



PowerPhotonic



PowerPhotonic

Enhancing Beam Performance

**Beam combination modules for coherent combination of
high power fiber arrays**



PowerPhotonic

About PowerPhotonic

Optical solution provider:

- Design and manufacture of precision fused silica wafer-scale freeform optics.
- Providing optics and assemblies for high power laser applications.
- Shipping products since 2006 to industrial, imaging, defence, scientific and medical application.



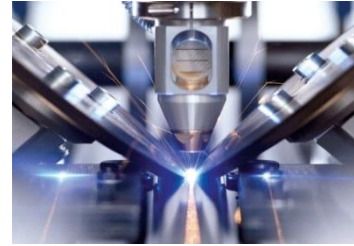
Dalgety Bay, Fife, UK

- 15,000 sq ft site with 3,000 sq ft cleanroom
- ISO9001 certified



Sahuarita (Tucson), Arizona, USA

- 14,000 sq ft site with 4,000 sq ft cleanroom
- ITAR registered
- Fully staffed by US citizens





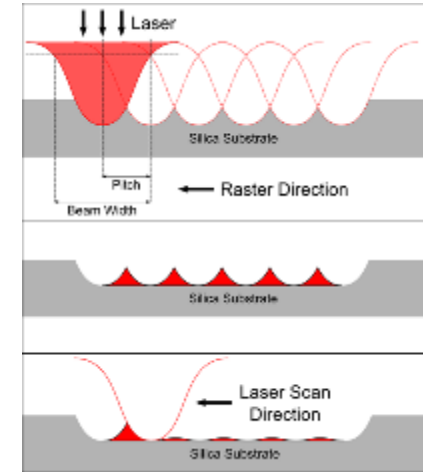
Freeform design and manufacture

Unique IP and capability for freeform optics design and manufacture

- Patent-protection in source characterisation, product design & fabrication process
- World-class team and toolset for freeform design and simulation
- Unique freeform fabrication capability

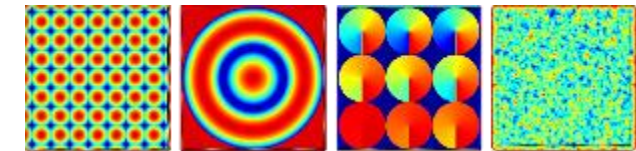
Laser direct-write fabrication in fused silica

- Laser machining process creates gross form
- Laser reflow creates ultrasmooth optical surface
- **Very low roughness = very low scatter = very high efficiency**



Fabrication of truly freeform optical surfaces

- No constraints on symmetry or complexity (within sag and slope range)
- Double sided manufacture on single substrate
- High performance from UV to NIR



Highly automated manufacturing

- 24/7 automated production in Class 1,000 production facility
- Automated design, data flow, test analysis
- ISO9001:2015 accredited





Theoretical Limits to Coherent Beam combining

- **Power-in-bucket (PiB) is a primary metric of LDEW systems; combiner efficiency should therefore be defined using PiB:**
 - **Ratio of power in the "main lobe" in the far field of the combined beam to the total input power from all fiber inputs to the combiner**

Design Principle	Theoretical PiB limit (%)	SWaP
Gaussian Only CBC, hex tiled	66%	High SWaP, additional channels required for a given power level, due to low efficiency
Flat Top, Hex tiled	>80%	Med SWaP, requiring individual adjusters per channel, increasing combiner and overall beam size and reduced MTBF
Flat Top, fully corrected, Hex tiled	>80%	Low SWaP, monolithic arrays and corrector plates



Advantages of Maximizing PiB CBC Combiner Efficiency

- **For the same input power:**
 - **Increased PiB, giving**
 - **faster defeat time**
 - **OR**
 - **longer engagement distance**

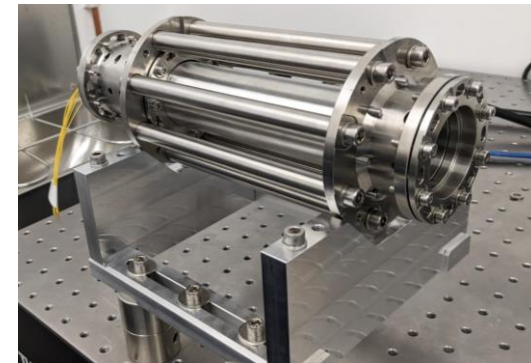
- **For the same PiB:**
 - **Reduced input optical power**
 - **Reduced power for optical pumps**
 - **Reduced heat generation**
 - **Reduced cooling requirements**
 - **Reduced total power consumption**
 - **Reduced size and weight**
 - **Reduced cost**

Sophistication of the fully corrected CBC combiner module is worth these real world advantages



Recent Advances on CBC Modules

- **Since 2022, PowerPhotonic has:**
 - **Optimized design sets of wafer-scale freeform optics for 7, 19, 37 and 61 channels**
 - **Designed, built and verified 7 channel CBC modules, utilizing "as built" alignment correction plates**
 - **Modelled performance of sets of wafer-scale freeform optics 19, 37 and 61 channel**





Benefits to end users using wafer-scale freeforms

PowerPhotonic

What PowerPhotonic Provide

Customer Benefit

Increase Power in bucket from 66% to 80% (20% increase efficiency)

For the same output power can remove 1 in 5 laser channels, or increase output power by 20%
Laser source takes up majority of LDEW system. Removing 1 in 5 channels will mean a 20% reduction in SWaP in full system (estimate)

Lower overfill (near field scatter) reduction from 9% to 3%

Internal beam dumps within the system can be significantly reduced, reducing complexity and SWaP.

High power handling monolithic array solution with wavefront correction capability

Reduction in beam combiner size, and output beam diameter allowing reduction in SWaP of beam director system.
Wavefront correction removes the need for complex alignment, increasing mechanical ruggedness and reducing SWaP.

Beam combiner module solution

Easy low tolerance interface to go from amplified fibre, to collimated, tiled and shaped beam, 'Drop in solution'.
Could be a line replaceable unit with minimal or no realignment required.