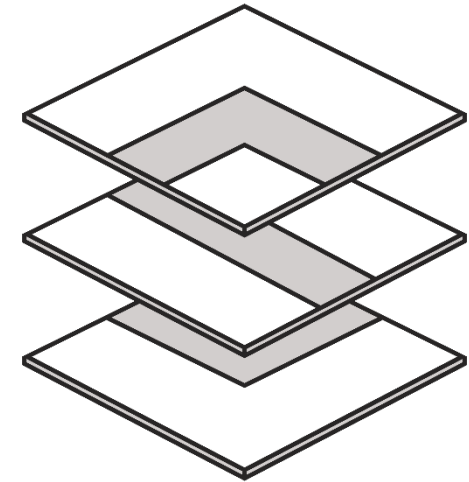


DTU



Agenda for TechForum 2022#1

- **Supply chain disruption**
- **Courses and lab access**
- **Lab expansions**
- **Facility closures**
- **New equipment**

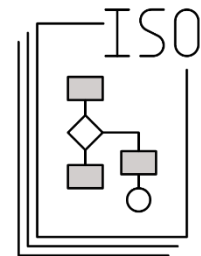


THE SURVIVAL KIT

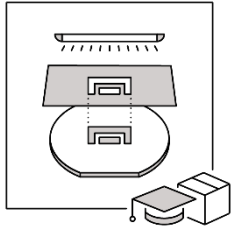
TO COPE WITH SUPPLY CHAIN DISRUPTION



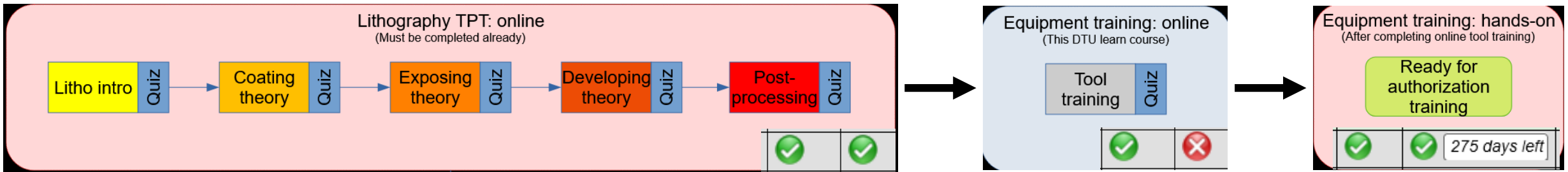
- Chemicals
 - Photoresist
 - Wafers
 - Metals
 - Spare parts
 - Technician support
-
- Apply non-lean principles – increase stock
 - Substitutions



COURSES AND LAB ACCESS



Litho TPT – new version on DTU Learn



To get full authorization on any lithography equipment, you must:

1. Complete the lithography TPT
2. Complete the online equipment training for the specific tool(s) you need
3. Complete the hands-on authorization training in the cleanroom

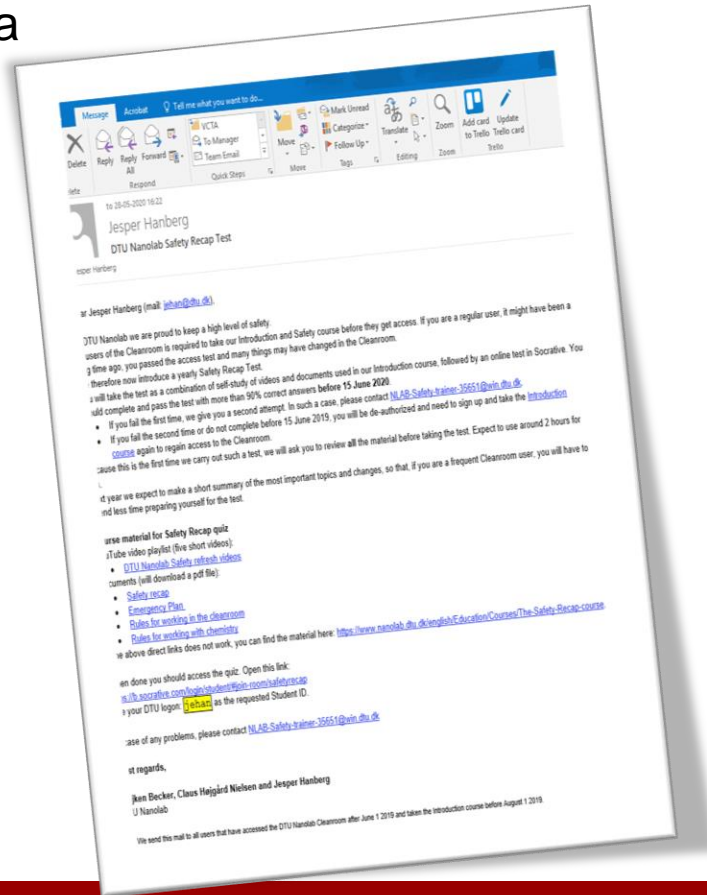
When choosing:

- E-Beam Writer 9500 an additional e-beam TPT before practical training
- DUV Stepper send a mail to training@nanolab.dtu.dk

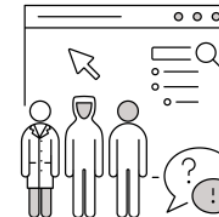
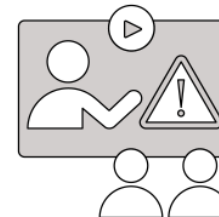
You sign up for the course through Nanolabs homepage from where you will be guided all the way

Annual safety update

- Safety recap was done two years ago
- Annual update in 2021 postponed due to Corona



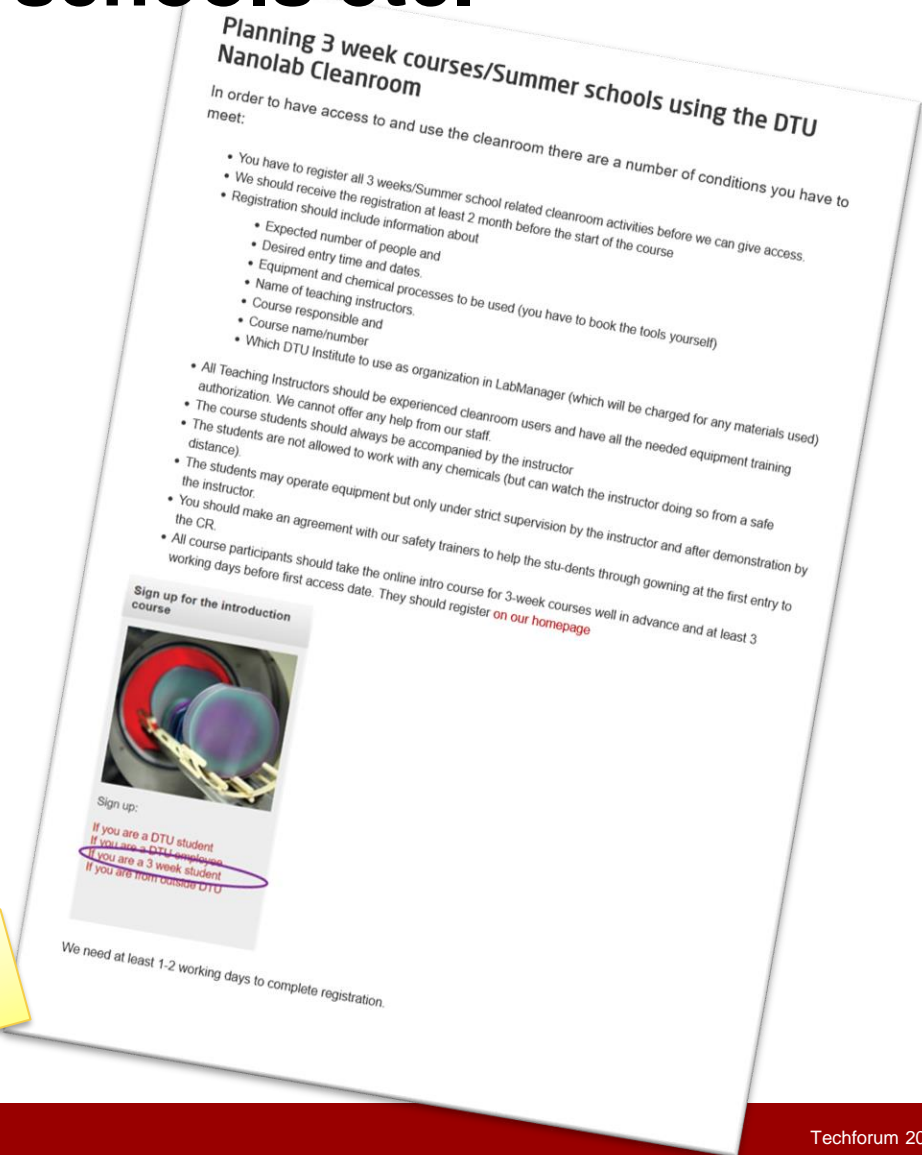
- New safety update/training planned for 2022
- Your safety knowledge for all types of facility access will be tested (Cleanroom, Microscopy, Basement 346, ...)
- The test will be online
- Currently working on the tests and to automate the process



3-weeks courses, summerschools etc.

- Plan in good time (two months ahead)
- Follow the guidelines given in
 - <https://www.nanolab.dtu.dk/About-DTU-Nanolab/FAQ/3weekCourse>
 - (Nanolab homepage > About > FAQ)
- Please spread this information to colleagues and “Institutstudienævn“
- If you are late consequence may be that we deny access due to:
 - No room in gowning or CR for students
 - Machines not available
 - No time for registration or proper introduction of students
 - ...

