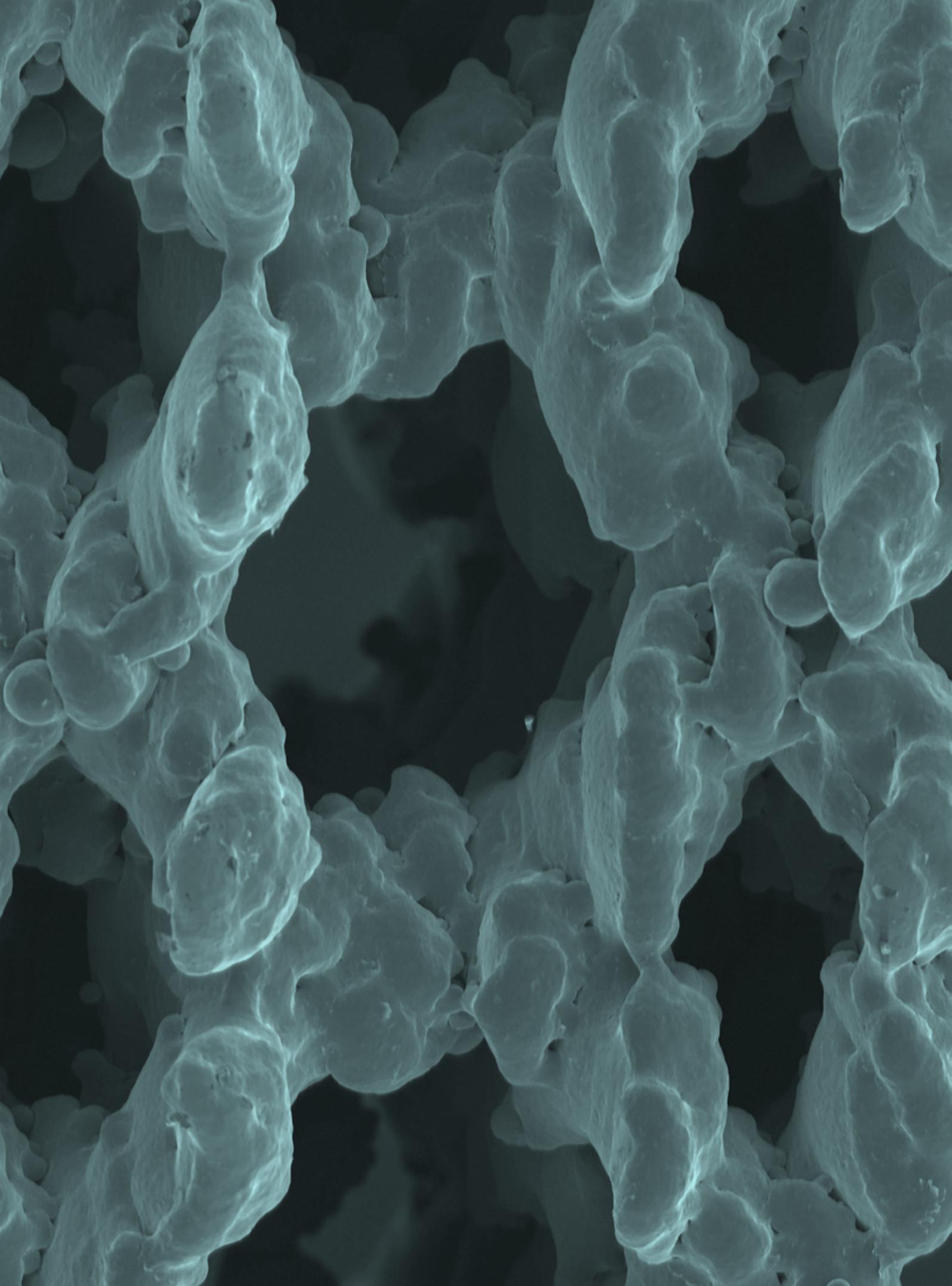


# JUST ADD

**Arcam** – the innovative leader in additive manufacturing solutions for the production of orthopedic implants and aerospace components.



# ARCAM

## YOUR INNOVATIVE PARTNER IN ADDITIVE MANUFACTURING.

**See what you can achieve together with Arcam. We are a pioneer and proven leader in cost-efficient additive manufacturing solutions for the production of orthopedic implants and aerospace components. At the heart of our total offer are the Arcam EBM® systems, based on cutting-edge electron beam melting technology. It gives you freedom in design, combined with excellent material properties and high productivity. You can also rely on industry-leading process validation technology and the support of our application specialists and field engineers to support your team every step of the way. Welcome to Arcam.**

Compared to traditional machining, additive manufacturing is all about adding material rather than removing it. Parts are built by melting thin layers of metal powder. Each layer is melted to the exact geometry defined by a CAD model. This makes it possible to build parts with very complex geometries without tooling or fixtures – and without producing any waste material.

### **Why additive manufacturing?**

Imagination is the limit. After all, the geometrical freedom of additive manufacturing allows you to engineer or design your part as you envision it, without manufacturing constraints. Imagine what this could mean when it comes to developing extreme lightweight designs, reducing part counts or improving bone ingrowth for an orthopedic implant, for example.

