Strategic Focus Area
Advanced Manufacturing

Empa
Materials Science and Technology

Capacity Build-up & Technology Platform Activities @ Empa

Annual Review Meeting Feb 14th 2024

Lorenz Herrmann

An initiative of the ETH Board

ETH-RAT

Participating ETH Institutions:

ETH zürich

EPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

PAUL SCHERRER INSTITUT
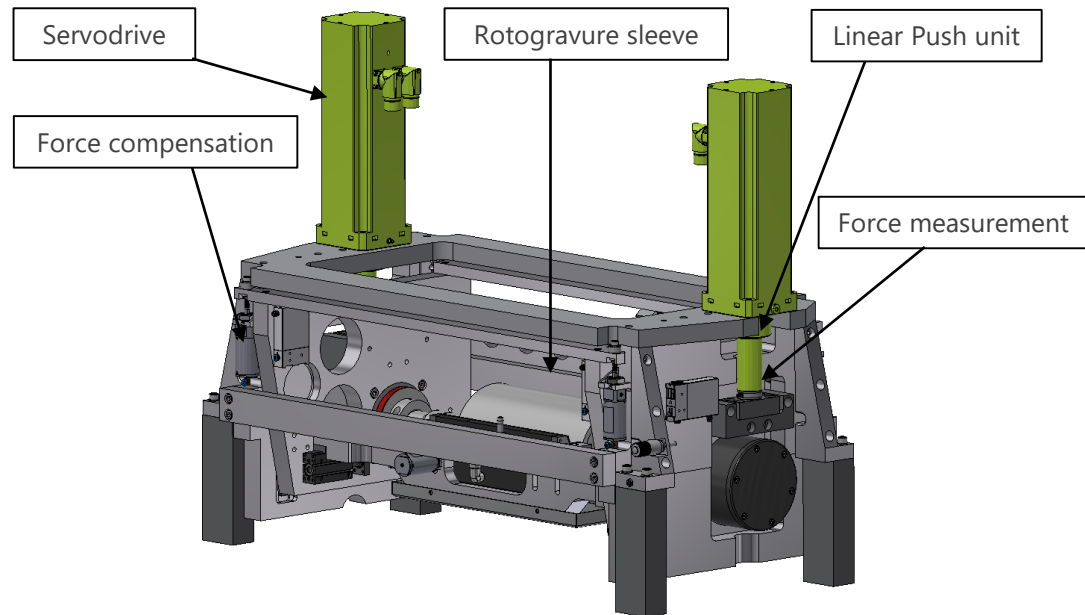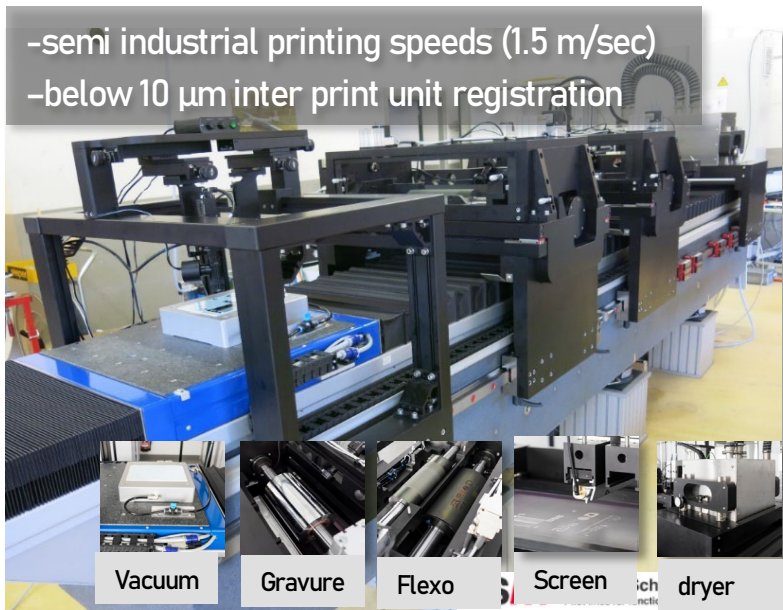PSI

