PowerPhotonic

Novel Beam Shaping Techniques to Enhance Laser Weld Quality

PowerPhotonic

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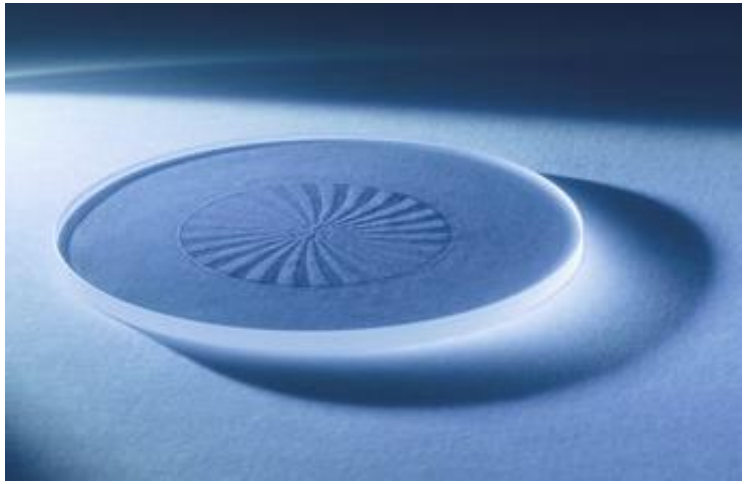
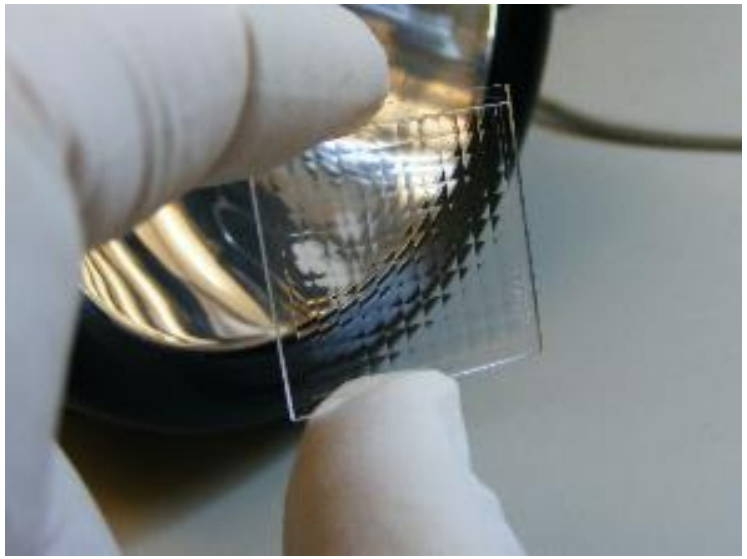
PowerPhotonic Beam Shapers

- **PowerPhotonic provides freeform beam shaping elements that can fit into current and future processing heads**
  - Low roughness, low scatter surfaces
- **Manufactured out of Fused Silica with very high LIDT Properties**
  - >100kW/cm proven performance
- **Refractive, freeform beam shaping**
  - Reduced diffractive effects, no zeroth order
  - No symmetry restrictions