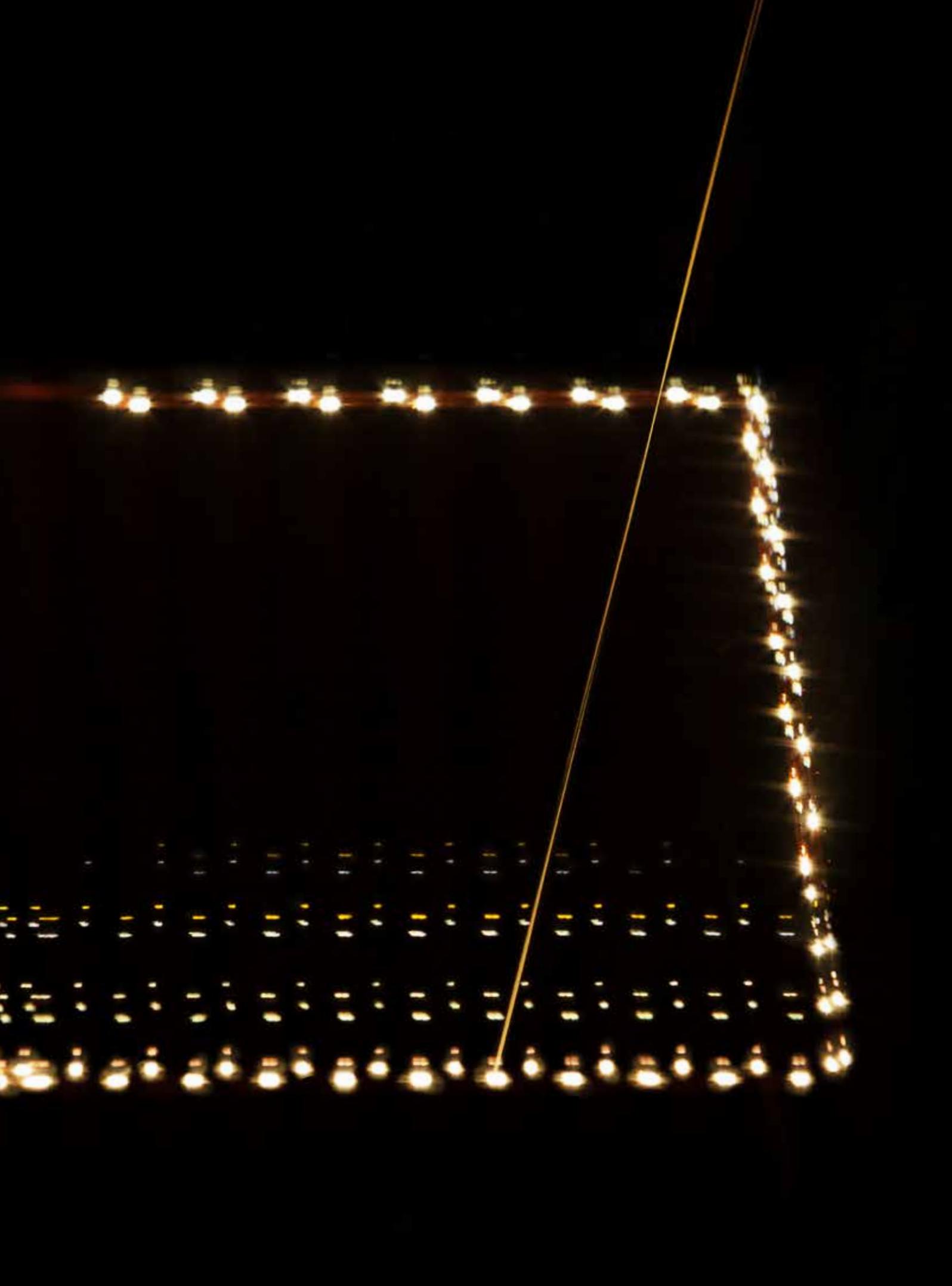
But there's more. Additive manufacturing offers important benefits throughout the production value chain. It can speed up the process, reducing the time it takes to go from a CAD design to a physical part. Because of its very high material utilization, additive manufacturing is also an energy efficient and more environmentally friendly way to go compared to traditional methods.

### **A pioneer in additive manufacturing**

We know additive manufacturing. In fact, you could say we pioneered the field. What's more, we are the only one to apply electron beam melting technology. We sold our first machine to a university in the U.S. way back in 2003. Three years later, an Arcam customer started serial production of orthopedic implants, using an Arcam EBM® system. Today, our systems are well-proven and hard at work at production installations and research facilities all over the world.

### **Keeping you at the forefront**

Over the years, we have gained a lot of specialist knowledge and experience, which we continuously apply, not just in our own product development, but also in the way we support our customers. Our passion is clear: to provide customers with innovative solutions that allow them to meet new challenges and realize new opportunities. We want to do the same for you.