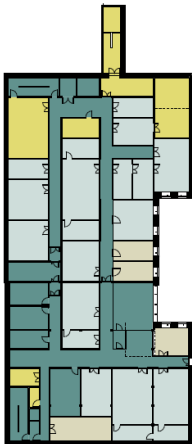
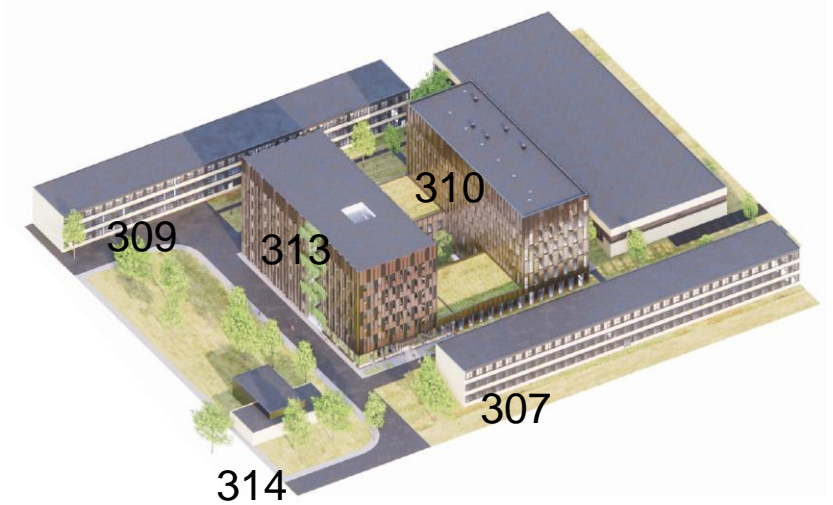
DTU Nanolab is low on staff in JULY



LAB EXPANSIONS

'Climate Challenge Laboratory' B313 update (JABW)

- Generic labs and offices
- Basement ready for sensitive instruments
- Building 313 is connected to 310
- Building site will occupy area between 307, 314, 309, and 310
- Building site from Nov. 1 2021 – Oct. 1 2023



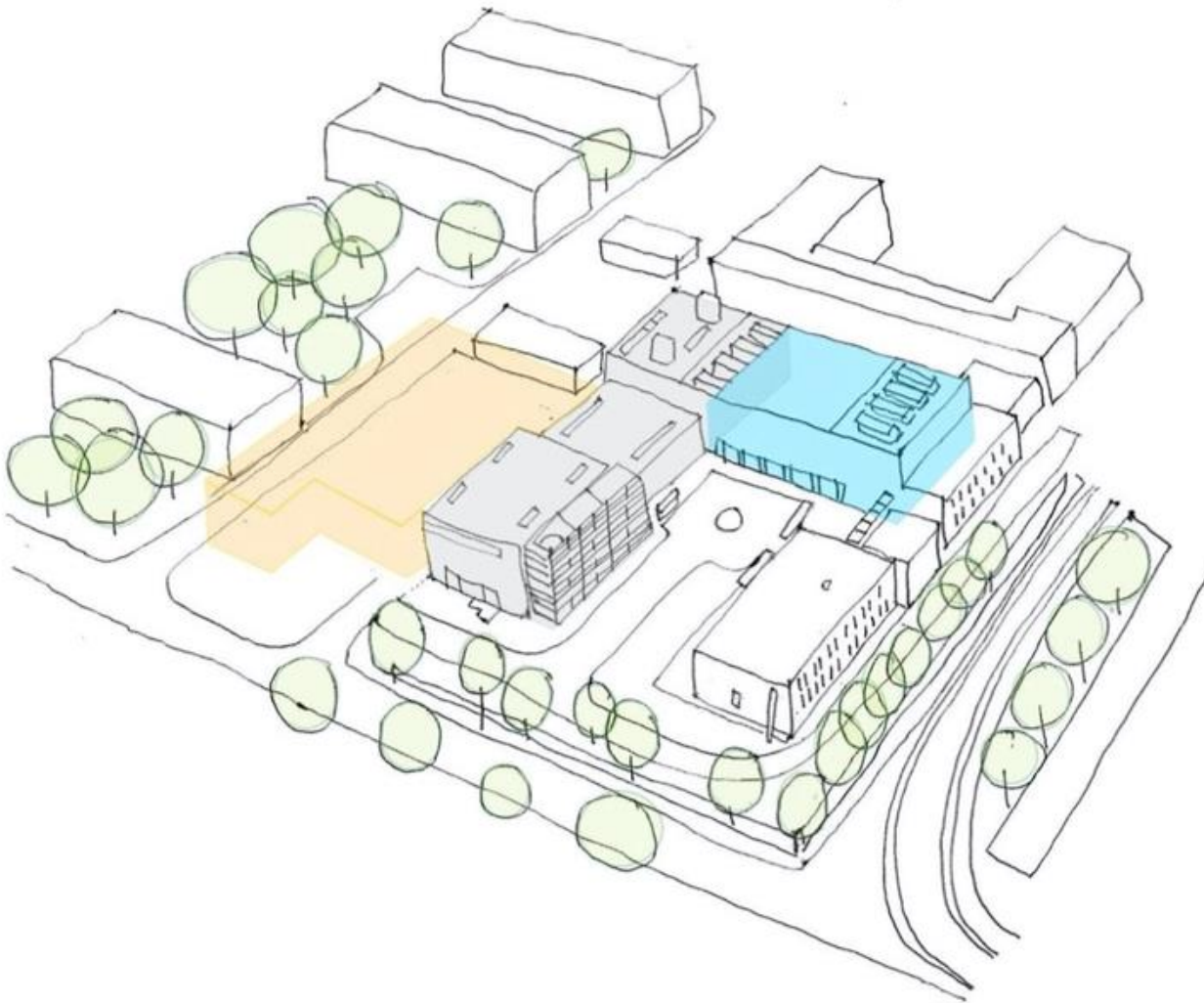
Basement



Above ground



Cleanroom Expansion bldg 346A - status



- No final approval
- Design study group
 - DTU Nanolab
 - CAS
 - Consulting engineers and architects
- Many design constraints need clarification
- No clear building footprint
- No clear layout of interior
- Cleanroom area unknown
- Ballroom cleanroom
- Clean subfab
- Seamless integration with existing cleanroom

The PolyFabLab Vision

- Fill the gap between research labs and existing cleanroom facility
- Maximise flexibility, accessibility and visibility
- Showcase the processes to the world around us
- Rapid exchange of various tabletop and stand-alone equipment

Enable work within:

- Full soft lithography line with SU-8 litho and PDMS casting
- Polymer printing (3D resin print and 2-photon-polymerization)
- Chemical surface modification (plasma polymerization and Parylene)
- Ink-jet printing
- Polymer replication (Nanoimprint and roll-to-plate)
- Prototype equipment (Slot-die coating...)

Work supported financially by Novo Nordisk Foundation with 12 Mkr.

Grant number:
NNF210C0068814



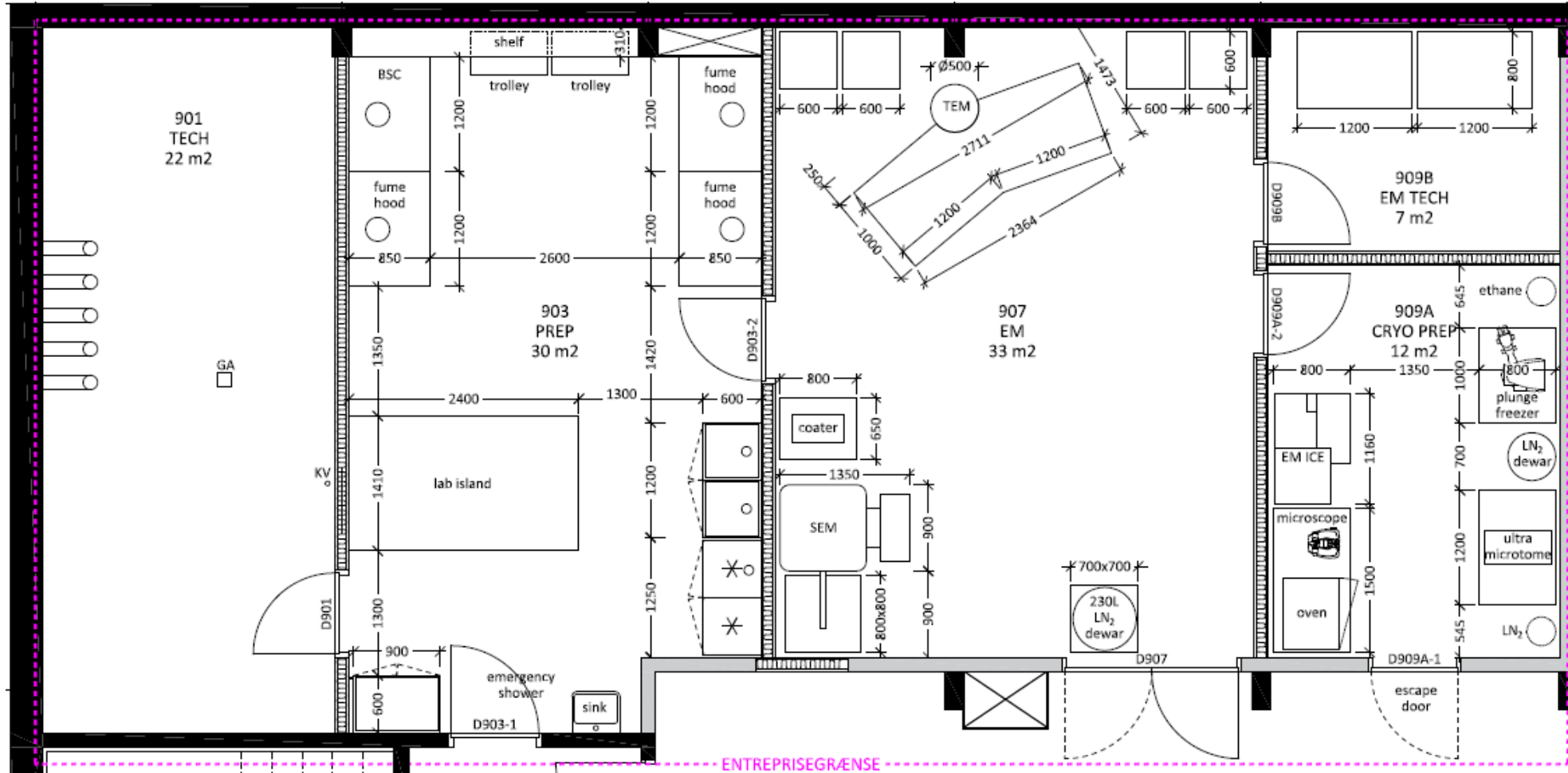
3D Model - PolyFabLab



- Design in progress
- Expected construction start: Dec-2022
- Expected move-in: Dec-2023
- Dates subject to change

