BRIDLE

Brilliant Industrial Diode Laser

Project Presentation
December 2012

www.bridle.eu

BRIDLE – European Commission Framework 7 Project Number 314719

The Consortium

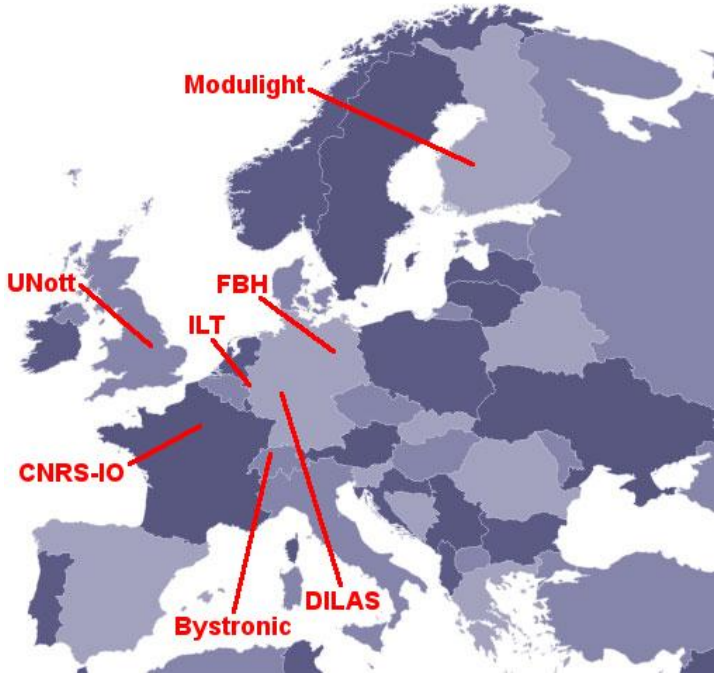
7 Partners from 5 Countries

- 3 Industrial
- 2 Research Institutes
- 2 Academic

DILAS The diode laser company.
Fraunhofer ILT
modulight on your wavelength
FBH Leibniz Ferdinand-Braun-Institut
The University of Nottingham UNITED KINGDOM · CHINA · MALAYSIA
cnrs INSTITUT d'OPTIQUE GRADUATE SCHOOL
Bystronic

Partner List

1. DILAS Diodenlaser GmbH, Germany *(DILAS)*
2. Fraunhofer-Institut für Lasertechnik, Germany *(ILT)*
3. Modulight, Inc., Finland *(Modulight)*
4. Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Germany *(FBH)*
5. University of Nottingham, United Kingdom *(UNott)*
6. Centre National de la Recherche Scientifique - Institut d'Optique, France *(CNRS-IO)*
7. Bystronic Laser AG, Switzerland *(Bystronic)*