Problem Outline & Test Set Up

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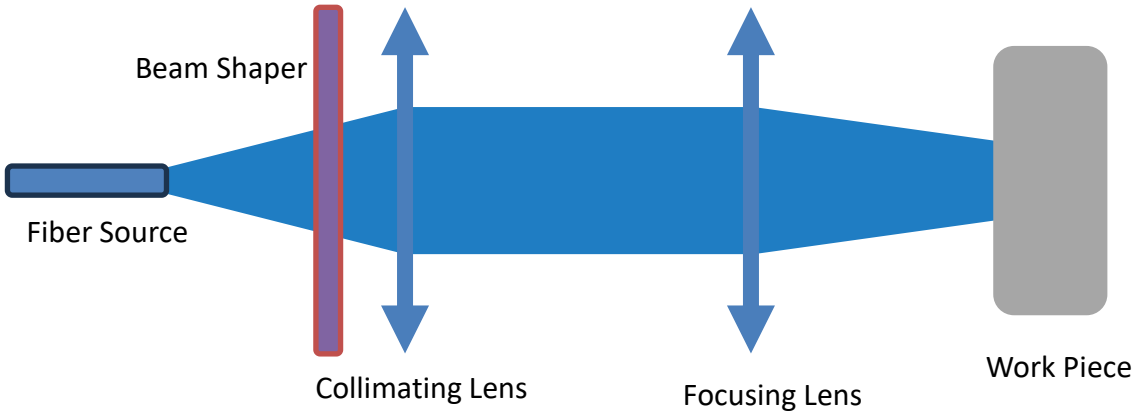
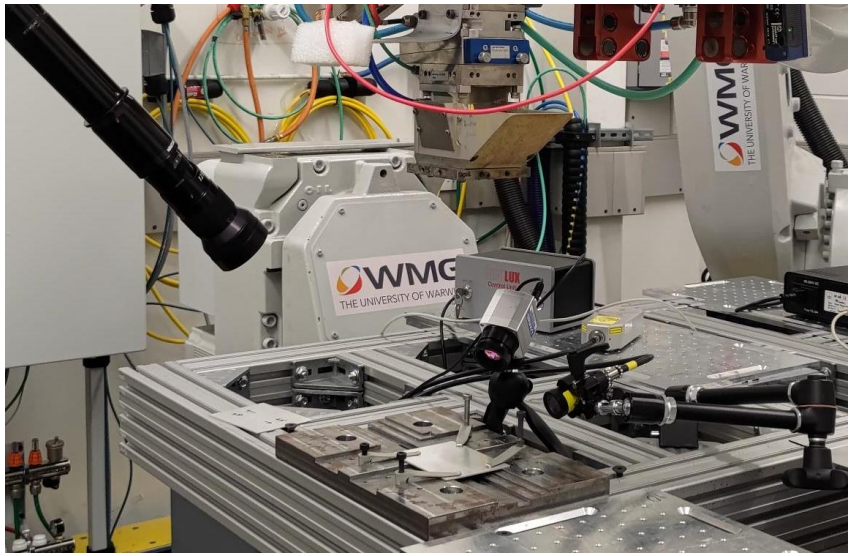
- **Welding of aluminium 6082 – commonly used in car bodies**
  - Current techniques use filler wire – complex, wasteful
  - Sensitive to cracking along the weld line
  - Aiming for an autogenous “laser weld only” process
- **Optical system**
  - Coherent Highlight FL10000-ARM Fiber Laser
  - 100 µm core, 0.1 NA fibre
  - Precitec YW51 Weldmaster welding head
  - 150/300 mm lenses (2x magnification)
  - Beam shaper replaces a protective window in the process head – simple swap of a glass plate, no major system modification
- **Welding setup**
  - 100x90x1.5mm AA6082 Alloy sheet
  - ‘Bead on Plate’ welding
  - Laser Beam inclined 5° from normal in Weld Direction
  - Focal offset at Zero
  - No Beam Oscillations