# ARCAM EBM® TECHNOLOGY

## CREATING NEW OPPORTUNITIES IN DESIGN AND PRODUCTION.

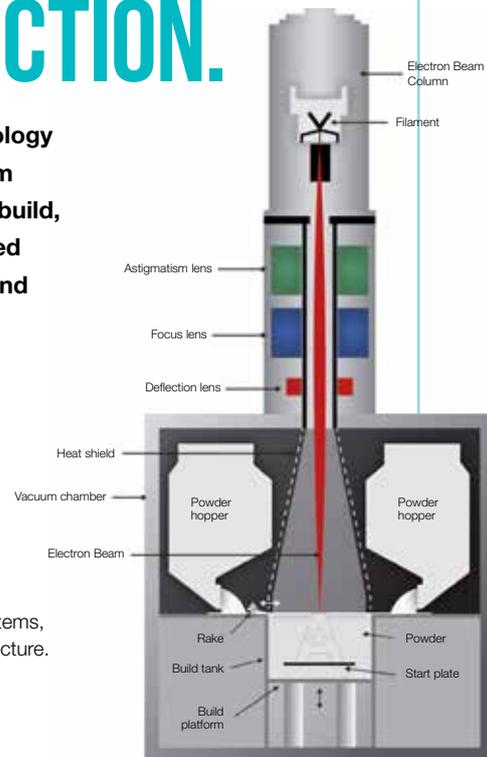
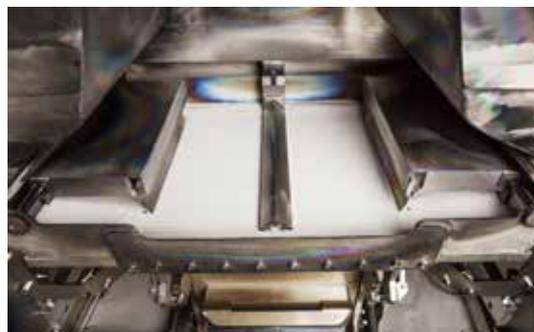
With Arcam, you can take full advantage of electron beam technology to differentiate your products and boost productivity. In the Arcam EBM® process, a powerful electron beam melts metal powder to build, layer-by-layer, a fully dense metal component. Each layer is melted to the exact geometry defined by the CAD model. This is speed and precision at work.

### Arcam EBM® – Electron Beam Melting

Arcam EBM® systems utilize a high power electron beam that generates the energy needed for high melting capacity and high productivity. It is built on state-of-the-art deflection electronics, enabling extremely fast and accurate beam control. This allows melting at multiple points simultaneously, without compromising surface finish, precision or build speed. We call it Arcam MultiBeam™.

### Controlled vacuum technology

The vacuum system provides a base pressure of  $5 \times 10^{-5}$  mbar or better throughout the entire build cycle. During the process a partial pressure of He is introduced to  $4 \times 10^{-3}$  mbar. This ensures a clean and controlled build environment, which is important to maintain the chemical specification of the build material.



Arcam EBM® systems, schematic architecture.

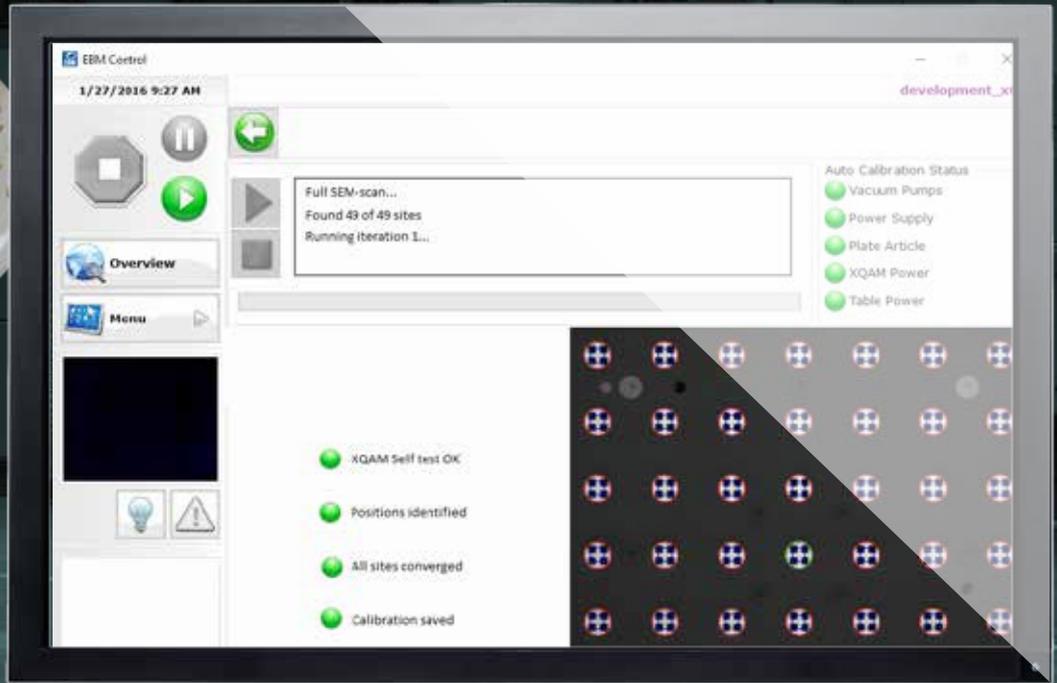
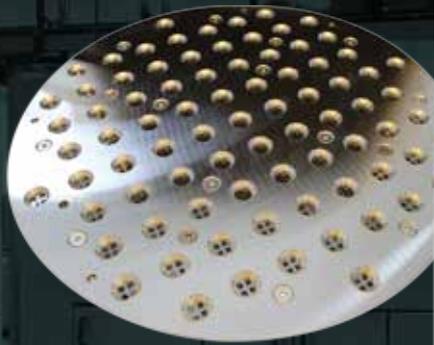
### Warm process

For each layer in the build, the electron beam heats the entire powder bed to an optimal process temperature, specific to the material used. As a result, the components produced with the EBM® process are free from residual stresses and have a microstructure free from martensitic structures.