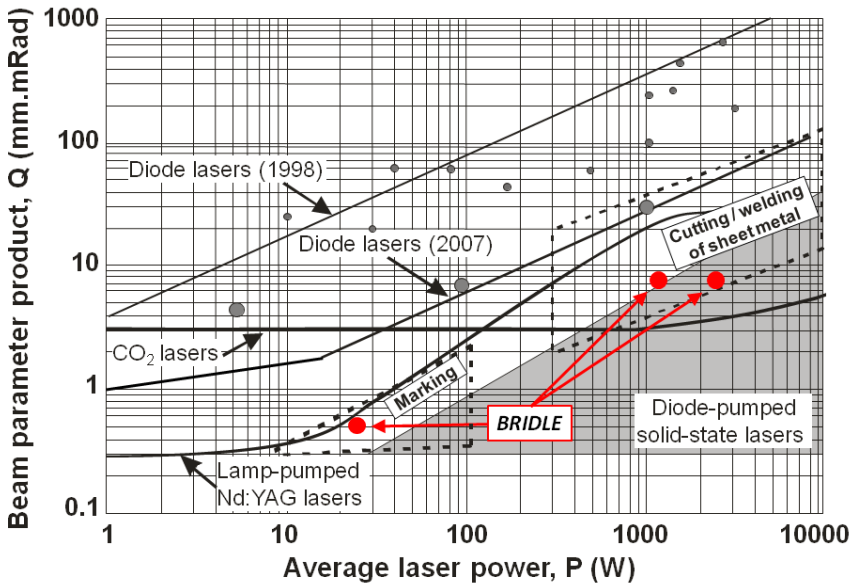


Project Motivation and Vision

Diode lasers are the most efficient technology for converting electrical energy into useful light, but this efficiency is not available to most industrial users due to the low brilliance of the diode sources

The BRIDLE Vision

"To deliver a technological breakthrough in cost effective, high-brilliance diode lasers, which will enable direct diode lasers to penetrate the lucrative metal processing market"

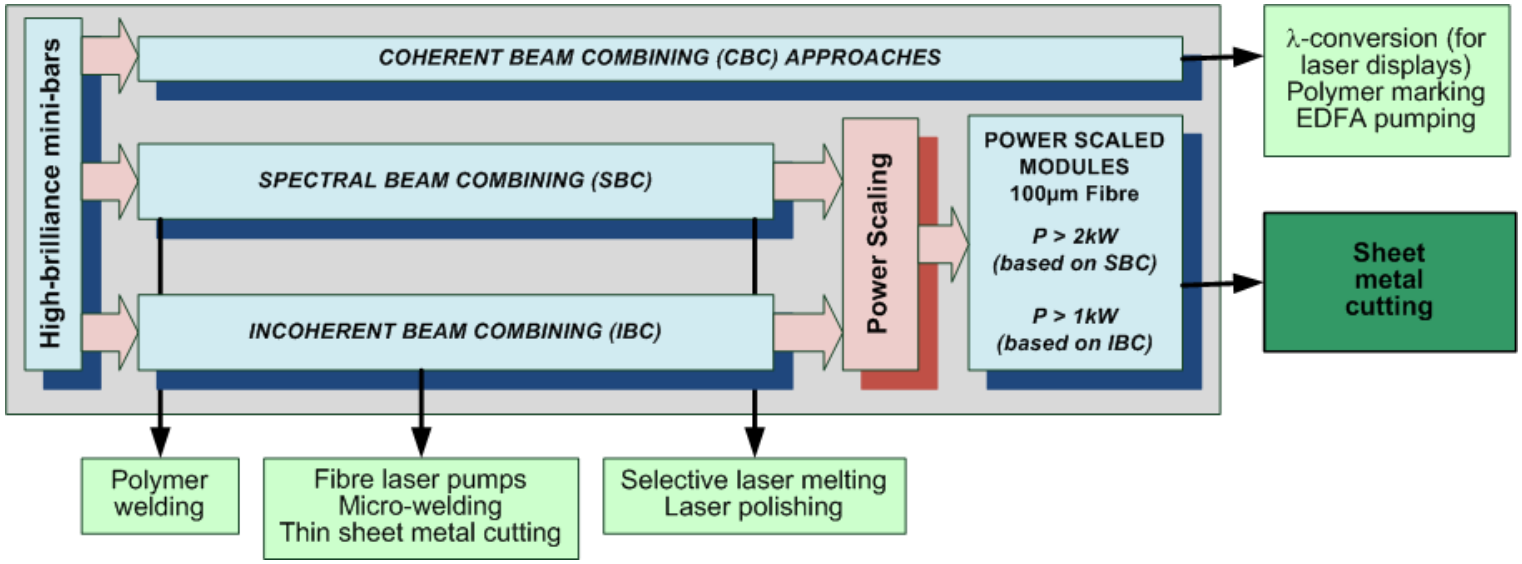


Typical beam parameters for different diode and non-diode laser systems and materials processing applications

