From Spot to Area Printing

3D metal printing has never been a cost-competitive method of production compared to traditional manufacturing—until now.

SEURAT

What's slowing AM down today?

Why high cost is slowing down the 3D printing adoption rate

Additive Manufacturing (AM) offers many advantages over conventional manufacturing methods: flexibility, design freedom, and enhanced product performance. It's no wonder that AM has been embraced for high-end and highly complex applications.

As of today, there are a limited number of profitable and serial production AM applications which can be found in the energy, medical, as well as the aerospace sectors. Besides those high-end industries, the technology has reached limited adoption rates. The main reason is neither due to lack of knowledge or poor performance of the technology, but rather it lays in the high total cost of ownership. Todays established metal AM technologies such as Laser Powder Bed Fusion (L-PBF) and Electron Beam Melting (EBM) cost between 1-2 $/cm³. To be competitive with traditional serial manufacturing, the cost must be reduced by more than a factor of 10 to less then 0.1 $/cm³.

Comparison of Seurat's Area Printing™ against incumbent metal AM technologies.

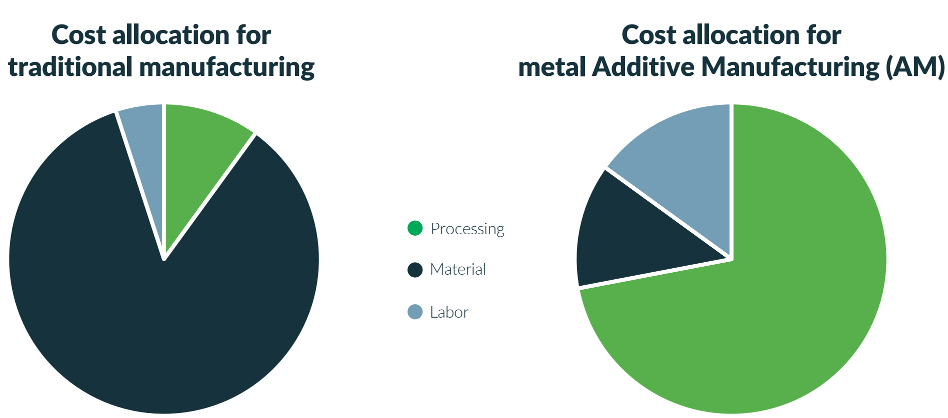
Current metal AM systems are too slow and expensive to gain meaningful production business.

		2024	2027	2030's
AREA PRINTING ™ From Seurat	FEATURE SIZE: LAYER THICKNESS: SPEED: BED SIZE:	100µm 25-50µm up to 3.0 kg/hr 450 mm	75µm 25-75µm up to 30 kg/hr 1-2m	25-50µm 10-100µm 300-1,700 kg/hr 2-10m
L-PBF Laser-Powder Bed Fusion	FEATURE SIZE: LAYER THICKNESS: SPEED: BED SIZE:	150-500 µm 25-75 µm up to 2 kg/hr 800mm	100-500 µm 25-100 µm up to 4 kg/hr 1.2m	75-500 µm 25-100 µm up to 5 kg/hr 2m
DED Directed-Energy Deposition	FEATURE SIZE: LAYER THICKNESS: SPEED: BED SIZE:	1,000-2,000 µm 500-6,000 µm up to 6 kg/hr 1 to 5m	750-5,000µm 500-6,000µm up to 15kg/hr 1 to 7m	500-10,000µm 500-8,000µm up to 30kg/hr 1-10m
BINDER JETTING	FEATURE SIZE: LAYER THICKNESS: SPEED: BED SIZE:	1,000 um 30-200 µm up to 3 kg/hr 400 x 250 x 200mm	~500um 30-200µm up to 5 kg/hr 600 x 500 x 350mm	~500um 30-200µm up to 8 kg/hr ~1m

Increasing productivity in today's metal AM technologies has its limits

With today's metal AM, the largest segment of cost allocation is processing, which accounts for about 70% of cost-per-part. To reduce cost-per-part, AM machine manufacturers typically have two approaches: some develop systems with higher productivity, or others optimize the machine cost to decrease depreciation.

Improvements in productivity are mainly achieved by increasing the number of lasers or larger build platforms. Increasing the number of laser sources has its physical and economical limits. Each additional laser source adds complexity and risk of failure due to miss-calibration or miss functionality of one element. Also, each laser source requires a scanner unit which adds significant cost. Scanners are highly complex systems which require exact calibration and dedicated heat management to work accurately. When build platforms are increased, multiple laser sources are necessary in order to cover the complete powder bed which adds to the complexity due to overlapping scanning fields. Build platforms are also limited in size due to gas flow management. A key element of the L-PBF process is an evenly controlled gas flow across the whole powder bed to avoid spatter and reduce shielding effects of the laser beam. Gas flow management becomes more challenging as the size of the powder bed increases.