Light Tunnel Generator (LTG) Profiles

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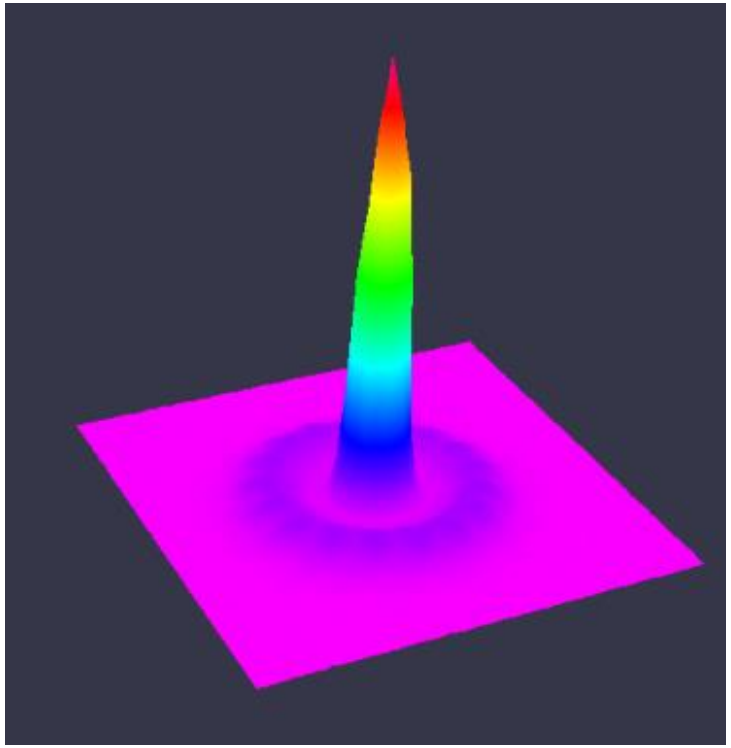
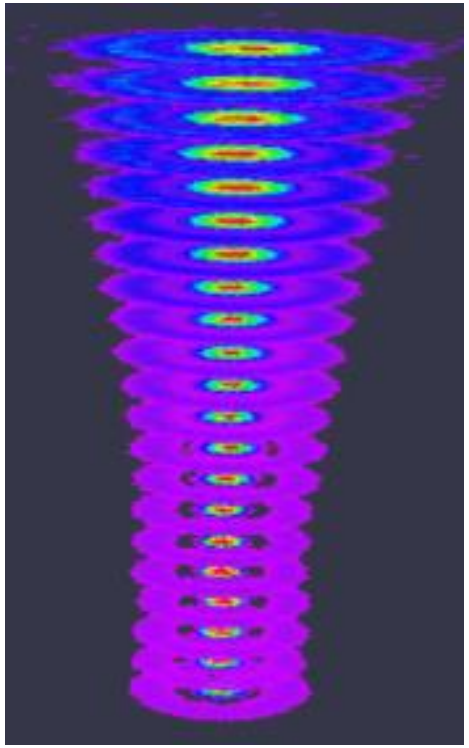
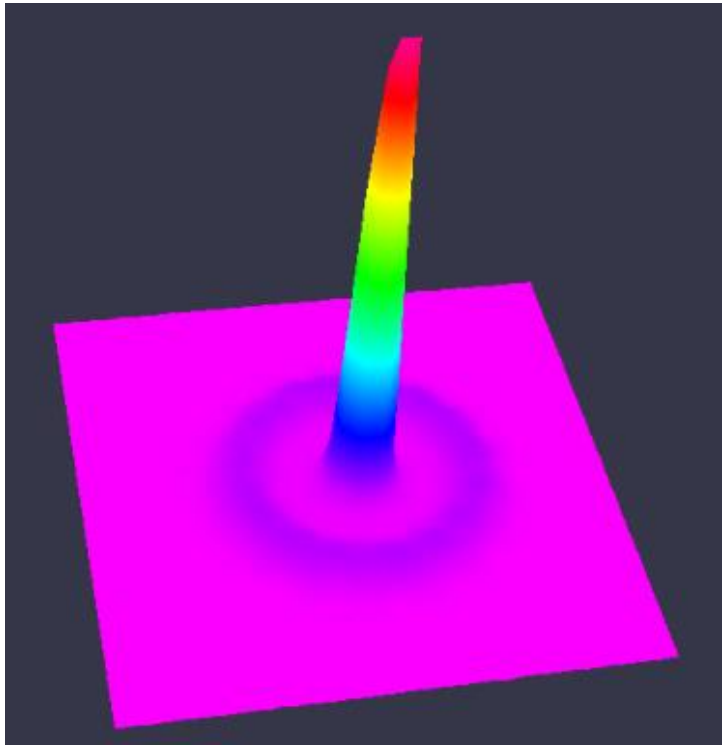
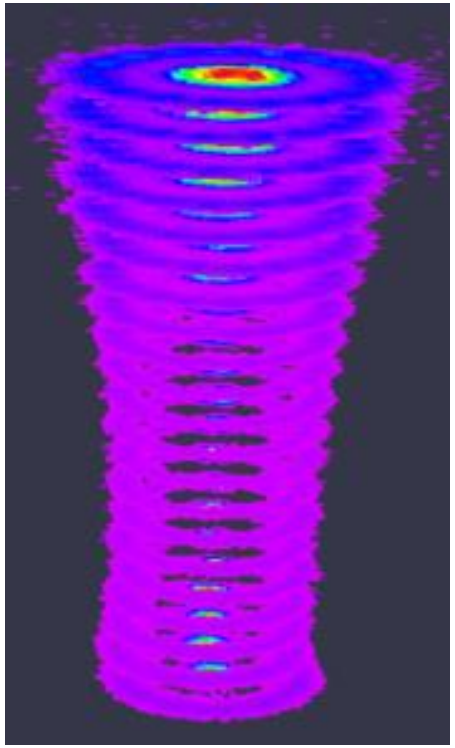
- 900um Ring Diameter (D4 Sigma)
- 1200um Ring Diameter (D4 Sigma)

