

2nd INTERNATIONAL CONFERENCE 3D MEASUREMENT AND IMAGING

MEDZINÁRODNÁ KONFERENCIA 3D ZOBRAZOVANIE A MERANIE (2. ročník)

IMAGING AND ADVANCED DIAGNOSTIC METHODS IN INDUSTRIAL PRACTICE

ZOBRAZOVANIE A MODERNÉ DIAGNOSTICKÉ METÓDY V PRIEMYSELNEJ PRAXI

Abstracts and Presentations

Abstrakty a prednášky

21. - 22. SEPTEMBER, 2017
ODOBORÁRSKA 21, BRATISLAVA

ABSTRACTS AND PRESENTATIONS

2nd INTERNATIONAL CONFERENCE **3D MEASUREMENT AND IMAGING** **IMAGING AND ADVANCED DIAGNOSTIC METHODS IN INDUSTRIAL PRACTICE**

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ODOBORÁRSKA 21, BRATISLAVA

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CONTENTS

21st September, 2017

Session 1 (10.15-12.30)

Dvojfotónová mikro-stereolitografia a jej aplikácie v biomedicíne / Two-photon micro-stereolitography and its applications in biomedicine –	1
<i>RNDr. Dušan Chorvát, PhD. and Mgr. Tibor Teplický, International Laser Centre (SK)</i>	
The future of machine vision cameras in embedded Applications –	2
<i>Christoph Noth, Allied Vision (EN)</i>	
Delivering Inline Metrology with FactorySmart® Sensor Technology –	30
<i>Christian Benderoth, LMI Technologies(EN)</i>	

Session 2 (13.30-15.30)

Imaging using near-field microscopy and near-field lithography –	58
<i>doc. Ing. Dušan Pudiš, PhD., University of Zilina (SK)</i>	
Výkonnosť v oblasti nanotechnológií / Performance in nanospace – TESCAN S8000 –	83
<i>Ing. Hana Tesařová, PhD., Tescan (CZ)</i>	
Kombinované laserové a fotogrametrické meranie zo vzduchu a zo zeme / Combined laser and photogrammetric measurement from the air and from the ground –	143
<i>Ing. Marko Paško, X3D (SK)</i>	

Session 3 (16.00-17.30)

Challenges in 3D scanning –	158
<i>Mgr. Ján Žižka, PhD., Photoneo (EN)</i>	

22nd September, 2017

Session 4 (9.30-11.00)

Methods of examining the condition of works of art in the current conditions of collector institutions –	187
<i>Akad. Mal. Veronika Gabčová, PhD. a Mgr. Branislav Horňák, Slovak National Gallery</i>	
3D wood analysis using electron microscope –	236
<i>Ing. Mamoňová PhD., TUZVO</i>	
Aplikácie bezkontaktných meracích systémov v autonómnej mobilite / Applications of contactless measurement systems in the autonomous mobility –	319
<i>prof. RNDr. Branislav Sitár, DrSc., FMFI UK (SK)</i>	

Session 5 (11.30-13.00)

Smart customization of 3D sensors with application specific algorithms –	333
<i>Andreas Hoffman, LMI Technologies (EN)</i>	
Inšpekcia a detekcia materiálov pomocou riadkových kamier/ Inspection and detection of materials using line scan cameras –	367
<i>Ing. Pavol Polóni, Camea</i>	

TWO-PHOTON MICROSCOPY, MICRO-STEREOLITOGRAPHY AND THEIR APPLICATIONS IN BIOMEDICINE

Dušan Chorvát¹, Tibor Teplický²

¹ International Laser Centre, Bratislava

² University of St. Cyril and Methodius, Faculty of Natural sciences, Trnava

Abstract

Design and fabrication of biocompatible microstructures is an important prerequisite for number of biomedical experiments. In this regard, two photon photopolymerization is a very useful tool for creation of micro and nano structures. It uses laser beam with longer wavelength and energy below the polymerization threshold, where the threshold can be reached in the focus by multi-photon absorption process. Moving of the laser focus spot through the resin allows to build up a complete 3D structure of a chosen design with micrometer resolution. Polymer structures presented in this work were made by 2-photon photopolymerisation of OrmoComp (Micro Resist Technology GmbH) using uFAB workstation (Newport) with Spirit ultrafast amplified laser running at 520nm.

Multimodal imaging combined with pulsed laser excitation is currently a leading-edge technology of optical microscopy. In particular, the combination of imaging, steady-state spectroscopic methods with time-resolved detection techniques provides more precise insight into native cell behaviour. Excitation by near infrared pulsed laser allows better spatial separation of fluorescence signal, as well as utilization of nonlinear imaging modes such as second-harmonic generation. In our contribution we present data obtained from confocal microscope LSM 510 META (Zeiss) with nonlinear optical excitation by ytterbium laser (t-pulse 50, Amplitude Systemes, 1040nm), combined with spectrally and time-resolved fluorescence imaging (Becker & Hickl HPM 100-40 detectors, BDL-475 laser and SPC-830 TCSPC board). We present application of this system for imaging of various biomedical structures and processes, such as the study of collagen in native tissue samples (Fig.1).

Acknowledgements

Supported by EU Horizon 2020 research and innovation programme under grant agreement No. 654148 Laserlab-Europe. We acknowledge Dr.M. Uherek for providing rat aorta samples.

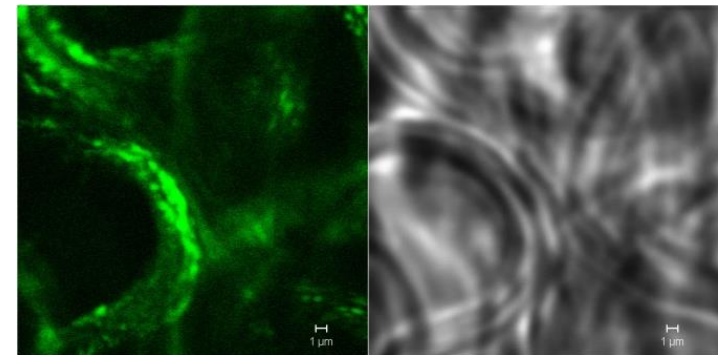


Fig 1 : Collagen matrix in rat aorta imaged by second harmonic generation microscopy (left) compared to transmitted light imaging (right).

The future of machine vision cameras in embedded Applications

Christoph Noth | Sales Manager EMEA

- // Allied Vision – Who we are?
- // The advantages and disadvantages of designing a machine vision camera based on ASIC technology
- // What is MIPI CSI-2 and why is it a relevant Interface for machine vision?
- // Characteristics of embedded vision systems

Allied Vision- Who we are?

The Right Camera for Each Application



Essential

Ultra-compact, affordable cameras with basic feature set for simple plug-and-play integration into commonly used image-processing systems.



Guppy PRO



Mako

Enhanced

Versatile cameras offering a large choice of sensors, modular options, and integrated image optimization functions for advanced machine vision applications.



Manta



Stingray

Extreme

High-performance cameras with special features such as high resolution, extended operating temperature range or infrared sensitivity to fulfill the most demanding requirements.



Prosilica GT



Goldeye

Applications Examples



Industrial Inspection



Ziemann & Urban
Inspection of BMW
instrument panel
carriers

Healthcare & Medical



Carl Zeiss Meditec
Ophthalmologic
examination device

Science & Nature



NASA
ISS astronaut-robot
Robonaut 2

Security & Traffic



Kria
Radar-free speed
enforcement

Multimedia & Entertainment

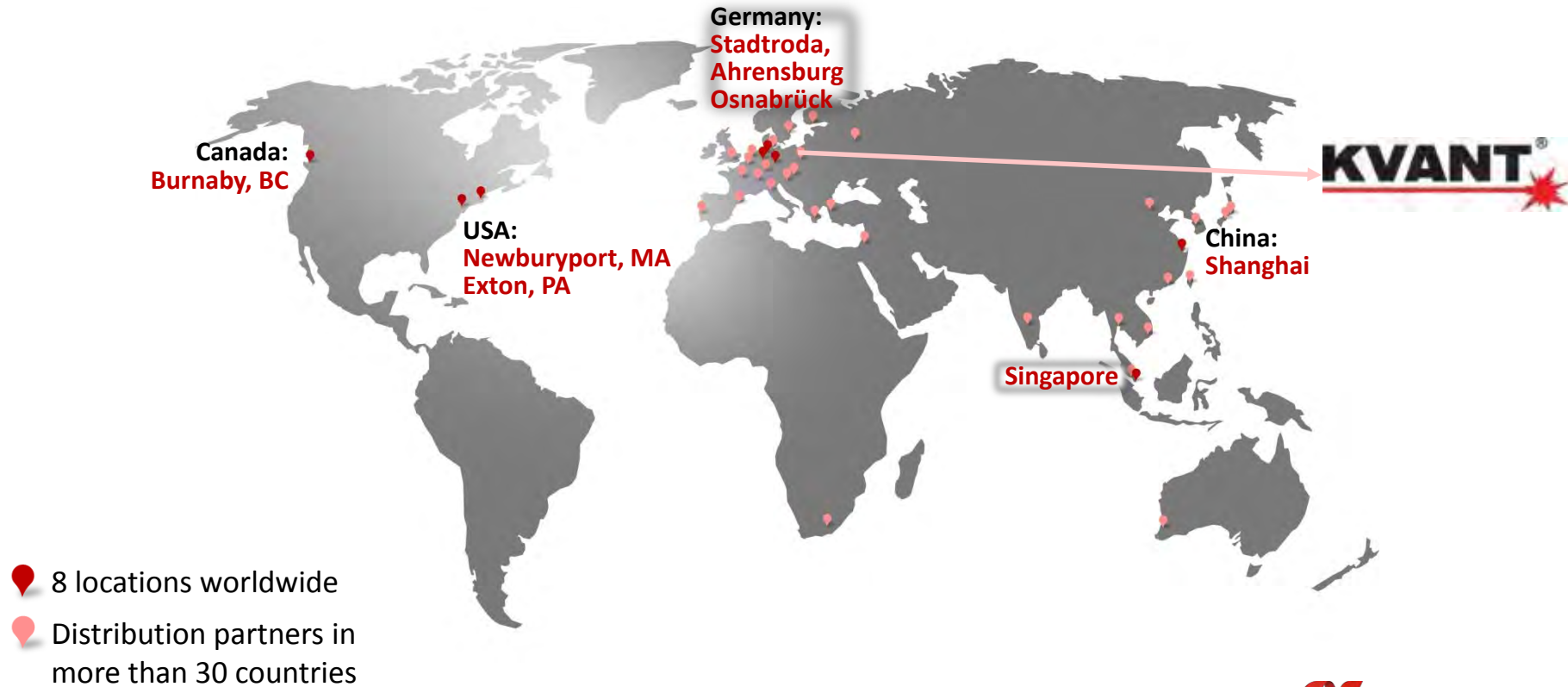


Forever 21/space150
Times Square, NYC
giant interactive
billboard

Our Success-Story

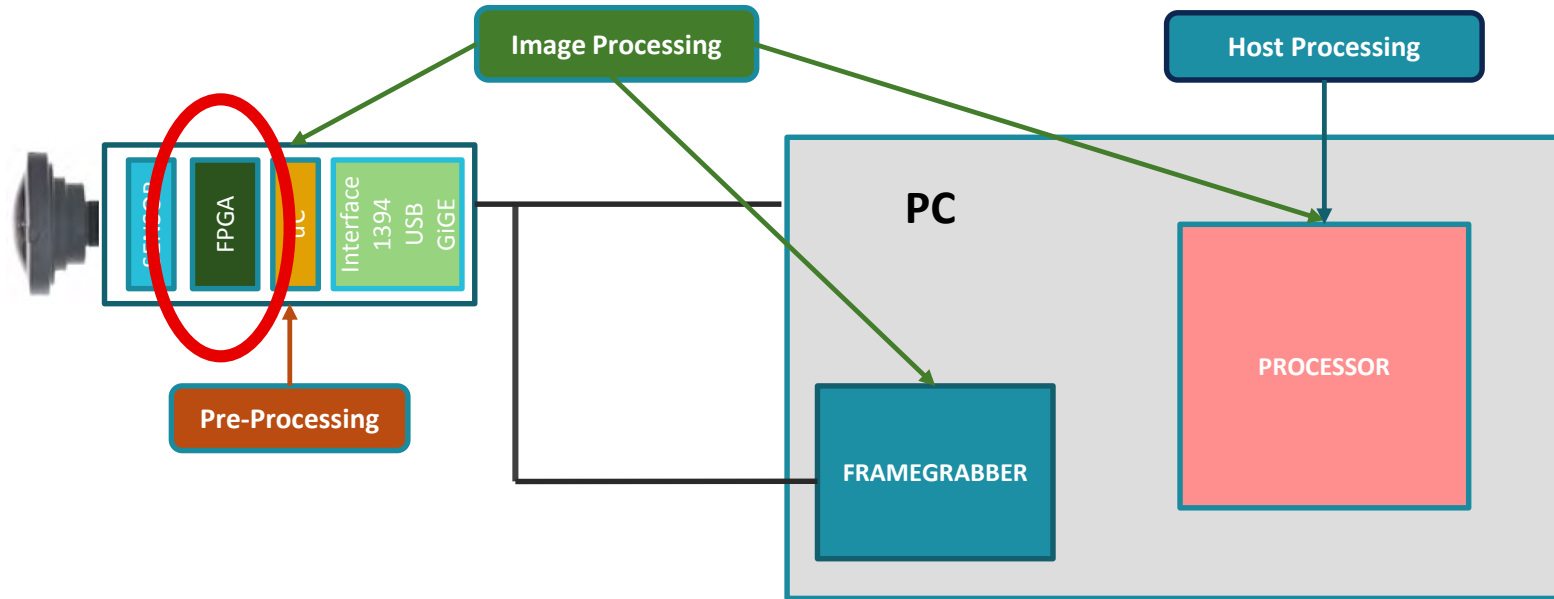
- 1989** Company founded as M. Sticksel CCD-Kameratechnik GmbH (Sony distribution)
- 1996** Production facilities opened in Stadtroda, Germany
- 2000** Acquisition by Augusta Technologie AG
- 2001** Renaming to Allied Vision Technologies
R&D center opened in Ahrensburg, Germany
- 2002** Launch of Dolphin, first Allied Vision-developed and Allied Vision-built camera
- 2006** Allied Vision Technologies, Inc. opened in Newburyport, MA (USA)
- 2008** Acquisition of Prosilica, Inc. in Burnaby, BC (Canada)
- 2010** Prosilica, Inc. renamed Allied Vision Technologies Canada Inc.
Allied Vision Technologies Asia Pte. Ltd. opened in Singapore
- 2011** Acquisition and integration of VDS Vosskühler GmbH in Osnabrück, Germany. Entry into the infrared market
- 2012** Allied Vision Technologies (Shanghai) Co. Ltd. opened in Shanghai, China
- 2014** New branding to Allied Vision
- 2015** Allied Vision becomes a member of the TKH Group

A Global Player



The advantages and disadvantages of designing a machine vision camera based on ASIC technology

Typical Machine Vision Architecture



*“A **field-programmable gate array (FPGA)** is an integrated circuit (IC) designed to be configured by a customer or a designer after manufacturing.”*

*“An **application-specific integrated circuit (ASIC)** is an integrated circuit (IC) customized for a particular use, rather than intended for general-purpose use.”*

General ASIC vs FPGA overview - this sums it up nicely



	FPGA	ASIC
Time to Market	Fast	Slow
NRE	Low	High
Design Flow	Simple	Complex
Unit Costs	High	Low
Unit size	Medium	Low
Performance	Medium	High
Power consumption	High	Low

Effort required to develop an ASIC



Market Analysis



ASIC Design

- Architecture Specification
- CODE Generation
- Synthesis
- Pre-Layout Verification
- Design Implementation
- Physical Implementation
- Post-Layout Verification
- Physical Verification
- Post-Layout Review

ASIC Production

- Mask Tooling
- Fabrication
- Wafer Sort
- Assembly
- Final Test
- Chip Qualification
- Chip Characterization
- Chip Reliability
- Corner Split