### Top quality material properties

Since the Arcam EBM® process takes place in a vacuum and at high temperature, the components produced are free from residual stress and have material properties better than cast and comparable to wrought material.

Arcam EBM® systems, robust powder distribution system.



# PROCESS VALIDATION TOOLS — ARCAM LAYERQAM AND ARCAM XQAM.

When it comes to process validation technology for additive manufacturing in production, Arcam is leading the way. In fact, the Arcam EBM® technology itself opens unique opportunities for monitoring and validating the process that would otherwise not be possible.

## Arcam LayerQam™ for defect detection

Arcam LayerQam is a high resolution camera system for powerful defect detection. It tracks porosity layer-by-layer and reports defects in the entire build and individual components.

## Arcam xQam™ – Autocalibration

Frequent high precision calibration is crucial for a robust and predictable operation. With Arcam xQam, a unique, built-in X-ray detection system, you can rely on quick, high precision autocalibration and system diagnostics that is completely operator independent.

## Arcam xQam – Future Applications

Arcam xQam technology works very much like a scanning electron microscope (SEM), which is widely used as a powerful material characterization tool. This new functionality will position Arcam xQam for future application possibilities for more robust monitoring and validating processes.



# ARCAM APPLICATION EXPERTISE — ADDING VALUE EVERY STEP OF THE WAY.

**You can rely on our highly competent application engineers to support you from design to production. In fact, you could say that this unique support and specialist knowledge comes standard with every service agreement.**

## **Design Phase**

In the design phase we can help you to optimize product designs that take full advantage of the capabilities of additive manufacturing. We can also help you to generate timely prototypes for design iterations, simulate production runs and develop ROI calculations. Not to mention support your product certification process.

## **Setting up a production case**

While setting up your production case, Arcam offers support to optimize build strategy, such as stacking of parts, and build parameters for highest possible

productivity. We can also support process validation with EBM-specific validation guidelines.

## **In Production**

Once you are in production, Arcam continues to offer on-going application support to ensure continuous optimization of your EBM production line.

This image highlights the ability to stack 108 acetabular cups in a single build.



# ARCAM AT WORK — FROM

**We've got you covered. With Arcam, you can look forward to a total solution for additive manufacturing designed in every detail to meet your specific production needs.**