Power Ratio of 50:50 Ring:Core

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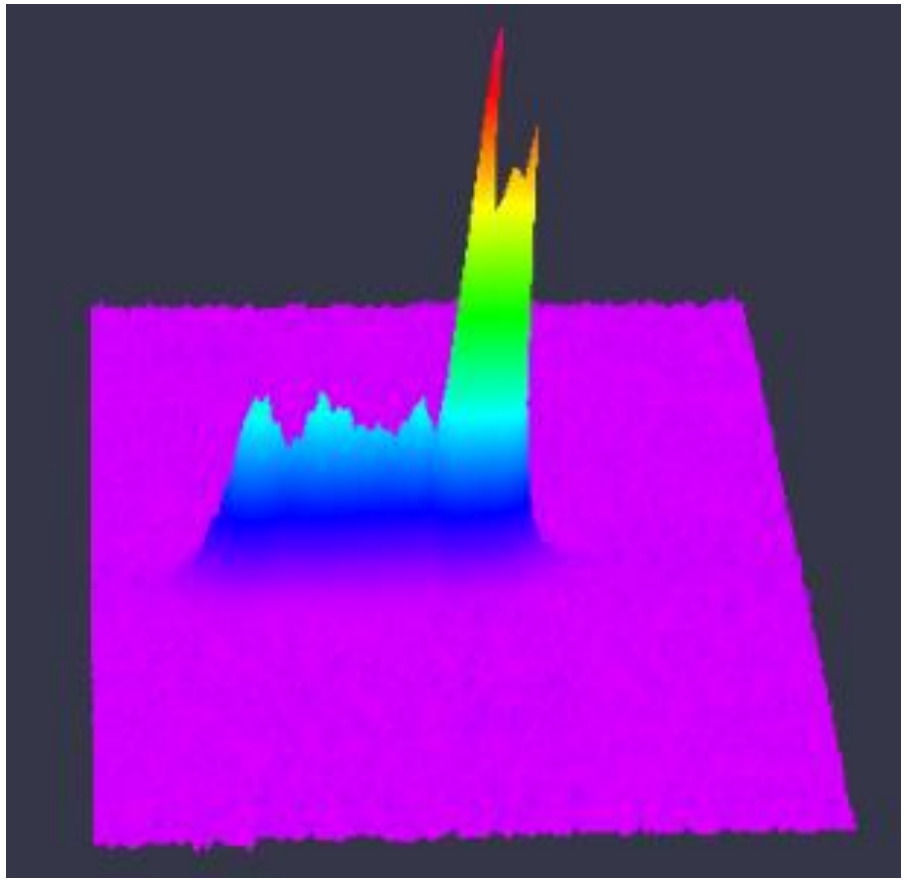
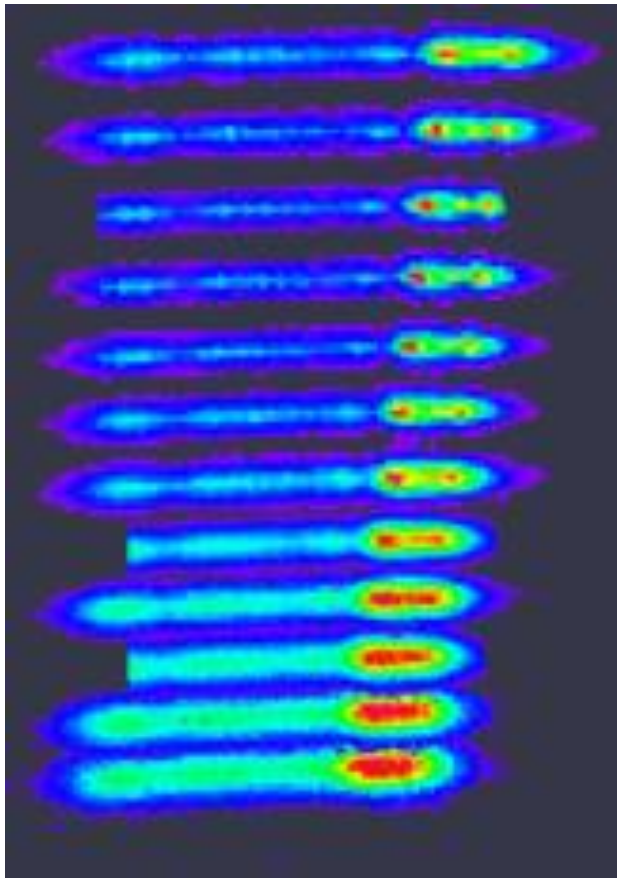
Tailshaper Profile

- Asymmetric profile
- 1 mm spot FWHM in X
- 0.3mm spot FWHM in Y
- Tail intensity ~ 0.3x peak intensity