Final ASIC



Practical considerations of using an ASIC for a machine vision camera design



// Market trend towards embedded vision systems



Cameras with low power consumption and small size required



// More and more mass volume vision applications



Low cost cameras with dedicated performance required

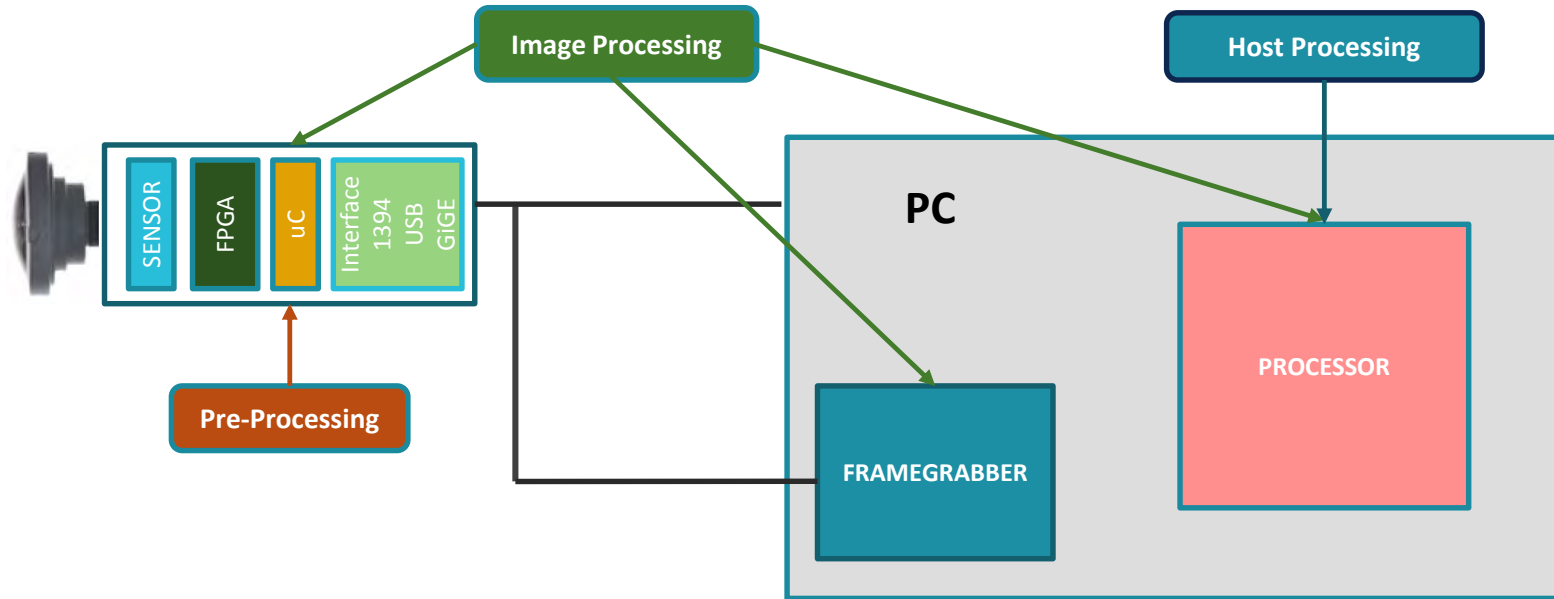


Comparison of an established camera versus new ASIC based camera

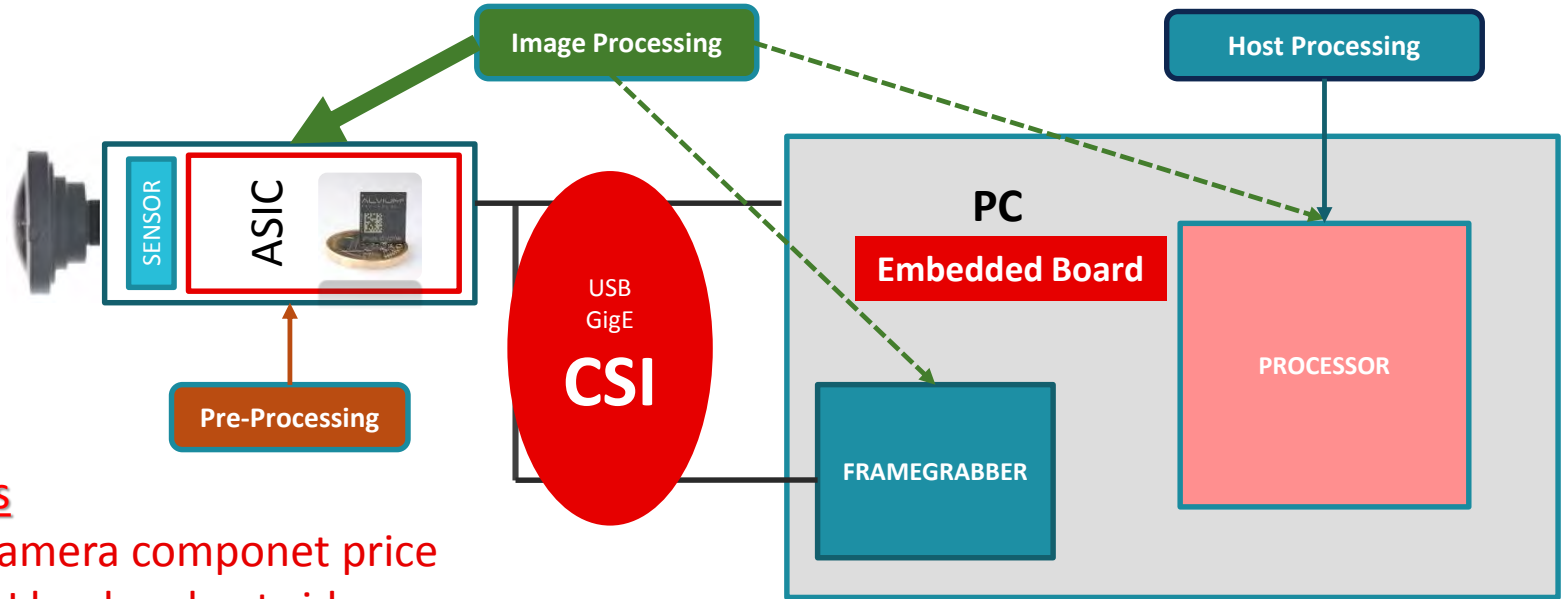


	FPGA based camera	ASIC based camera
Power consumption	High	Low
Unit size	Medium	Small
Costs	Higher unit costs / Low NRE	Low unit costs / High NRE
Feature level	Oversized	Dedicated to application
Time to Market	Fast	Slow
Performance	Lower	High

Typical Machine Vision Architecture



ASIC based machine vision Architecture



Advantages

- Lower camera component price
- Less CPU load on host side
- Less power consumption
- Higher performance
- **!!! New Interface: CSI !!!**

What is MIPI CSI-2 and why is it a relevant Interface for machine vision?

What is CSI?



// **CSI** stands for **C**amera **S**erial **I**nterface

// and is a specification of the

// **M**obile **I**ndustry **P**rocessor **I**nterface (**MIPI**)

alliance.



Prevalence of CSI-2 on embedded processing boards



Comparison of CSI-2 to other commonly used Machine Vision Interfaces

	CSI-2 D-PHY	USB3.0 USB 3.1	GigE Vision
Bandwidth	Up to 2.5Gbit/s per lane 4 lanes up to 10Gbit/s	5Gbit/s	1Gbit/s
Cable Length	Up to 0.6m	Up to 8.0m	Up to 100m
Integration effort	High	Easy	Easy
CPU load on host	Low	High	High
Availability on embedded boards	High	Limited (only high-end)	Limited (only high-end)



Adapters of CSI-2 – Embedded boards & CoM



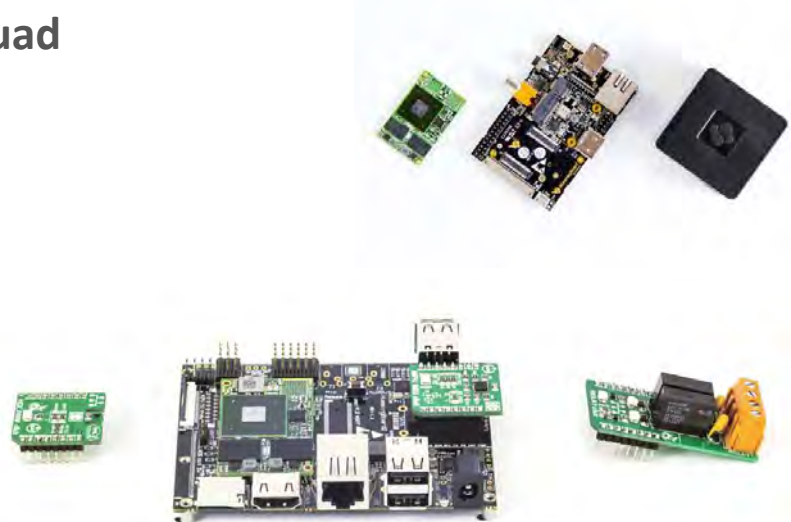
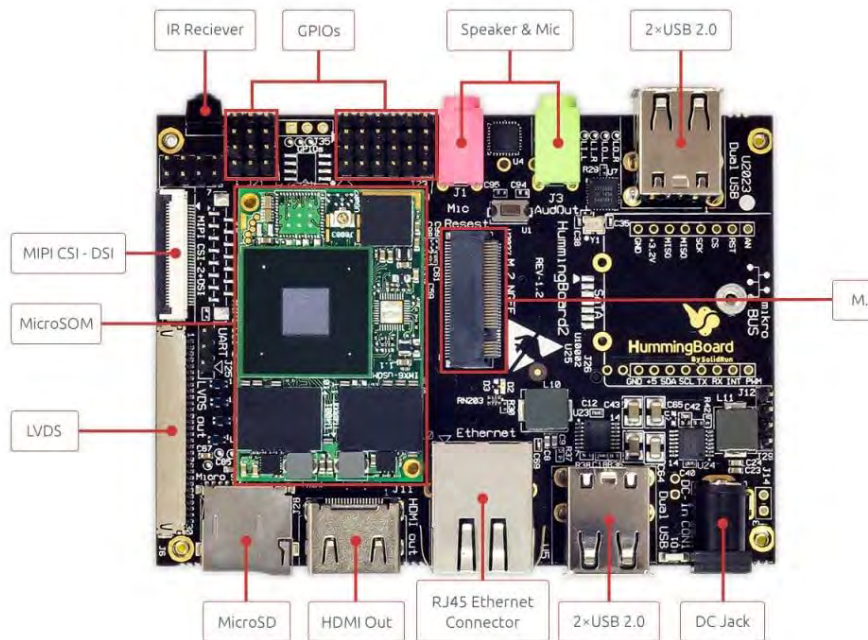
- **Broadcomm 64bit QuadCore ARMv8**
 - Raspberry Pi Zero **(10€)** *(CSI-2...yes we can ☺...)*
 - Raspberry Pi 3 model B **(35€)**
 - Quad Core 1.2GHz Broadcom BCM2837 64bit CPU
 - 1GB RAM
 - BCM43438 WiFi and Bluetooth Low Energy (BLE) on board
 - 40-pin Extended GPIO
 - 4x USB 2 ports
 - 4 Pole stereo output and composite video port
 - HDMI
 - CSI camera port for connecting a Raspberry Pi camera
 - DSI display port for connecting a Raspberry Pi touchscreen display
 - Micro SD port for loading your operating system and storing data



Adapters of CSI-2 – Embedded boards & CoM



- NXP Freescale ARM Cortex - iMX6 solo/Dual/Quad
 - SoM modules for iMX6 by SolidRun (85€)



!!! Issue is only USB2.0 ports but CSI-2 and Ethernet 1Gb with IEEE1588 ☺

Adapters of CSI-2 – Embedded boards & CoM



- NVIDIA
 - JETSON TK1 & TX1 CoM modules (500€)

UNMATCHED PERFORMANCE

- The world's first supercomputer on a module
- Highest performance and power efficiency
- Revolutionary NVIDIA Maxwell™ architecture with 256 CUDA cores delivering over 1 TeraFLOPs
- 64-bit CPUs
- 4K video encode and decode capabilities
- camera interface capable of 1400 MPix/s
- Applications:
 - Computer vision, graphics, and GPU computing.



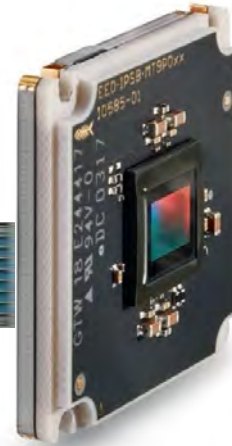
Embedded machine vision application



**Allied Visions
1 Productline**

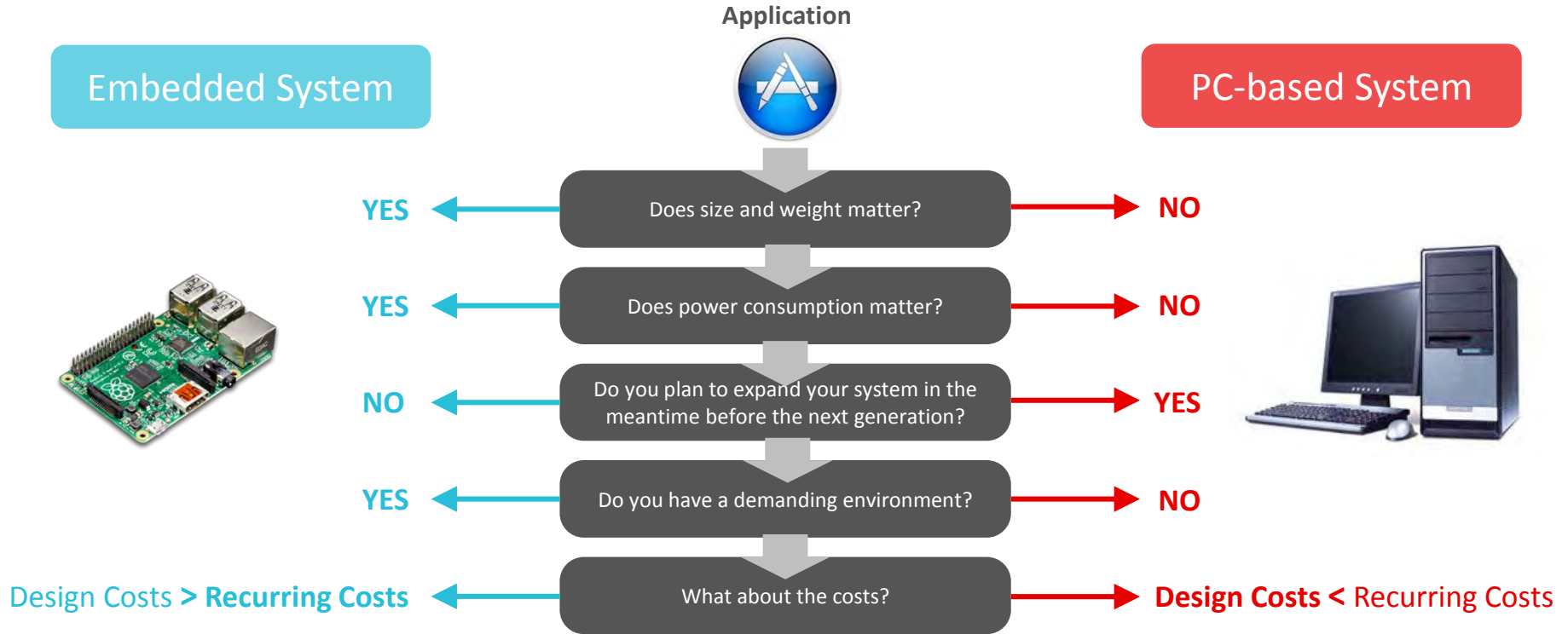


The MIPi logo consists of the word "mipi" in a lowercase, black, sans-serif font. Above the letters "i" and "p" is a semi-circular arc of seven small, colored dots in red, orange, yellow, green, blue, and purple.



Characteristics of embedded vision systems (low power/size/runtime cost; high effort/upfront development cost)

Characteristics of embedded vision systems (low power/size/runtime cost; high effort/upfront development cost)



Thank You/Q&A

DELIVERING INLINE METROLOGY WITH FACTORYSMART® SENSOR TECHNOLOGY

Christian Benderoth¹

¹ Regional Development Manager EMEA, LMI Technologies

Abstract

In this talk, LMI will discuss the state of the metrology industry, which has largely focused on first article or random part inspection for comparison to CAD or reverse engineering. With the increasing need for inline metrology, LMI will present how 3D smart sensors provide an effective solution to achieving 100% quality control leveraging new multi-sensor capabilities to deliver inspection solutions that can reach a high degree of accuracy and repeatability in correlation to CMM machine studies.

DELIVERING INLINE METROLOGY WITH FACTORYSMART SENSOR TECHNOLOGY

2nd International Conference 3D Measurement and Imaging

21 September, 2017

Christian Benderoth
Managing Director / Regional Development Manager



QUICK FACTS



Owned by TKH Group

39+ years experience
1978 – Present



*One of our
Selcom
displacement
sensors
developed in the
1970s*

**100+ patents
and 220+
employees**



**110,000+ sensors
in the field**



ABOUT LMI TECHNOLOGIES



Vancouver,
Canada
Headquarters

GLOBAL PRESENCE

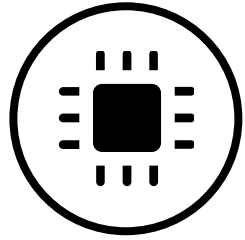


ABOUT LMI TECHNOLOGIES

Gocator

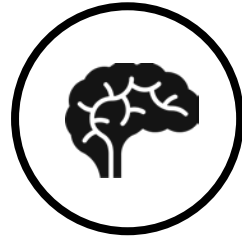


UNIQUE BUSINESS APPROACH



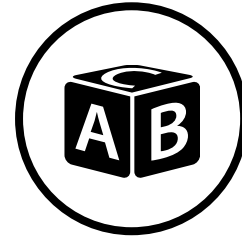
CHIP LEVEL ENGINEERING

We design and deliver proven technologies at the lowest cost



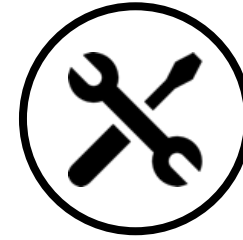
SIMPLE USER EXPERIENCE

You don't need to be a rocket scientist to use our products – just point and click



PROGRESSIVE PARTNERSHIPS

We build OEM and SI solutions in support of our long term partnerships



STATE OF METROLOGY

» Why can't we achieve accuracy and precision in the factory?



