CHALMERS
UNIVERSITY OF TECHNOLOGY

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 CAM^2

- 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)

<u>Materials addressed:</u>
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

Centre for Additive Manufacture – Metal (CAM^2)

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)

- 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 (CAM^2)

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 (CAM^2)

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***
  - ***Ortoma 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

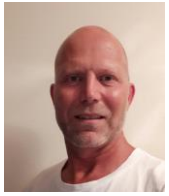
Helena Oskarsson, ***Siemens*** Industrial Turbomachinery
Project manager

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,

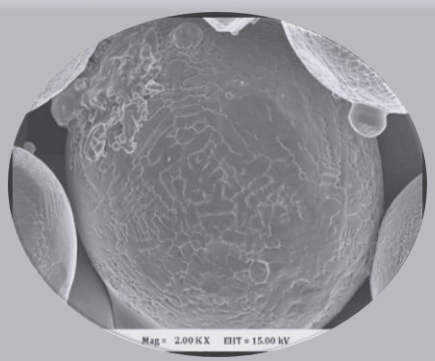
Centre for Additive Manufacture – Metal (CAM²)

Internationalisation

Research Organization	Contact
San Diego State University, USA	Prof. Eugene Olevsky
North Carolina State University	Prof. Ola Harryson
Oak Ridge National Laboratory, USA	Dr. Ryan Dehoff
The University of Sheffield, UK	Prof. Iain Todd
Manufacturing Technology Centre, UK	Dr David Brackett
Fraunhofer ILT, Germany	Dr. Ing. Andreas Gasser
Fraunhofer IWU, Germany	Dr. Ines Dani
Fraunhofer IFAM, Germany	Prof. Berndt Keiback
Erlangen University, Germany	Prof. Caroline Körner
Direct Manufacturing Research Center (DMRC, Paderborn)	Dipl.-Wirt.-Ing. Christian Lindemann
Politecnico di Torino, Italy	Dr Mariangela Lombardi
CEIT, Spain	Prof. Francisco Castro
DTU, Danmark	Prof. Ole Sigmund

International Industrial Partners	Contact
Materialise NV, Belgium	MSc Paula Maghales
EOS Finland Oy, Finland	Dr Olli Nyrhilä
GKN Aerospace, UK	Dr Steven Mckown
The Carl Zeiss IMT GmbH, Germany	MSc S. Tomaschko
Linde AG, Germany	Dr. Pierre Foret
Siemens AG Power and Gas, Germany	Dr.-Ing. Sebastian Piegert

Centre for Additive Manufacture – Metal (CAM^2)