- Leading or trailing intensity to provide pre- or post- heating





Unshaped Welding

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- Weld speed: 25 mm/s
- Power: 1400 W

LTG Welding

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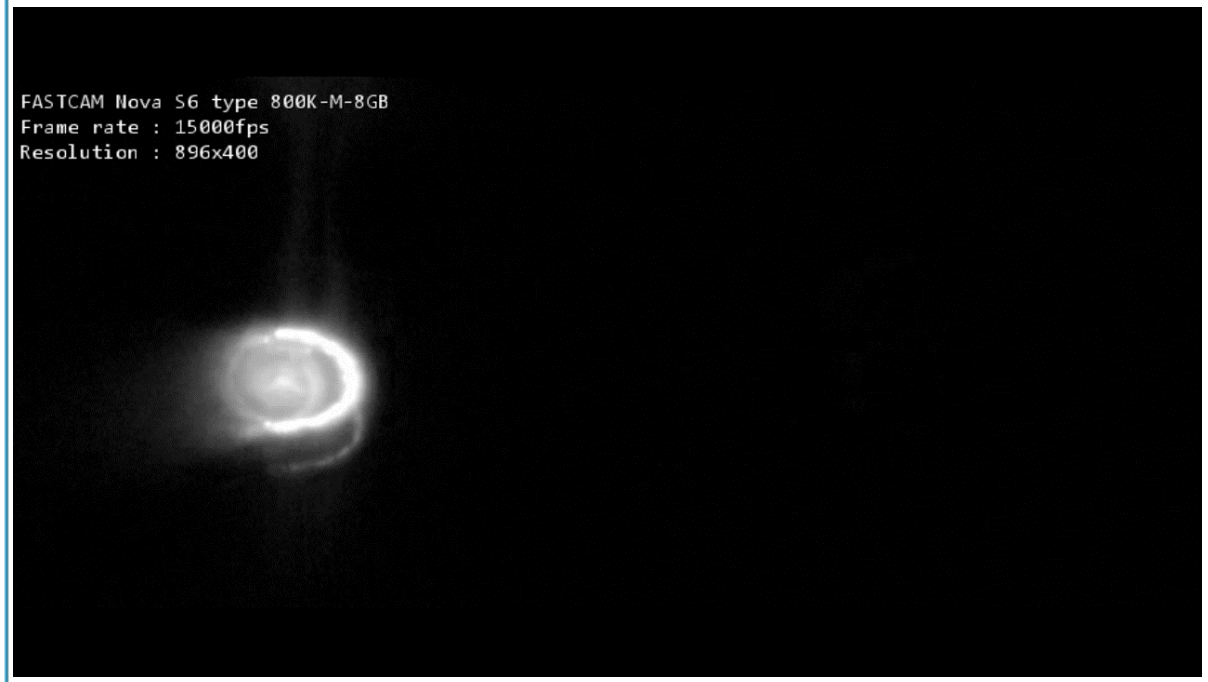