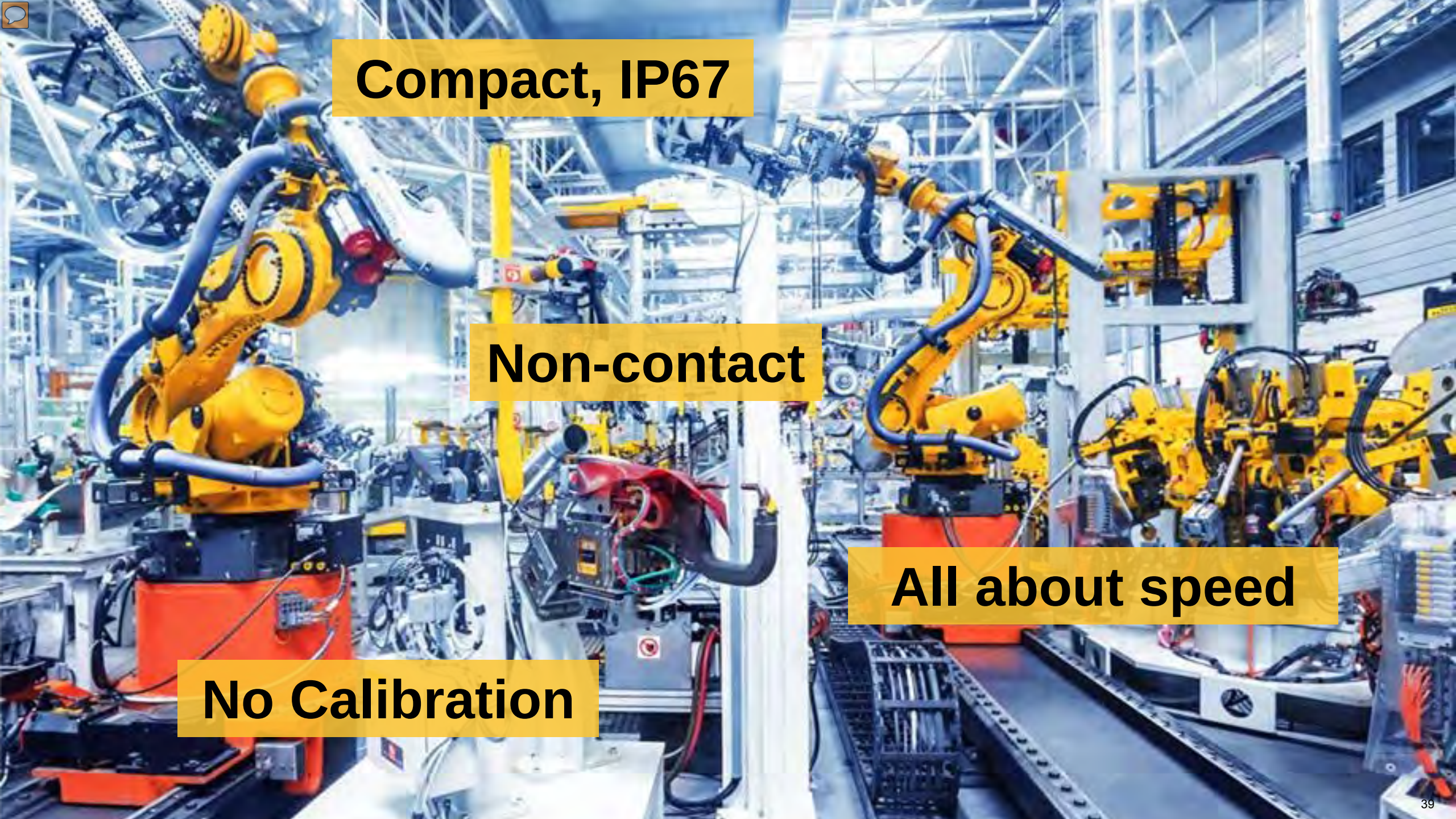


Lab environment

Contact-based

Calibration required

Slow

A photograph of a modern industrial factory floor. Several yellow robotic arms are visible, mounted on red bases, working on a production line. The background shows a complex network of metal structures and overhead lighting. The scene is brightly lit, emphasizing the industrial environment.

Compact, IP67

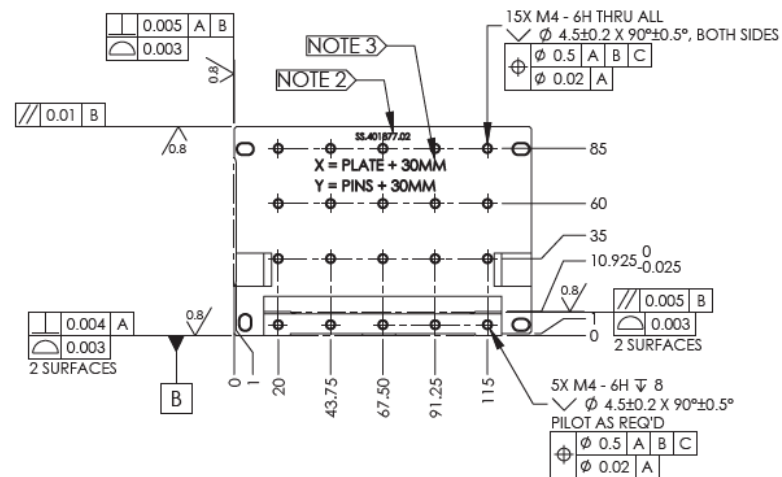
Non-contact

All about speed

No Calibration

TYPICAL METROLOGY PROCESS

- » Metrology today has traditionally focused on acquiring accurate 3D scans of real world objects, for:
 - » Comparison of first articles to CAD models

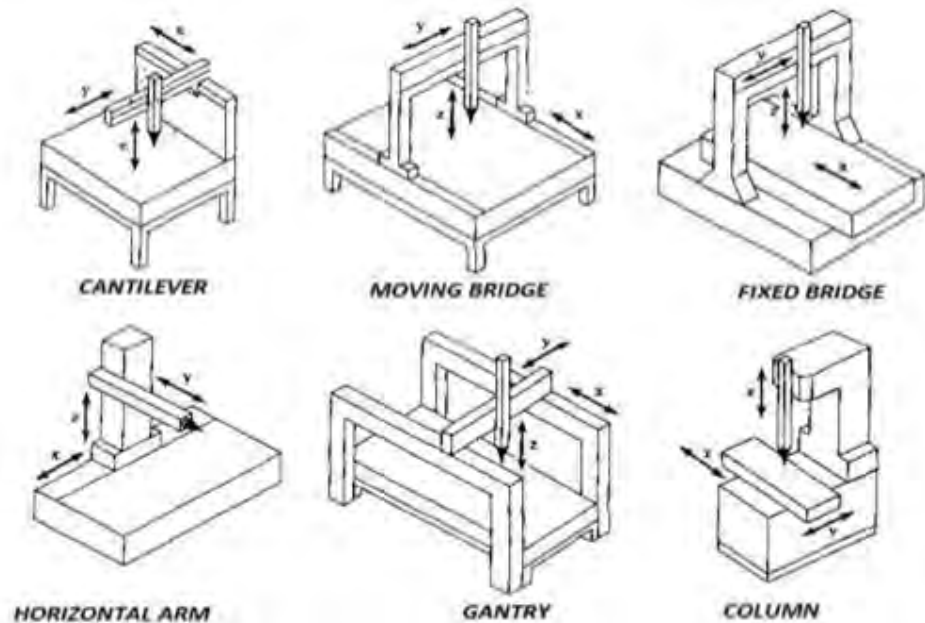


TYPE OF TOLERANCE	CHARACTERISTIC	SYMBOL
FORM	STRAIGHTNESS	—
	FLATNESS	▭
	CIRCULARITY	○
	CYLINDRICITY	⊘
PROFILE	PROFILE OF A LINE	⌒
	PROFILE OF A SURFACE	⌒
ORIENTATION	ANGULARITY	∠
	PERPENDICULARITY	⊥
	PARALLELISM	∥
LOCATION	POSITION	⊕
	CONCENTRICITY	⊙
	SYMMETRY	≡
RUNOUT	CIRCULAR RUNOUT	↗
	TOTAL RUNOUT	↗↗

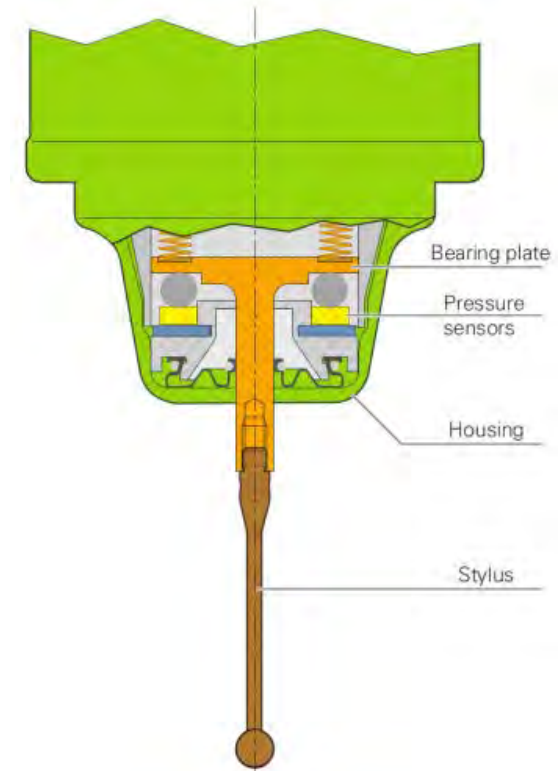
TYPICAL METROLOGY MACHINE

Coordinate Measuring Machine

- » A 3D device for measuring the physical geometrical characteristics of an object
- » Manually controlled by an operator or computer



Mechanical CMM Structures



FROM THE LAB TO THE FACTORY FLOOR

- » Over the past 5 years, advances with structured light scanners or handheld portable scanners with laser trackers have produced 3D scans sufficiently fast and accurate enough to move onto the factory floor to support random sampling part verification.
- » Contact based → non contact-based





COMPARISON: METROLOGY VS. INSPECTION

Metrology	Inspection
Offline in measuring room, clean and controlled	In-line or at-line (if not fast enough), factory environment introduces lots of variation (ambient light, vibration, temp, dust, water, oil, etc.)
Largely contact based using touch probes	Always non-contact based using lasers or structured light
Long acquisition process; takes minutes	Short acquisition, short tact/cycle times; take milliseconds
Highest level of accuracy; performs GD&T analysis and reporting	Performs PASS/FAIL and communicate results with all factory networking protocols
Requires regular or frequent calibration	No calibration needed!





THE NEW STATE: INLINE METROLOGY

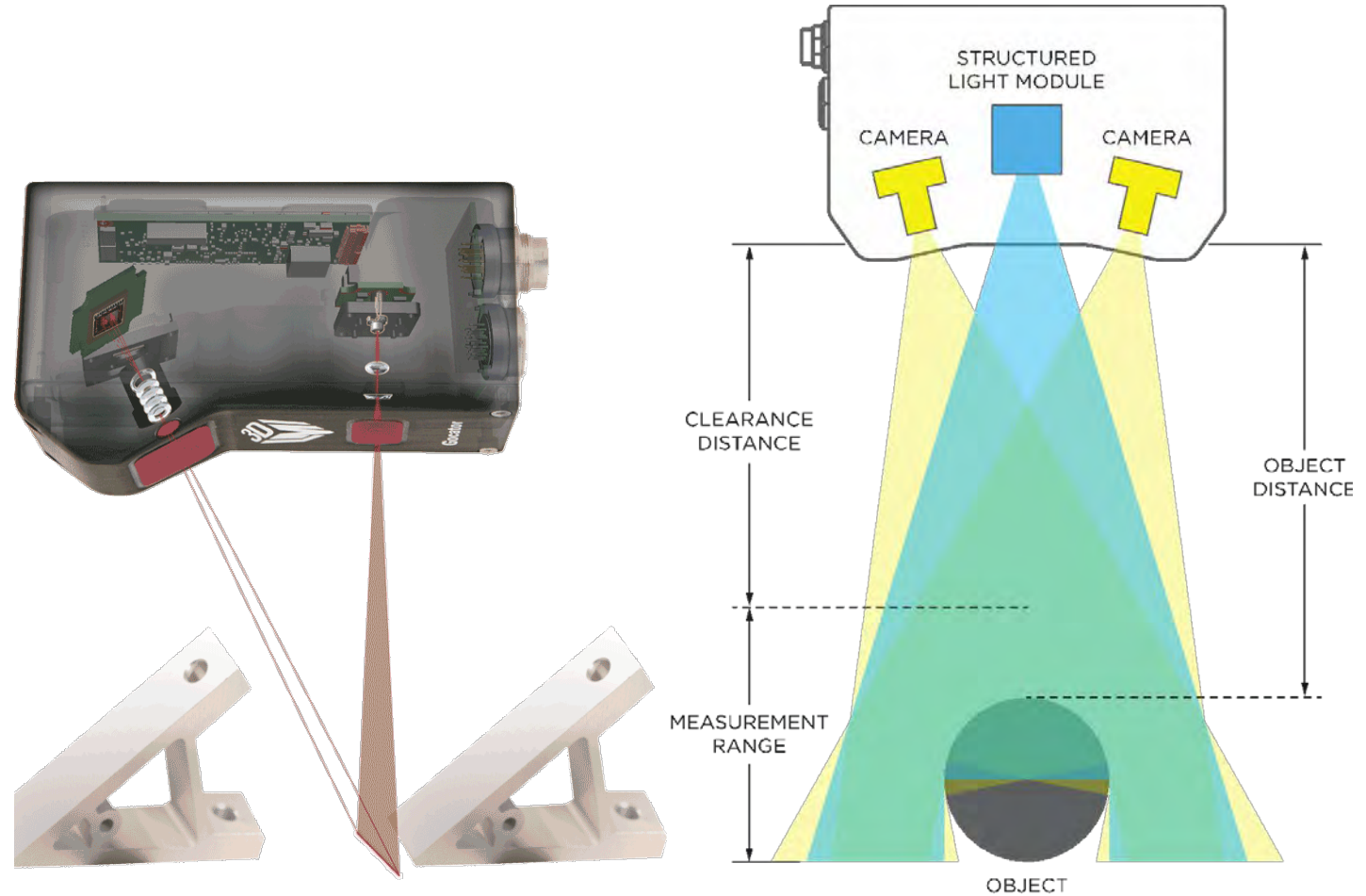
Inline Metrology

	In-line, factory environment introduces lots of variation (ambient light, vibration, temp, dust, water, oil, etc.)
	Always non-contact based using lasers or structured light
	Short acquisition, short tact/cycle times; take milliseconds
Highest level of accuracy with high repeatability	Performs PASS/FAIL and communicates results
	No calibration needed!