Performance targets of some of the BRIDLE modules are also marked

Project Aims and Approach

BRIDLE **plans to develop a sequence of increasingly high brilliance demonstrators, each targeting a specific industrial application, leading up to an affordable diode laser source with an output power of >2kW from a ϕ100µm optical fibre and efficiency >40%, which will target industrial applications requiring the cutting and welding of sheet metal**



BRIDLE's modular approach and typical applications to which BRIDLE laser modules will be suited

Project Innovation

To realise our vision, *BRIDLE* targets many technical and scientific advances including:

In laser diode technology…

- Mini-bars with chirped-DBR mirrors for low-cost spectral multiplexing
- High-brilliance tapered laser mini-bars with extremely low divergence
- Near-single-mode narrow-stripe broad-area lasers, using innovative integrated mode filters
- High-power arrays of single-mode ridge waveguide lasers for coherent combining

In packaging and laser systems…

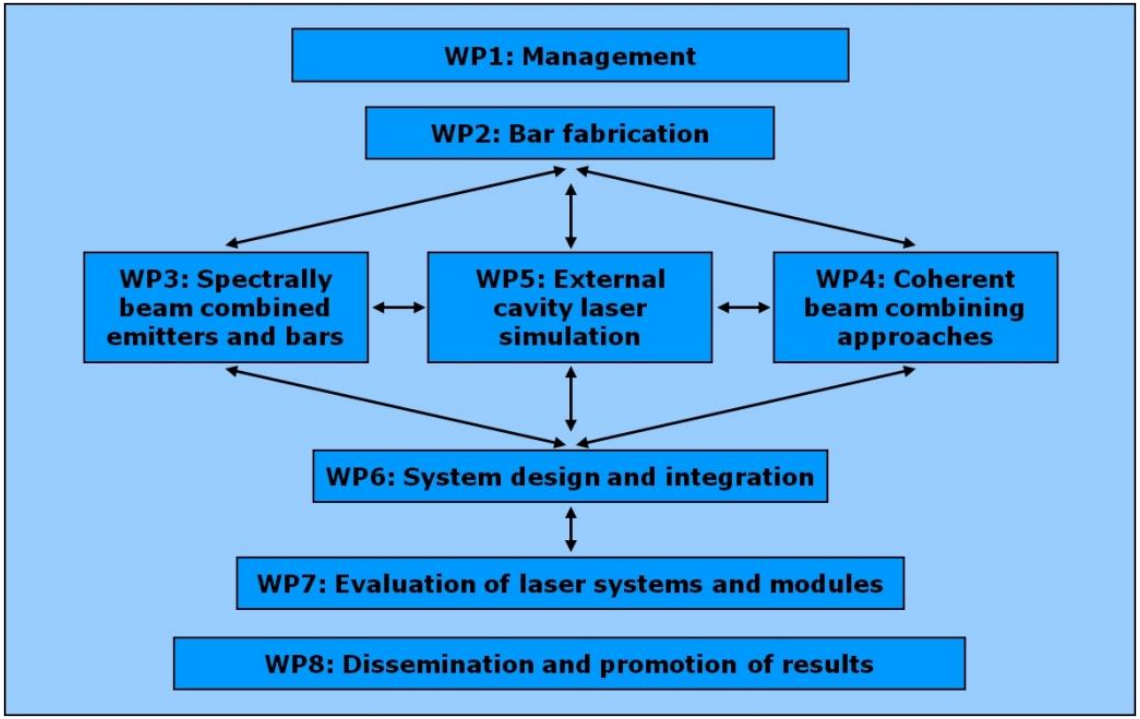
- Highly efficient and compact dense wavelength division multiplexing devices based on volume gratings, reflective gratings or dichroic mirrors
- High-power integrated multimode fibre beam combiners
- Packaging for individually addressable diode lasers based on either p-side down mounting or a segmented PCB structure on the heatsink

In laser design and simulation…

- Detailed evaluation of external cavity phase locking configurations for diode laser arrays
- Identification and control of factors affecting emitter phase locking in practical laser arrays
- Demonstration of the first system-level design tool for high-power diode laser sources, which bidirectionally couples the simulation of the laser array with optical design software

