Additiv tillverkning: Möjligheter och utmaningar

Department of Industrial and Materials Science
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Additive Manufacturing@Chalmers
Powder Metallurgy  Materials Development  Process Development

- 14 R&D-project on-going involving Chalmers
- **Competence centre for additive manufacturing – metal CAM²**
- Additive Manufacturing – focus area within Area of Advance Materials Science and Area of Advance Production at Chalmers
- Close co-operation with industry: powder manufacturers, manufacturers of AM-products, equipment providers, users of AM-products
  - 7 PhD students, 1 post-doc, 1 engineer, 2 researchers
Before and in addition to CAM²

- MSc course on additive manufacturing (~40 students)
- Bachelor course on additive manufacturing (~10 students)
- Chalmers either co-ordinator (C)/project partner (P) in a number of projects:
  - Swedish Arena for Additive Manufacturing of Metals (P)
  - Industrial PhD student supported by Höganäs (C)
  - Industrial PhD student supported by Linde (C)
  - HQ-PM-AM funded by Vinnova/Metalliska material (C)
  - LIGHTCAM funded by Vinnova/LIGHTer (P)
  - FAMCOP funded by Vinnova/Production 2030 (C)
  - INNOKOMP funded by Vinnova/UDI (C)
  - 3DPrintPlus funded by Västragötalandsregionen/Tillväxtverket (C)
  - AMtoFLEX funded by Vinnova/Production 2030 (P)
  - RecAM funded by Vinnova/Metalliska material (P)
  - AM-Ni-base funded by Vinnova/Materialbaserad konkurrenskraft (C)
  - RAMP-UP funded by Vinnova/Metalliska material (P)
  - Re-Led 3D funded by Vinnova/FFI (P)

**Materials addressed:**
SS, Ni-base, Cu-base, Fe-base, etc.
Infrastructure

EOS M 100, EOS GmbH
Build volume: ø 100×95 mm
Energy type: 200W Yb-fibre laser

EOS M 290, EOS GmbH
Build volume: 250×250×325 mm
Energy type: 400W Yb-fibre laser

Source: EOS GmbH

Smaller printers for plastics (ZYYX 3D) and composites (MarkForge)
AM Softwares: Magics, Simplify 3D, Eiger
FOCUS:
- Material development for powder-based metal AM

Purpose and Goals
- Needs-driven top-quality research (pre-competitive, low TRL);
- Advantage for commercial/public sectors:
  - access to new knowledge that can be used in product and process development and other areas;
  - the opportunity to influence universities based on their needs;
  - individuals with strategic competencies that meet the needs of companies.
Centre for Additive Manufacture – Metal (CAM²)

Product Areas
- Automotive
- Heavy truck
- Turbomachinery
- Aerospace
- Food, oil and pharmaceutical industry
- Industrial gas supply
- Powder manufacturing
- Mining
- Tooling
- Customized implants

- Novel materials for AM
- Robust AM processes
- Skilled engineers
- Characterization and qualification
- Industrial AM integration
- New product areas

Financing: equally divided between three parties:
- VINNOVA
- Companies
- Academic partners
- Year 1: 12 MSEK in total
- Year 2-5: 24 MSEK/year in total
- special funds for the SMEs (separate process).
Centre for Additive Manufacture – Metal (CAM²)

Organisation

Research partners
- Chalmers (Department of Industrial and Materials Science) - Coordinator
- Fraunhofer-Chalmers Centre
- University West (Production Technology West group)
- Linköping University (Department of Management and Engineering)
- Swerea IVF
Centre for Additive Manufacture – Metal (CAM²)

Industrial partners

- **Core members**
  - AB SANDVIK
  - Alfa Laval Lund AB
  - Arcam AB
  - Atlas Copco AB
  - GKN Aerospace Sweden AB
  - Höganäs AB
  - Saab AB
  - Siemens Industrial Turbomachinery AB
  - Volvo Cars Corporation AB
  - Volvo Lastvagnar AB

- **Basic members**
  - AGA Gas AB
  - Carl Zeiss AB
  - Quintus Technologies AB
  - RZ Riboverken AB

- **Small and medium enterprises**
  - AIM Sweden AB
  - Brogrens AB
  - Cascade Control AB
  - Lasertech LSHAB
  - Modul System AB
  - Ortomat AB
  - Permanova Lasersystem AB
  - Tooltec AB
International Advisory Board

Prof. Eugene Olevsky, San Diego State University, USA

Prof. Carolin Körner, Erlangen University, Germany

Prof. Iain Todd, The University of Sheffield
Centre Board

Lars Nyborg, 
*Chalmers*
Prof. of Surface Technology, centre co-director

Christian Wolfe, 
*Alfa Laval*
Senior manager, Technology Development of manufacturing processes globally

Sima Valizadeh, 
*Atlas Copco*
Mining and Rock Excavation Technique Empowering Innovation Manager

Fredrik Olofsson, 
*Brogren Industries*
Member of the management team, R&D Manager