B307 basement Soft Matter Lab Sketch

- Soft Matter lab for:
 - Sample preparation
 - Cryo SEM and TEM
- Key requirements include:
 - Temperature stability 1°C P-P/24hrs
 - Low vibration levels
- Lab area >100m²



B307 basement Soft Matter Lab

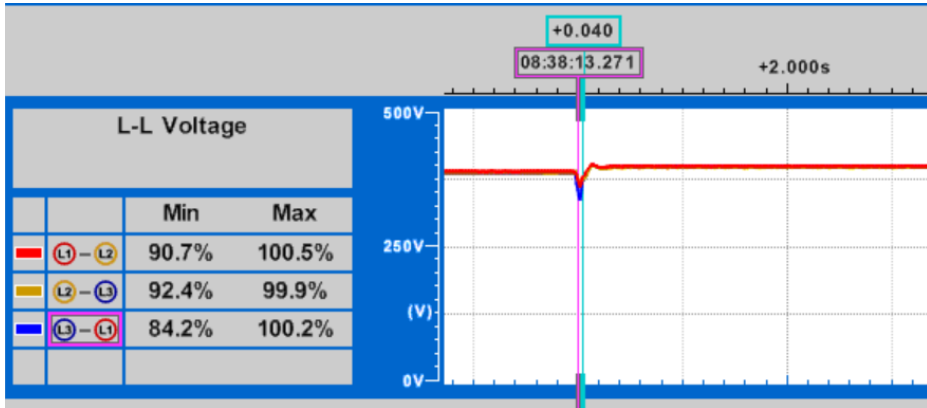
- Project tender & contracting:
Now-April
- Lab construction:
Q2-Q3, 2022
- Project completion:
Q3, 2022



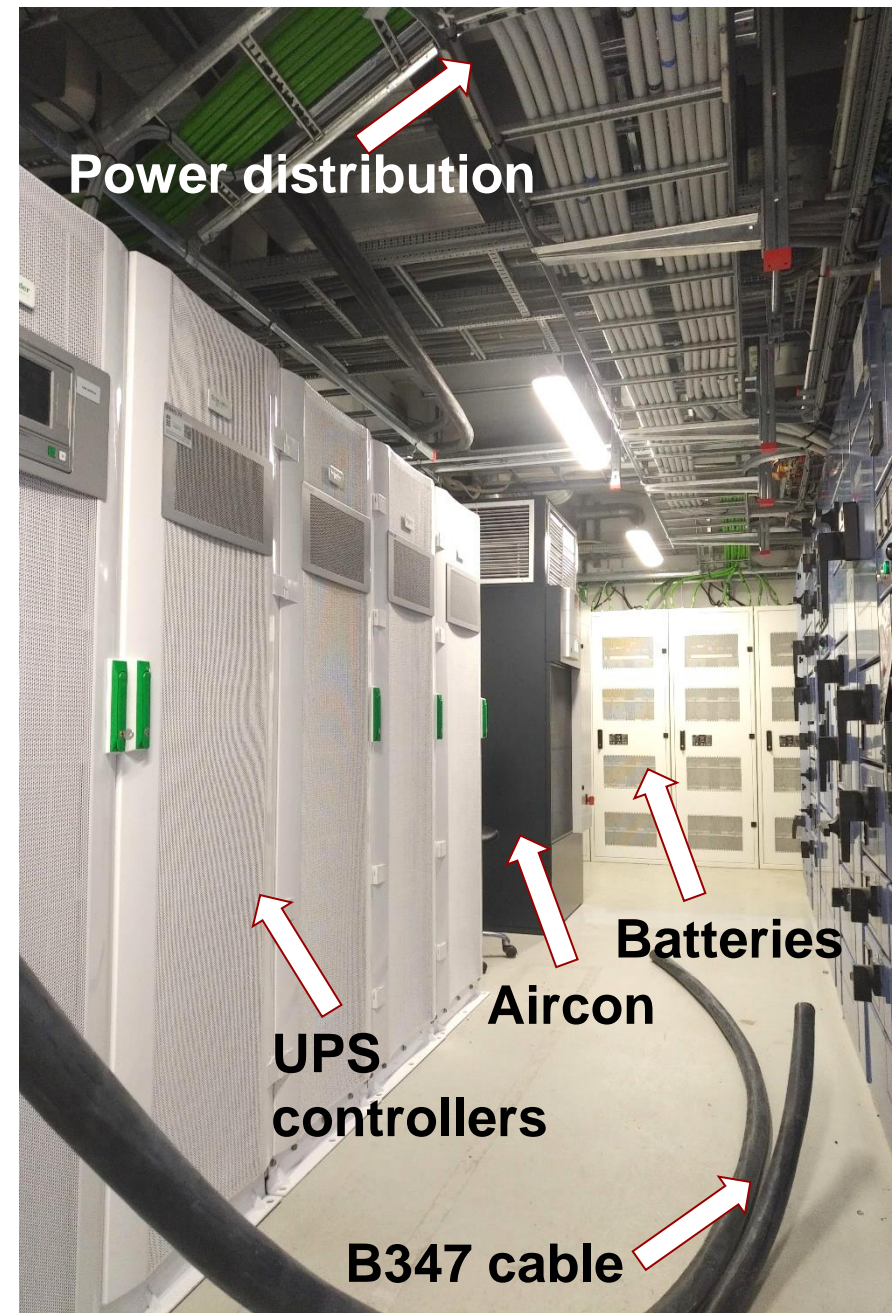
FACILITY CLOSURES AND PROJECT UPDATES

B346 UPS update

- B346 now protected against power glitches < 20 min
- 65 min power cut in Jan-2022: Capacity verified
- 9 known glitches “caught” since Jan-2022.
- No known damages – the system works

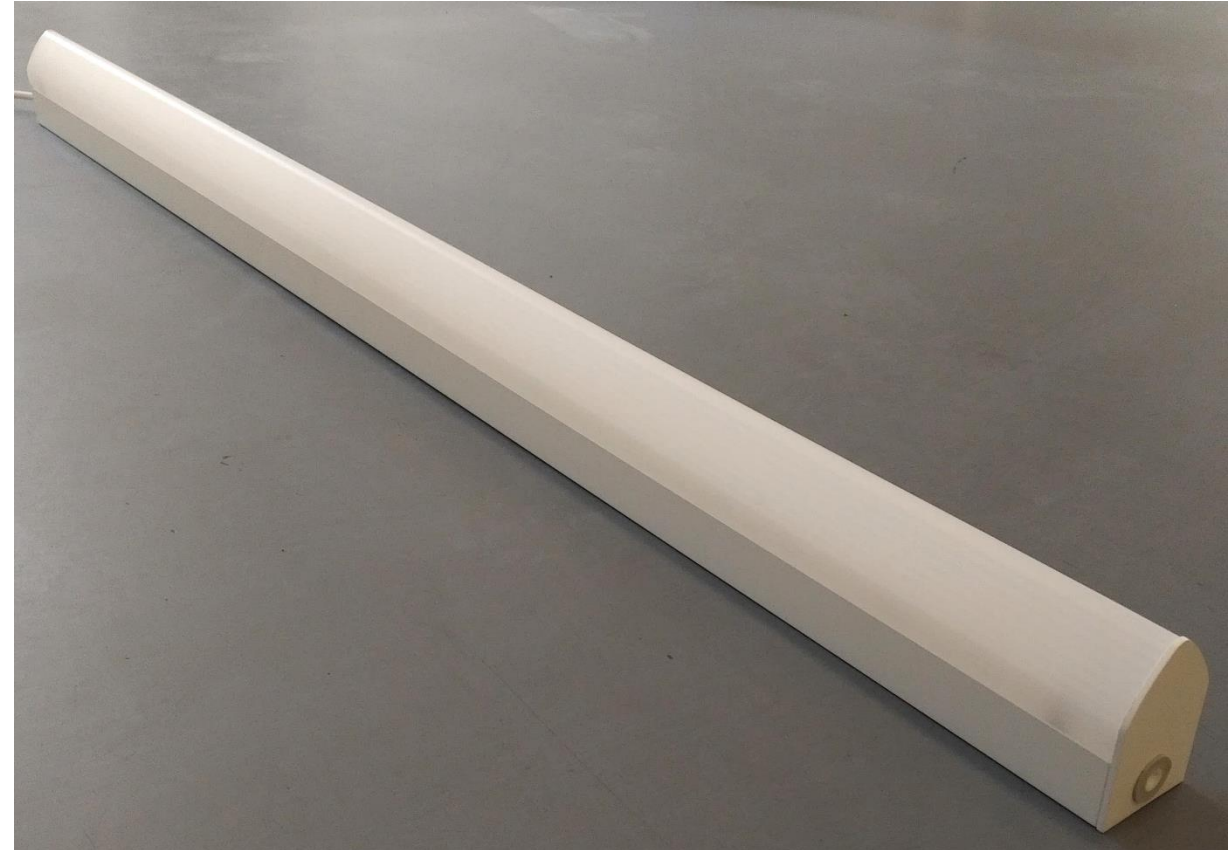
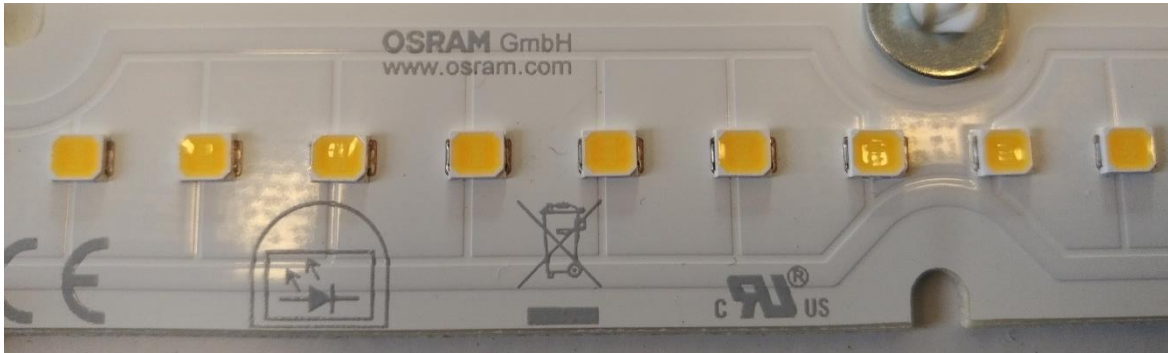