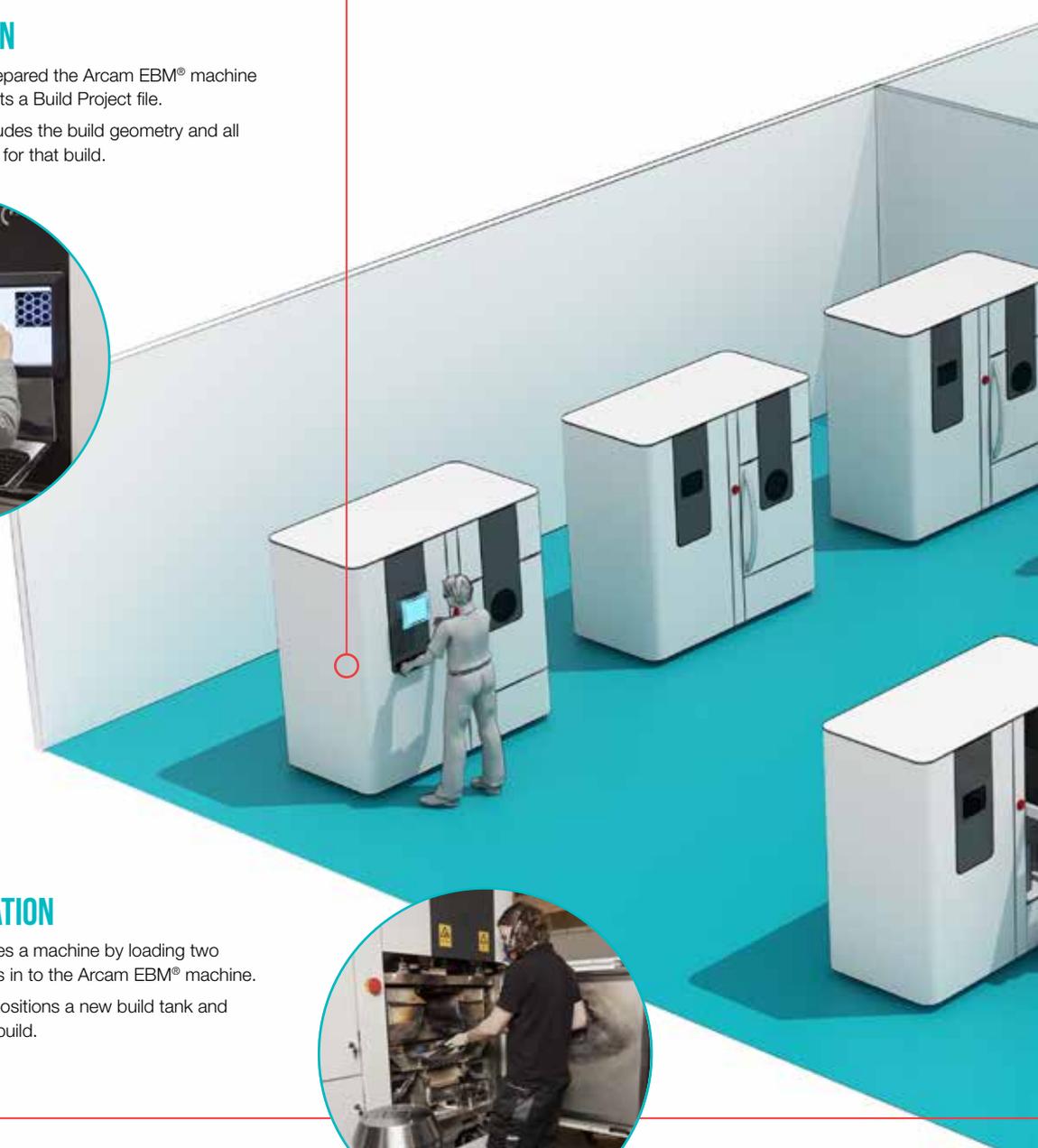
## BUILD PREPARATION

- An EBM operator has prepared the Arcam EBM® machine for a new build and selects a Build Project file.
- The Build Project file includes the build geometry and all process settings relevant for that build.



## MACHINE PREPARATION

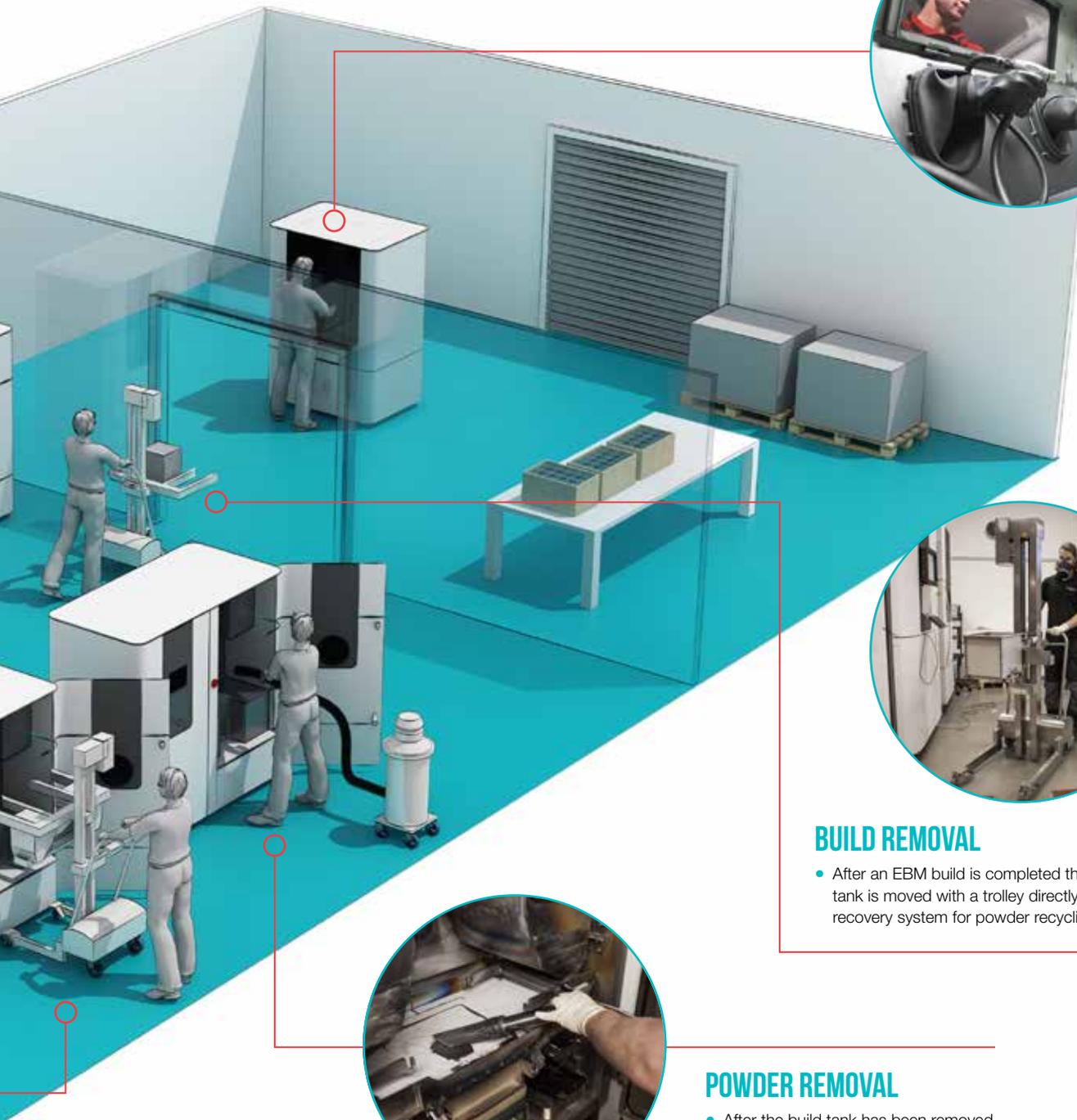
- An EBM operator prepares a machine by loading two refilled powder containers in to the Arcam EBM® machine.
- The EBM operator also positions a new build tank and a start plate for the next build.