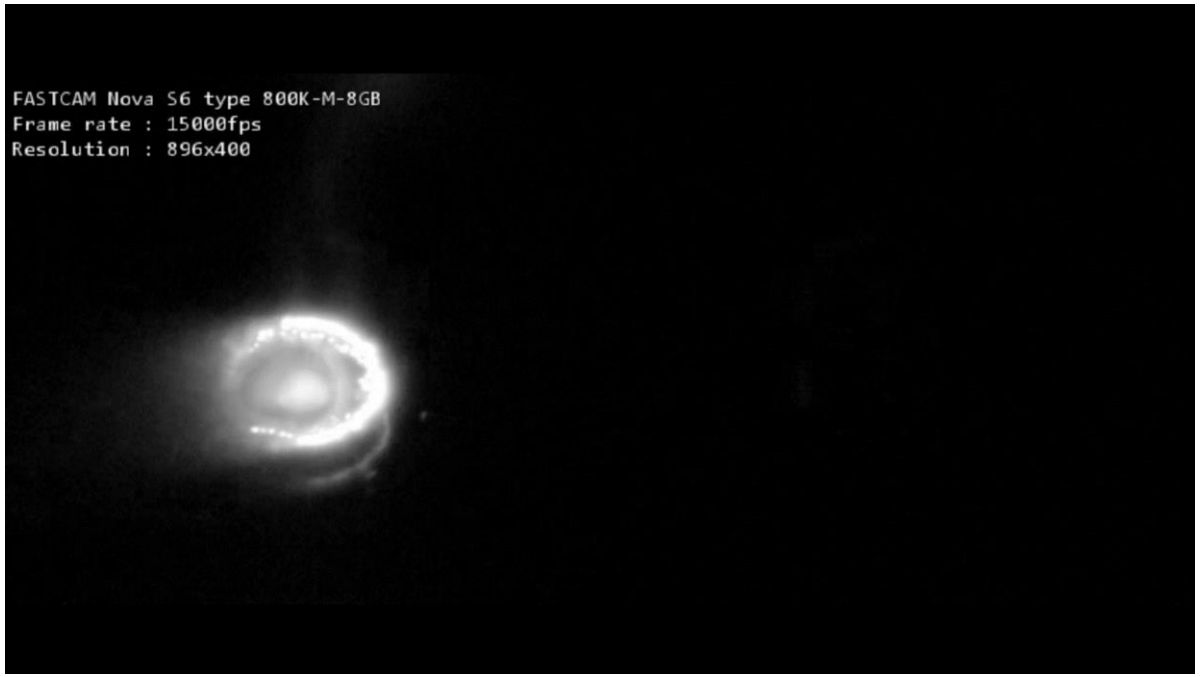

- Weld speed: 25 mm/s
- Power: 1400 W

Tailshaper Welding

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- Tail forward – pre-heating

- Tail behind – post-heating

- Weld speed: 25 mm/s
- Power: 4000 W

Visual Comparison

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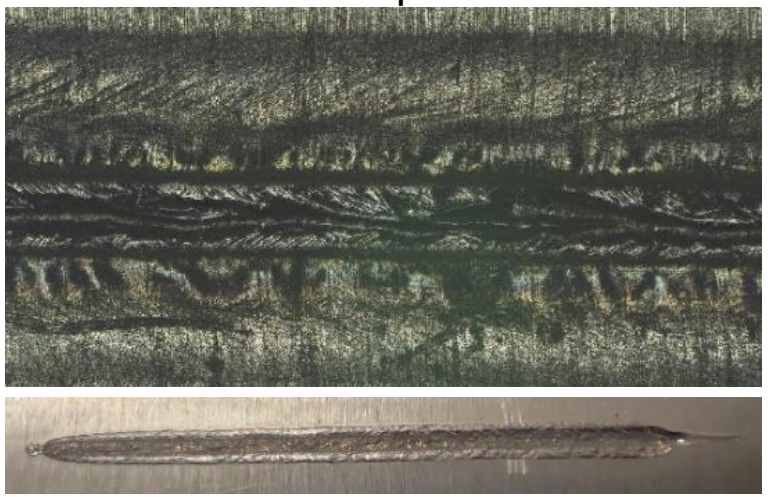
Unshaped