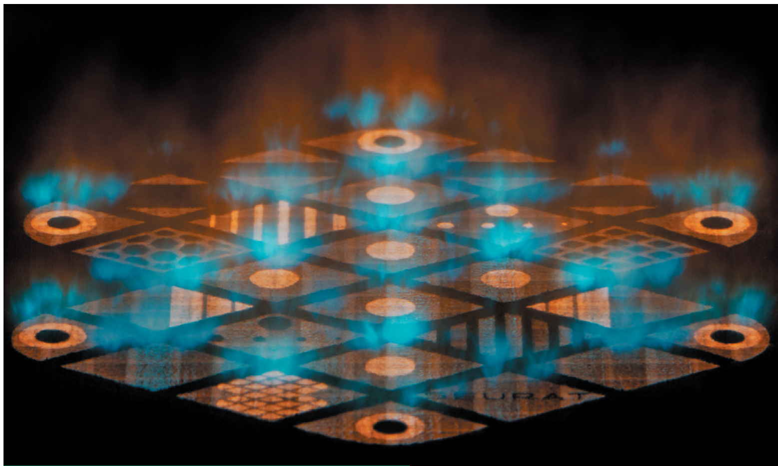
Source: Indicative analysis by AMPOWER

A truly innovative approach to serial production.

Two million points of light building high density parts

So, why don't L-PBF suppliers simply replace the laser spots with a laser projector? The answer lays in the immense amount of energy that is needed to melt metal. Metal printers focus 200-1,000W on a single spot of 80-100 µm diameter. Todays L-PBF systems use a continuous wave (cw) laser source and achieve the short interaction time through a scanning device, which moves the laser spot across the metal powder bed.

Instead of a cw laser source, Seurat's Area Printing™ technology utilizes a pulsed IR laser, with a single pulse per area. Pulsed laser systems generate much higher peak laser power but only emits in very short pulses, with incredible power and energy scalability, achieving printing of a whole area at once instead of a single focus spot. The Area Printing™ technology goes through multiple steps of shaping the laser first into a square field and then into a patterned field. This last step is the true innovation of the technology. By overlaying the laser beam with a patterned blue light emitted by a conventional projector, a so called optically addressable light valve (OALV) polarizes the laser beam according to the blue light overlap. This way, a patterned laser field is generated which melts the whole projected area at once.



TOP: Conventional L-PBF Spot Printing
BOTTOM: Area Printing from Seurat Technologies

1

Beam shaping of pulsed IR laser source to create a homogenous square field.

2

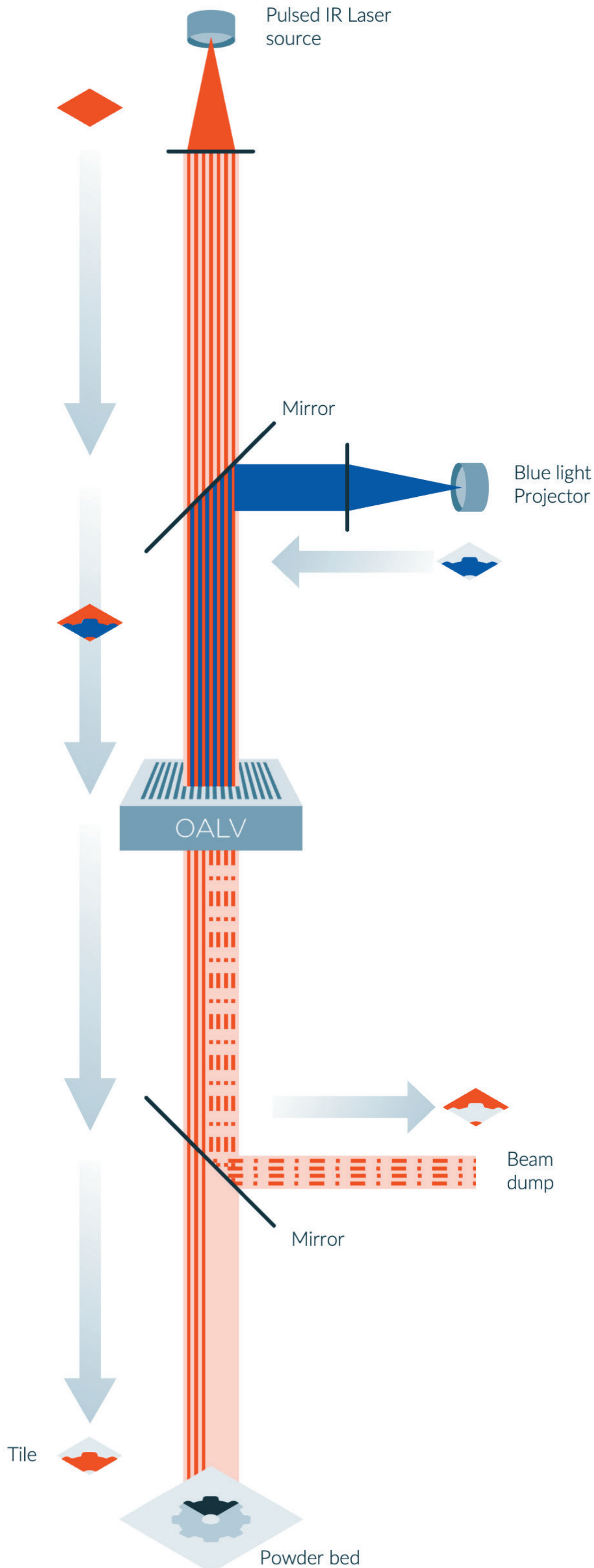
Generating projection of area pattern with blue light projector at same size as square laser beam. Aligning both light beams.