# “CAD TO METAL<sup>®</sup>”

## POWDER RECYCLING

- Unmelted powder is removed from the built components by blasting and is sieved for future use.
- The sieved powder is refilled into new powder containers.



## BUILD REMOVAL

- After an EBM build is completed the closed build tank is moved with a trolley directly to the powder recovery system for powder recycling.



## POWDER REMOVAL

- After the build tank has been removed, any excess powder is removed with an ATEX-classified vacuum cleaner.

# Q 10plus



## ARCAM Q10PLUS – FOR ORTHOPEDIC IMPLANT MANUFACTURING.

The Arcam Q10plus is designed specifically for cost-efficient production of orthopedic implants. The size of the build area is designed to allow for optimal stacking of the most common implant types, and the build chamber interior is developed for easy powder handling and fast turn-around times. The Arcam Q10plus is particularly ideal for the production of high volume press-fit implants with advanced trabecular structures as well as one-off custom implants built with data derived from CT scans of individual patients.



The Arcam EBM® process offers freedom of design, opening up a world of opportunities for product differentiation. Since the process takes place in a vacuum and at elevated temperatures, it eliminates residual stress and ensures superior material properties.

### Higher productivity

In addition to enhanced precision and process robustness, Arcam Q10plus offers high productivity. This is made possible by many important new features, including groundbreaking Arcam xQam technology for high precision autocalibration, a powerful new software platform and electronics for efficient and accurate beam control.



Arcam Q10plus build chamber.

Max. build size	200 x 200 x 180 mm (W x D x H)
Max. Beam power	3000 W
Cathode type	Single crystalline
Min. Beam diameter	140 µm
Max. EB translation speed	8000 m/s
Active cooling	Water-cooled heat sink
Vacuum base pressure	5 x 10 <sup>-4</sup> mbar (chamber pressure before start of process)
Build atmosphere	4 x 10 <sup>-3</sup> mbar (partial pressure of He)
He consumption, build process	1 liter / hour
He consumption, build cool down	50-75 liters / build
Power supply	3 x 400 V, 32 A, 7kW
Size	1850 x 900 x 2200 mm (W x D x H)
Weight	1420 kg
CAD interface	Standard: STL

### Standard implants

Arcam EBM® technology is a cost-efficient process for manufacturing both press-fit implants and cemented implants. Solid and porous sections of the implant are built in one process step, eliminating the need for expensive secondary processes for applying traditional porous materials. This also ensures structural continuity between the solid and porous sections. In addition, you can manufacture all porous implants for augments, wedges, blocks, etc.



### Trabecular Structure – Engineered Porous Materials

With Arcam EBM® technology, you have the opportunity to design and manufacture your own trademarked trabecular structure designs, since it eliminates the design constraints typical in traditional methods for building porous materials. This allows you to develop a unique trabecular structure design with the desired properties, optimized in terms of pore geometry, pore size, relative density, roughness or structure thickness. It all starts in a CAD environment with a minimum of capital investment.



### Patient-specific implants

Arcam EBM® technology offers a direct “CAD to Metal™” process allowing production of patient-specific implants using data derived from Computed Tomography (CT). The CT data is used to create an exact CAD model of the desired implant. This CAD model is then used by the Arcam EBM® machine to build the actual part. It's as easy as that.



- EASY-TO-USE OPERATOR INTERFACE
- LATEST GENERATION EB GUN
- EFFICIENT POWDER HANDLING
- ARCAM XQAM FOR HIGH PRECISION AUTOCALIBRATION
- ARCAM LAYERQAM FOR BUILD VERIFICATION
- SOFTWARE ADAPTED TO VOLUME PRODUCTION

# Q 20plus



## ARCAM Q20PLUS — FOR PRODUCTION OF AEROSPACE COMPONENTS.

The Arcam Q20plus is specifically designed for cost-efficient production of aerospace components, such as turbine blades, structural airframe components and much more. The build envelope is impressive and allows for building large components and optimal stacking of smaller ones. Like the Arcam Q10plus, the build chamber interior is developed for easy powder handling and fast turn-around times.

The Arcam EBM® process takes place in a vacuum and at elevated temperatures, resulting in stress-relieved components with material properties better than cast and comparable to wrought material. Like the Arcam Q10plus, the Arcam Q20plus includes advanced validation technology, including Arcam LayerQam for inline part quality verification and the groundbreaking Arcam xQam for autocalibration.