Project Organisation

The project is organised into eight workpackages (WPs), which cover all scientific and technical activities, project management and the dissemination and promotion of results

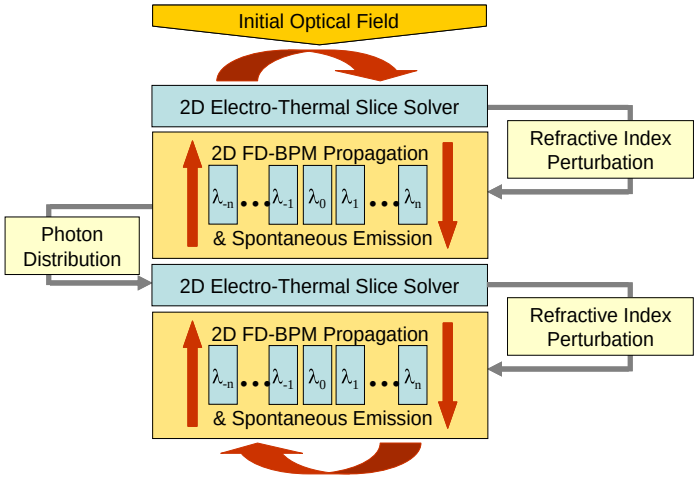


Organisational diagram of the BRIDLE project

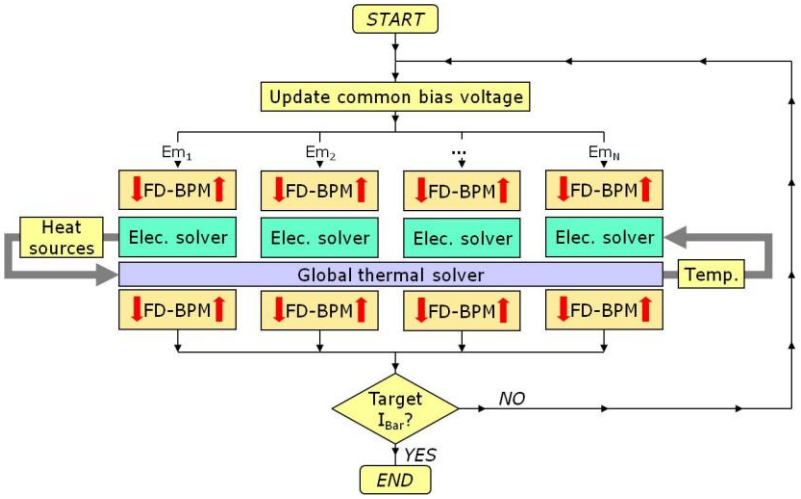
Design and Simulation

State-of-the-art simulation tools are being used at all levels to optimise designs

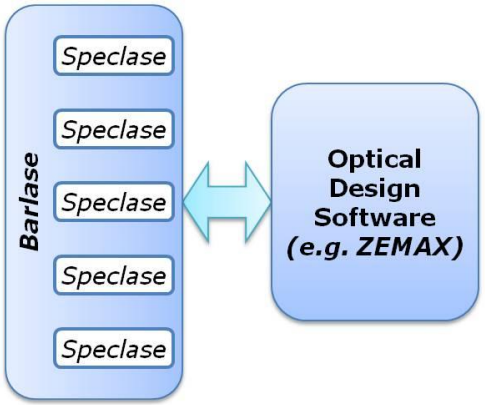
- Laser diode emitters
- Laser diode bars
- Laser systems, including external optics



Schematic of a 2.5D spectral laser model 'Speclase' for single emitters



Schematic of 'Barlase' software for laser bars



System design within BRIDLE:

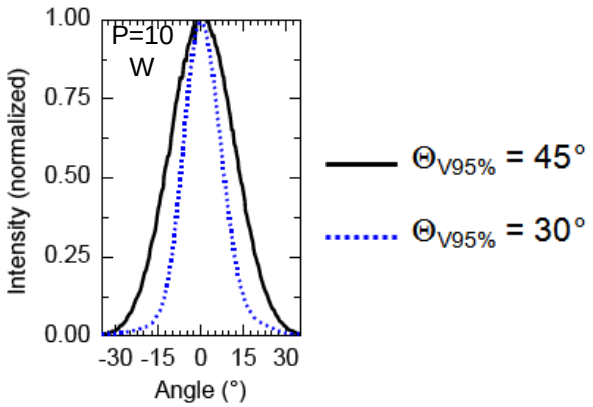
Bi-directional coupling of Barlase/Speclase to optical design software

Laser Bar Fabrication

***BRIDLE* is developing high brilliance emitters incorporating several advanced technologies**

1. Low vertical divergence

- Reduced coupling losses
- Less sensitive to bar smile

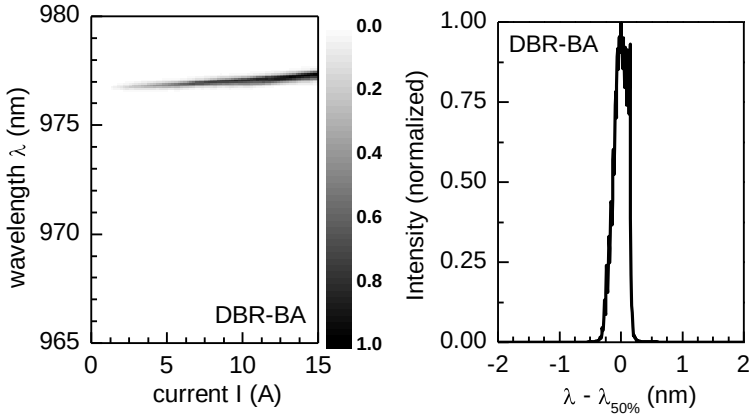


Vertical far-fields for reference (black) & low-divergence (blue) 90μm-stripe single emitters

Crump et *al.*, *Photon. Technol. Lett.*, **24**, 703 (2012)

2. Integrated DBR mirrors

- Very narrow spectral widths
- Emission stable with bias

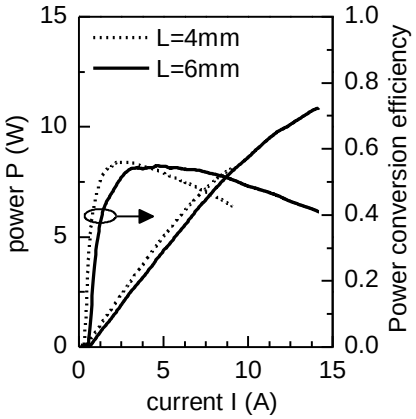


Demonstration of spectral stability and narrow linewidth in a 100μm BA laser with a rear facet DBR

Crump et *al.*, *Proc. SPIE* **8241**, 82410N (2012)

3. In-plane mode filtering

- Narrow-stripe broad area
- Tapered lasers



CW output characteristics of narrow stripe BA lasers with W = 32μm

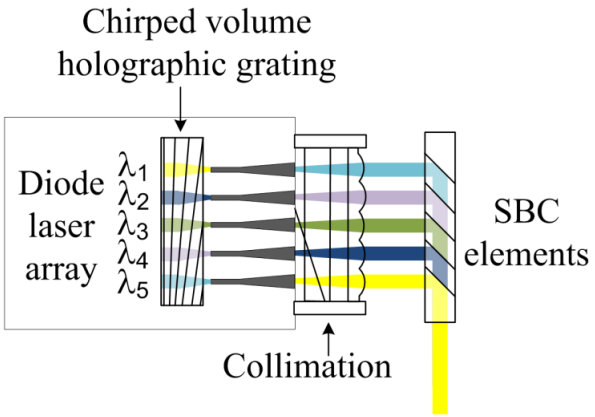
Crump et *al.*, *Proc. SPIE* **8241**, 82410U (2012)