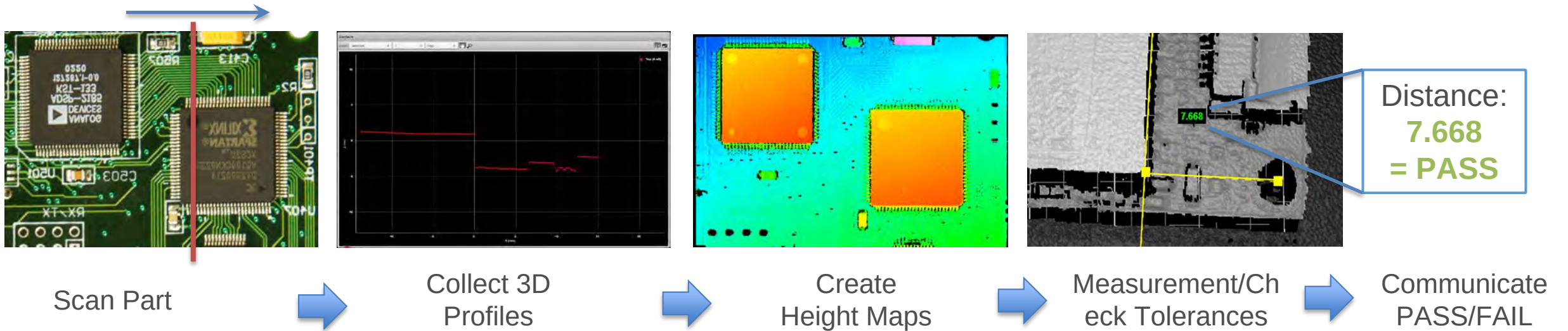
TYPICAL INLINE MEASUREMENT DEVICES

- » 3D sensor technologies:
 - ◉ Laser triangulation
 - ◉ Structured light
- » Industrial housing
- » Calibrated once in the factory, holds accuracy in industrial environments
- » Embedded processing makes hardware “smart”



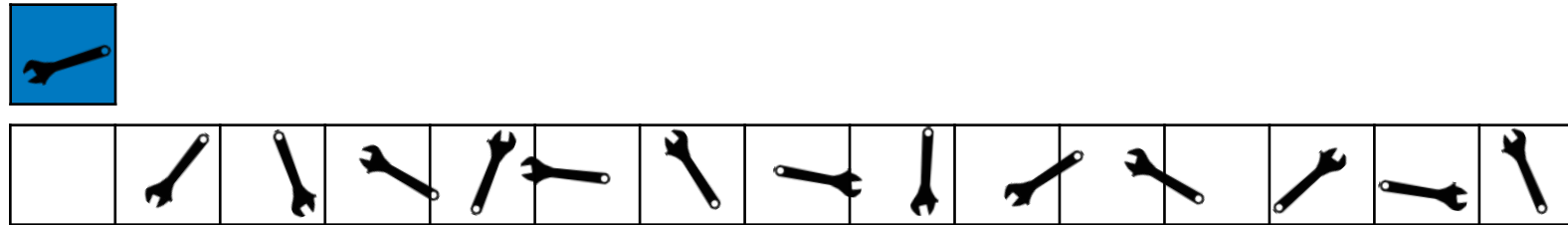
TYPICAL INSPECTION PROCESS

- » Inspection carries out scanning, measurement, and control – all inline while a part is in motion:
 - » A trigger causes a profile scan or an area scan
 - » 3D point clouds are generated
 - » Measurements computed
 - » Check to tolerances
 - » Communicate pass/fail

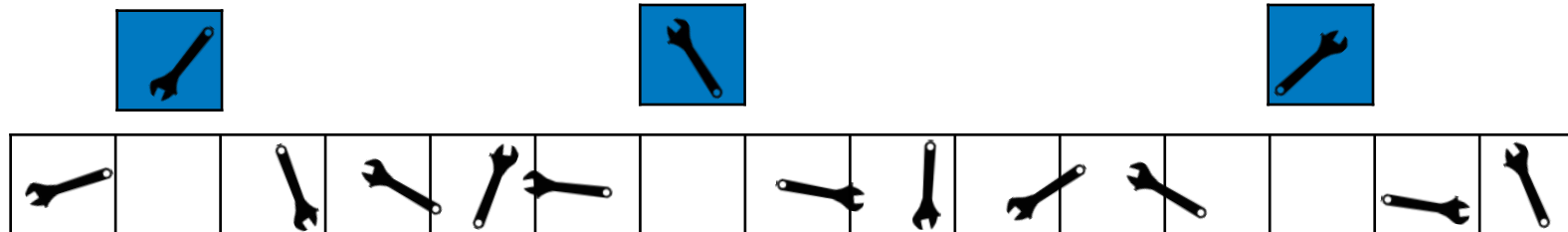


TOWARDS 100% QUALITY CONTROL

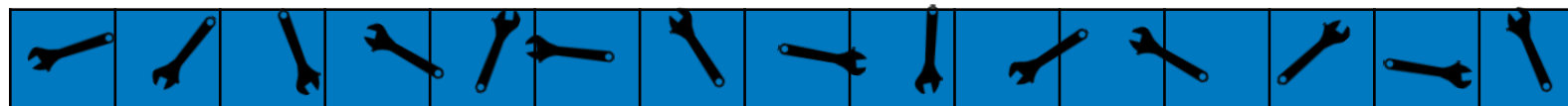
Part Inspection



At-line
Random part
inspection

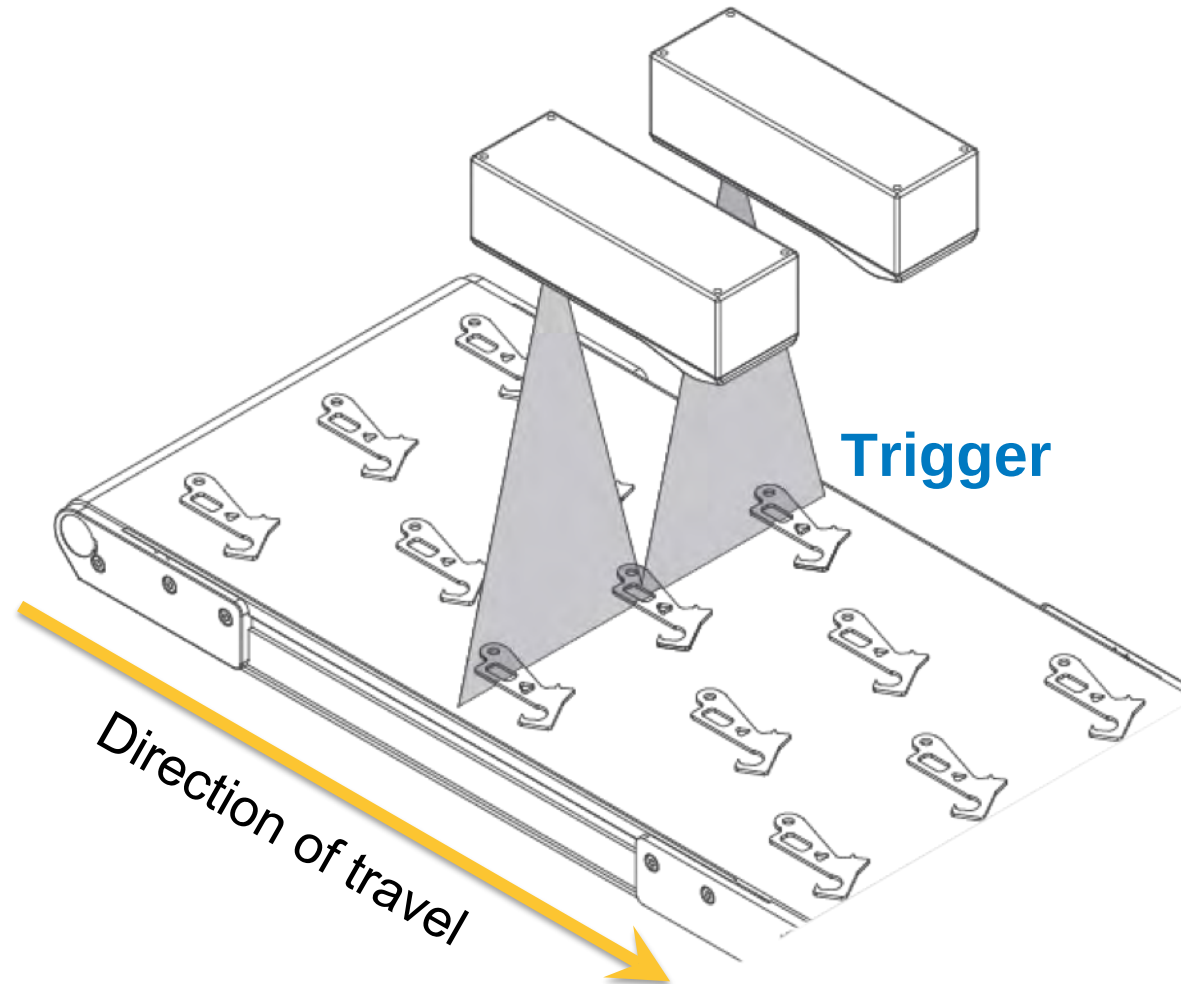


In-line 100%
part inspection



TOWARDS 100% QUALITY CONTROL

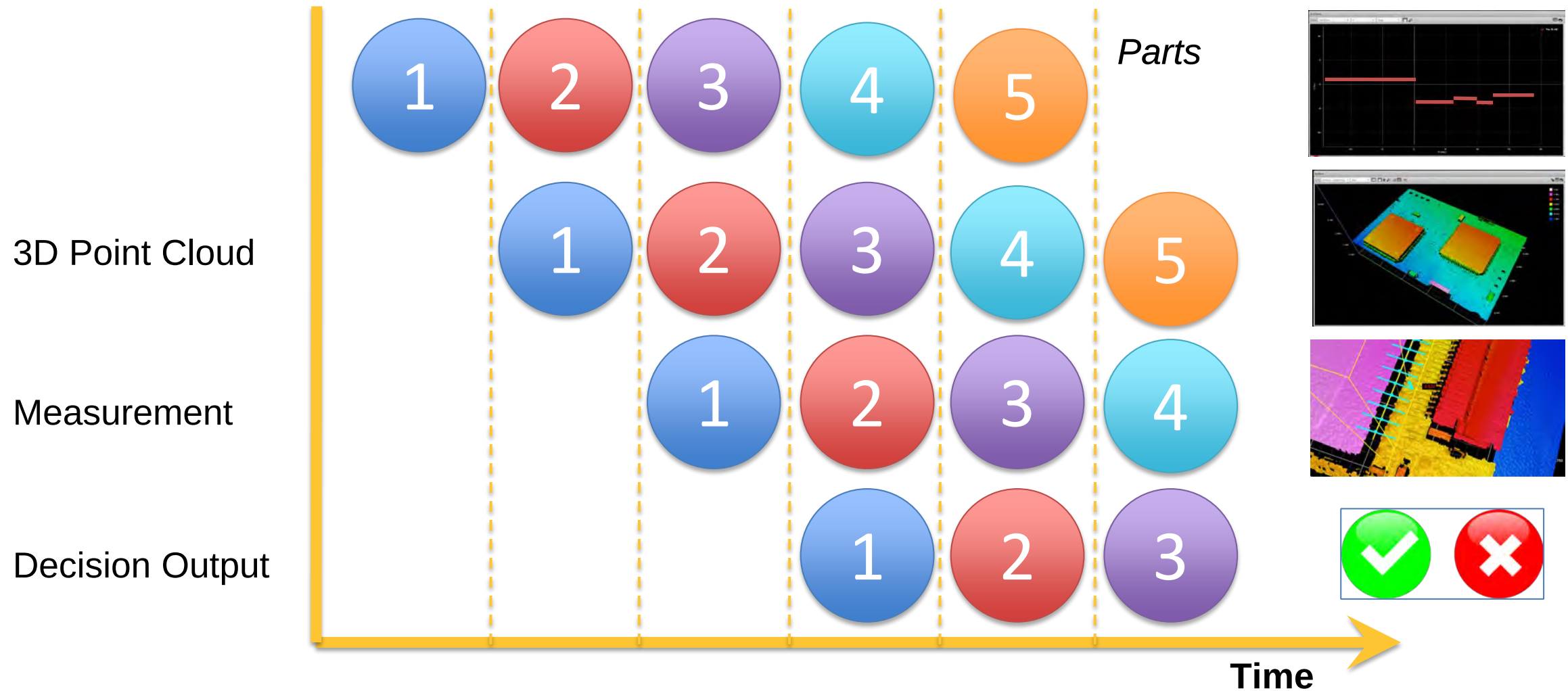
- Need for speed increases
 - Acquisition time is short: scanning, measuring
 - Running in milliseconds
- Size of measuring devices become smaller (because of space constraints)



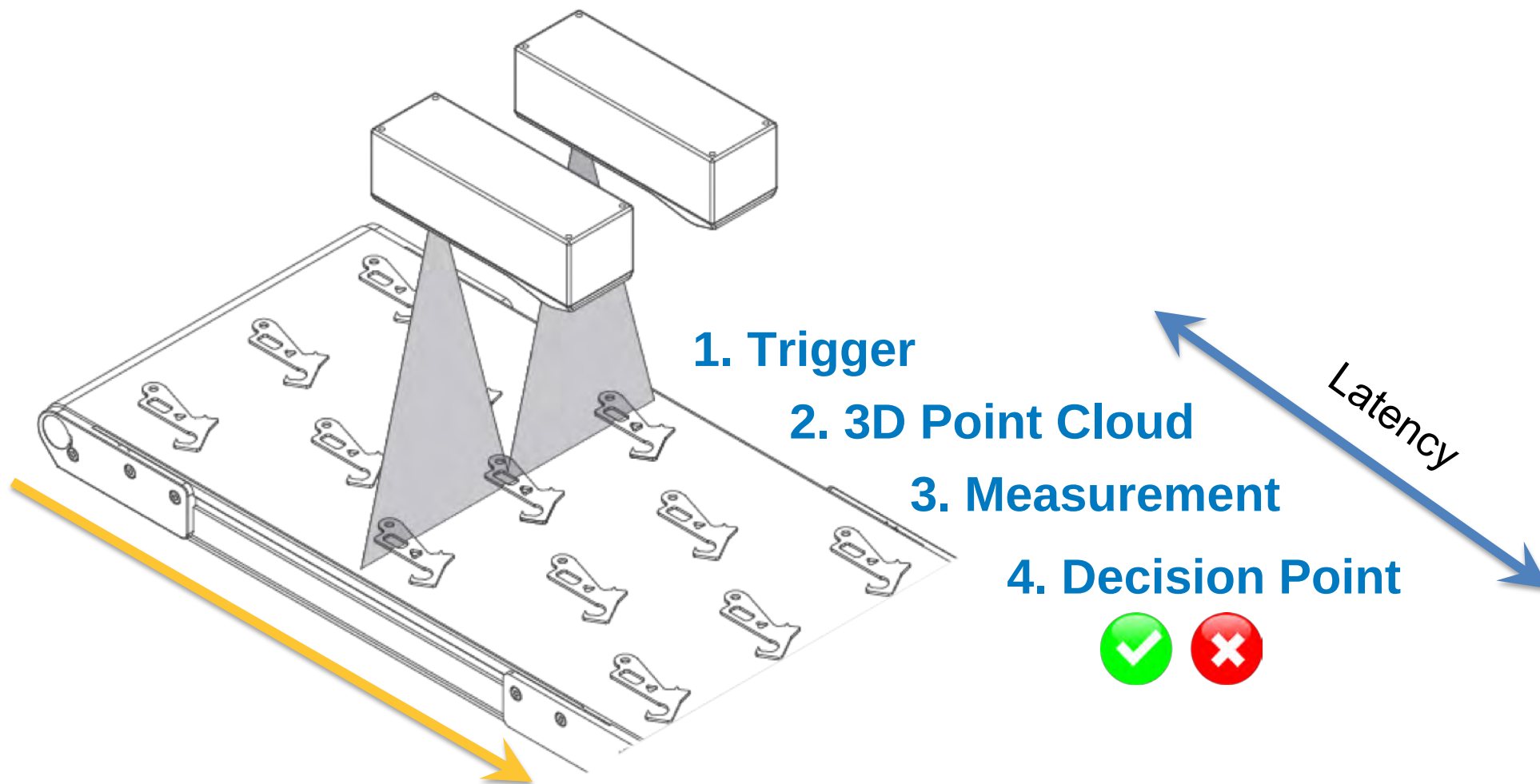
Decision Point



GOCATOR REAL-TIME PIPELINE PROCESSING



GOCATOR PIPELINE LATENCY



SMART STANDALONE VS. PC

- » Trigger
- » 3D point cloud generation
- » Part segmentation
- » Part rotation
- » Part sectioning
- » Measurement
- » Pass/fail decision outputs

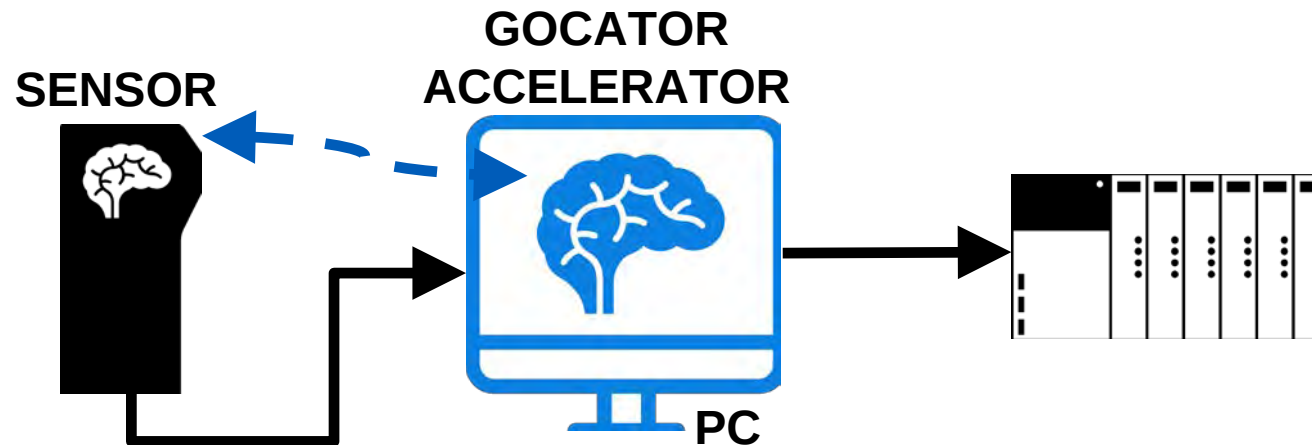
PC-Accelerated

- » Speed up processing times to reduce cycle times
- » Manage and control multiple sensors
- » Stitch multiple 3D point clouds

