PowerPhotonic
Enhancing Beam Performance

Freeform Beam Shaping Solutions for Laser Welding Optimisation

EPIC Online Technology Meeting on Industrial Laser Processes for Automotive and Electro Mobility

Dr. Alex Griffiths – PowerPhotonic Ltd.

St David's Business Park, 5A St David's Dr, Dalgety Bay, Dunfermline KY11 9PF, UK

Laser Welding Optimisation

Laser power

Beam delivery

Wavelength

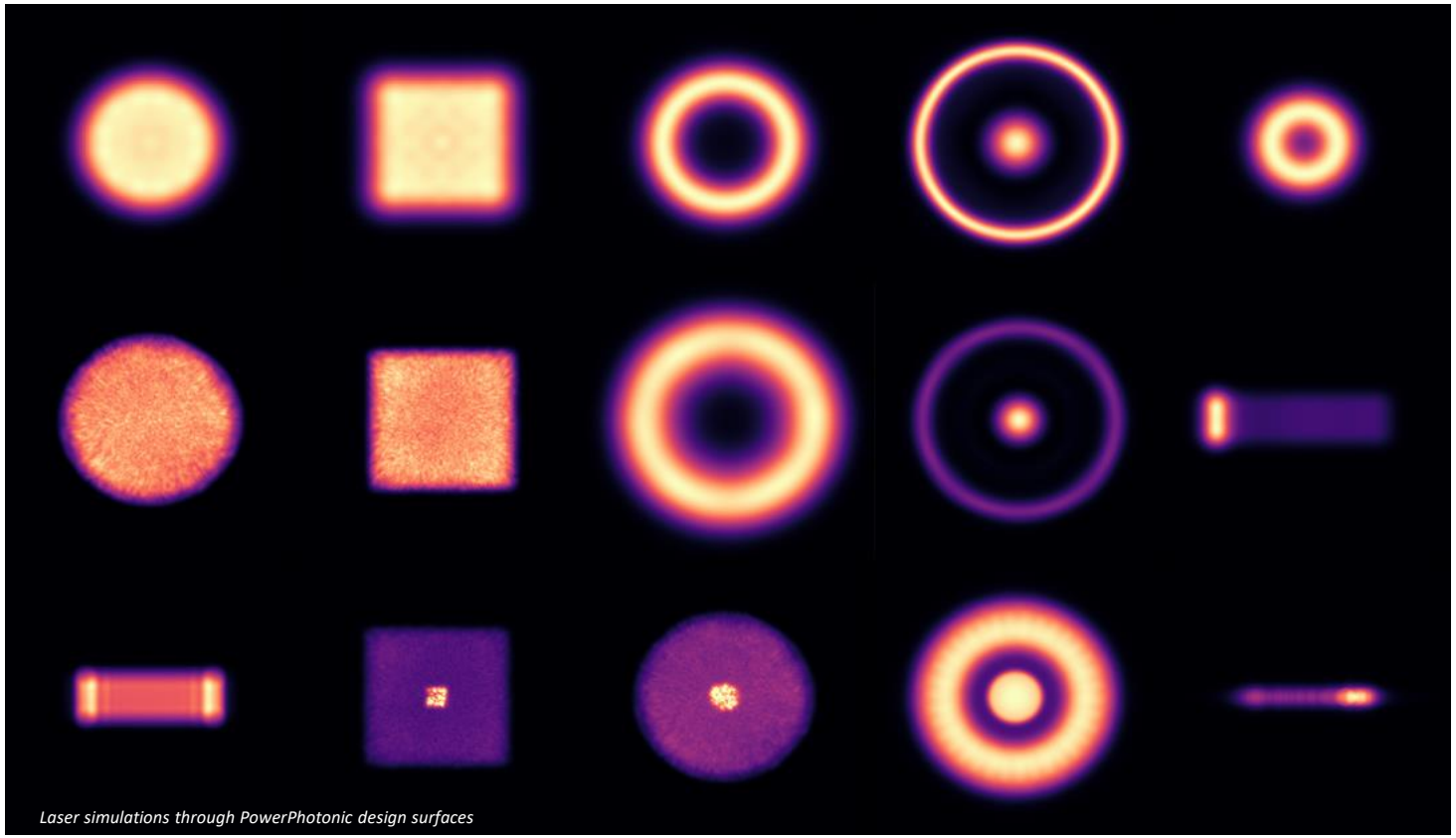
Weld speed

Laser mode

Wobble

CW/pulsed

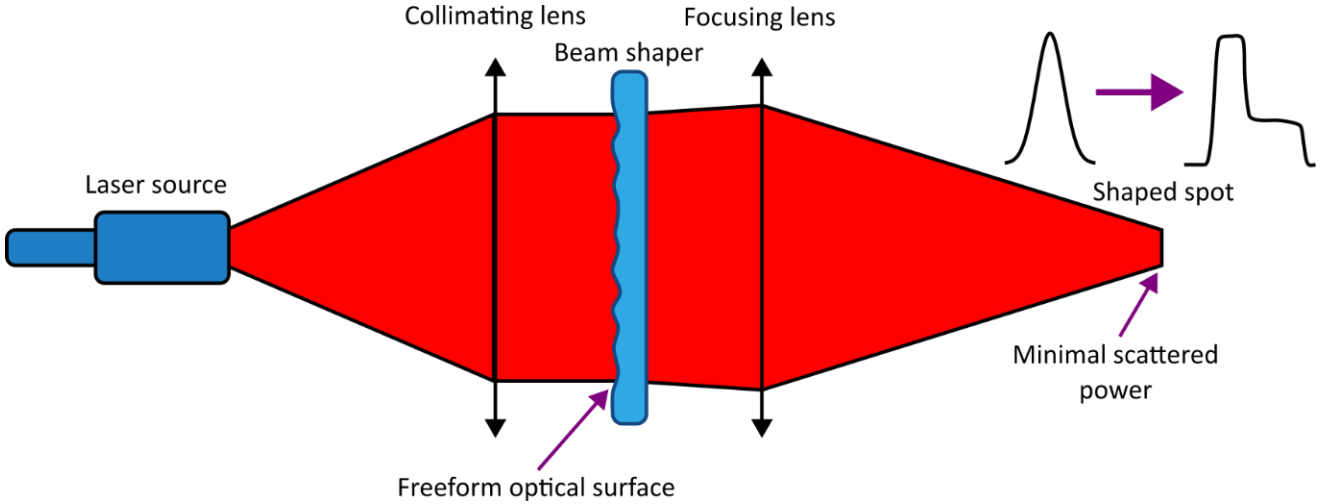
Spot size



Laser simulations through PowerPhotonic design surfaces

PowerPhotonic
Enhancing Beam Performance

Beam Shaping With Refractive Optics

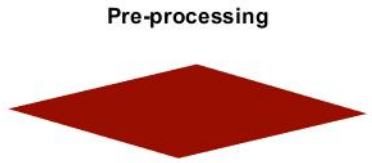