- Remaining: Re-route safety systems power
 - One day’s closure of B346 – Date unknown
- B347 will also be connected to the UPS system
 - May require closure of B346



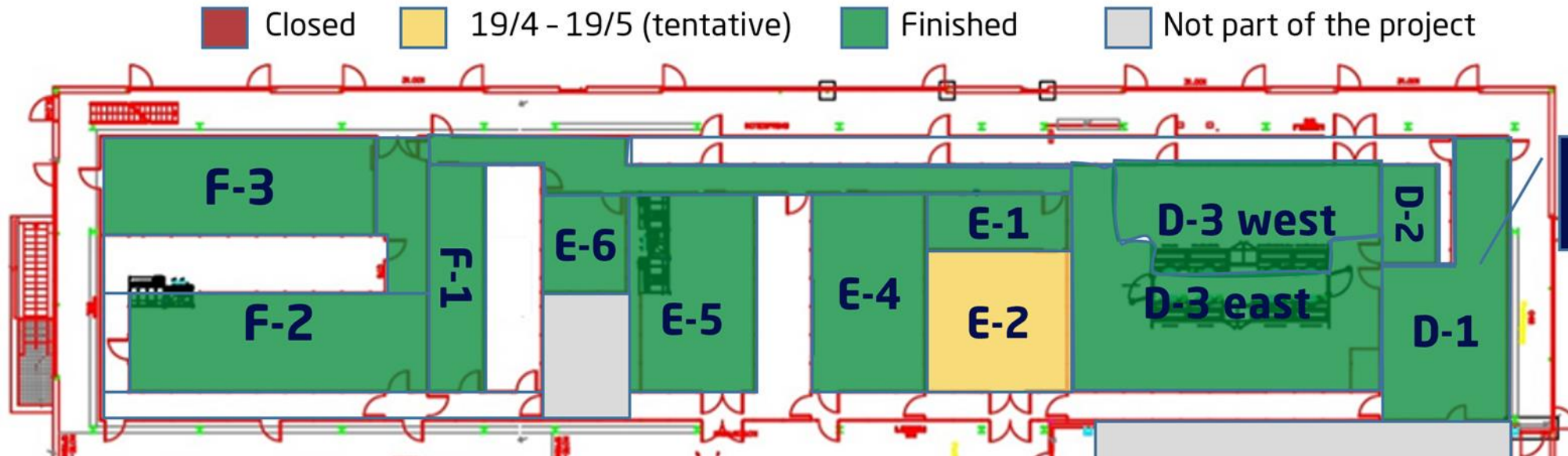
LED installation

- Change from fluorescent to LED light in entire cleanroom (old and new)
- Lower power consumption
- Further power saving: Turn off light in unused areas
- Original plan: Simultaneous FFU & LED change
- But: LED 9 months delayed
- Project start around May/June 2022
- 2-4 days closure of each room.
- Schedule negotiations with contractor in progress
- **Time schedule will be available at**
- <https://sites.dtu.dk/ffunanolab>



FFU exchange

- All rooms finished – except e-beam room (E-2)
- Finished rooms: Clean & low noise
- Power saving: FFU rampdown when nobody in cleanroom
- FFUs in E-2 will be changed together with LED light
- E-beam room will be out of service for 7 weeks (!) – time schedule pending
- New FFU power board: New cleanroom (D, E and F) closed for ca. 1-2 days (dates unknown)
- **Time schedule will be available at <https://sites.dtu.dk/ffunanolab>**



B346 Shutdown overview

- Re-route safety systems to new UPS: Close B346 one day – date unknown
- Connect B347 to new UPS system: Potential closure – p.t. unknown
- FFU & LED change in e-beam room: E-2 closed 7 weeks
- LED change: Each cleanroom bay closed 2-4 days
- New FFU power board: New cleanroom (D, E & F) closed for 2 days
- Few of these closures can be bundled

IDEAS FOR NEW CAPABILITIES

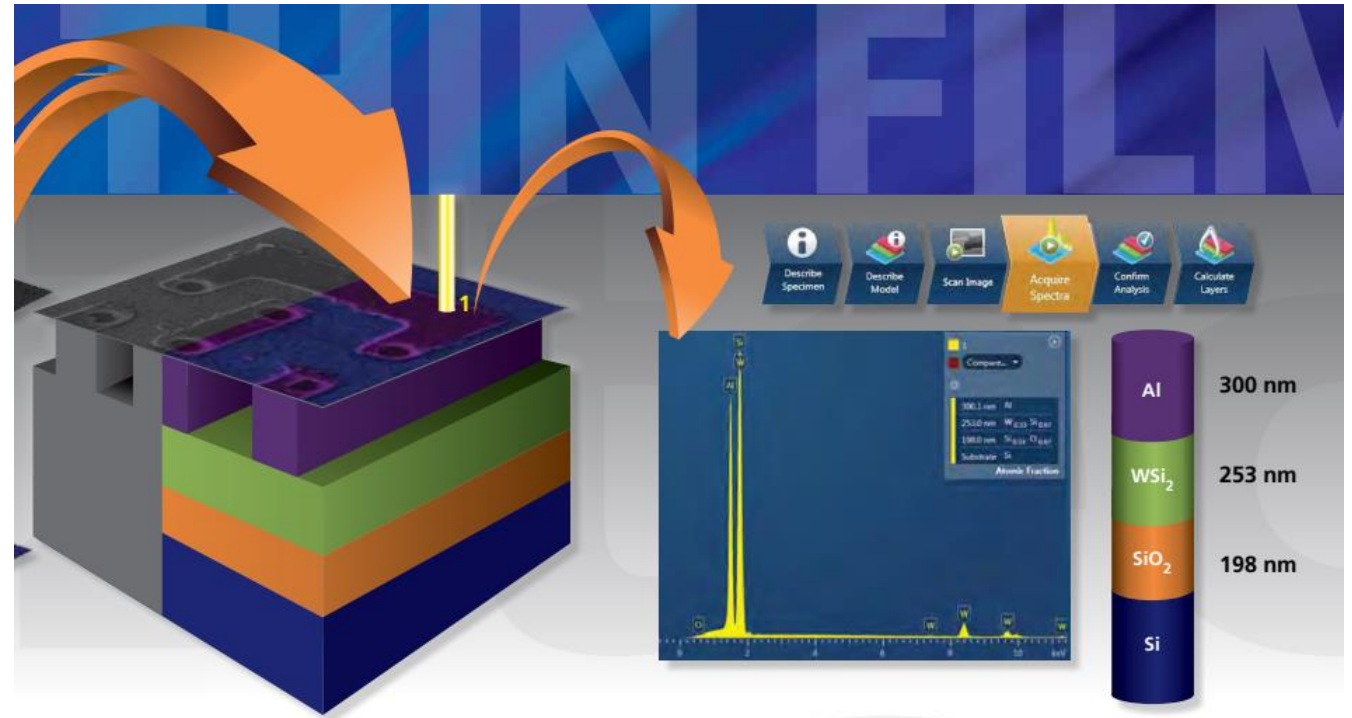
LayerProbe Software for thin-film EDX in our SEMs (Oxford Instruments)

<https://nano.oxinst.com/products/aztec/layerprobe#product-information-tabs>

This is a **software** tool for EDX analysis of thin films on a substrate (rather than bulk materials).

It can be added as an option to the existing AzTec software used in most (all?) SEM microscopes with EDX capability at Nanolab.

- **Advantage #1:** it gives the thickness of the film
- **Advantage #2:** it corrects for the effect of the substrate on the EDX spectra, and therefore gives a better estimation of the composition of the film.