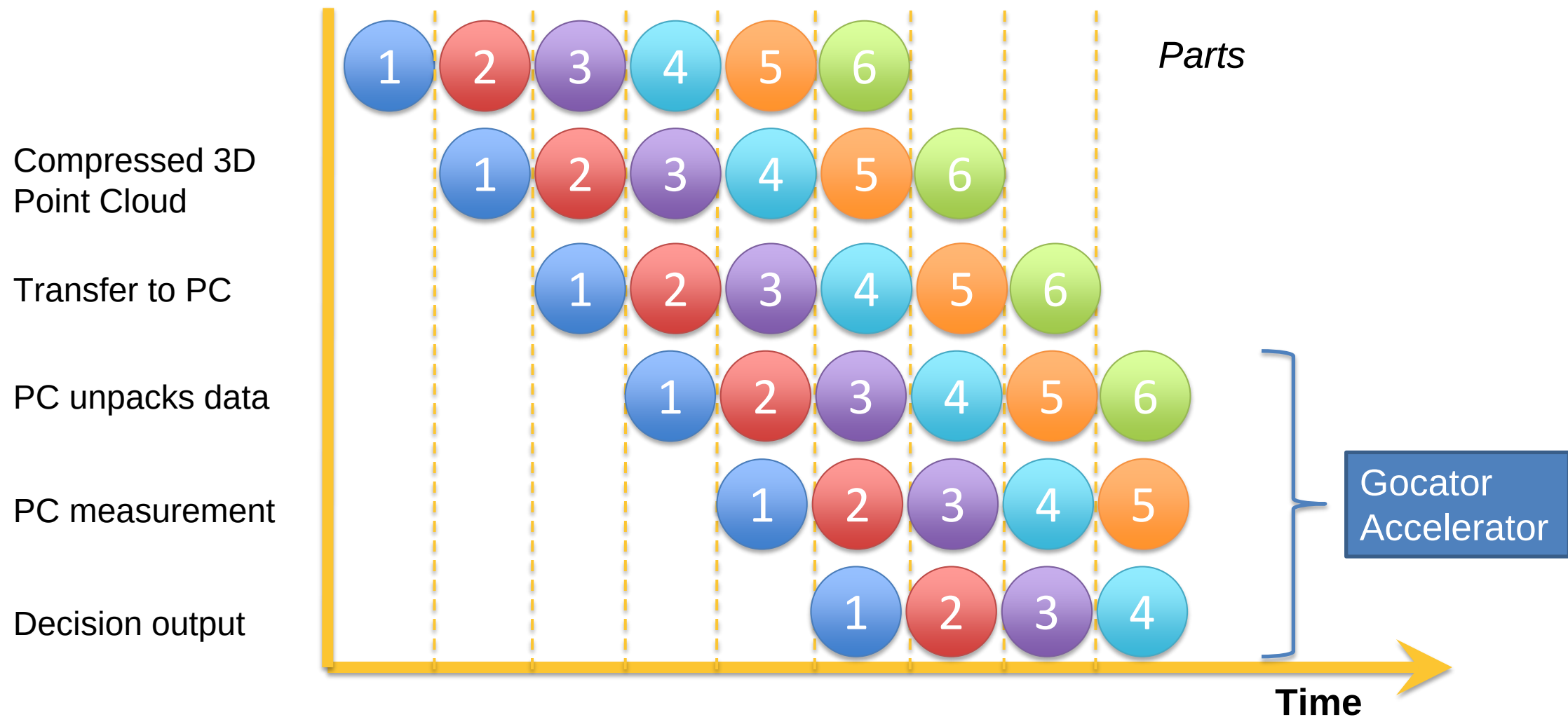


SEAMLESS ACCELERATION

- » With Gocator Accelerator:
 - » Adds faster data-processing power
 - » Windows PC application that adds the processing power of one or more PCs
 - » Reduce cycle time and remove memory limitations



FASTER PIPELINED RESULTS WITH ACCELERATOR



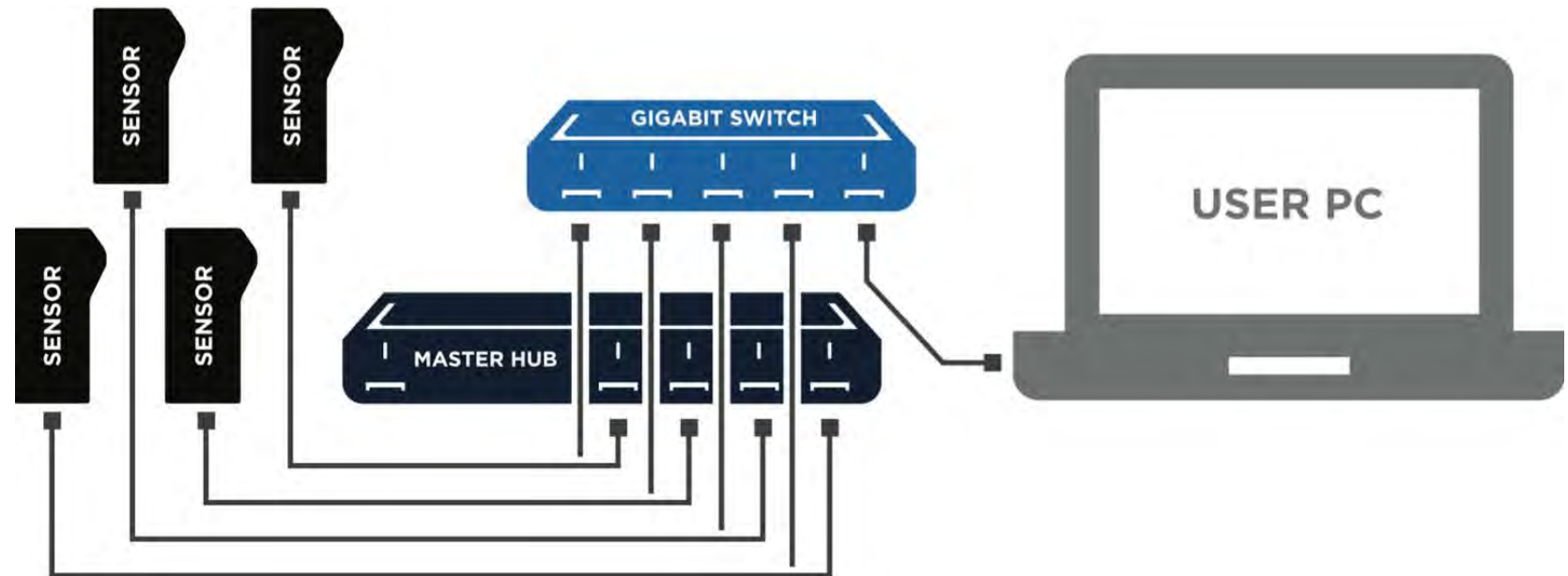
GOCATOR MULTI-SENSOR NETWORKING CAPABILITIES

- » Need a wider view or different angles?
- » Requires synchronization, discovery, layout, alignment, and stitching to build a dense 3D point cloud
- » The latest smart 3D sensors from LMI - Gocator - provides built-in support for multi-sensor networking and full 3D feature measurement
- » Increase FOV while maintaining extremely high resolution



A NETWORK OF SMART SENSORS

- » In the “smart” automated factory, networked smart 3D sensors connect with factory infrastructure to report results, web browsers for diagnostics and monitoring, the Internet for upgrades, and even with other sensors to exchange or combine data
- » Gocator Accelerator unpacks, stitches, and generates new point clouds with data from networked sensors



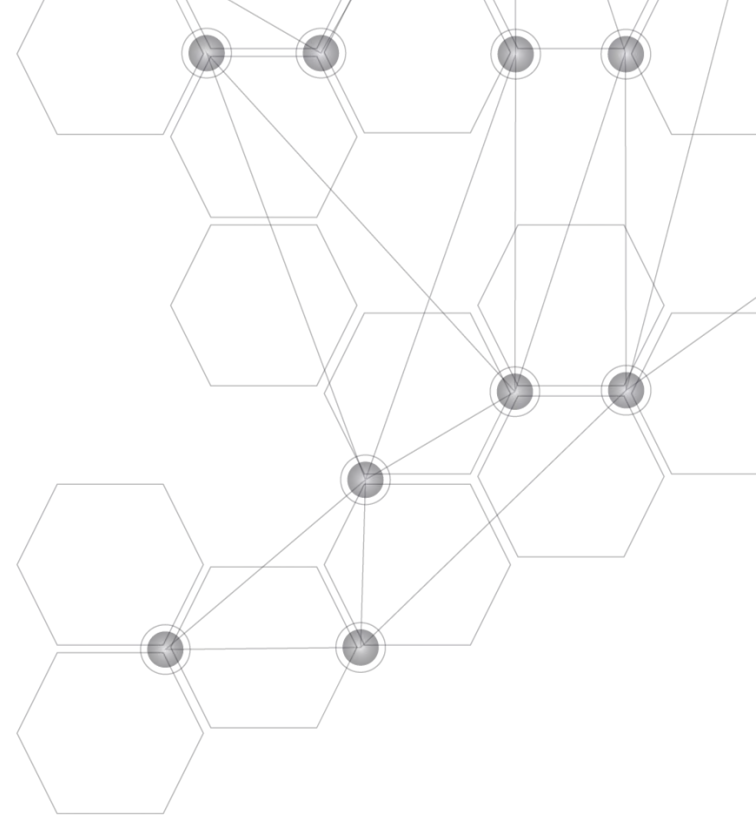
CONCLUSION

- » 3D inline inspection and traditional metrology are two very different environments
- » 3D Smart Sensors allow for 100% Quality Control
- » With the Accelerator processes can be speed up while cycle time are reduced
- » Multi-Sensor-Network allows for a wider FOV, different angles while maintaining extremely high resolution





LMI TECHNOLOGIES



IMAGING USING NEAR-FIELD MICROSCOPY AND NEAR-FIELD LITHOGRAPHY

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² Dept. of Physics, Faculty of Electrical Engineering, University of Žilina, Žilina

³ Dept. of Physics, Faculty of Electrical Engineering, University of Žilina, Žilina

Abstract

In this contribution we presented the near-field scanning optical microscope (NSOM) as an effective tool for high resolution imaging. The NSOM uses the high resolution optical fiber probe prepared from tapered optical fibers in combination with nanoposition 3D system. The NSOM was used for characterization of the near field of light emitting diodes (LED's) with patterned submicrometer structures. The NSOM images show the submicrometer resolution of the emitted optical field from the LED's. The NSOM technique was also used for lithography of semiconductor surfaces. Using the NSOM lithography different surface patterns with submicrometer resolution were prepared in photoresist layer and GaAs surface.

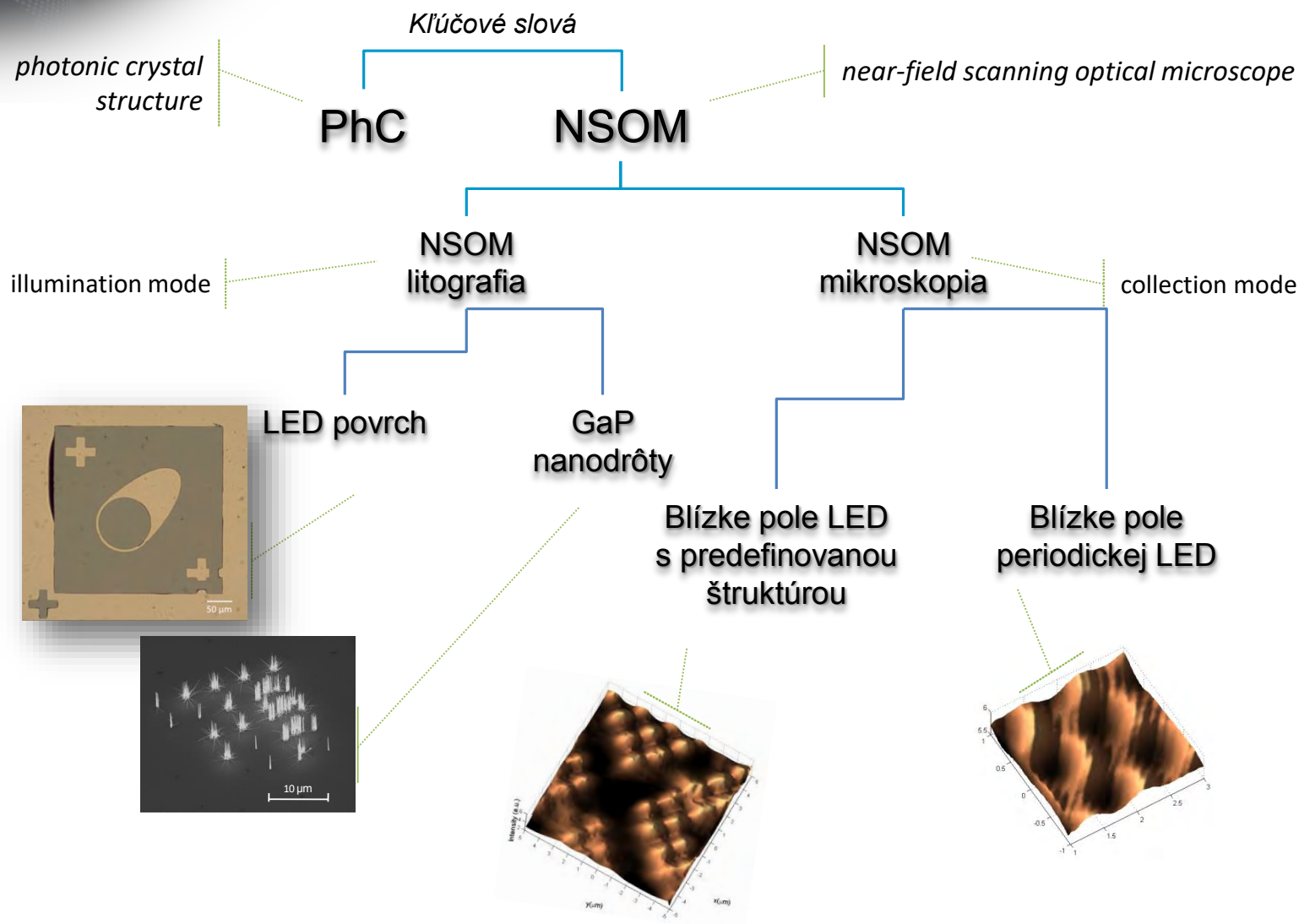


Zobrazovanie pomocou **mikroskopie v blízkom poli a litografia v blízkom poli**

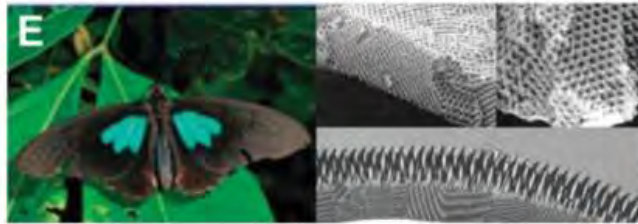
Dušan Pudiš

Ľ. Šušlik, I. Lettrichová

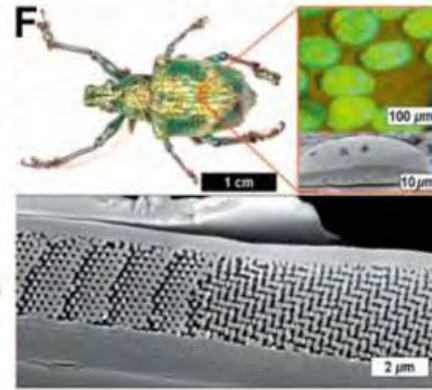
Dept. of Physics, Faculty of Electrical Engineering, University of Žilina, Slovakia