Spectral Beam Combining

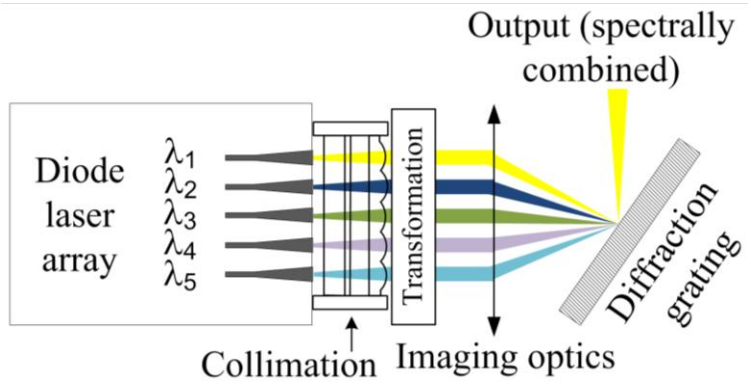
BRIDLE **is pursuing a range of spectral beam combining (SBC) architectures where beams from individual lasers/emitters with non-overlapping wavelengths are co-aligned and spatially overlapped using wavelength sensitive optical elements, resulting in an overall slow axis beam quality of the bar that is close to that of the constituent emitters**

Examples of possible SBC architectures

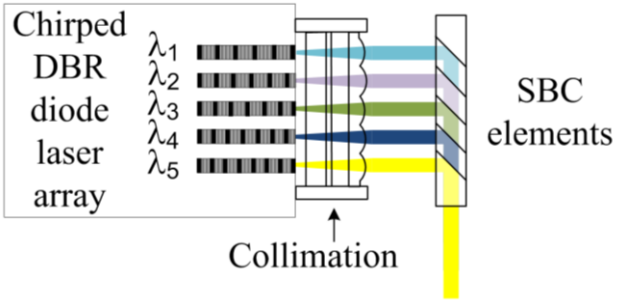
1. External cavity with a front-facet diffractive feedback element