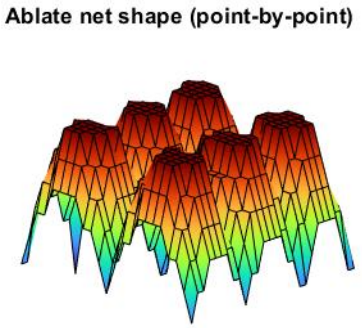
- Transmissive optical components
- Positioned in the optical train between source and workpiece
- Incident light is refracted to fine tune the intensity distribution at the working plane

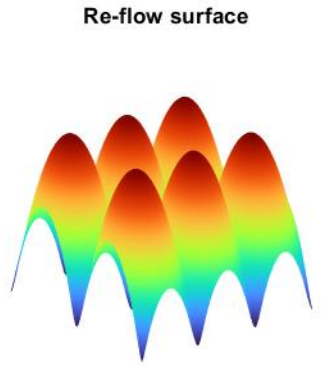
PowerPhotonic
Enhancing Beam Performance

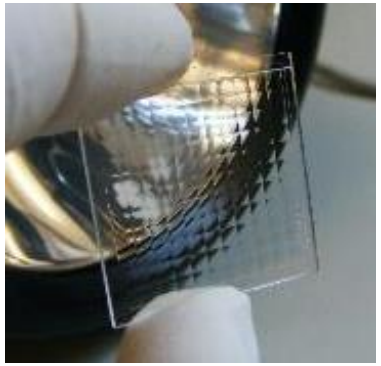
PowerPhotonic's Freeform Manufacturing Process

- Laser-based manufacturing process for fused silica
- Laser ablation defines the net shape of the surface
- Laser polishing reflows the material resulting in an optically smooth surface – low roughness, high power handling
- Refractive, freeform optics with no symmetry restrictions – enabling vast flexibility for beam shaping