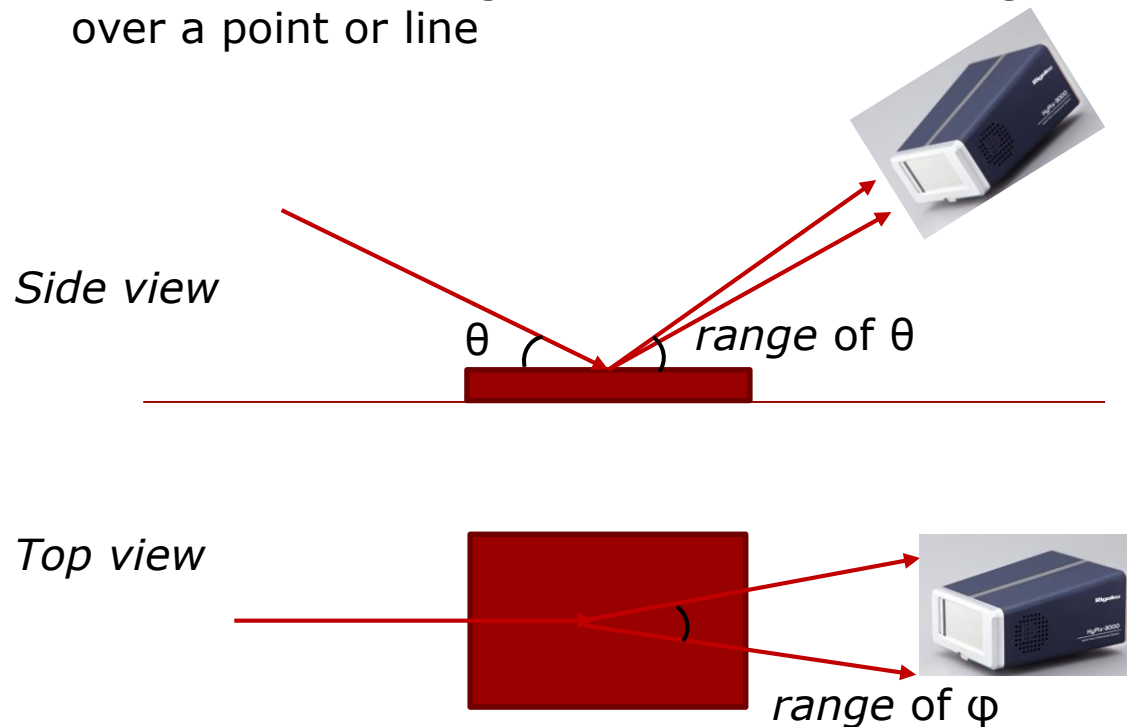


This analysis mode is quite standard in XRF (x-ray fluorescence), but for some reason is not widespread in EDX

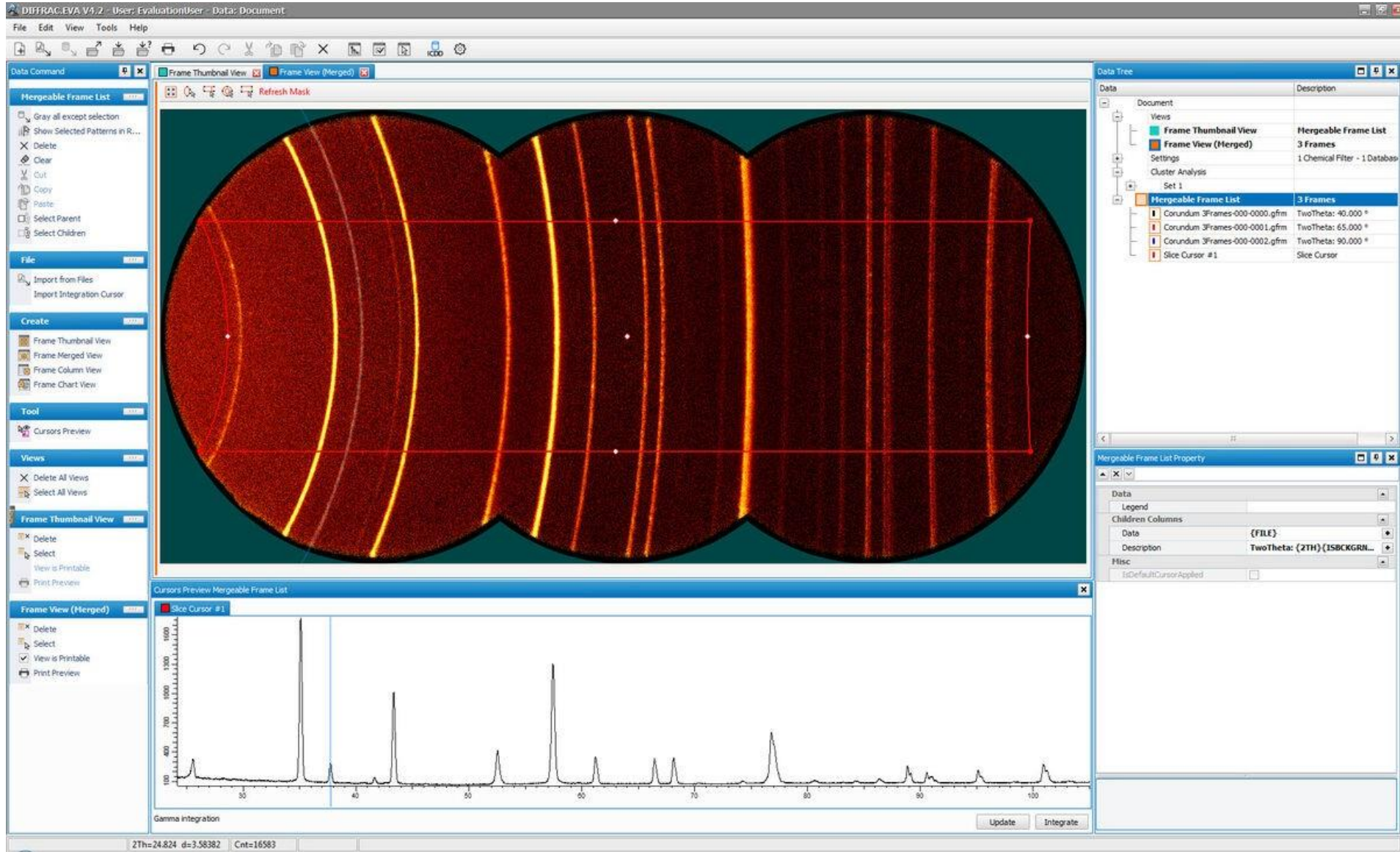
HYPIX-3000 Hybrid pixel array detector (Rigaku)

<https://www.rigaku.com/node/424>

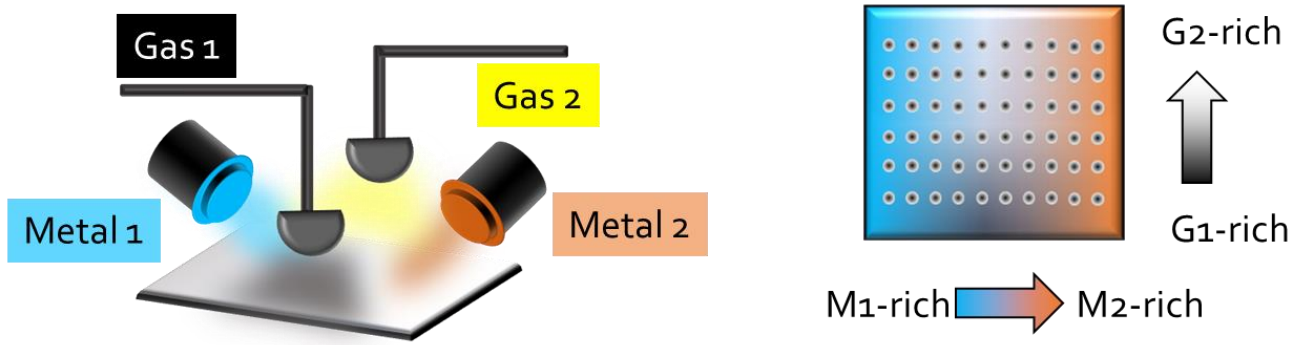
- A 2D detector that can be used on our Rigaku SmartLab XRD and can also work as a 1D and 0D detector.
- **Advantage #1:** diffraction information on a 2D plane
- **Advantage #2:** Faster "standard" theta-2 theta measurement, because you integrate the data from a large area instead collecting it over a point or line



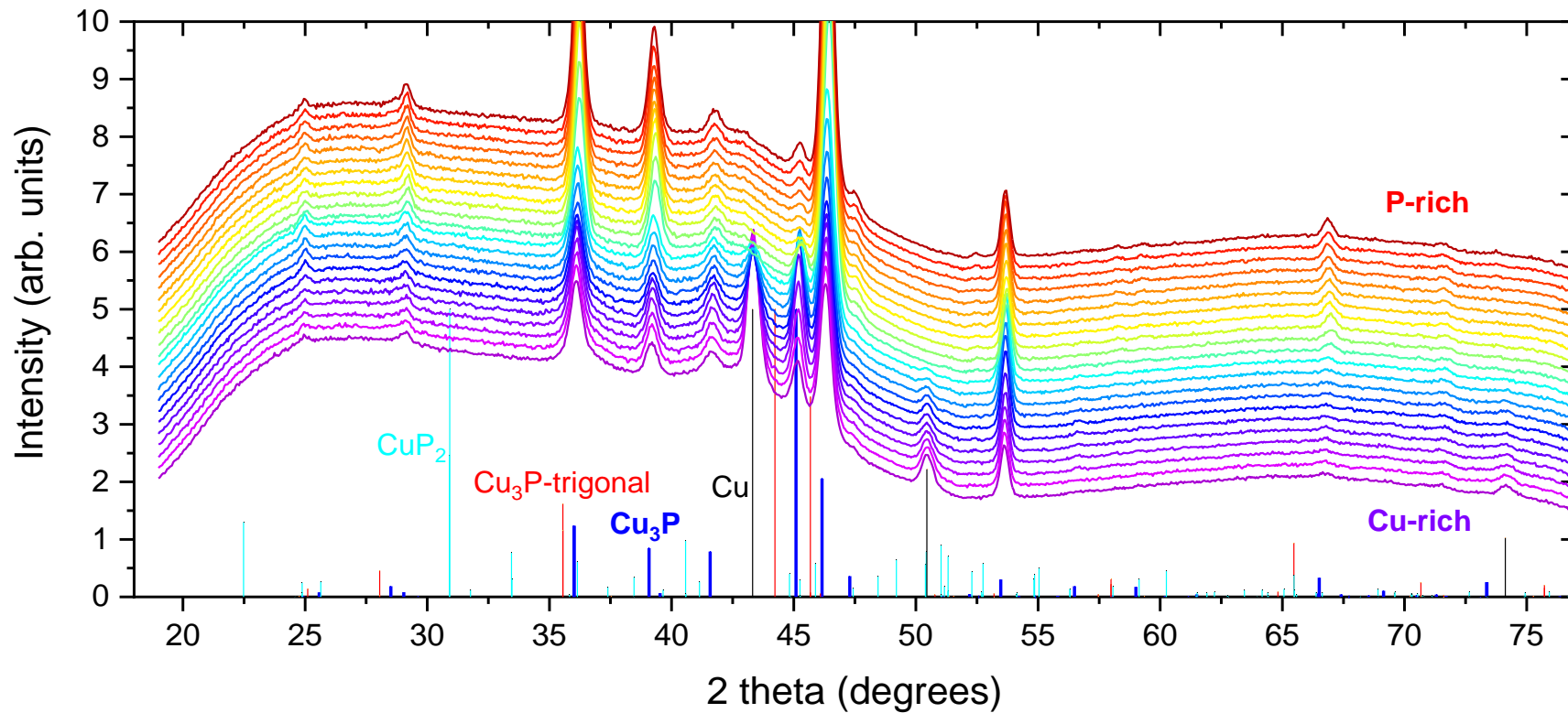
Result



Applications (own results)