Arcam Q20plus build chamber.

### Higher productivity

In addition to enhanced precision and process robustness, Arcam Q20plus offers high productivity. This is made possible by many important new features, including groundbreaking Arcam xQam technology

Max. build size	350 x 380 mm (Ø/H)
Max. beam power	3000 W
Cathode type	Single crystalline
Min. beam diameter	140 µm
Max. EB translation speed	8000 m/s
Active cooling	Water-cooled heat sink
Vacuum base pressure	5 x 10 <sup>-4</sup> mbar (chamber pressure before start of process)
Build atmosphere	4 x 10 <sup>-3</sup> mbar (partial pressure of He)
He consumption, build process	4 l/h
He consumption, build cool down	100-150 l/build
Power supply	3 x 400 V, 32 A, 7 kW
Size Approx.	2300 x 1300 x 2600 mm (W x D x H)
Weight	2900 kg
CAD interface	Standard: STL

for high precision autocalibration, a powerful new software platform and electronics for efficient and accurate beam control.

### Cost reduction

Finding ways to reduce weight is key in the aerospace industry. So is cost reduction. Of particular interest is the so-called Buy-to-Fly ratio – the weight ratio between the raw material used for a component and the weight of the component itself. Ratios as high as 15-20 for flying components are common, adding a lot of cost to the component for material and machining. The Arcam EBM® process opens up exciting opportunities to produce light-weight components with a Buy-to-Fly ratio very close to 1.

### Shorter lead times

Aerospace companies often have to rely on a few dominant suppliers for traditional casting of components, and the lead-time for design iterations can be many months. Since Arcam EBM® technology is a tool-less production technology, it allows design modifications to be made with minimal lead-time and cost.

### New design possibilities

The freedom in design provided by Arcam EBM® technology enables designers to create completely new and innovative product designs. Components can be optimized in terms of weight reduction or functional aspects such as improved cooling, heating or filtering characteristics.



Low pressure turbine blade by Y-TIAL.

- EASY-TO-USE OPERATOR INTERFACE
- LATEST GENERATION EB GUN FOR HIGH PRODUCTIVITY AND SURFACE FINISH
- EFFICIENT POWDER HANDLING
- ARCAM XQAM FOR HIGH PRECISION AUTOCALIBRATION
- ARCAM LAYERQAM FOR PART QUALITY VERIFICATION
- SOFTWARE ADAPTED TO VOLUME PRODUCTION

# A<sup>2X</sup>



## ARCAM A2X — FOR AEROSPACE PRODUCTION AND MATERIALS R&D.

The Arcam A2X is the ultimate additive manufacturing solution for processing materials that require high process temperatures and titanium alloys. It is specifically designed for cost-effective production of demanding applications such as low pressure turbine blades and structural aerospace parts that must meet the highest material standards.

The Arcam A2X system is designed for production of functional parts within aerospace, as well as general industry for a wide range of materials. It is also used at important universities and research institutes worldwide.



Arcam A2X is an ideal tool for the industry as well as research organizations focusing on process development for new materials.

### Process temperatures up to 1100° C

The build chamber of the Arcam A2X is specifically designed to withstand extremely high process temperatures, up to 1100° C. This makes it particularly useful for manufacturing components in TiAl and Inconel 718. In addition to production, the Arcam A2X is very well suited for research and process development for new materials. Arcam has an open material strategy that can actively support customers working with their process development. The Arcam A2X is ideal for this purpose.

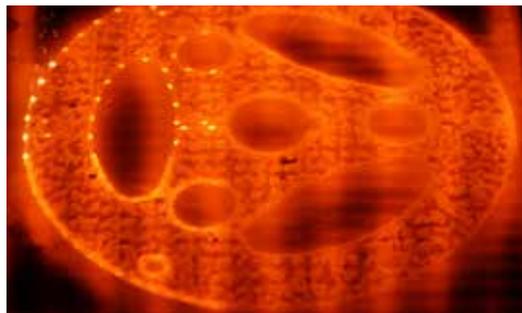
Max. build size	200 x 200 x 380
Max. beam power	3000 W
Cathode type	Tungsten filament
Min. beam diameter	250µm
Max. EB translation speed	8000 m/s
Active cooling	No
Vacuum base pressure	5 x 10 <sup>-4</sup> mbar (chamber pressure before start of process)
Build atmosphere	2 x 10 <sup>-3</sup> mbar (partial pressure of He)
He consumption, build process	1 litre/h
He consumption, build cool down	50-75 litres/build cycle
Power supply	3 x 400 V, 32 A, 7 Kw
Size Approx.	1850 x 900 x 2200 mm (W x D x H)
Weight	1 700 kg
CAD interface Standard:	STL

### Process temperatures up to 1100°

Since the Arcam A2X system is designed to process titanium alloys as well as materials that require elevated process temperatures, such as titanium aluminide and Inconel, it is well suited for both production and materials R&D. This EBM® platform offers a build envelope of 200x200x380 mm.