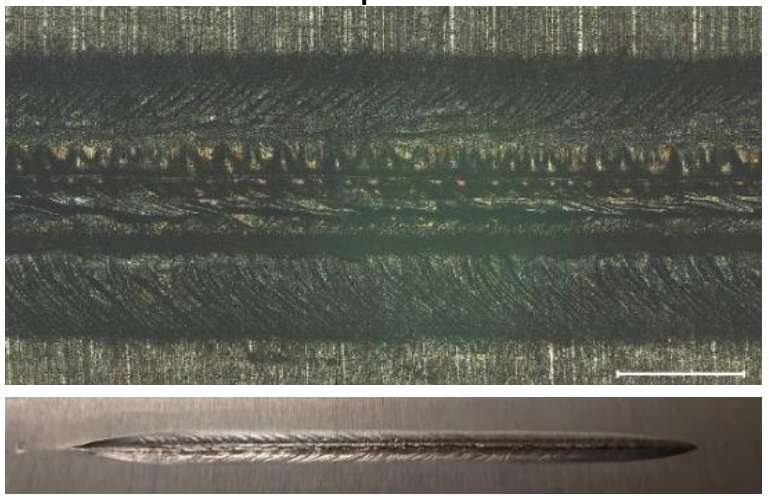
LTG 900

LTG 1200

Tailshaper rear



Tailshaper forward



Electron Back Scatter Diffraction (EBSD) Mapping

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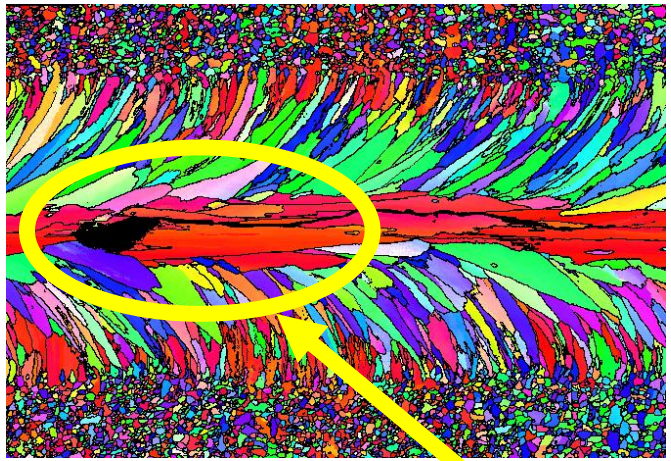
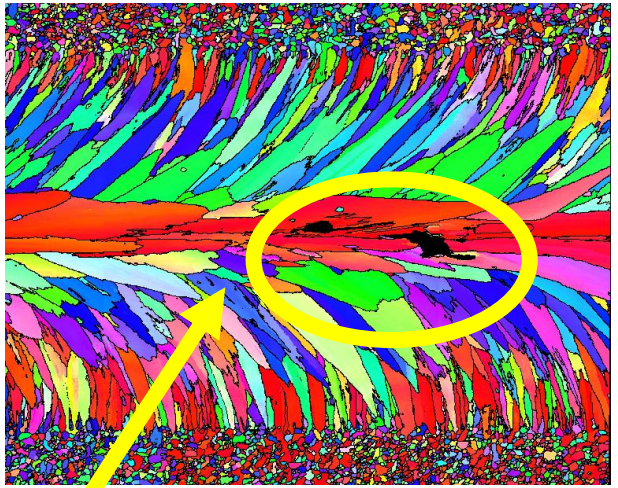
Unshaped