Empa
Materials Science and Technology

Agenda

- Printed Electronics (update)
- Additive Manufacturing (update & outlook)
- Large Scale Laser Equipment (update)
- Quantum Materials and Devices (outlook)
- Solid State NMR (outlook)
- 2 last SFA-financed Projects (outlook)
- Summary

Printed Electronics @ Empa

C600 Gravure Flexo Screen

–semi industrial printing speeds (1.5 m/sec)
–below 10 µm inter print unit registration

Vacuum | Gravure | Flexo | Screen | dryer

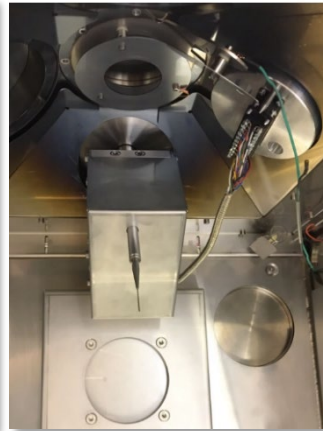**Contact person:**

Dr. Jakob Heier (jakob.heier@empa.ch)

Servodrive

Rotogravure sleeve

Linear Push unit

Force compensation

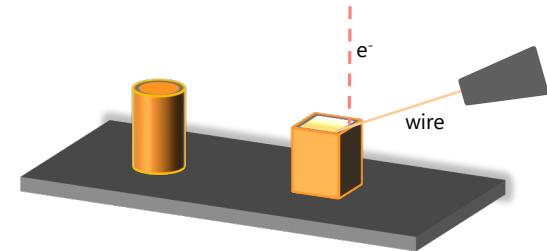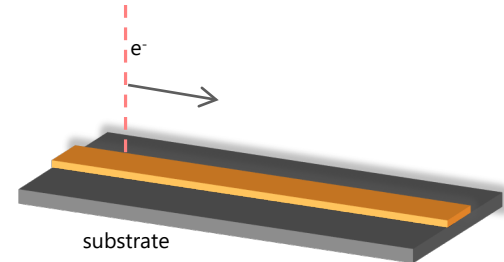Force measurement

- Position and force controlled nip pressure between printing cylinder and substrate and between doctor blade and printing cylinder.
- Variable doctor blade angle 55° - 65°.

Additive Manufacturing @ Empa – new
Modular R&D Platform – micro e-beam AM facility

Unique wire-fed micro e-beam AM setup
Combining 3D Printing Techniques and Electron Microscopy

- Electron Beam Melting   50 µA – 33 mA @ 60kV / 2kW
- Wire feed AM   300 – 800 µm
- Vacuum   < 10^{-6} mbar
- Building volume   50 x 50 x 50 (mm^3)

Fabrication of Cu/Ti and Au/Ti parts
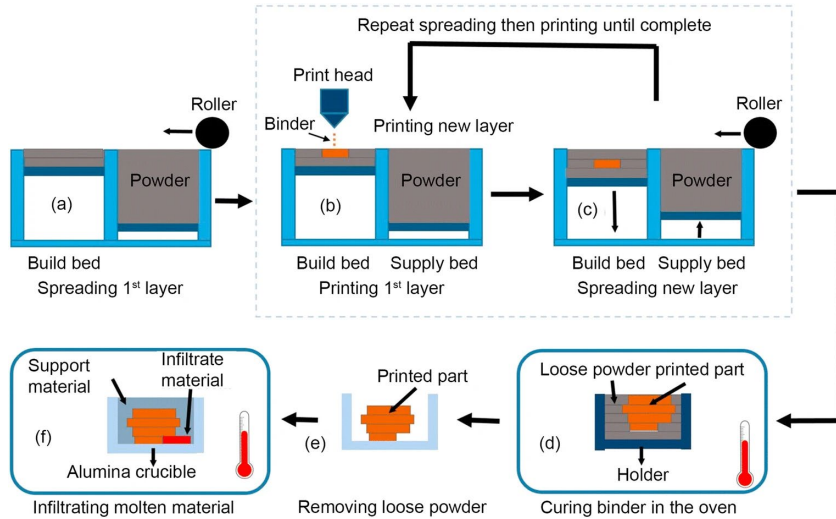(MSc thesis project starting in March 2024)