Louise Chen, 
*Höganäs*
Manager market development, Surface coating

Elisabeth Åbom, 
*Saab*
Aeronautics Vice President, Head of Airframe development

Dr. Anna Hultin Stigenberg, 
*Sandvik*
Coromant Senior Technology Manager

Helena Oskarsson, 
*Siemens Industrial Turbomachinery*
Project manager

Anna Davidsson, 
*Volvo Cars Corporation*
Manufacturing Research and Advanced Engineering Manager

Sören Wiberg, 
*AGA Gas*
Product Manager Heat Treatment

Robert Reimers, 
*GKN Aerospace Engine Systems*
Manager R&T AM Center

Robert Gorner, 
*Volvo Group Trucks Operations*
Director Manufacturing Engineering Powertrain

Anders Snis, 
*Arcam*
Senior manager, Technology Development of manufacturing processes globally.
## Internationalisation

<table>
<thead>
<tr>
<th>Research Organization</th>
<th>Contact</th>
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<tbody>
<tr>
<td>San Diego State University, USA</td>
<td>Prof. Eugene Olevsky</td>
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<tr>
<td>North Carolina State University</td>
<td>Prof. Ola Harryson</td>
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<tr>
<td>Oak Ridge National Laboratory, USA</td>
<td>Dr. Ryan Dehoff</td>
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<tr>
<td>The University of Sheffield, UK</td>
<td>Prof. Iain Todd</td>
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<tr>
<td>Manufacturing Technology Centre, UK</td>
<td>Dr David Brackett</td>
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<tr>
<td>Fraunhofer ILT, Germany</td>
<td>Dr. Ing. Andreas Gasser</td>
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<tr>
<td>Fraunhofer IWU, Germany</td>
<td>Dr. Ines Dani</td>
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<tr>
<td>Fraunhofer IFAM, Germany</td>
<td>Prof. Berndt Keiback</td>
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<tr>
<td>Erlangen University, Germany</td>
<td>Prof. Caroline Körner</td>
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<tr>
<td>Direct Manufacturing Research Center (DMRC, Paderborn)</td>
<td>Dipl.-Wirt.-Ing. Christian Lindemann</td>
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<tr>
<td>Politecnico di Torino, Italy</td>
<td>Dr Mariangela Lombardi</td>
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<tr>
<td>CEIT, Spain</td>
<td>Prof. Francisco Castro</td>
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<td>DTU, Danmark</td>
<td>Prof. Ole Sigmund</td>
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<th>International Industrial Partners</th>
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<tr>
<td>Materialise NV, Belgium</td>
<td>MSc Paula Maghales</td>
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<tr>
<td>EOS Finland Oy, Finland</td>
<td>Dr Olli Nyrhilä</td>
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<tr>
<td>GKN Aerospace, UK</td>
<td>Dr Steven Mckown</td>
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<tr>
<td>The Carl Zeiss IMT GmbH, Germany</td>
<td>MSc S. Tomaszko</td>
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<td>Linde AG, Germany</td>
<td>Dr. Pierre Foret</td>
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<tr>
<td>Siemens AG Power and Gas, Germany</td>
<td>Dr.-Ing. Sebastian Piegert</td>
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Centre for Additive Manufacture – Metal (CAM²)

- powder metallurgy science
  Chalmers and IVF

- advanced materials characterization
  Chalmers and LiU

- process development and simulation
  Chalmers, FCC and UW
Centre for Additive Manufacture – Metal (CAM²)

CAM² research areas (RA) cover whole chain of powder-based AM
## Powder for AM

**Comparison of powder size requirements for different AM processing with gas atomizing powder**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Alloys</th>
<th>Powder</th>
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<tbody>
<tr>
<td>LS</td>
<td>12 (Al-Si, Co-Cr, IN718, IN625, Hast.X, Fe18Ni9Co, 174P-H, 316L, PH1 steel, GP1 stainless steel, CX steel, Ti-6Al-4V)</td>
<td>20</td>
</tr>
<tr>
<td>EBM</td>
<td>4 (Ti-6Al-4, Ti, Co-Cr, Inc718)</td>
<td>5</td>
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Lack of materials for AM!

Sustainable AM development: cheaper powder, high-volumes, new alloys

Additive Manufacturing: Metal Powder Demand

As the volume of metal additive manufacturing increases, so too will the demand for metal powder, a primary component for the process.
Powder for AM

Sweden has 25% of the world powder production

~ 0% of the powder for AM!
Powder development for AM
Public events/Open seminars - first one – October 11-th
Some examples printed in our EOS M290

- Student project
- Probes for wind tunnel
- Large component
Student project

- Vertical axis wind turbine
- Printed in stainless steel (316L)
- Printed in four pieces
- Mounted with snap-locks
Probes for wind tunnel

- Probe diameter 2.5 mm
- Printed in stainless steel (316L)
- Contains five channels (diam 0.55 mm)
- Internal channels electro polished
Large component

- Printed for \( \text{CAM}^2 \) member
- Printed in stainless steel (316L)
- Built height 264 mm
- Complex geometry
Thank you very much!