

## Industrializing Additive Manufacturing

# Beam Shaping: Enhancing Cost-to-Value in L-PBF.

### Advantages of Laser Beam Shaping

Laser Powder Bed Fusion (L-PBF) is the industry-preferred method for producing geometrically complex metal components in substantial volumes. However, industries are seeking enhancements in productivity and process stability while reducing the high costs associated with this technology.

Laser beam shaping effectively addresses these challenges. Due to a more homogeneous energy input into the melt pool, it is possible to avoid evaporation effects and to use almost the entire laser energy within the process zone for material deposition. Figure 1 shows three commonly used beam shapes. It qualitatively compares the different intensity and temperature profiles, as well as the melting areas in the cross-section.

A Gaussian-shaped laser beam profile introduces too much energy into the melt pool in the center, whereas it is barely sufficient for melting in the edge area. A ring-shaped beam profile, on the other hand, ensures an even distribution of temperature. It prevents evaporation effects and enhances productivity and process stability.

### Achieving Success with Fraunhofer IAPT

Over the past 10 years, the Fraunhofer IAPT in Hamburg has investigated the effects of various beam shaping technologies on a range of materials, including steel, aluminum, titanium, and copper. In each instance, an increase in the build-up rate was achieved alongside enhanced process stability.

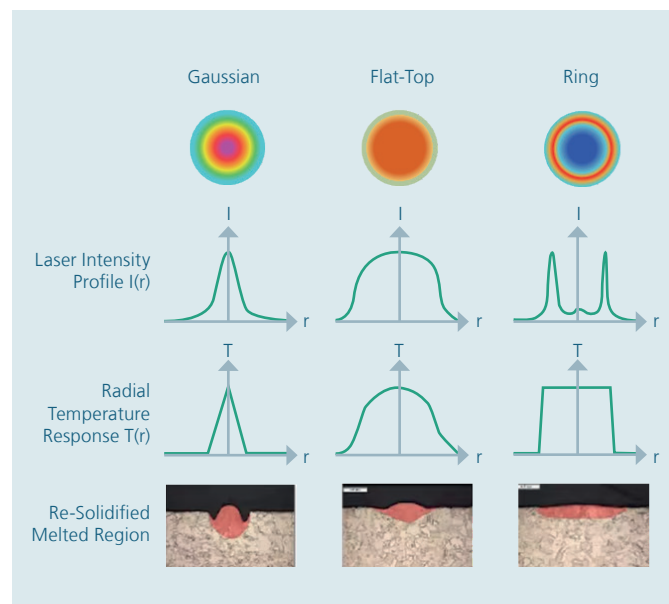


Figure 1: Intensity and temperature profiles as well as the resulting melting areas of different laser beam profiles according to nLight (<https://www.nlight.net/articles-content/ring-beams-change-the-game-for-powder-bed-fusion>)

This leads to a significant reduction in manufacturing costs, as there are fewer process interruptions and higher productivity at the same time. Depending on the material, build-up rates and process stability could be increased by a factor of 2 to 3 in fair comparisons, leading to a substantial decrease in part costs. In the example shown in Figure 2, a cost saving of 15 % could be realized, although other investigations at Fraunhofer IAPT together with their industrial partners have shown significantly higher cost reductions of up to 46 %.

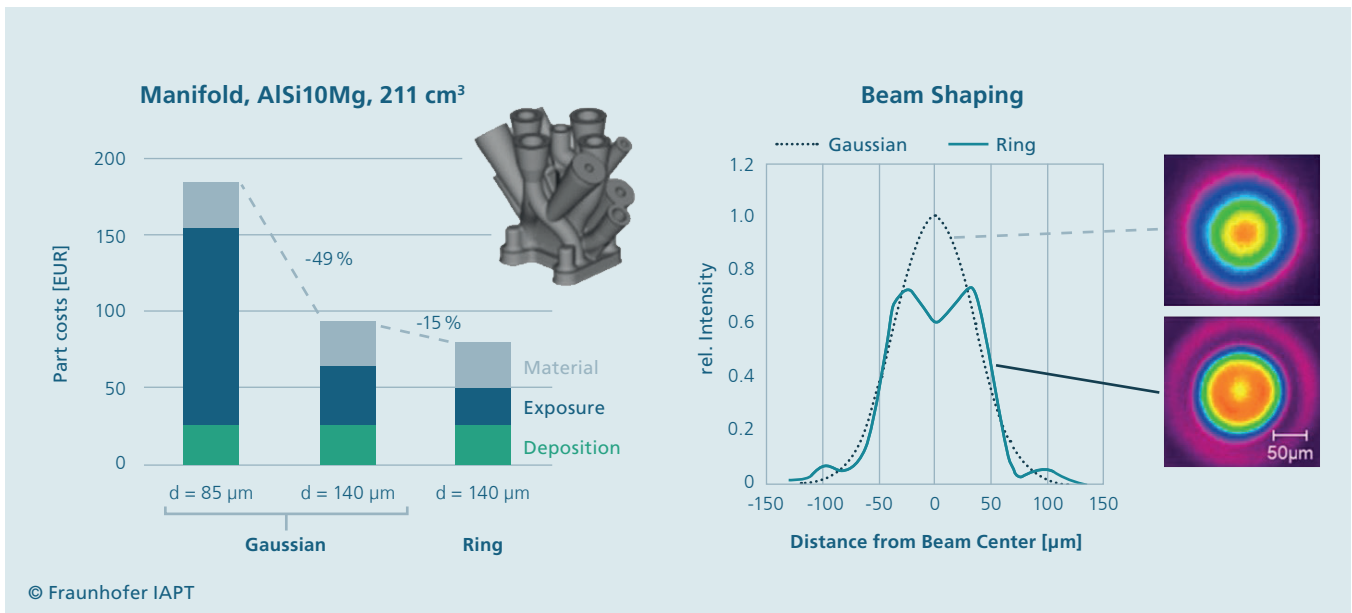


Figure 2: Beam shaping in Laser Powder Bed Fusion and impact on part costs demonstrated on a manifold

The incorporation of optical elements into the beam path or the use of innovative fiber lasers allows for both static and dynamic beam shaping, enhancing the efficiency of energy application in L-PBF manufacturing. In addition to increasing the build-up rate and process stability, this technology allows for the specific adaptation of material properties in different areas of the components.

## Major Advantages

The implementation of laser beam shaping for L-PBF technologies offers a variety of advantages:

- Increase build rate for enhanced productivity
- Reduce component costs for better profitability
- Improve process stability for consistent quality
- Broaden the process window for greater flexibility
- Decrease the number of process by-products, such as process spatter

## How Fraunhofer IAPT can Assist

The expert team at Fraunhofer IAPT assists L-PBF machine manufacturers, end users, powder material producers, and other stakeholders in the implementation of laser beam shaping.

- We evaluate the benefits of laser beam shaping for your specific applications.
- We assist you in quickly and successfully integrating this technology into your L-PBF systems.
- You will benefit from tailored, stable processes that enhance your production capabilities.
- Based on the data you provide, we calculate the resulting cost benefits of laser beam shaping and identify further business cases.



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