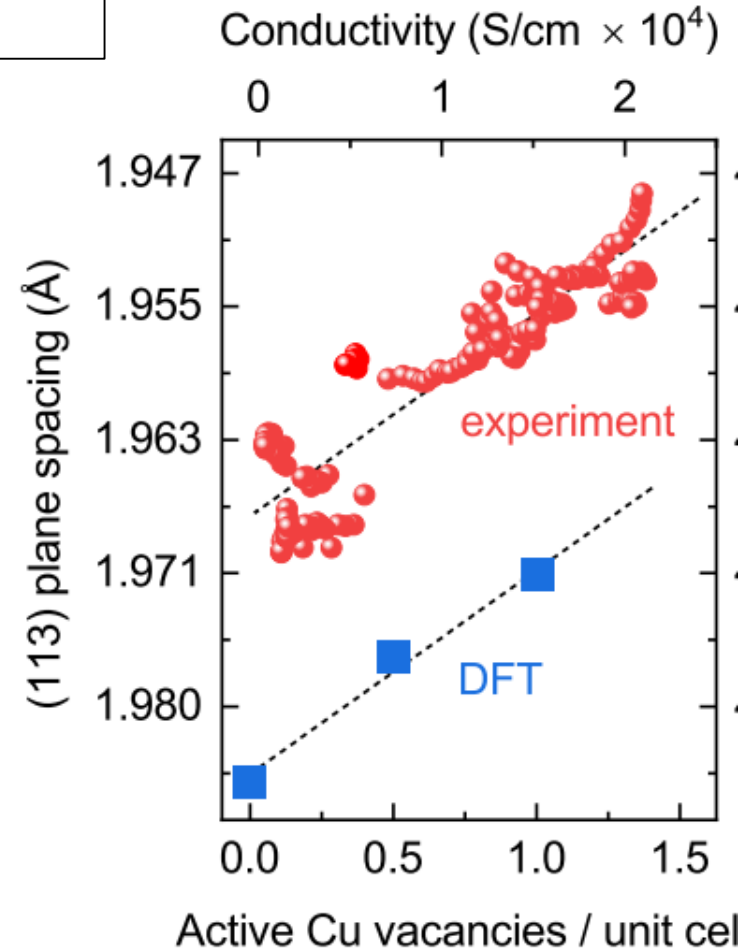
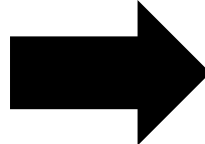
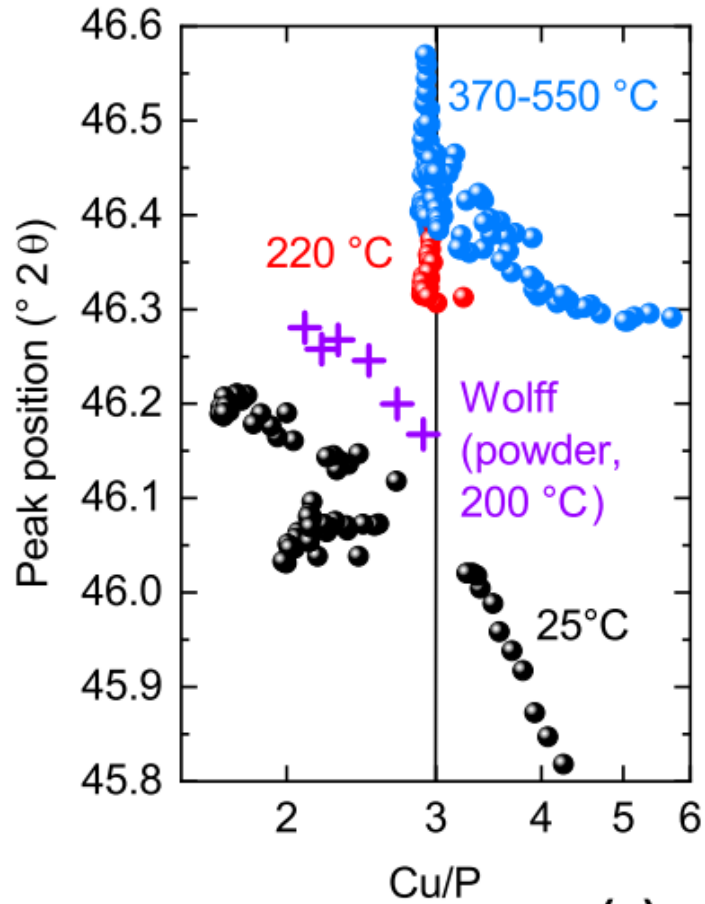


44 quality XRD patterns from one combinatorial sample obtained in **~ 2 hours**



Applications (own results)

Fast screening of materials in composition space



NEW EQUIPMENT

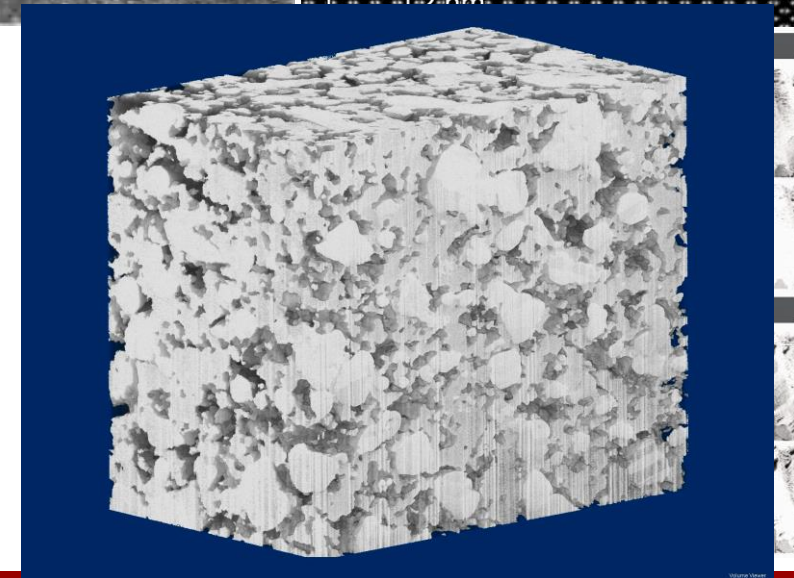
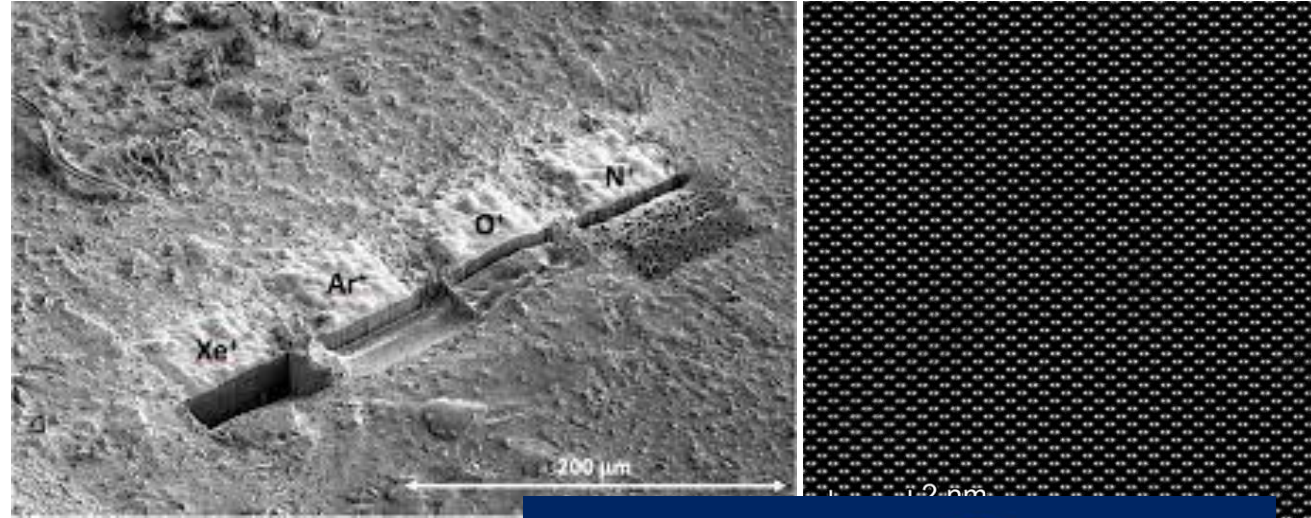
NEW Dual Beam Helios Hydra G5 (JABW)

Purpose/specs:

Addition current Helios G1

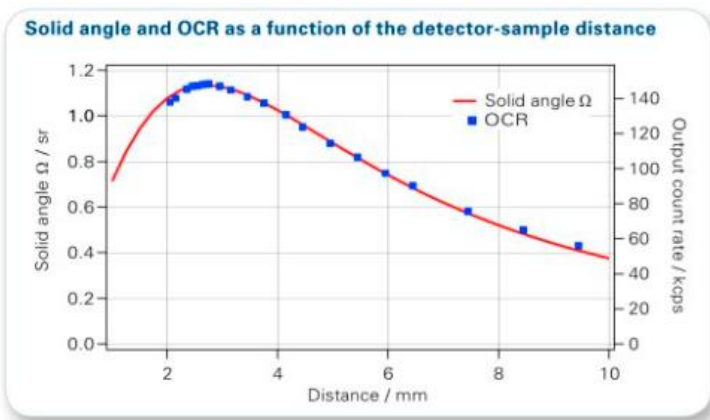
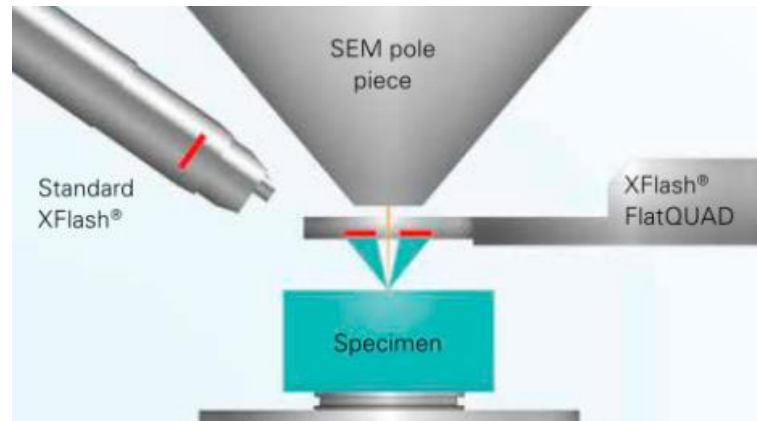
- Multi Gas Plasma FIB (Xe, N, O and Ar)
- Automated TEM Lamella Prep
- Automated Atom Probe Tomography
- Monochromated E Beam for sub nm resolution down down to 500eV

Status: Instrument installed. After some hick-ups in the beginning, the training has started and the instrument is released.



FlatQUAD detector

Purpose/specs: Maximum Efficiency in X-ray Detection



To be installed in Helios microscope 314

Ordered, but delivery date unknown ☹️

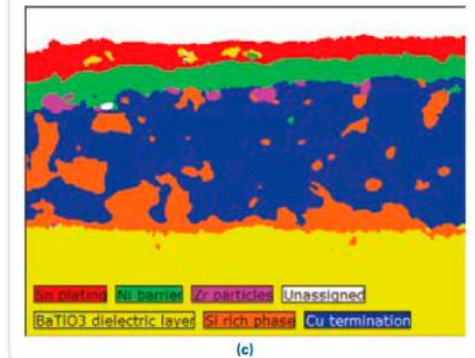
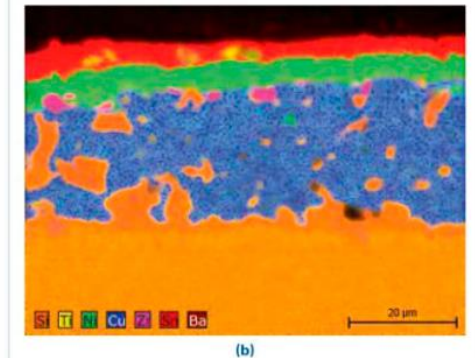
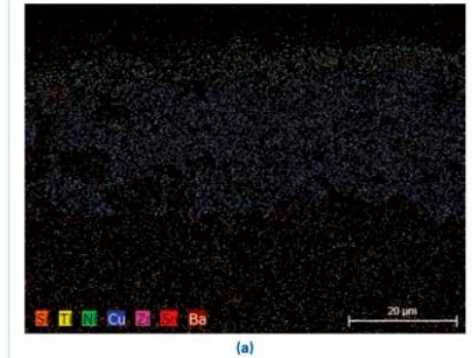
QUANTAX FlatQUAD is an EDS micro- and nano-analysis system that performs where conventional systems reach limitations:

- Extremely fast mapping at highest output count rate, using only moderate beam currents
- Analysis of beam-sensitive materials at low to extremely low beam currents (< 10 pA), e.g. of biological or semiconductor samples
- Investigation of samples with topography, avoiding shadowing effects
- Analysis of nanoparticles and nanostructures at low kV and highest magnification
- Measurement of thin samples (e.g. TEM lamellae) and other specimens with low X-ray yield.

Fast mapping

QUANTAX FlatQUAD can operate at up to 100x the speed of conventional SDD-based EDS systems. This enables map acquisition with excellent statistics in seconds without compromising SEM performance parameters.

Analysis of a ceramic capacitor



(a) Map of a multilayer ceramic capacitor containing Si, Ti, Ni, Cu, Zr, Sn and Ba obtained with a conventional EDS detector, showing very poor statistics. Size 512 × 384 pixels, HV 10 kV, acquisition time 170 s, input count rate (ICR) 260 cps, 41,000 counts total.
 (b) Same specimen mapped under identical conditions using the XFlash® FlatQUAD, ICR 28,000 cps, 4,800,000 counts total.
 (c) Results obtained with the XFlash® FlatQUAD can be used for further processing, e.g. chemical phase analysis as shown here.

RTP (Rapid Thermal Processing) system: Jipelec JetFirst 200C

Purpose/specs:

Replacing current Jipelec system

- Cold-wall system (water cooled stainless steel)
- Temp range: ambient to 1000 C (1200 C for 1 min)
- Temperature control: TC & Pyrometer
- 2 (N₂ & Ar) + 1 gas lines (MFCs) + purge line
- Dry pump (nXDS6i scroll)



- **“Fixed” susceptor** set-up: Better temp-control (TC) + “easier” usage
BUT restrictions (gas flow and max temp ramping)
- Contact us (thinfilm@nanolab.dtu.dk) for new processes
- old RTP is leaving soon

6"/8" Oxidation Furnace (E1) – retrofit

Purpose:

- Furnace tube for 8" / 6" / (4") dry-wet oxidation
- Up to 50 wafer batches
- Accepted November 2021 – **Released**

Results Wet Oxide (acceptance test):

3 runs (x50 wafers): Peak-to-peak: 1.3%

Wafer-to-wafer: 0.35%

Run-to-run: 0.64%

Breakdown voltage in test: 0.85 V/nm (**dry oxide**)





Candidate: Carl Zeiss GeminiSEM 560

Next SEM in 346?

Several top-of-the-line SEM's will be considered and evaluated.

Status:

- A set of **challenging samples** has been collected for **evaluation at demos**:
 - Profile inspection: **ALD deposited multilayers** (down to 5 nm) on Si and SiO₂
 - Tilted top view: **Nanostructures in beam sensitive resists** on fused silica wafer
 - Profile inspection: **Optical gratings in quartz**
 - Tilted top view: **Nanostructures on entire surface** of 150 mm wafer
- **Demos** at Thermofisher and Carl Zeiss have been planned, Hitachi soon to follow...
- **EU tender** this summer - signed contract by the end of the year.

Features:

- **Sophisticated in-column detectors:** The detectors have seen a lot of development since the Supra models. The column now hosts detectors with **energy-selective filtering** to reveal **subtle material contrasts** – from both secondary and backscattered electrons.
- **Greatly improved low vacuum modes: Local charge compensation** that enable the use of in-column detectors (usually reserved for high vacuum) of secondary and backscatter electrons thus dramatically **improving the imaging capabilities on non-conducting samples**
- **STEM detector:** Will be considered.
- **Also: A variety of automated features, beam deceleration...**



Next E-Beam Evaporation System ?

Candidate: FC2000 from FerroTec-Temescal



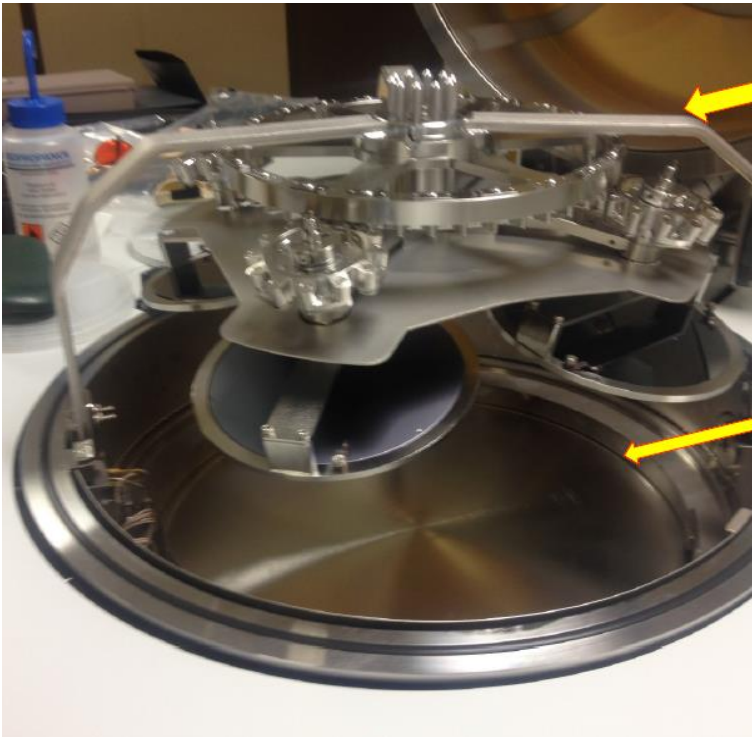
Features in general

- Robust & reliable system – easy maintenance
- High flexibility (substrate sizes)
- Many-pocket (>6) crucible
- High throughput - loadlock
- High-uniformity deposition
- Low sidewall deposition (for lift-off)