Contact persons:
Dr. Christian Leinenbach (christian.leinenbach@empa.ch)
Dr. Marc Leparoux (marc.leparoux@empa.ch)

Additive Manufacturing @ Empa – new
Binder-based additive manufacturing

Repeat spreading then printing until complete

Print head

Binder

Printing new layer

Roller

Roller

Powder

Powder

Powder

(a)

(b)

(c)

Build bed
Spreading 1st layer

Build bed   Supply bed
Printing 1st layer

Build bed   Supply bed
Spreading new layer

Support
material

Infiltrate
material

Printed part

Loose powder printed part

(f)

(e)

(d)

Alumina crucible

Holder

Infiltrating molten material

Removing loose powder

Curing binder in the oven

/Do T, Kwon P, Shin CS (2017) Int J Mach Tools Manuf 121:50–60/.

- **Binder-based metal additive manufacturing**
  - AM of precious metals (Au, Ag, Pt)
  - AM of composites and multi-materials (metal-ceramics)
  - …
- **Optimization of alloy powders for accelerated sintering**
- **Optimization of debinding and sintering processes**

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Dr. Christian Leinenbach (christian.leinenbach@empa.ch)
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Additive Manufacturing @ Empa – under construction

Metal AM in construction
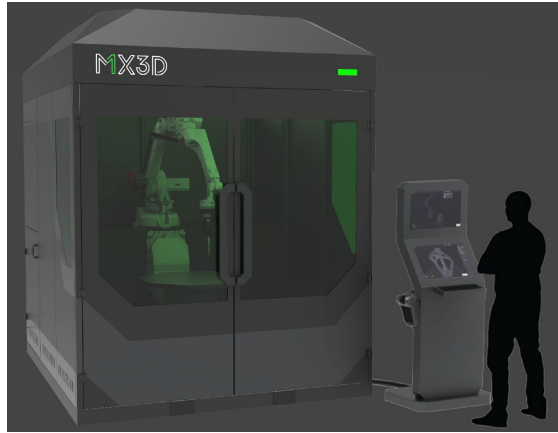
Wire–Arc Additive Manufacturing (WAAM) for printing medium to large-scale components in civil infrastructures

- WAAM system was purchased from MX3D, with a total price of 329'000 Euro, in a tender process.
- WAAM system is now being prepared at MX3D and will be installed and operated at Empa-Abt. 303 in April 2024.
- SFA contribution: 200'000 CHF (already paid by SFA)
- 25% of the purchase cost is taken over by Prof. Andreas Taras at ETHZ, fostering a close collaboration with Empa-Abt. 303 for future on R&D projects.
- Research proposals on WAAM topic at Abt. 303:
  - Joint DFG-SNSF project, submitted on September 2023,
  - Research Partnership Grants with South Asia and Iran, submitted on January 2024, and
  - Joint NSF-SNSF project with the University of Memphis (will be submitted in April 2024).
- There are ongoing discussions with industry to launch industrial R&D projects.