### Superior material properties

The Arcam A2X system can deliver a beam power of up to 3000W and maintain a scan speed that allows melting at multiple points simultaneously. The vacuum system is designed to maintain a vacuum level of 1x10<sup>-5</sup> mBar or better throughout the entire build cycle. This, combined with elevated temperatures, eliminates residual stress and ensures superior material properties.



High temperature process of Inconel 718 – Contour melting.



High temperature processing of Inconel 718 – Bulk melting.

- HIGH PRODUCTIVITY
- LARGE BUILD VOLUME
- HIGH PROCESS TEMPERATURES
- EASY-TO-USE OPERATOR INTERFACE

# HIGHEST QUALITY METAL POWDER...

**When it comes to the manufacturing of orthopedic implants and aerospace components, achieving target material properties is absolutely vital. At Arcam, we are committed to ensuring first-class mechanical properties throughout our portfolio of materials. You can also rely on our Powder Recovery System (PRS) to minimize manual intervention and enable efficient powder recycling.**

Components built by Arcam EBM® systems have excellent material properties verified by extensive testing of mechanical and chemical properties.

## **Advanced materials**

Arcam offers a total solution for a selection of standard materials. For these materials Arcam provides metal powder, process settings and support.

- Titanium Ti6Al4V
- Titanium Ti6Al4V ELI
- Titanium Grade 2
- Cobalt-Chrome, ASTM F75
- Inconel 718

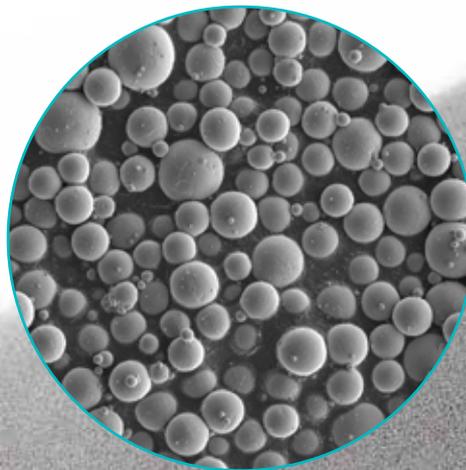
In addition to these standard materials, Arcam allows and supports our customers to independently develop the process for other materials.

## **Powder supply**

High quality powder at competitive pricing is crucial for reliable and cost-efficient production. Arcam offers powders of the highest possible quality and the most competitive prices through our own manufacturing company AP&C.

## **Tested and validated**

Arcam has a validated powder supply chain with full traceability of every powder batch delivered. All powders supplied by Arcam are extensively tested before delivery to our customers. This includes ensuring that the EBM® parameter settings (process themes) are optimized to work well with the metal powder used.



# ... AND EFFICIENT POWDER HANDLING.

## Powder Recovery System

In addition to our range of Arcam EBM® machines, we offer a suite of auxiliary equipment designed for easy and safe powder handling and tough industrial standards. It includes explosion-protected vacuum cleaners (ATEX-classed), powder handling trolleys and a range of Powder Recovery Systems (PRS) for safe and efficient powder recycling.



Recycling of pre-sintered powder.



- EFFICIENT
- CLEAN
- SAFE
- POWDER RECYCLING



# 24-7 AT YOUR

**We are here for you. With Arcam, our commitment to you does not stop with the delivery of a new Arcam EBM® system. It's just the beginning. After all, when it comes to the cost-efficient manufacture of products with an advanced design and function, there is no room for compromise or guesswork. For us, your success is always in focus – and we would not have it any other way.**

We want you to get the very most out of your Arcam solution. In addition to the support of our application specialists, you can rely on our dedicated team of highly skilled service engineers to keep your Arcam EBM® system up and running and available for work.

#### **Service and support**

Our maintenance agreements are designed to help ensure optimal performance and efficiency throughout the lifetime of your Arcam EBM® system. They include basically everything – from spare parts, hardware and software updates, and 24/7 phone



Field Service engineer performing scheduled maintenance.



A comprehensive training package is an integral part of the Arcam offering.

# SERVICE.

and mail support to preventive maintenance actions and emergency support. To meet the specific needs of your operation, you can select from different service levels.

## Training for perfection

Arcam offers initial operator training with every delivery of an Arcam EBM® system. We also offer advanced training courses if you want to develop the EBM® process for new materials, for example. And of course our training packages are tailored to meet your specific needs and requirements.

## Let's talk

See what you and your team can achieve together with Arcam. Our total solution for additive manufacturing includes well-proven Arcam EBM® systems, software, high quality metal powder, and reliable services and training. Not to mention a lot of knowledge and experience gained over many years.

Yes, when it comes to additive manufacturing – and Electron Beam Melting in particular – we know what we're talking about. Our goal is clear: to add value through our competence and solution orientation. And support you every step of the way.

For more information, please visit [www.arcam.com](http://www.arcam.com) or even better give us a call at +46 31 710 32 00.

[WWW.ARCAM.COM](http://WWW.ARCAM.COM)

**Arcam provides cost-efficient additive manufacturing solutions for production of metal components. Arcam's EBM® technology offers freedom in design combined with excellent material properties and high productivity.**

**Arcam is an innovative partner for manufacturing in the orthopedic implant and aerospace industries, where we deliver customer value through our competence and solution orientation.**