3

Polarizing the IR laser beam horizontally where blue and IR light “pixels” are overlapping via optically-addressable light valve (OALV). Polarizing vertically where IR and blue are not overlapping.

4

Splitting vertically and horizontally polarized IR laser beams. Resulting in area pattern further processed through scanner system to melt powderbed in patterned field.



About pixels, frequency and field size

The driving parameters for traditional L-PBF technologies are laser power, scanning speed and spot size. Area Printing™ is introducing a number of new parameters that describe the power and accuracy of the system. The technology uses a pulsed laser as the main source of energy (instead of using laser power and scanning speed), with pulse energy as the main parameter for this process.

Parameter	Unit	Typical value range	Explanation
Laser pulse energy	J	10 - 60	Amount of energy emitted by the laser source for each pulse to power one tile.
Tile size	mm	5 - 10	The size of each square tile that is being exposed at the same time.
Pixel per tile	-	>2.3M	The number of pixels of each field which is equivalent to the xy-resolution of the system
Field frequency	Hz	20 - 60	The speed in which the tiles are being exposed. 20 Hz means 20 fields are exposed per second.

The Area Printing™ process prints one tile next to the other. Each laser pulse covers one tile. After a very short timespan, the next tile is exposed, introducing the parameter of tile size. It describes the speed in which the process proceeds.

Besides performance parameters, Area Printing™ also introduces pixel parameters to the powder bed fusion process. Each tile has a specific resolution, based on the blue light projector. Typically, over 2.3M pixels are used to define the shape of each tile achieving a pixel size of 6-10µm which exceeds current xy-resolution of L-PBF systems by far. The blue light projector also allows to control the laser power of each pixel individually which gives more control over the melting process and opens vast opportunities for optimization from graded material properties to support-free part production.

Productivity is not all

High speed and low cost are clearly the main driver of the Area Printing™ technology. However, the process has several other advantages that enable high volume Additive Manufacturing while maintaining level of detail and design flexibility.

1

High resolution

Each pixel of the area field is controlled by a corresponding blue light pixel. By controlling the gray scale of the blue light, Area Printing™ allows for different laser power on each pixel of the covered area. This allows for custom parameters to enable support-free building or different material properties. The exposure time and energy ramp up and ramp down rates for each pixel are also controllable during the exposure cycle time.

2

Spatter & soot-free melting

The high power and short interaction time of laser light and powder bed leads to a spatter-free melting pool. Furthermore, nearly all soot is eliminated from the process. Soot is a major issue for traditional L-PBF technologies. The soot hinders a clear beam path and the soot particles can reduce the density of parts.