4D printing: AM of Fe–SMA negative stiffness cellular structures as dampers.
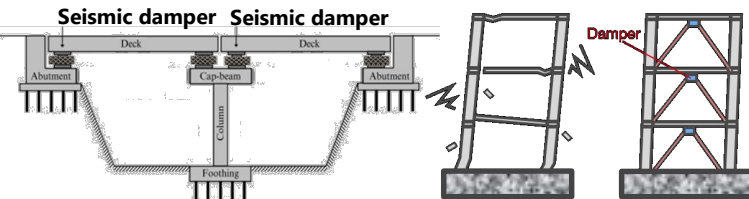
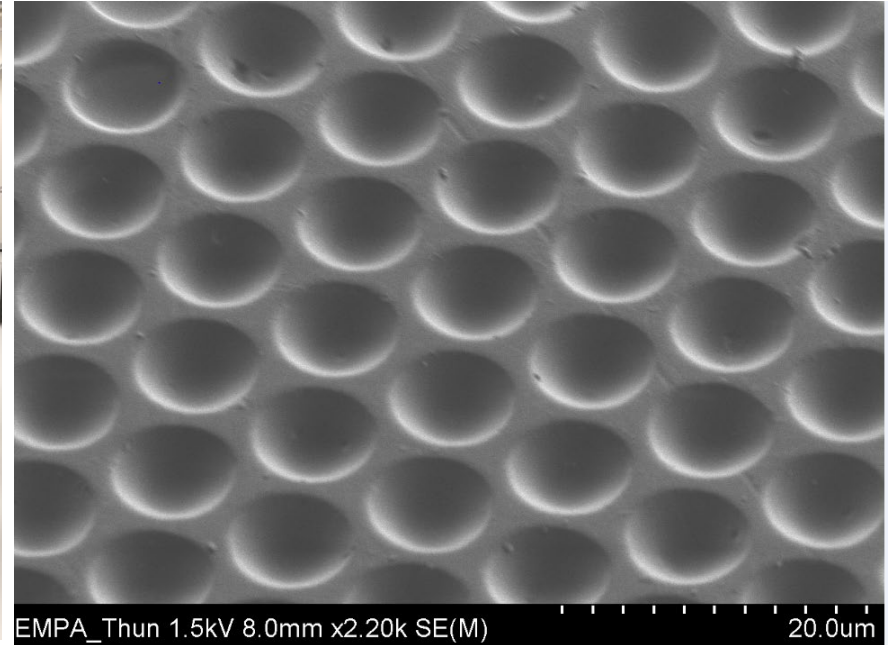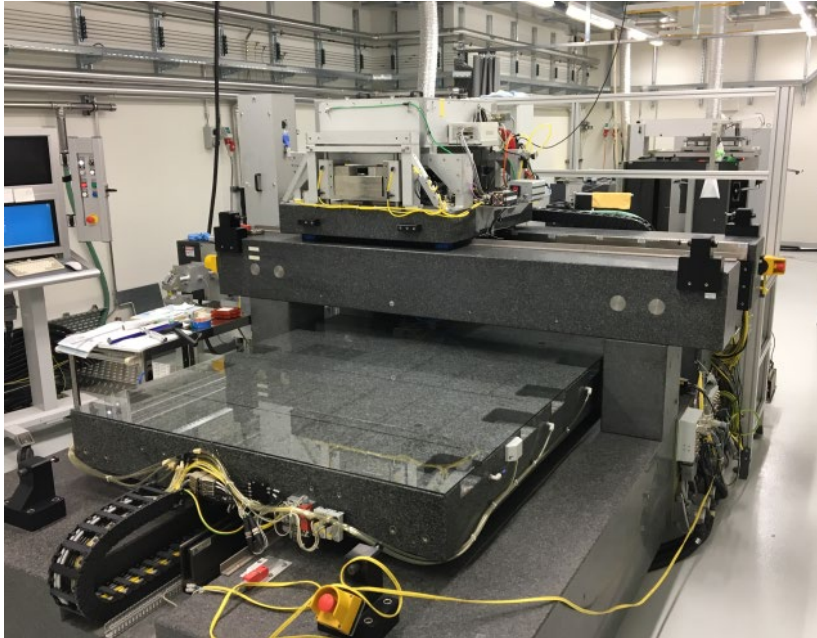**WAAM for optimized structural components**
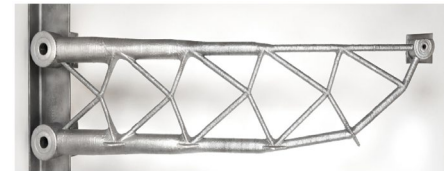
Contact persons:
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Dr. Maryam Mohri (Maryam.Mohri@empa.ch)
Dr. Hossein Heydarinouri (Hossein.Heydarinouri@empa.ch)

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■ Control electronics of equipment was replaced.