H. Wang, K. Q. Zhang, *Sensors* **2013**, 13(4), 4192-4213

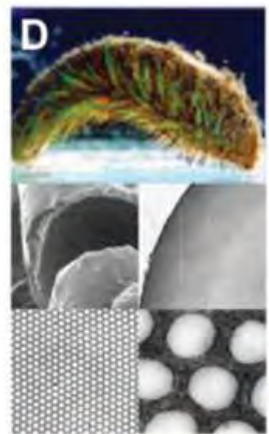


Morská myš
Páv



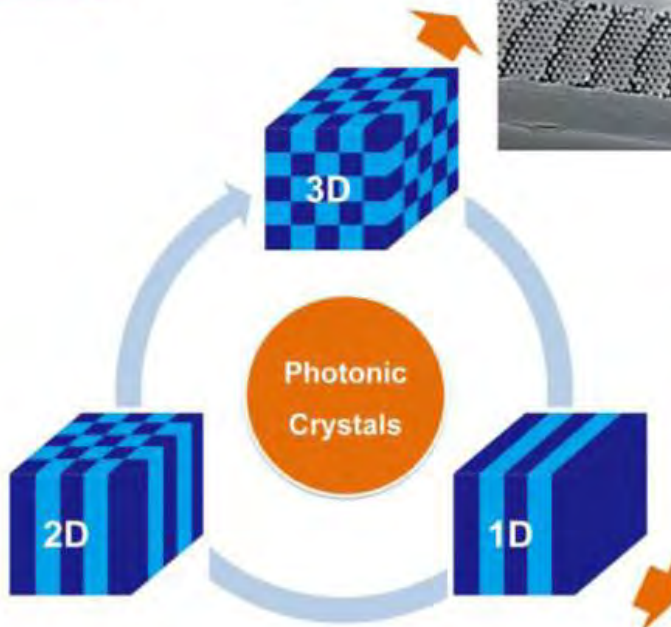
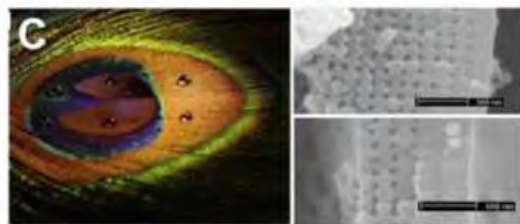
« *Parides sesostris*
(3D inverzný opál)

< *L. augustus*
(3D diamantová štruktúra)



Morpho

Tmesisternus isabellae
(mokrý/suchý)

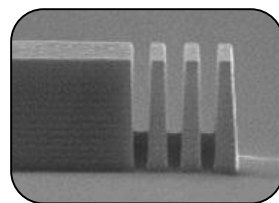
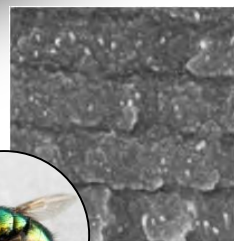


Príroda

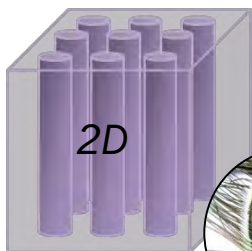
Technológia



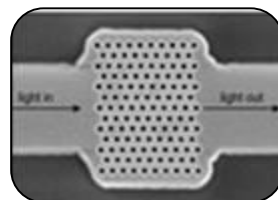
1D



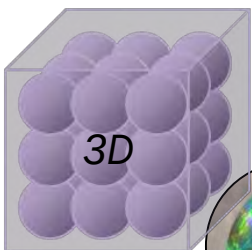
Bragg reflector



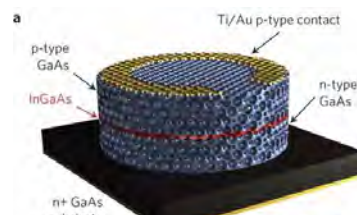
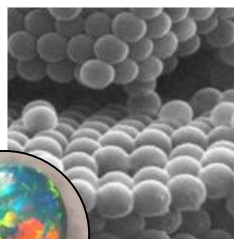
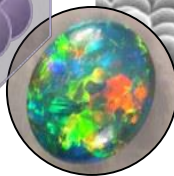
2D



PhC slabs

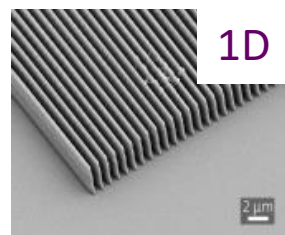


3D

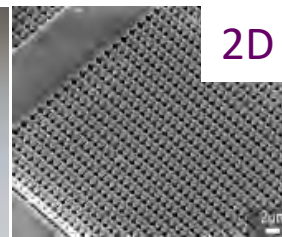


3D PhC laser

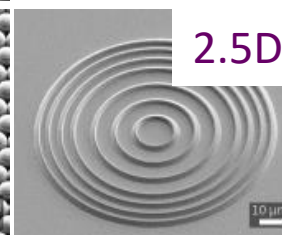
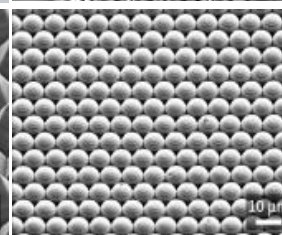
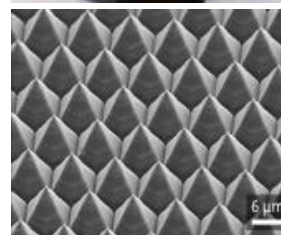
www.nanoscribe.de (Markus Thiel)



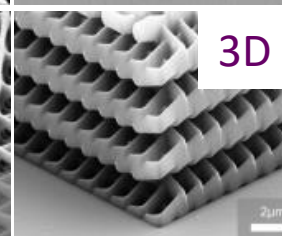
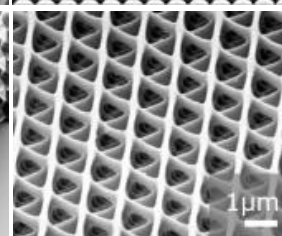
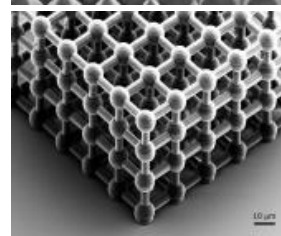
1D



2D

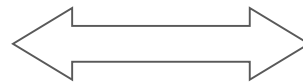


2.5D

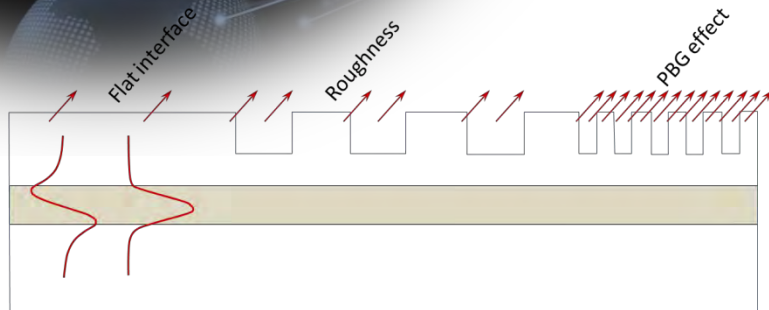


3D

Nárast účinnosti vyžarovania

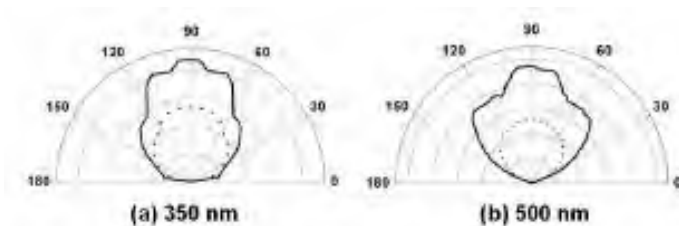
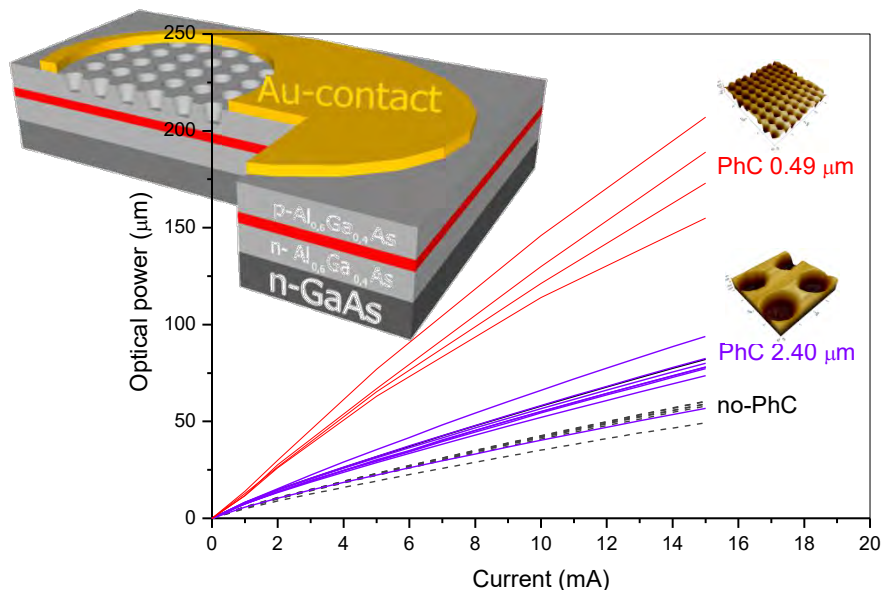


Modifikuje sa vyžarovací diagram

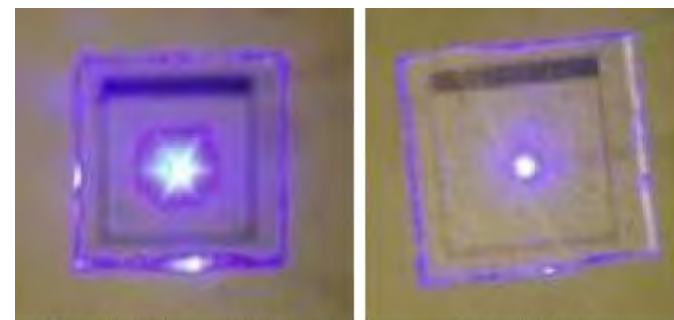


- asi 30% žiarenia sa stráca odrazom naspäť do čipu
- v dôsledku PhC sa vylepši vyviazanie žiarenia

M. Charlton et al. Proc of SPIE Vol. 6486 (2007)



Y. J. Lee et al. Opt. Express 13 (15) (2005)



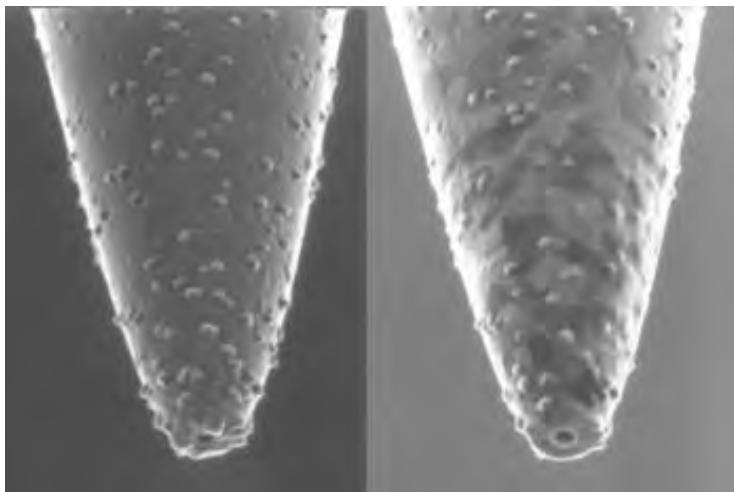
PhC lattice = 200 nm

Non-PhC

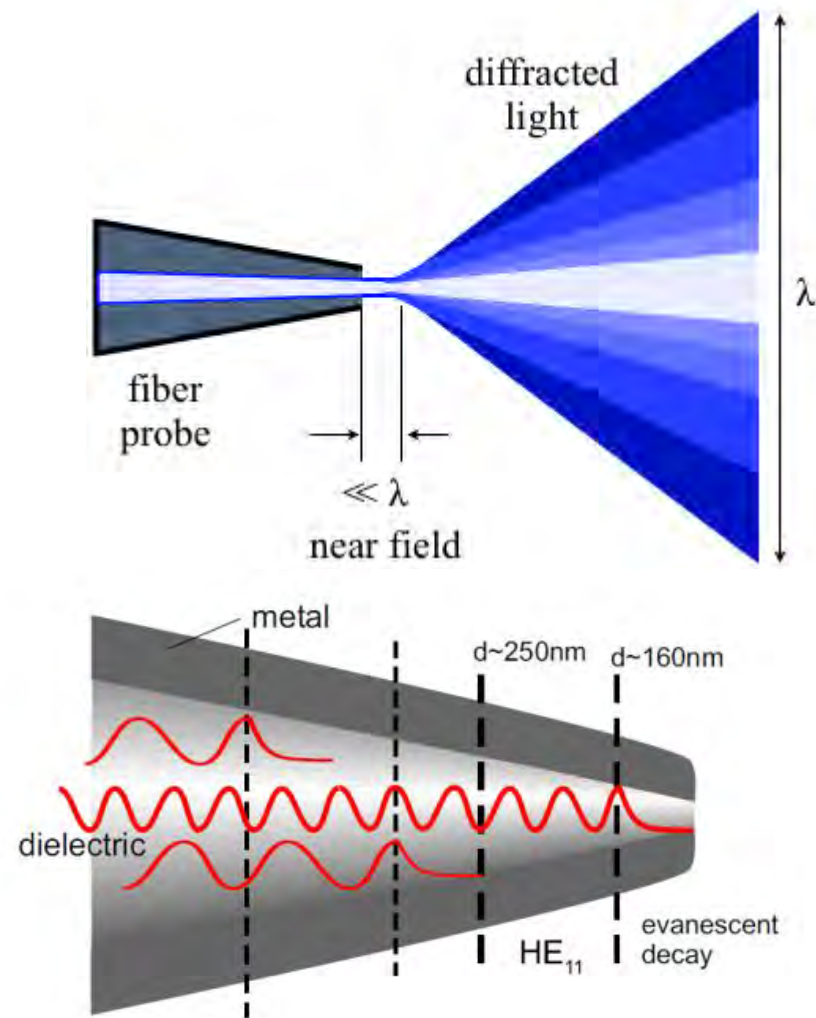
J. J. Wierer, Appl. Phys. Lett. 84, 3885 (2004)

D. Pudis et al. Appl. Surf. Sci. 269, 116 (2013)

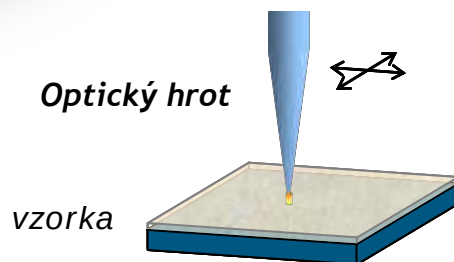
Blízke pole - pole, kde nedochádza k difrakcii (zväčša pre $d \ll \lambda$)



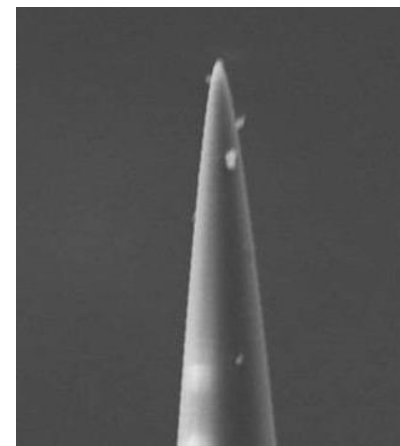
SEM obrázok pokoveného hrotu s apertúrou



Novotny L, Hecht B. Principles of nano-optics. Cambridge University Press. New York 2006.