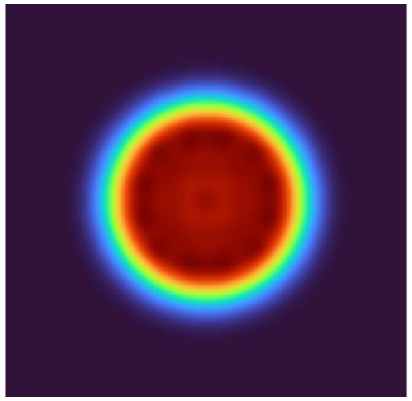




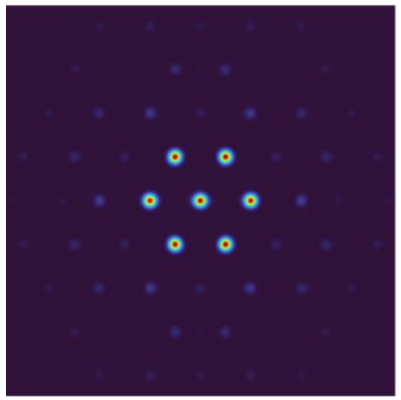




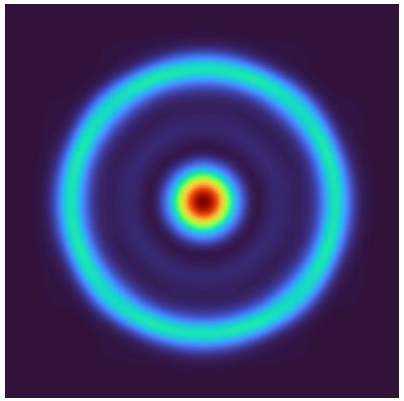
Flat top



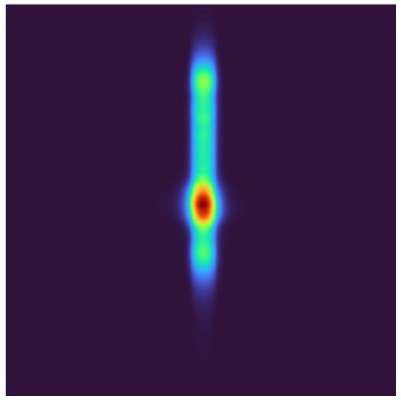
Multi spot



Core & ring



Tail shape



PowerPhotonic
Enhancing Beam Performance

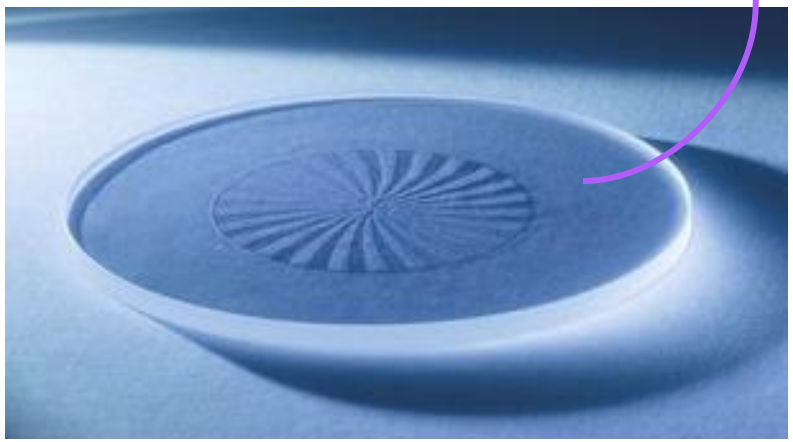
Beam Shaper Installation

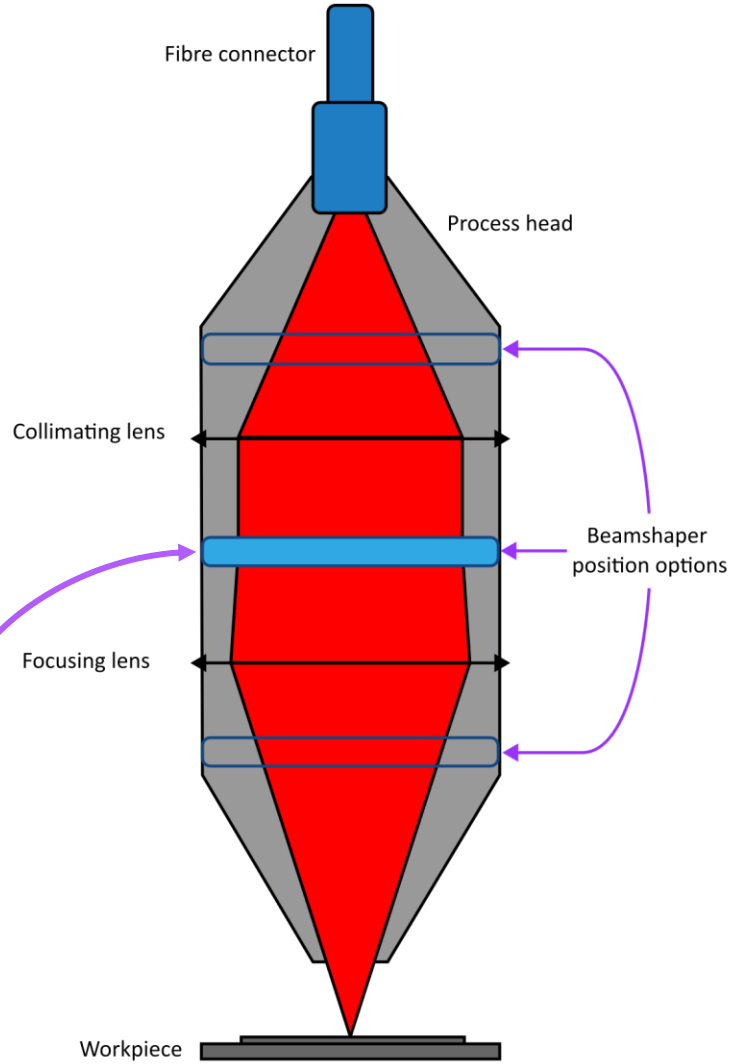
For R&D tests:

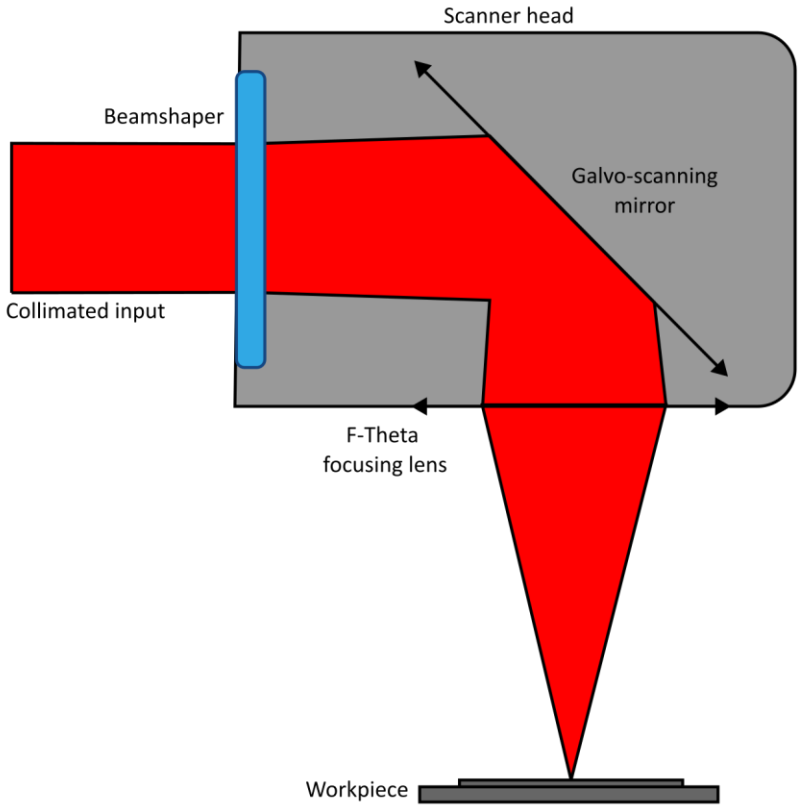
- The beam shaper can be installed in place of a protective window
- Straightforward installation for initial proof-of-concept work

For permanent installation:

- An additional, low-profile module installed in the beam path
- Removable tray for adding, removing and swapping beam shapers