Quantum Materials and Devices @ Empa – in planning

Quantum Materials and Devices Laboratory

Vision: A dedicated system interconnecting material synthesis, characterization, and device integration of low dimensional quantum materials in ultra-high vacuum (UHV) conditions

GNR Reactor
fast and reproducible fabrication

Dry-transfer
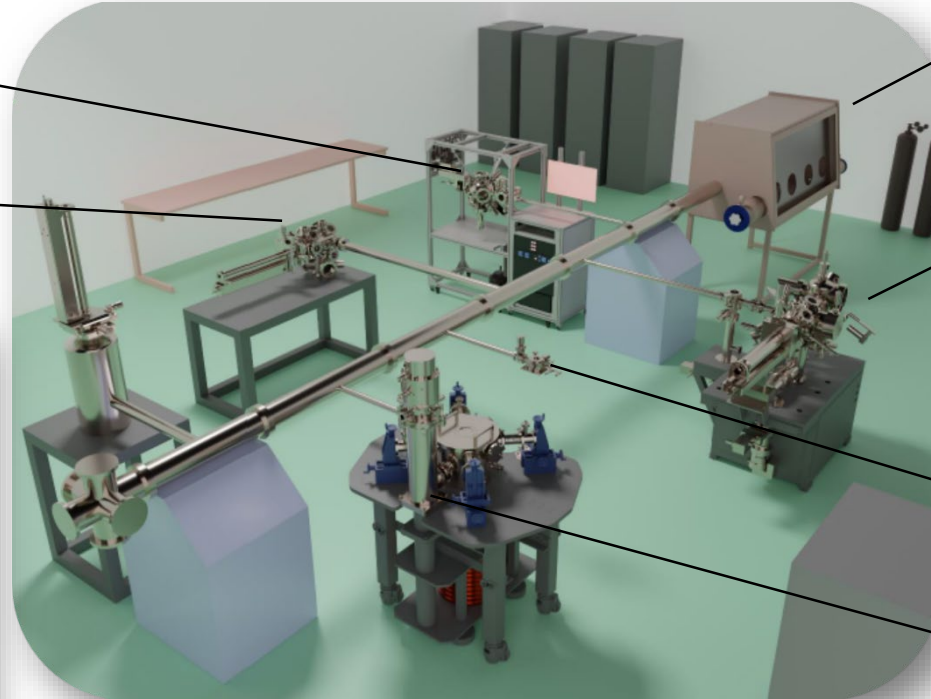Substrate transfer and device integration

Glovebox
Device fabrication and post-processing

Stream-STM
topographic and electronic characterization

Raman
In-situ vibrational spectroscopy

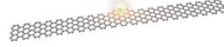*Probestation*
(thermo)electric and magneto transport
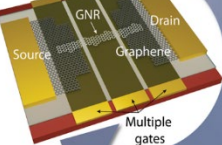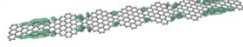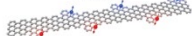
Solid State NMR @ Empa – in planning
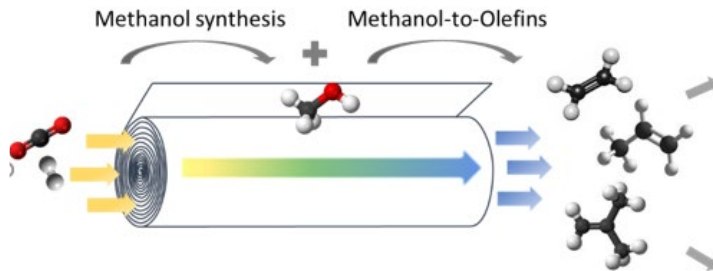## *New (unique) equipment for ETH domain*

MAS Broadband CryoProbe for Material Science

- Improved signal-to-noise ratio due to cooled cryo-probe→ 10 x faster measurements
- Support Research in the following areas: battery research, fuel cells, concrete and functional polymers

Last Projects starting

- **Large Scale Microstructured ceramic foils for catalysis**

- **Interface Manufacturing for ReUse of Materials**