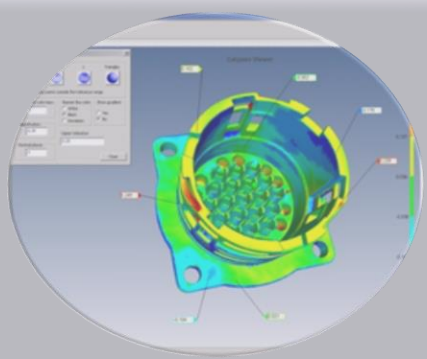


powder metallurgy science

Chalmers and IVF

advanced materials characterization

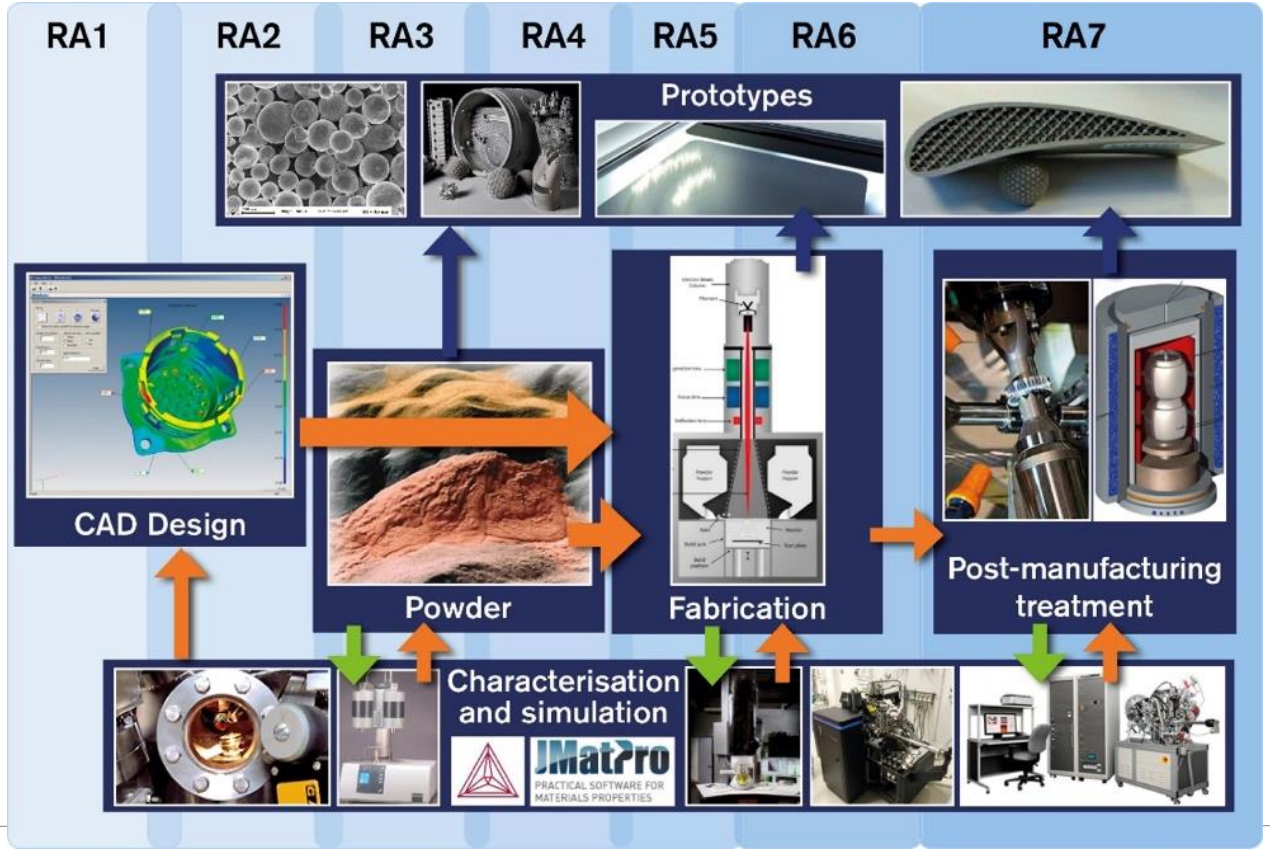
Chalmers and LiU



process development and simulation

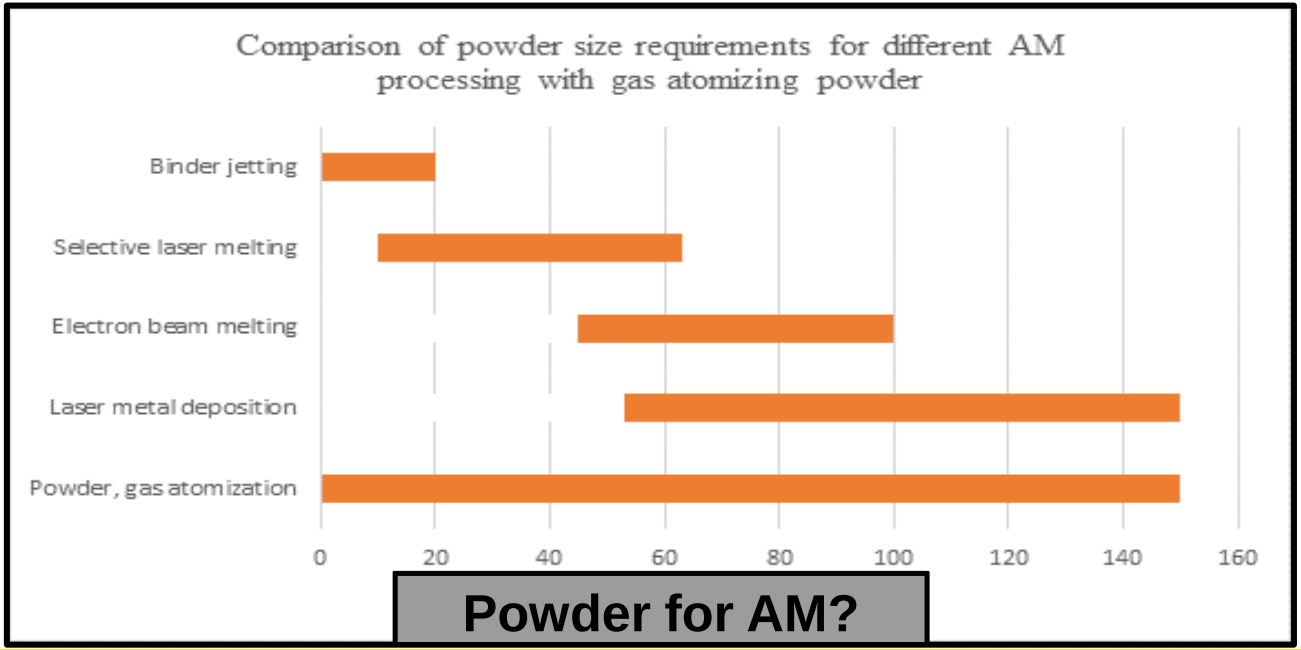
Chalmers, FCC and UW

Centre for Additive Manufacture – Metal (CAM^2)