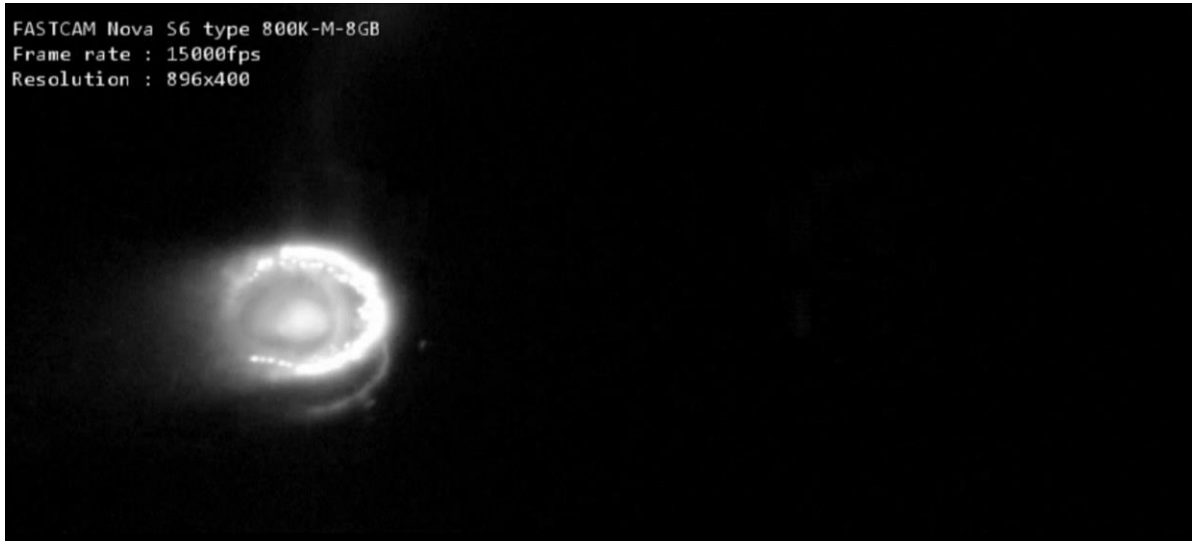




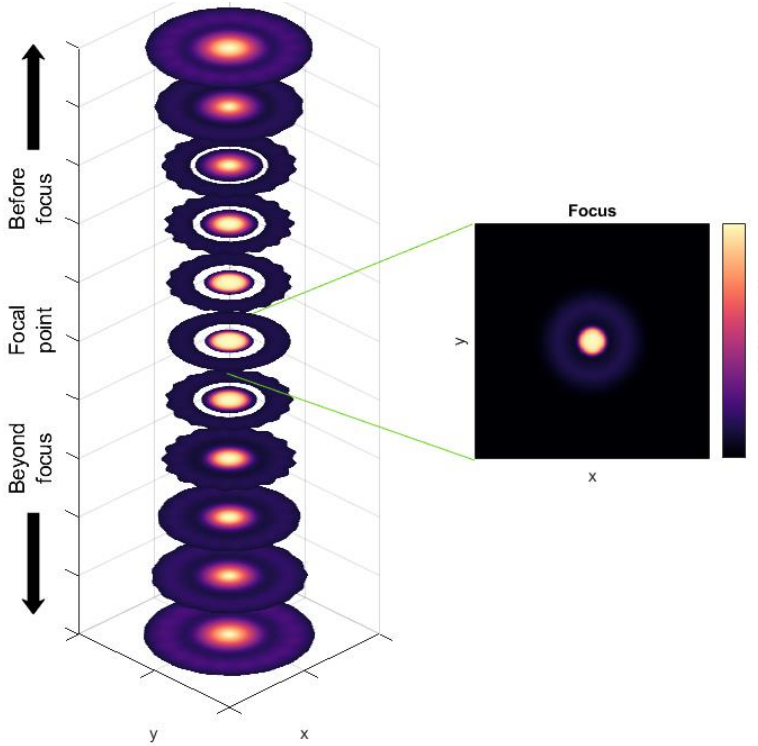
PowerPhotonic
Enhancing Beam Performance

Core & Ring Shaping

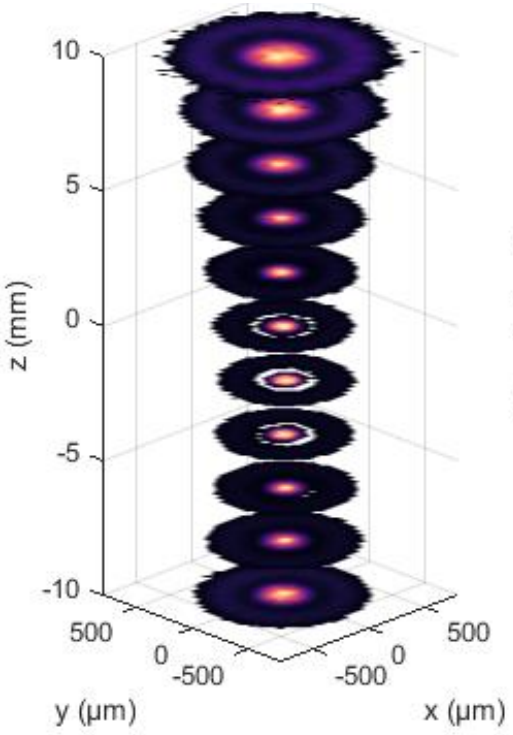
- PowerPhotonic's solution provides a long depth-of-focus core & ring *caustic*
- Demonstrated for autogenous welding of aluminium 6082
- Improved melt-pool stability during welding
- **Tensile stress limit increased from 175 MPa to 262 MPa. +49.7%**