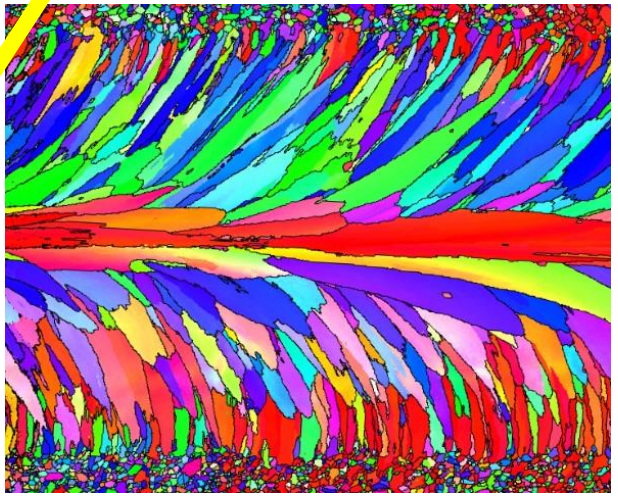


Cracking

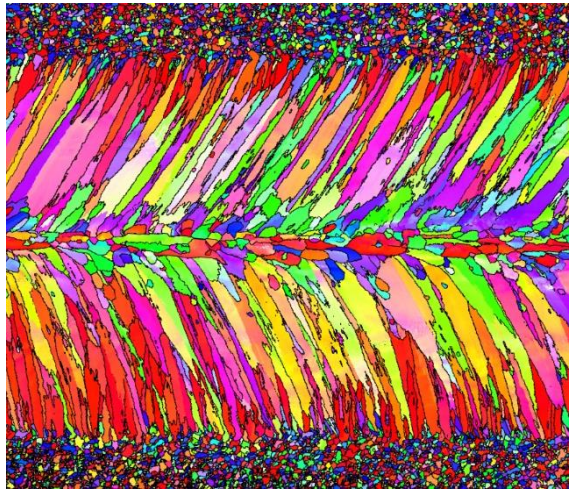
LTG 900



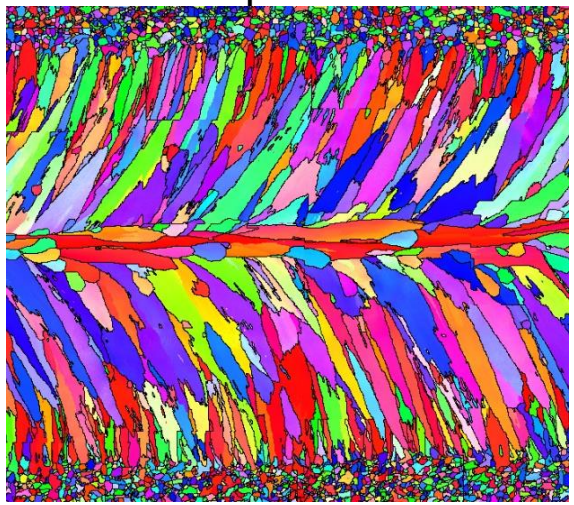
LTG 1200



Tailshaper rear

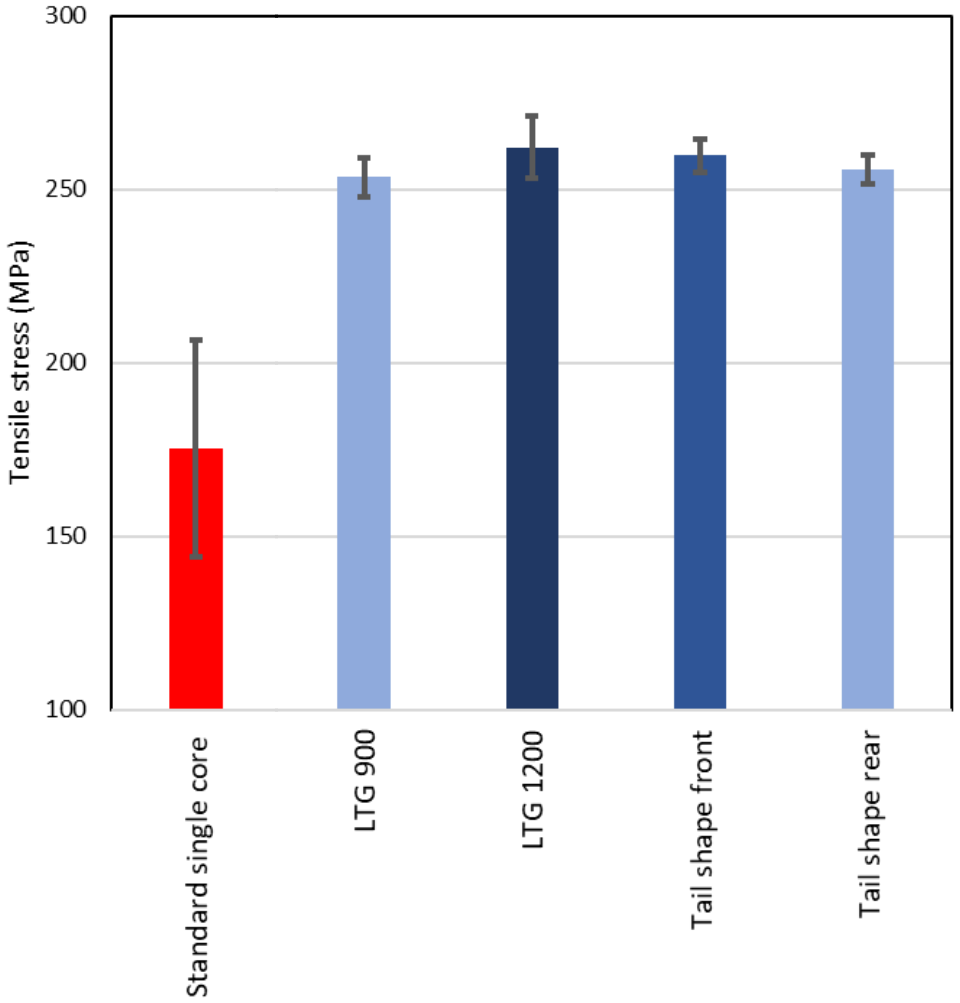


Tailshaper forward



Tensile Stress

- **Welding with the unshaped spot has lower tensile strength**
  - Prone to cracking due to central grain structure
- **LTG and Tailshaper welds both show increased tensile strength**
  - Finer microstructure, with more favourable grain orientation



Conclusions

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- **Tailoring the beam shape provides stronger welds**
- **Leading, trailing and annular intensity for pre- and post-thermal treatment is effective in stabilising the molten pool**
- **Intensity profile significantly affects weld morphology – grain sizes, shapes & orientations**
- **Approximately 25% increase in weld strength**
- **Profile optimisation may yield further improvements**

What we can do for you

- Process enhancement through beam shaping
- Simple modification to existing equipment
- Intensity tailored to process requirements
- (Almost) arbitrary output profiles

What you can do for us

- Discuss challenges seen in welding where modified thermal profiles may help
- Work with us to run trials and optimise intensity profiles for commercial applications