3

Scalability

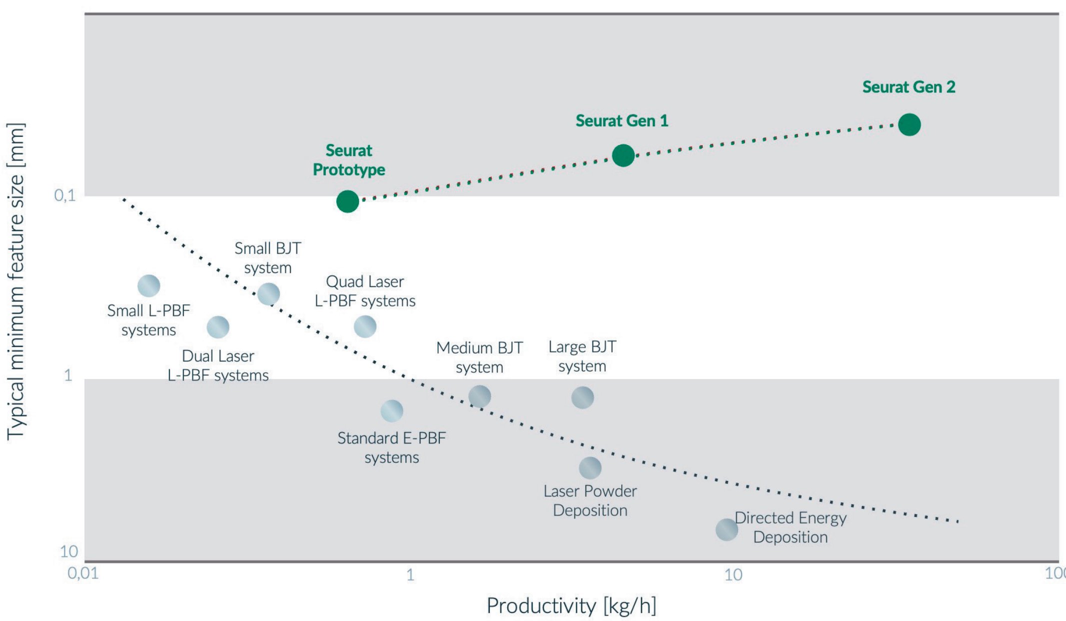
Adding more lasers leads to diminishing returns due to higher cost and more variables that affect part quality. In addition, it's difficult to increase print rates while improving resolution and reducing costs. Area Printing™ decouples print rate and resolution through the patterning of lasers. The pulsed laser architecture also allows for greater scalability in laser power.

Decoupling build rate and resolution

In today's metal AM landscape, there is an unspoken law of a connection between increasing build rates coupled with decreasing feature size. Typically, high build rates have to go along with low resolution which leans towards near "net shape parts" as opposed to producing the final shape. Extensive post processing and machining is the result of high build rate technologies such as Directed Energy Deposition. Metal Binder Jetting has the potential to flatten this curve but still has significant limitations when it comes to high volume sintering, thick walls, or very detailed parts.

The technical setup of Area Printing™ targets to decouple this connection and enable high productivity rates while maintaining the level of detail. This makes it possible to print parts in high volume with high surface quality and end part precision that requires minimal post processing for many applications.

Build rate vs. feature size



Source: Indicative analysis by AMPOWER and Seurat

The impact on the process chain

As of today, metal AM is a technology for high value components that often come in low volumes and involves a high degree of manual labor. Area Printing™ has proven to be capable of radically disrupting manufacturing with the capability to unlock applications for AM further down the cost per kg line.

However, the printing process is only one element along the value chain. Auxiliary processes such as unpacking and powder management are destined to scale in the same degree to make mass manufacturing possible. As of today, powder handling, sieving and storage are mainly manual process steps and automatization of the unpacking process is still at its infancy and focused on low volume batch production. With a maturing Area Printing™ technology, a closed-loop of unpacking and powder handling has to be created. This will enable automated loading of fresh powder feedstock on the one side and unloading of finished parts on the other side of the system, achieving a constant supply of metal printed parts in predictable cycle times.

Manual powder handling in L-PBF today

Analysts' opinion

AMPOWER is the leading international consultancy in the field of industrial Additive Manufacturing. AMPOWER advises their clients on strategic decisions in Additive Manufacturing by analyzing market environments and compiling technology studies. On operational level, AMPOWER supports the introduction of Additive Manufacturing through targeted transitioning programs enabling companies to leverage the benefits from an Additive supply chain.
AMPOWER publishes regular market reports and technology studies with a global readership among leading AM players.

AMPOWER

Matthias Schmidt-Lehr

Managing Partner
AMPOWER

"For the past years, powder bed fusion grew into a widely used and accepted manufacturing technology for metal components. Maturity came at the price of smaller productivity innovation leaps and the range of applications is still limited to high value parts. Area Printing is a true disruption with a radically new approach to an established AM technology. This technical innovation will lead to massively increased application opportunities due to the strong productivity increase. Now, that proof of concept is real, SEURAT must demonstrate its capabilities, to turn a technology concept into a reliable production machine. A journey full of challenges and opportunities."

About Seurat

Seurat has built the only 3D metal printing process that can compete with the volumes, quality, and price points of traditional manufacturing. In addition, Seurat's technology will help offset carbon emissions and is helping the world achieve net-zero emissions by 2050. Seurat is the only Additive Manufacturing Technology that can scale to meet the production rate, quality, and economic targets demanded by conventional manufacturing.

Please contact us to learn more.

info@seurat.com
seurat.com