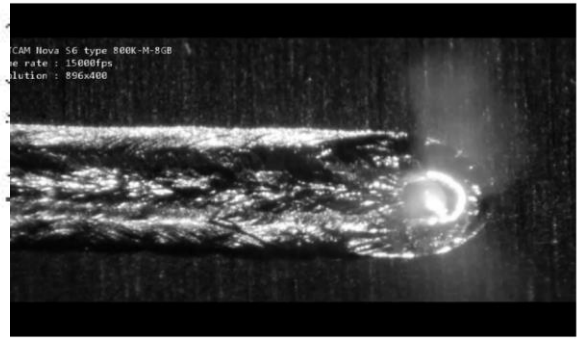


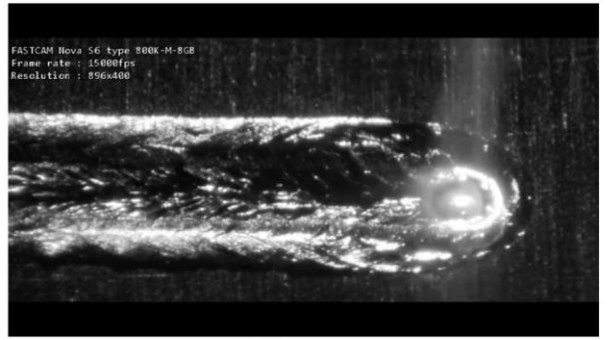
Simulated



Measured





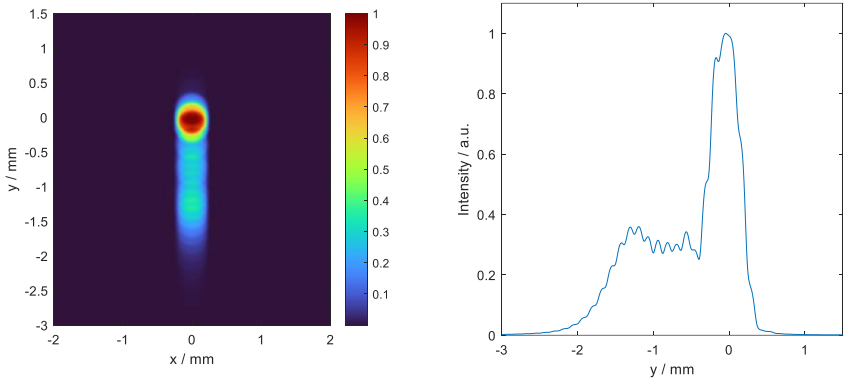


WMG
THE UNIVERSITY OF WARWICK

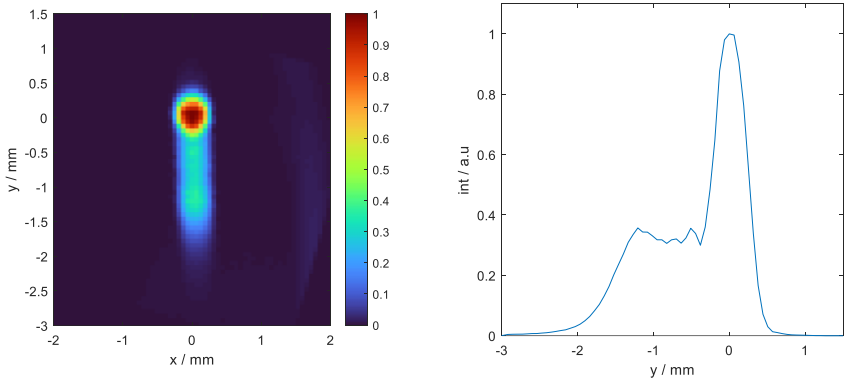
PowerPhotonic
Enhancing Beam Performance

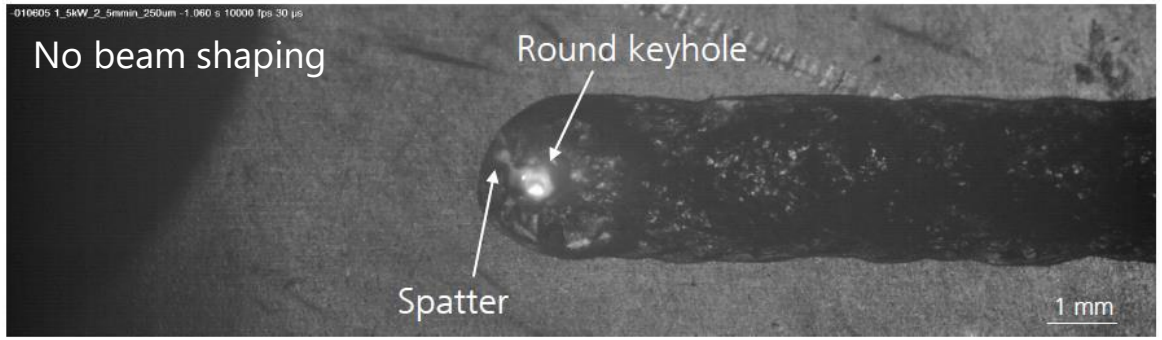
Tailshaper - Asymmetric Intensity Profiles