CAM^2 research areas (RA) cover whole chain of powder-based AM

Powder for AM

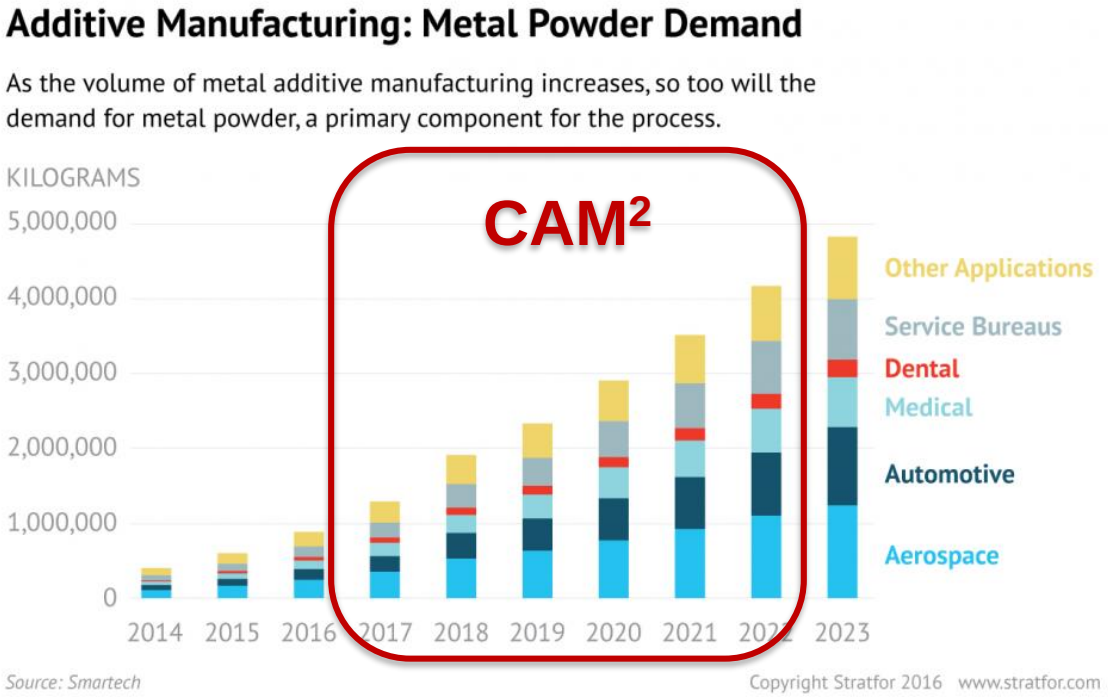


Powder for AM?

Technology	Alloys	Powder
LS	12 (Al-Si, Co-Cr, IN718, IN625, Hast.X, Fe18Ni9Co, 174P-H, 316L, PH1 steel, GP1 stainless steel, CX steel, Ti-6Al-4V)	20
EBM	4 (Ti-6Al-4, , Ti, Co-Cr, Inc718)	5

Lack of materials for AM!