2. Simultaneous wavelength stabilisation & spectral beam combining (Littrow cavity)

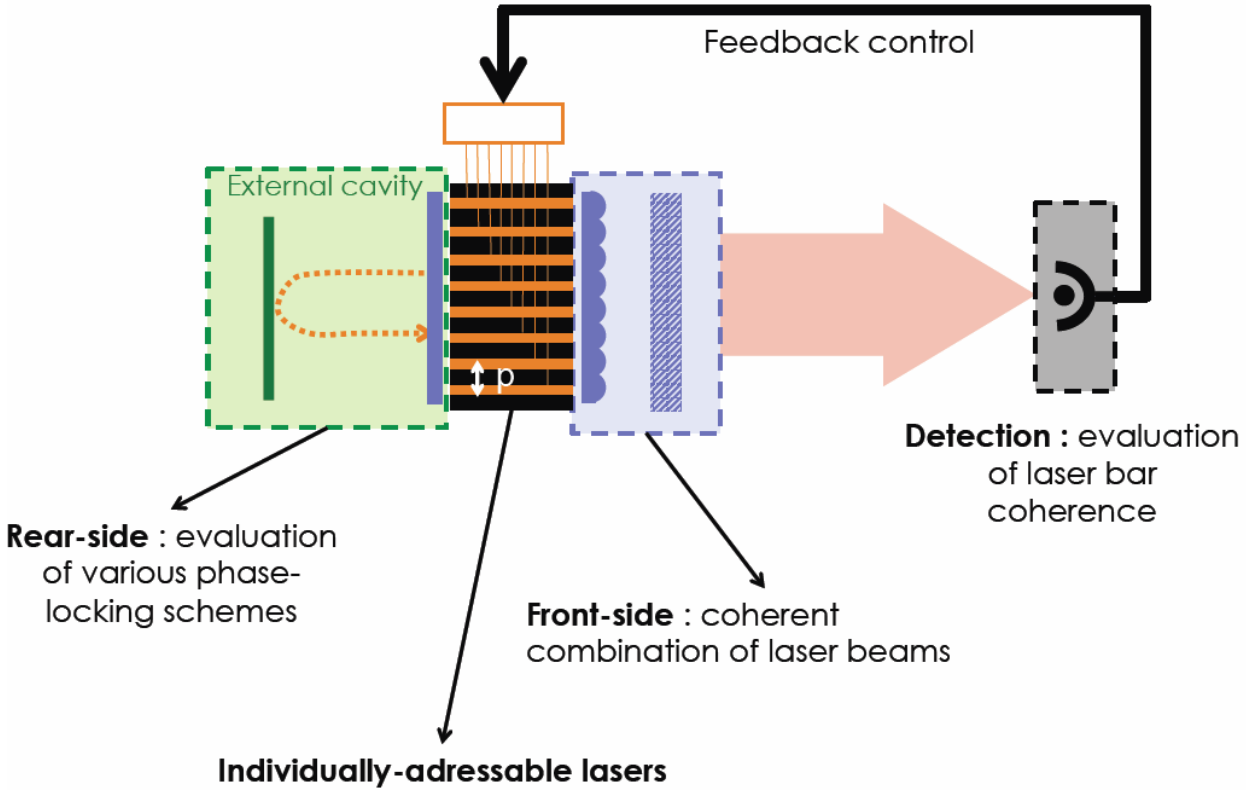


3. Internal stabilisation employing chirped DBR laser structures



Coherent Beam Combining

BRIDLE **is also pursuing advanced coherent beam combining techniques to develop phase-coupled mini-bars with a nearly diffraction limited output, which will ultimately facilitate further significant improvements in both spatial and spectral brilliance**



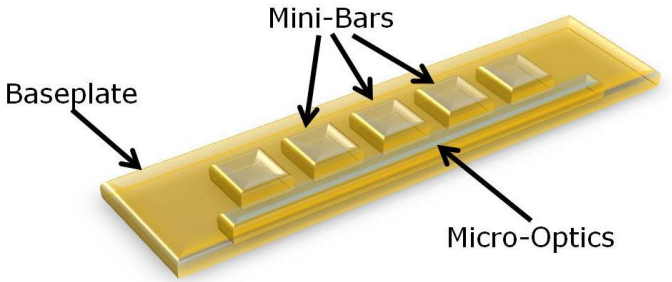
- ***A range of rear-facet phase-locking configurations will be evaluated (e.g. Talbot cavity, superposition cavity)***
- ***Coherent combination of the phase-locked laser beams will be implemented at the front-facet***
- ***Current tuning of individually addressable laser emitters will be used to optimise the phase locking and evaluate the overall laser bar coherence***