Near-field
Scanning
Optical
Microscope



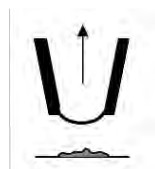
Optický hrot

Illumination mode



NSOM litografia

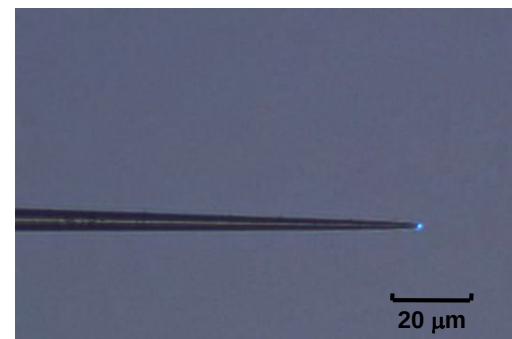
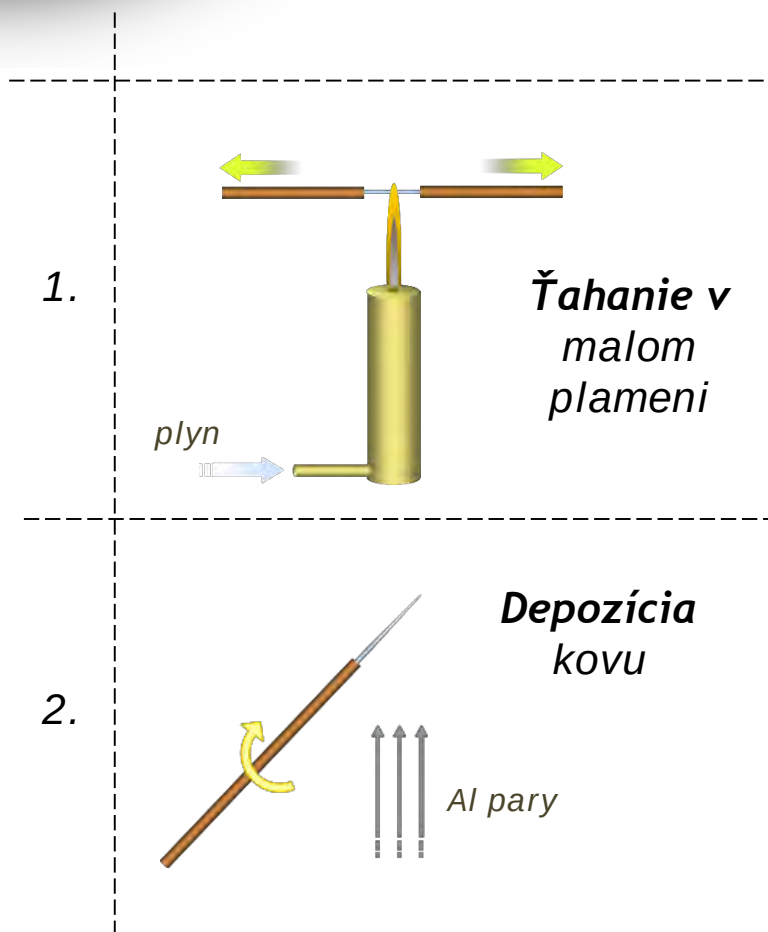
Collection mode



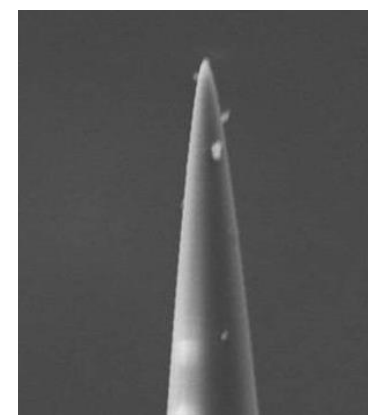
NSOM mikroskopia

v **FF mikroskopii** – Abbey difrakčné kritérium ~ **vlnová dĺžka**

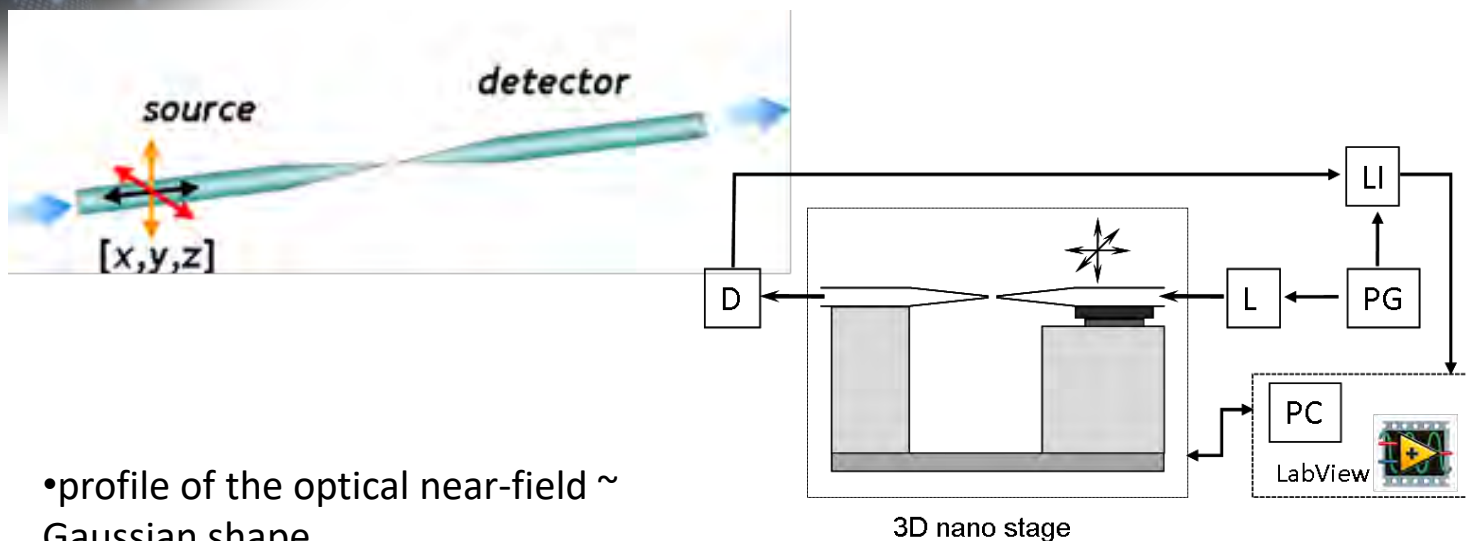
v **NF mikroskopii** – rozlíšenie ~ **priemer apertúry**



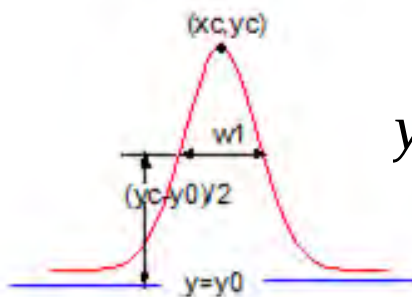
Optická sonda, obrázok optický mikroskop



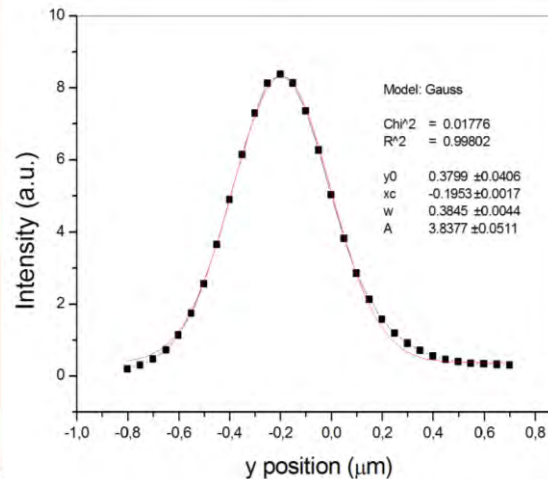
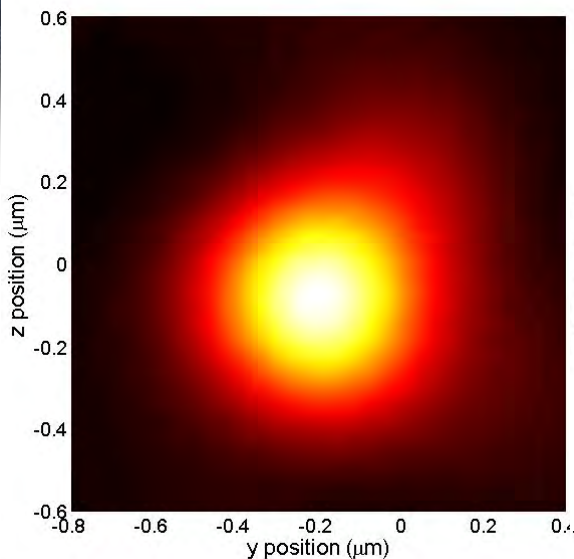
Optická sonda, SEM obrázok



- profile of the optical near-field ~ Gaussian shape

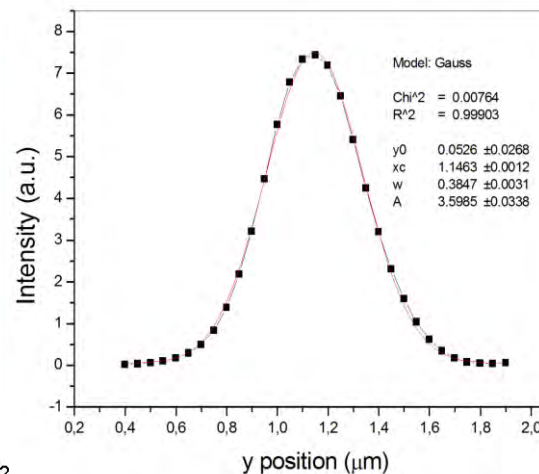
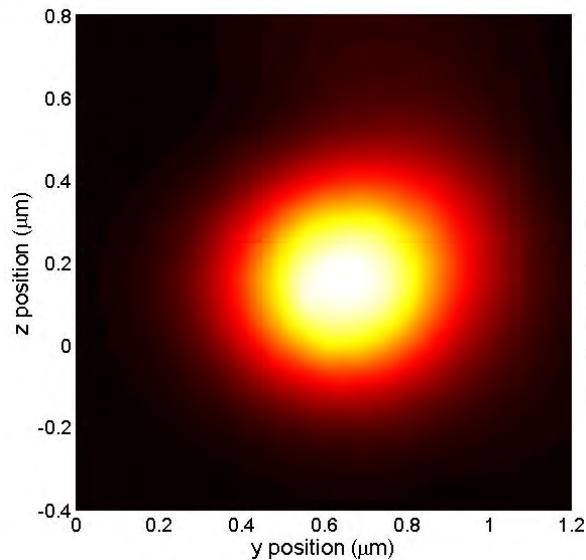


$$y = y_0 + \frac{A}{w\sqrt{\pi/2}} e^{-2\frac{(x-x_c)^2}{w^2}}$$



$$w_A = (384.5 \pm 4.4) \text{ nm}$$

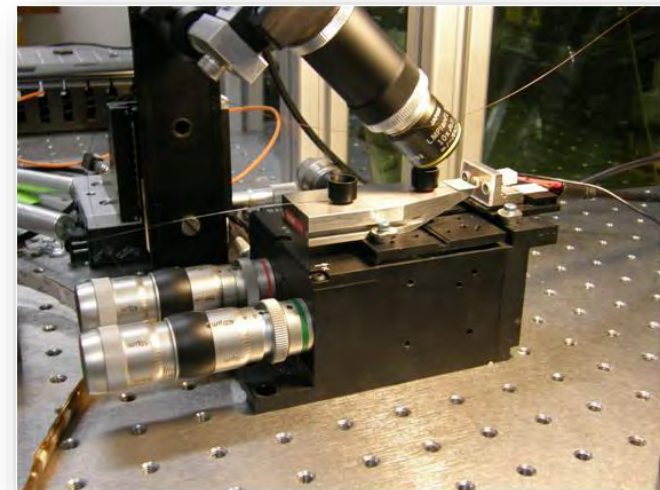
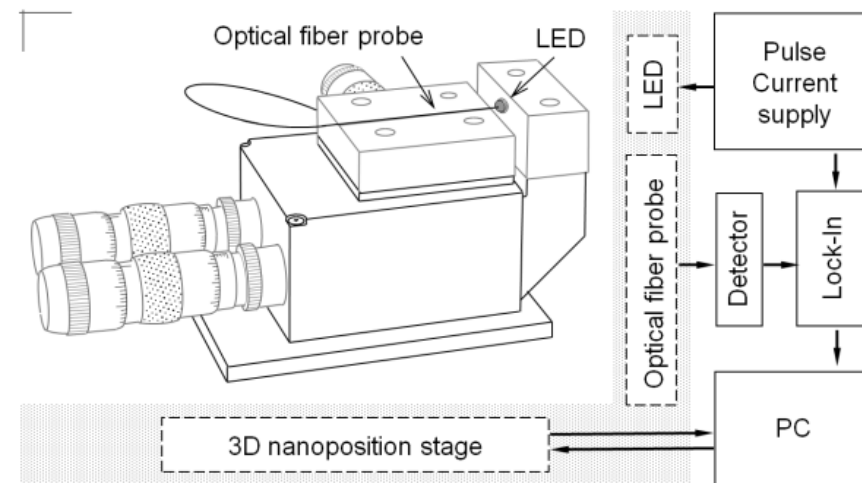
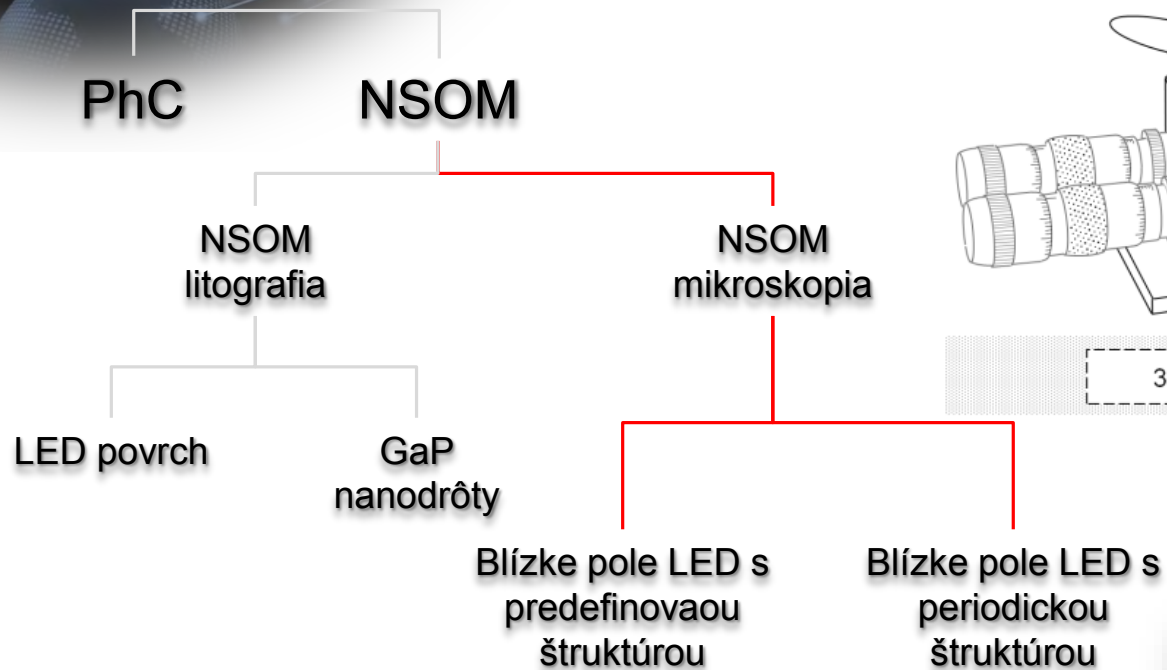
$$\Rightarrow FWHM_A \sim 460 \text{ nm}$$



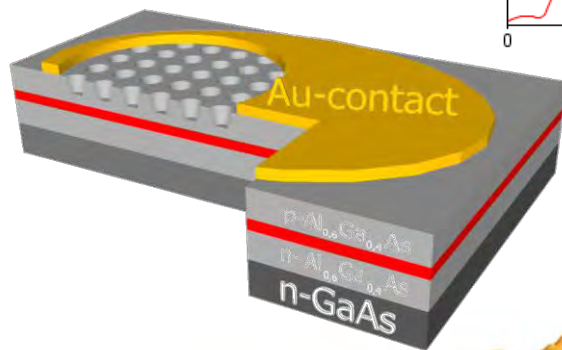
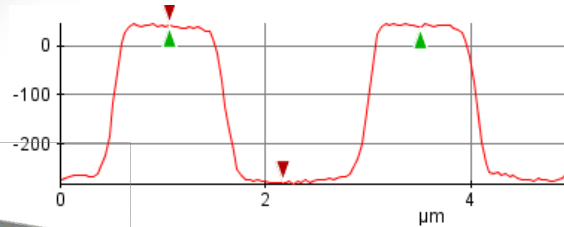
$$w_B = (384.7 \pm 3.1) \text{ nm}$$

$$\Rightarrow FWHM_B \sim 460 \text{ nm}$$

• => apertúra
priemer menej
ako 460 nm

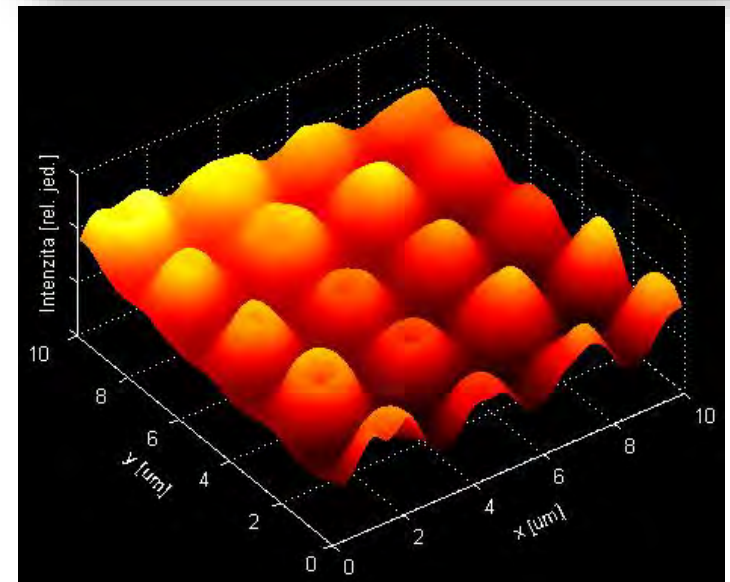
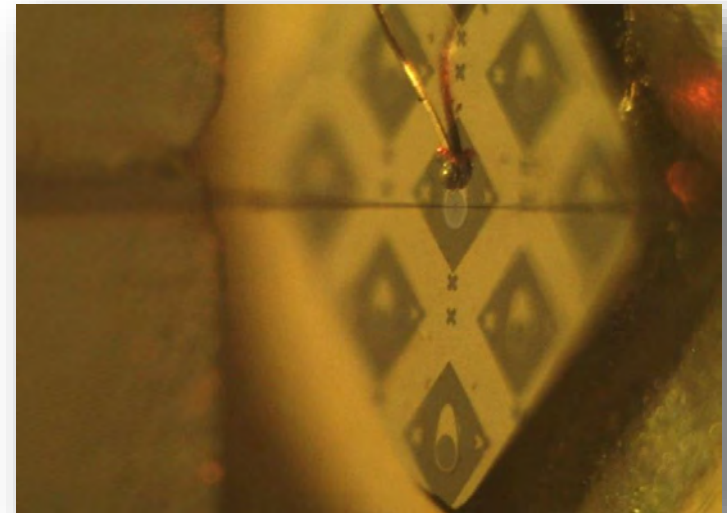
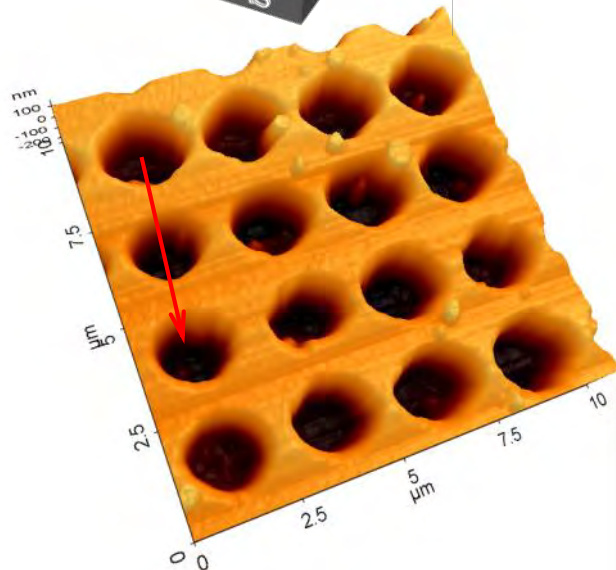