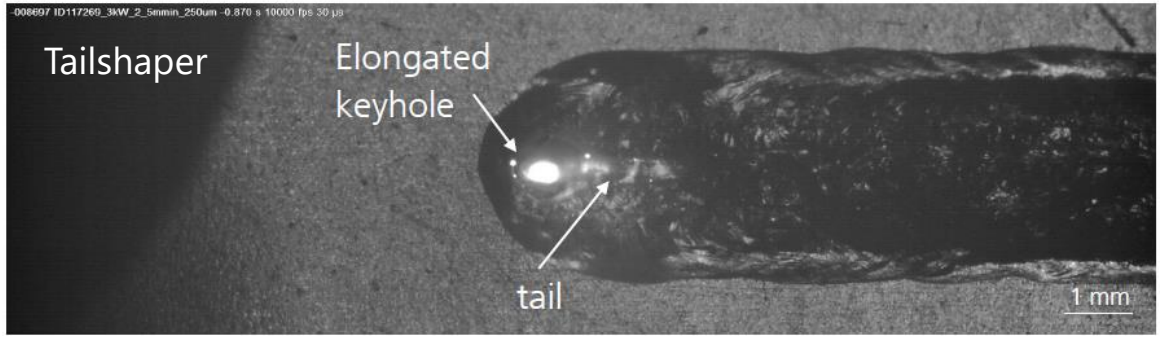
Simulated

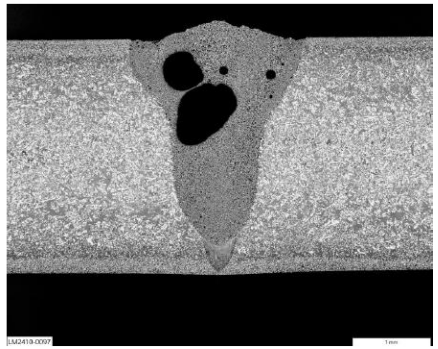


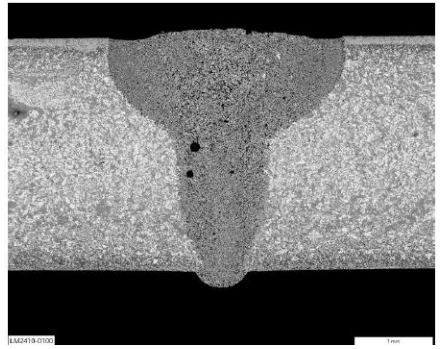
Measured











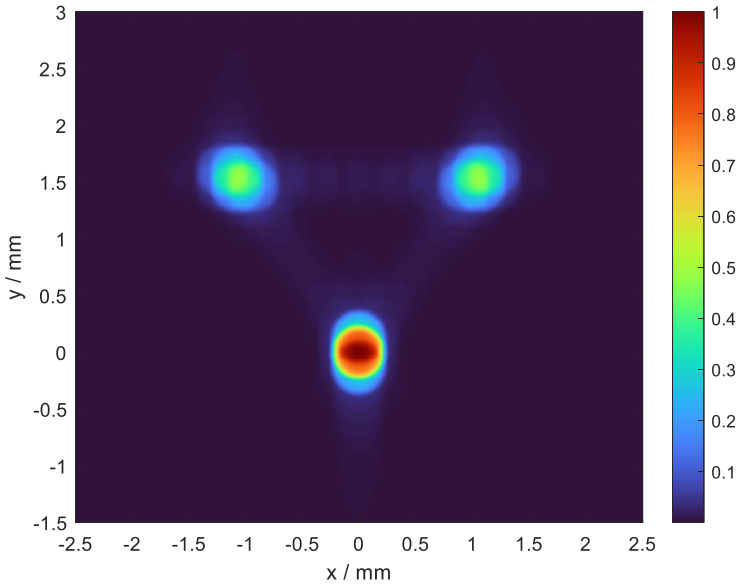
- Trailing intensity in line with the weld
- Additional conduction welding produces a smoother finish
- Elongated keyhole observed when welding AlSi9 – **reduces porosity in the weld** (https://doi.org/10.2351/7.0001150)

Fraunhofer IWS
PowerPhotonic
Enhancing Beam Performance

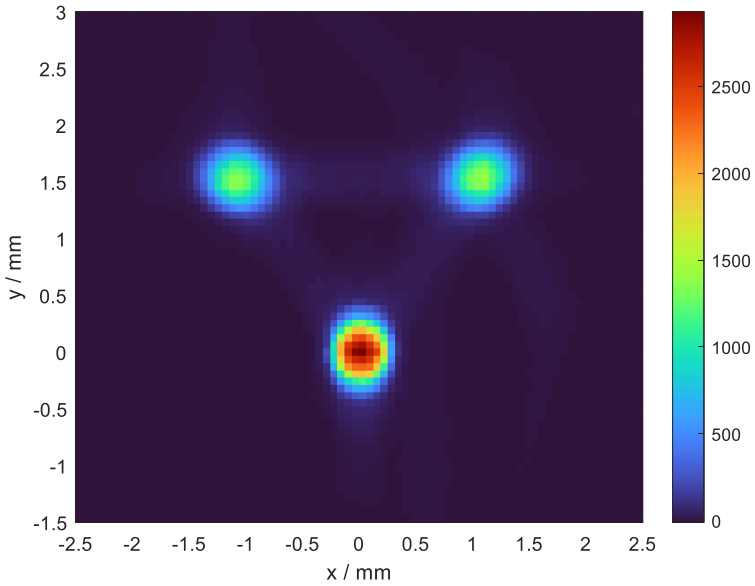
Multi-spot Outputs

- Customised beam splitting optic
- Additional spots either side of the weld
- **Affects the cross section and top profile of the weld**

