

# Near Diffraction-Limited Beam Shaping for Scanner & other Long Focal Length Optical Systems for Laser Material Processing

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Many industrial lasers produce a circular shaped output beam with a gaussian intensity profile; and many laser material processing applications would be measurably more efficient if a different intensity profile was used, with further efficiency gains if the laser beam incident on the work piece had a square shaped spot.

Many scanner based applications where a laser spot is rastered across the workpiece – additive manufacturing, remote welding, heat treating – can have significantly increased efficiency if a square shaped spot with a flat top profile is used. However, the long working distance of scanner based systems means that whatever spot is produced needs to remain as close as possible to the diffraction limit the unshaped beam.

Traditional optics approaches to creating a square shaped flat top profile are generally inefficient and result in spots that are either too large or with too shallow an intensity profile. However, freeform optical components have the potential to create steep profile, close to diffraction limited spots. We present recent work on the development of flat top beam shapers made as freeform surfaces in fused silica that are (i) easy to use with existing scanners; (ii) are robust & capable of very high power handling (CW and pulsed); (iii) have a very high conversion efficiency.

We present the design limits of freeform optical beam shapers for the generation of square shaped flat top profile spots, with an emphasis on the functional performance of these beam shapers, with results showing practical implementation.