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

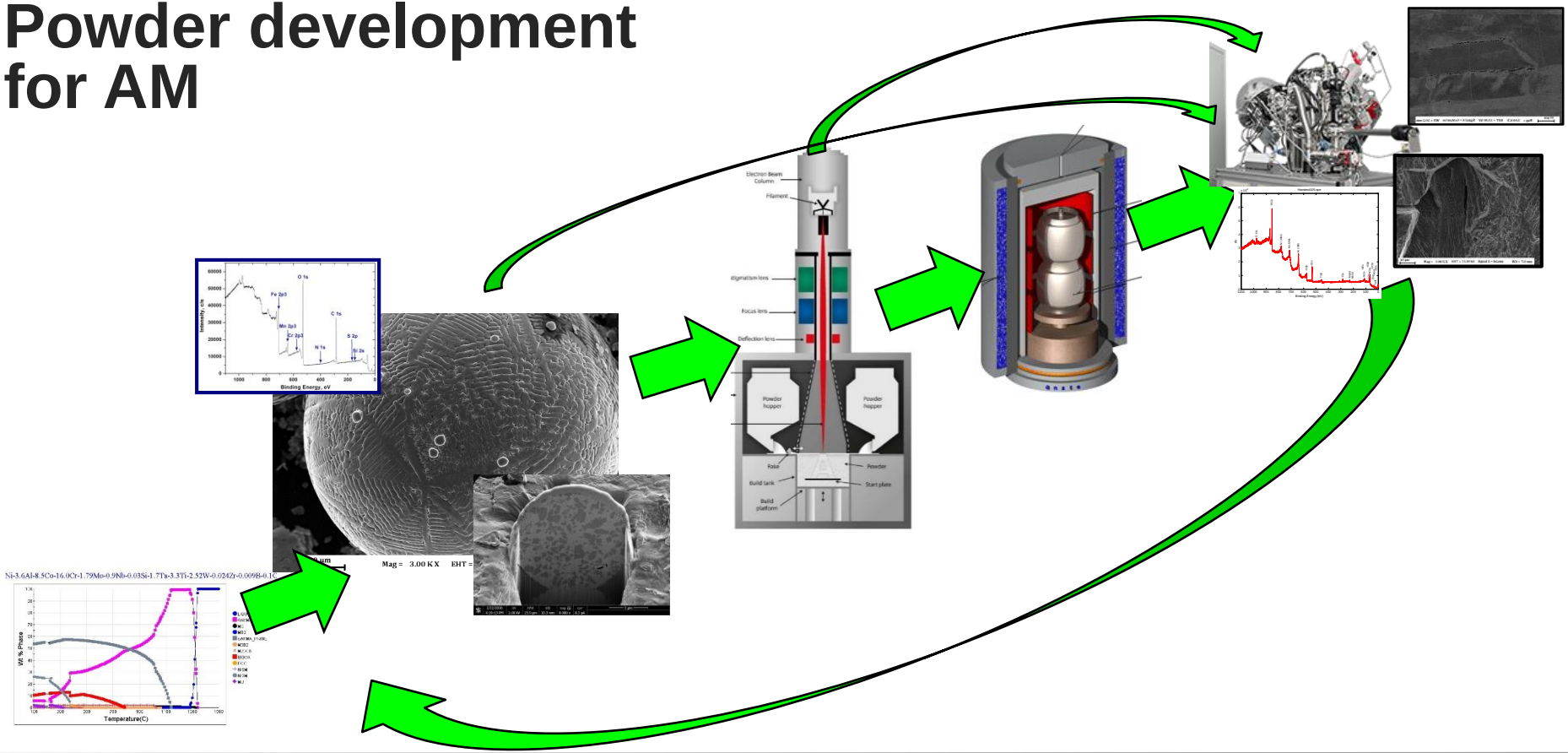


Powder for AM

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

The additive manufacturing technology – or metal 3D printing – is revolutionary with potential to alter the manufacturing landscape. In this two days initiative seminar, Chalmers presents expert talks on the latest development in materials, process, equipment and software development.

PRELIMINARY PROGRAM

11 OCTOBER – SEMINAR DAY

Confirmed speeches

Metal Additive Manufacturing, a Reality Check
Olaf Diegel, Associate Consultant at Wohlers Associates/Lund University

The additive manufacturing revolution in the Piemonte region. State of the art and strategic approach
Prof. Paolo Fino, Politecnico di Torino

Design rules for metal additive manufacturing
Dipl.-Wirt.-Ing. Christian Lindemann, Director Manufacturing Research Center, Universität Paderborn

Additive Manufacturing at Materialise
Sören Olsson, Materialise Scandinavia

Additive Manufacturing is materials
Olli Nyrhilä, EOS Finland Oy

Materials perspective in EBM
Fouzi Bahbou, Arcam

How new Binder Jetting materials and processes will expand the PIM market
Rick Lucas, ExOne

CAM² Inauguration
(see next page)