Focus points

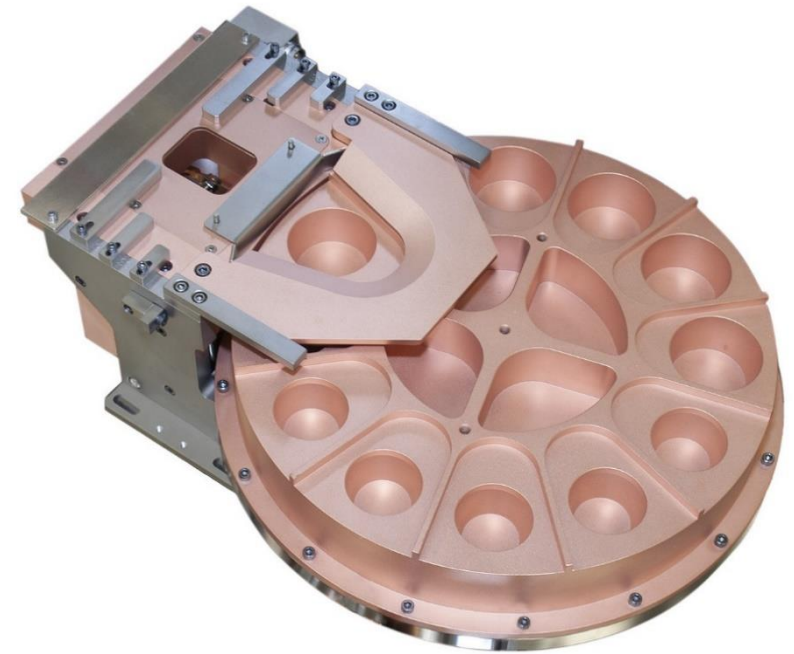
High-Uniformity Lift-off Assembly (HULA substrate holder)

- ensures that wafers spend equivalent periods in high- & low-density regions of the vapor cloud + low sidewall deposition



Many-Pocket system (10 x 25 cc pockets crucible)

- ensures high flexibility on material selection at any time





Dicing saw (JEHAN)

- Dicer Disco DAD 3241
 - for wafers up to 200 mm
 - **Silicon**, (Glass/quartz, ...)
 - Touch screen interface
 - Many advanced features but easy to work with
- Wafer cleaner Disco DCS 1441 (cleaning after dicing)
 - High pressure and Atomizing Nozzle water cleaning
- Various accessories
 - Tape mounter
 - UV tape release
- For training: e-mail training@nanolab.dtu.dk



Thomas P and Disco technician Brian

Plasma Asher 3: Descum



From Packlab -> Cleanroom

Diener Plasma asher Pico

Sample size: up to one 4" wafer
places horizontal in chamber

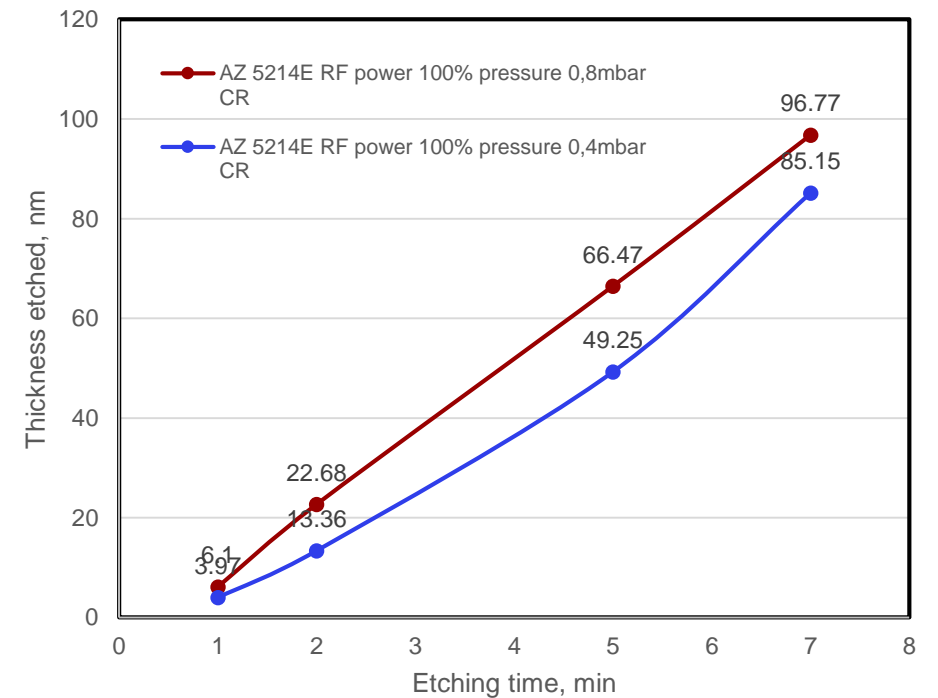
Gas 1: Oxygen

Gas 2: N₂

Plasma power: 0-100% (0-100Watt)

Process time: 0:01-99:59 minutes

AZ 5214E etching with different pressure

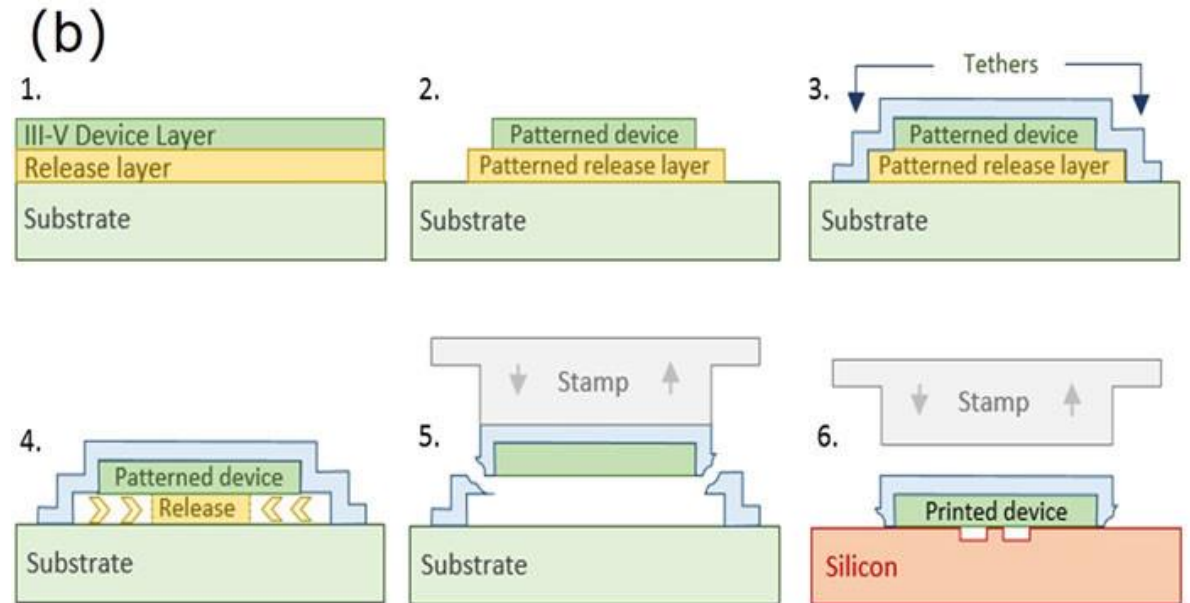
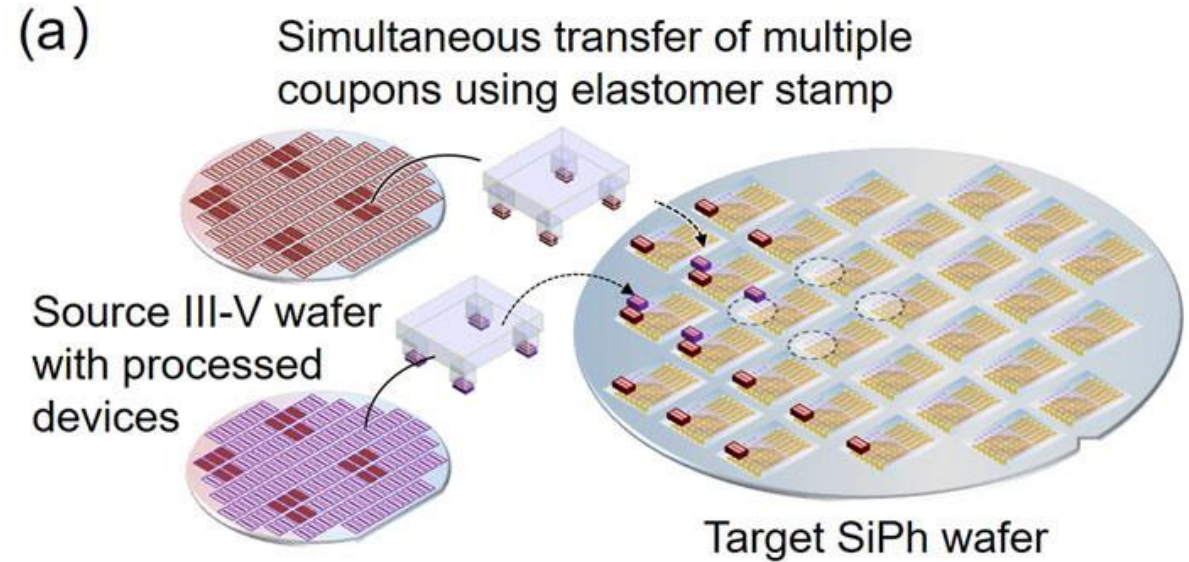


For training: send training request to training@nanolab.dtu.dk

For more test results: take a look at labadviser

μTransfer printing

- Aligned transfer of coupons from one wafer to another.
 - Accuracy like optical aligner.
 - Single more accurate than many.
- Good for moving expensive/incompatible material to larger wafers (silicon/glass etc)
 - Processed III-V semiconductors (or pieces).
 - Processed CMOS chips
 - LiNbO₃, c-Si, BaTiO₃, ???, ???
- Purchased in cooperation with DTU Photonics.
- Expected delivery in September 2022



Raith e-Line e-beam writer moves to cleanroom

- Originally installed in B314
- Has been moved into cleanroom
- Waiting for installation and Raith service
- An alternative to the JEOL 9500
- Expected operational June 2022



End of Presentation

- The supply chain is not as robust as it used to be, measures are taken to stabilize the operation
- Several restructuring projects: soft matter lab, packlab -> PolyFabLab
- **Major facility upgrades/replacements cause closures and inconveniences, FFU**
- Slides will be available online at LabAdviser