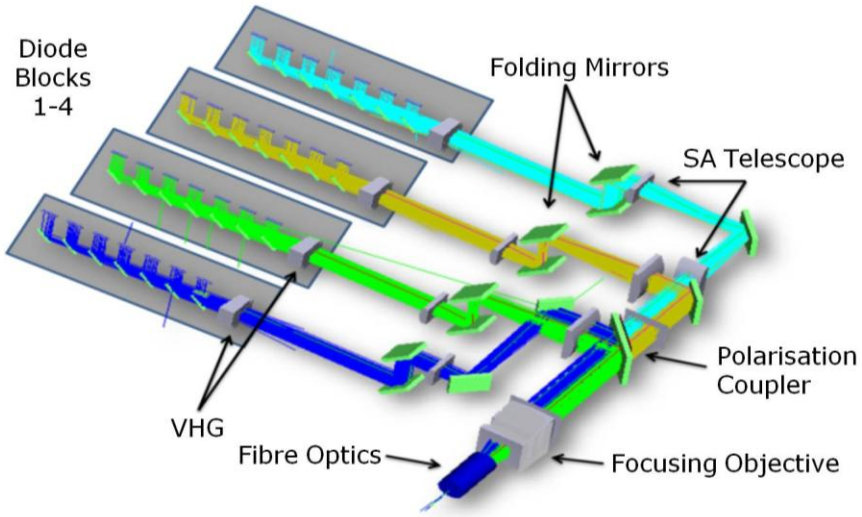
Laser Systems and Modules

***BRIDLE* is pursuing approaches that are modular, scalable and forward compatible**

***BRIDLE* approaches are based on state-of-the-art high brilliance mini-bars**

- Mini-bars require only simple optics (just FAC/SAC) → no beam transformation
- 5 to 7 devices arranged monolithically → allows automation of mounting and lensing
- Modules then based on multiple baseplates with simple combining optics



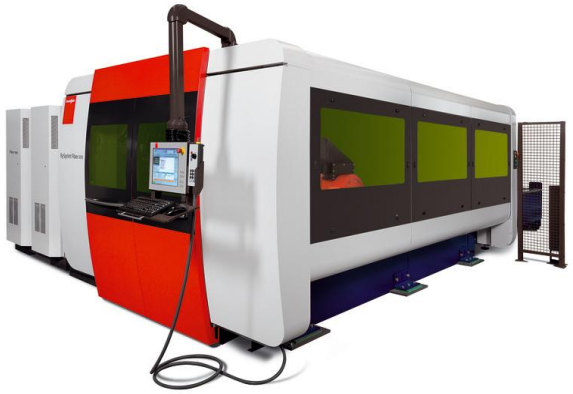


Electro-optical circuit board (baseplate) with laser bars and optics mounted using automated process (above right) and optical configuration of module employing four baseplates (below right)

System Integration and Testing

***BRIDLE*'s final objective of a diode laser source with an output power of >2kW from a ϕ100µm optical fibre and efficiency >40% will be suitable for sheet metal cutting**

An existing fibre laser cutting system (see below) will be fitted with the *BRIDLE* direct diode source and comprehensive cutting tests will be performed



Laser cutting system 'BySprint Fiber 3015'

Laser cutting head in action

Example of a laser cut metal component

Potential Exploitation

Final >2kW *BRIDLE* laser targets industrial applications requiring the cutting of sheet metal

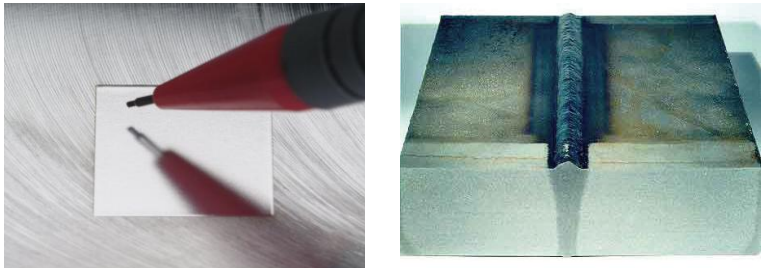
***BRIDLE's* high efficiency sub-modules will benefit laser processing applications**

- Selective laser melting (typical build rate 5-20 cm^3/hour)
- Laser polishing (typical process time 0.1-2.0 minutes/cm^2)

Examples of parts made by selective laser melting

Significant further power scaling beyond *BRIDLE* is also possible

- Laser powers >10kW (300µm fibre) possible by fibre combining
- Laser powers >8kW (100µm fibre) possible by adding more wavelengths
- Resulting system suitable for sheet metal welding



Examples of laser polishing (left) and welding (right)

Contact Details and Further Information

For more information and contact details, please visit out project website:

www.bridle.eu

or

www.bridle-laser.eu

Sign up for our project e-Newsletter (to be published every 9 months) by emailing:

subsrcibe@bridle.eu

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