for real processes through meta-models.

Images courtesy of Fraunhofer ILT
Novel passive components

- **Optical isolators**
  - Novel designs to permit the unusual beam polarisations used in HALO
  - Comprehensive modelling to understand thermal and optical effects resulting from novel beam shapes
  - Materials for use in high power operation will be investigated

- **Fused fibre devices**
  - Novel hollow core fibre tapers will provide ring-shaped pump beam for selecting desired LG mode
  - Customised MM pump combiners will be built for high power thulium pump sources.
Novel acousto-optic components

- **Acousto-optic Q-switches**
  - Exceptionally low insertion loss
  - Very good power handling
- **RF signal ON**
  - Induces a temporary diffraction grating
  - Deflects a proportion of the laser beam
  - Increased cavity losses prevents lasing
- **RF signal OFF**
  - Cavity losses decrease rapidly
  - Intense laser pulse evolves
- **HALO advances**
  - Fibre-coupled polarisation insensitive AO Q-switches
  - First of their kind polarisation selecting and control AO devices
  - Preservation of Laguerre Gaussian “doughnut modes.”
• Holmium-doped hybrid (fibre laser-pumped) solid-state laser
  • Generation of high average power laser output at ~2 µm
  • Adaptable output beam profile (doughnut shape to a quasi-top hat)
• Novel technique for direct generation of required beam profile
  • Components located within the laser resonator
  • Architecture compatible with high power operation
    - Continuous-wave (CW)
    - High peak power pulsed modes.
Hybrid laser development comprises three stages:
- High-power cladding-pumped Tm fibre laser pump source
- Low-loss fibre-based pump beam shaping and delivery scheme
- High-power Ho:YAG laser at ~2.1 µm
  - Adjustable near-field and far-field intensity profile
  - Doughnut or top hat

Hybrid laser will be evaluated in various laser processing trials.
• Currently CO₂ lasers offer state-of-the-art edge quality
  • E.g. 12 mm stainless steel

• In principle solid state lasers offer a much more efficient process
  • 3x higher absorption

• HALO objectives
  • Improve cutting with solid state lasers
  • Increase cutting quality and productivity
  • Use of extra-cavity beam converters
  • Quality criteria
    - roughness of edges
    - dross length.
• HALO will investigate the cutting of brittle materials using ultra-short pulsed lasers
  • Glass
  • Ceramics
  • Sapphire
• Effect of spatial and temporal beam shaping
• Understanding laser-material interactions
  • Absorption and ablation mechanics
  • Thermal behaviour
• HALO objectives
  • Reduce material damage
    - Roughness, micro-cracks and chipping
    - Improved bending strength
  • Increase process efficiency, quality and throughput
    - Ablation rate and cutting speed
    - Edge sharpness kerf width.

Images courtesy of Trumpf Laser GmbH
Laser micro-jet cutting

- Utilizing 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 beam is entirely contained within the water jet as a parallel beam, similar in principle to an optical fibre.

- This allows improved cutting with reduced heat damage, contamination and deformation.

Images courtesy of Synova SA
Demo-Water jet cutting 2

• HALO will demonstrate:
  • Cutting of delicate materials including glass and sapphire
  • End user trials in an industrial environment
    • Brittle materials
    • Sheet metal

• HALO targets:
  • Cut precision <15 µm
  • 20% bending strength increase for glass cutting
  • Cut precision from reduced nozzle diameter <15 µm.
HALO summary

- HALO will develop technology for adjustable lasers for materials processing
  - Active and passive components
  - Novel adaptable beam solid-state lasers
  - Adaptable beam optics
  - Simulation of adjustable beam laser cutting
  - Process optimisation

- HALO hardware and processes will offer measurable efficiency and quality improvements
- Validation and demonstration for key cutting applications
  - Brittle material
  - Sheet metal
  - Liquid-jet.

Images courtesy of Trumpf Laser GmbH

www.halo-project.eu
HALO Industrial Group (HIG)

• HALO will establish a group of interested parties to:
  • Guide HALO research
  • Develop new exploitation routes
  • Identify novel applications

• Target organisations:
  • End users
  • Research organisations
  • Universities
  • Industrial companies.
Project info

• HALO is funded under the European Commission’s Seventh Framework Programme
  • Programme acronym FP7-ICT

• Area: Smart Factories
  • Energy-aware, agile manufacturing and customisation (FoF-ICT-2011.7.1)

• Project Reference 314410

• Project cost 5.71 M€
• Project funding 3.86 M€

• Start date 01-Sep-2012
• End date 31-Aug-2015
• Duration 36 months.
Thanks for your attention!

For further information, please contact:

tdurrant@goochandhousego.com       Technical

bruce@vividcomponents.co.uk         Admin & HIG