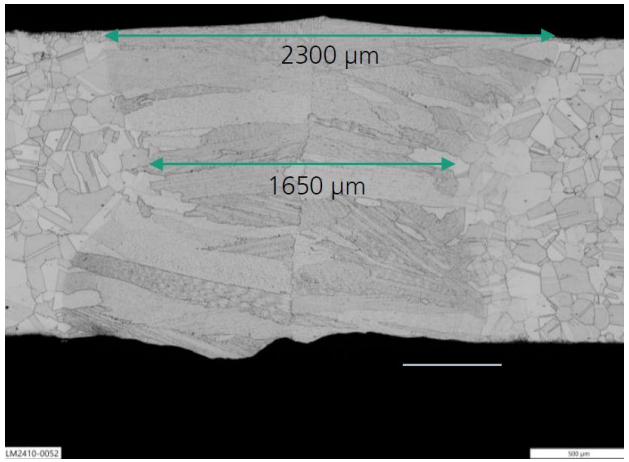
Simulated



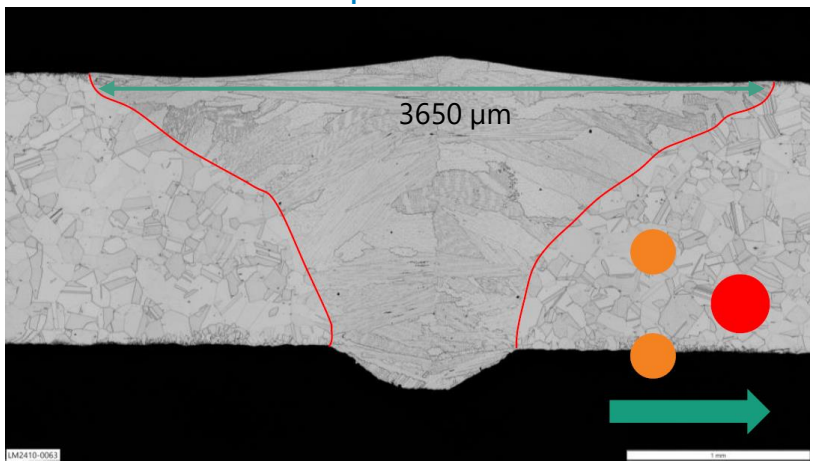
Measured



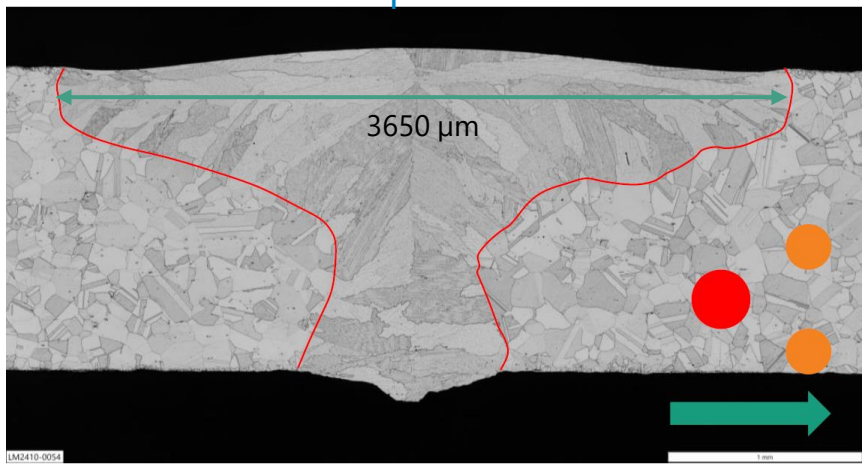
No beam shaping



Main spot forward



Main spot behind



Fraunhofer IWS
PowerPhotonic
Enhancing Beam Performance

Conclusions

- Refractive, freeform beam shapers provide flexible intensity patterns with simple system modifications
- Intensity patterns can be tailored to affect key parameters in welding

What we can do for you:

- Provide beam shaping optics
- Highly customised, freeform intensity patterns for process enhancement

What you can do for us

- Present challenges seen in laser applications
- Collaborate on the optimisation of intensity profiles for specific applications

Acknowledgements

Fraunhofer IWS

WMG THE UNIVERSITY OF WARWICK