Some examples printed in our EOS M290

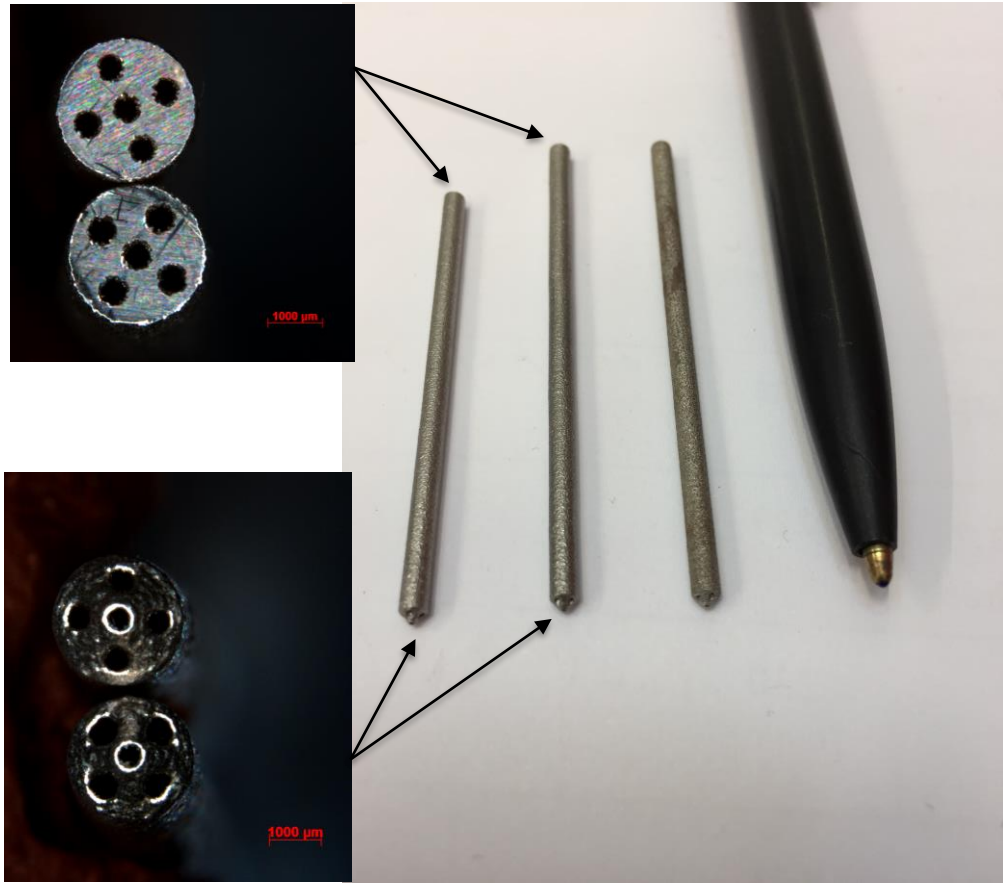
- Student project
- Probes for wind tunnel
- Large component

Student project

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

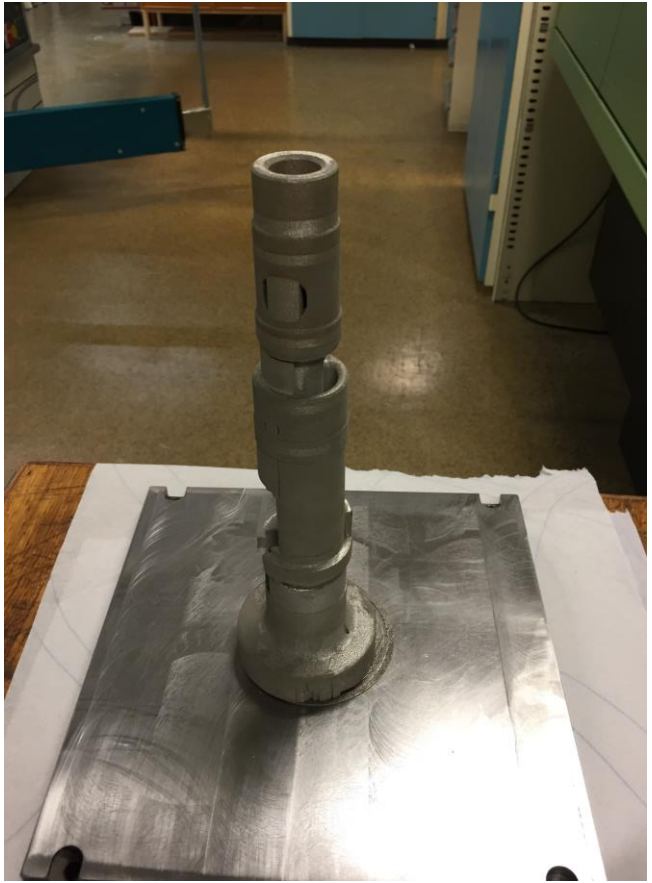
Probes for wind tunnel

- 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 CAM^2 member
- Printed in stainless steel (316L)
- Built heigth 264 mm
- Complex geometry



Thank you very much!