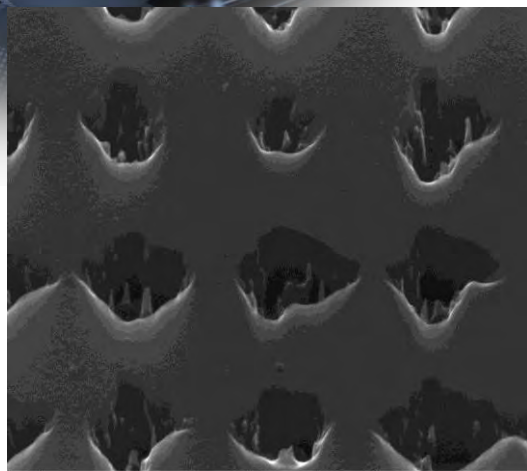
■ 2,4 μm Period
■ 320 nm Depth



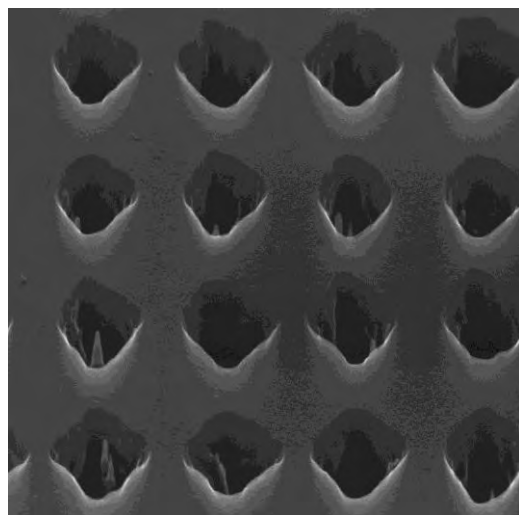
Pohl'ad na sondu a čip

Blízke pole LED

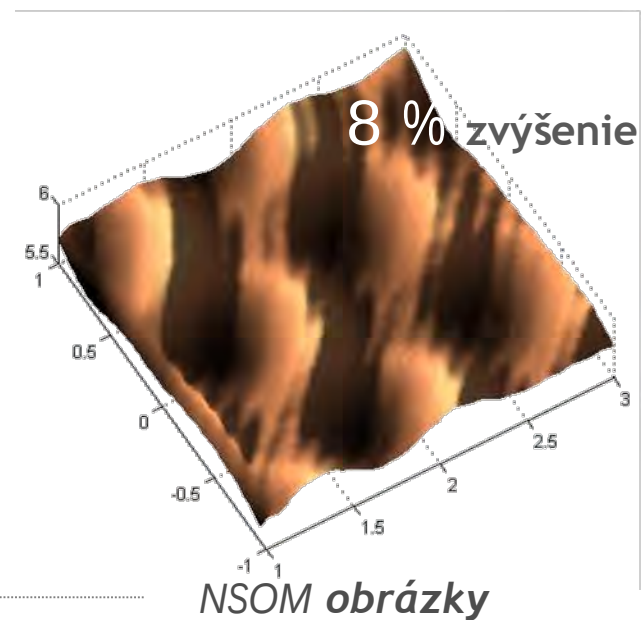




SEM snímky

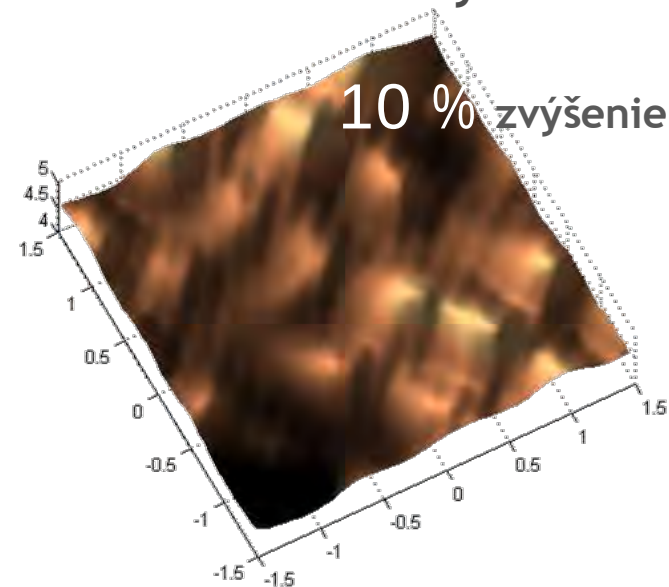


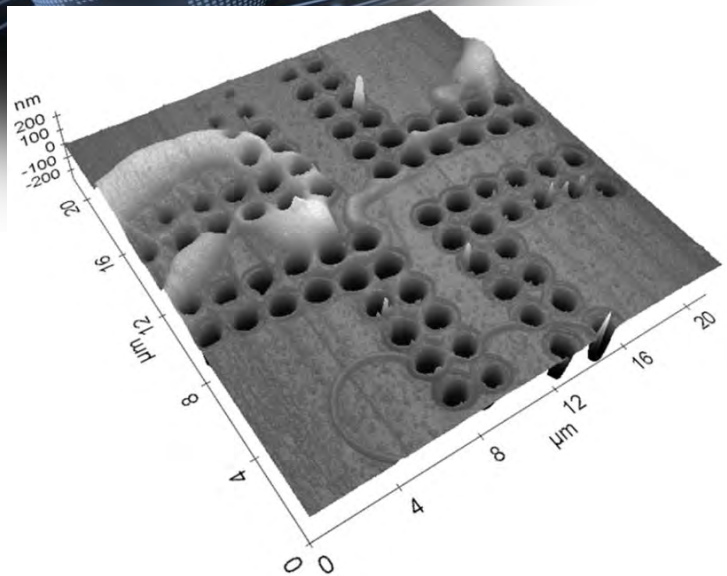
perióda
900 nm



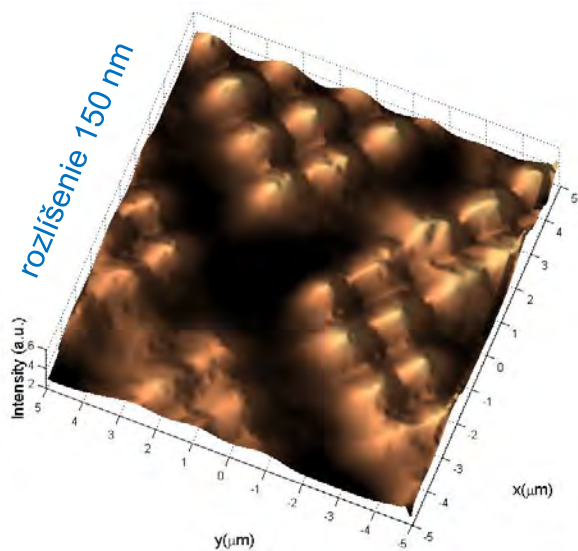
NSOM obrázky

perióda
750 nm

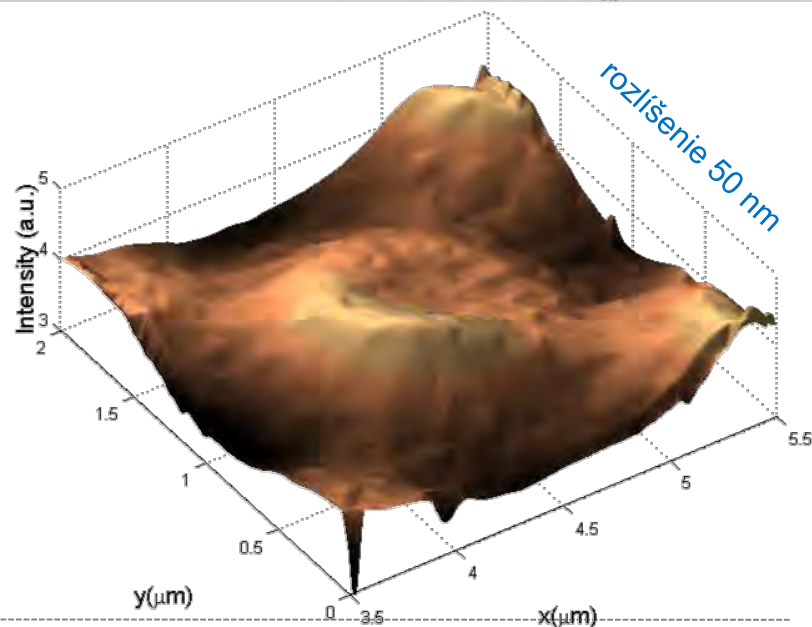
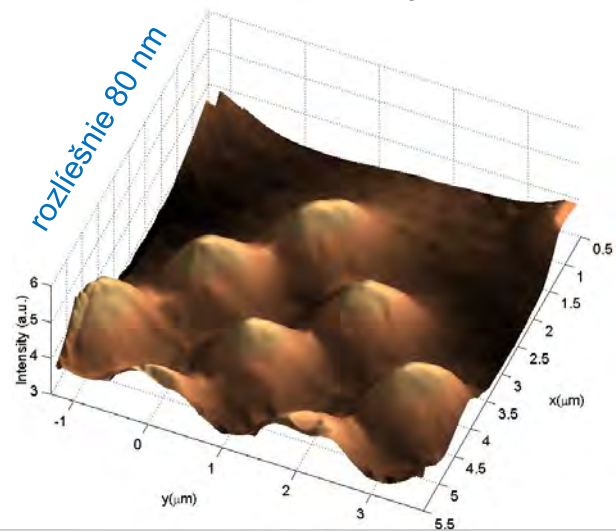


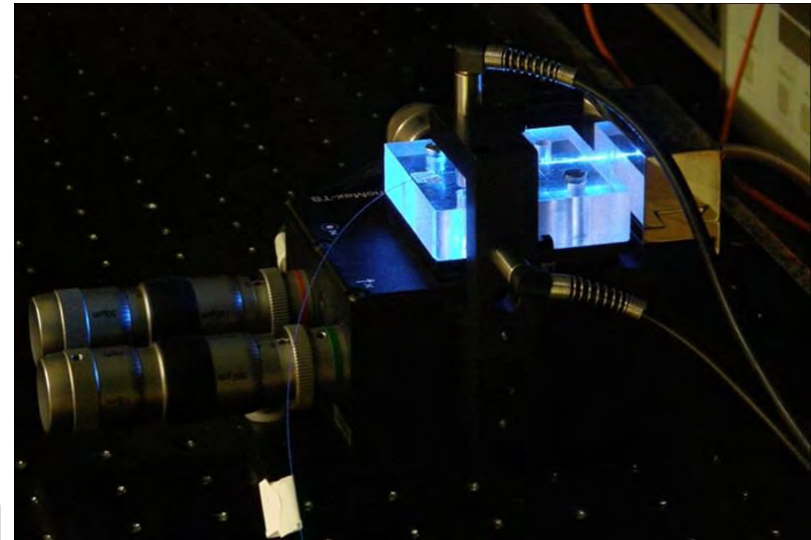
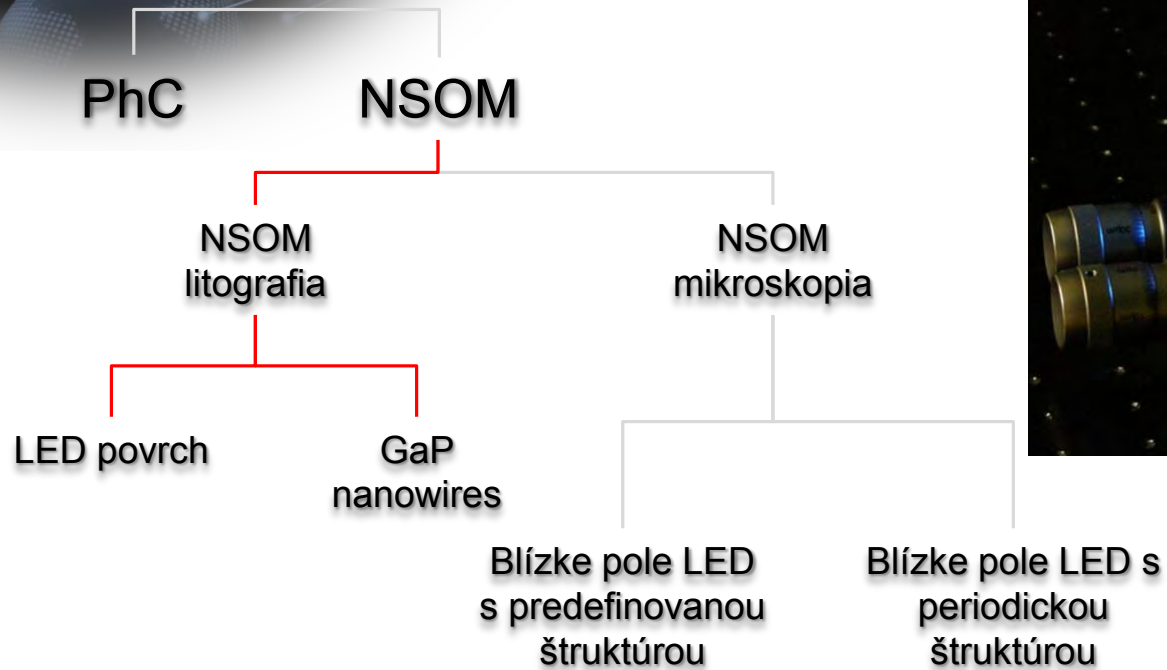


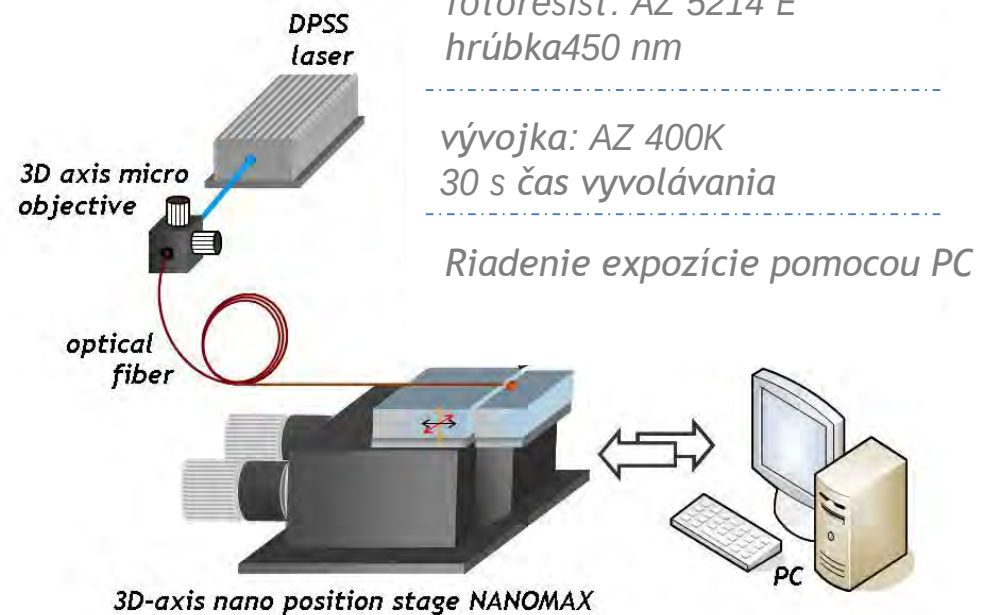
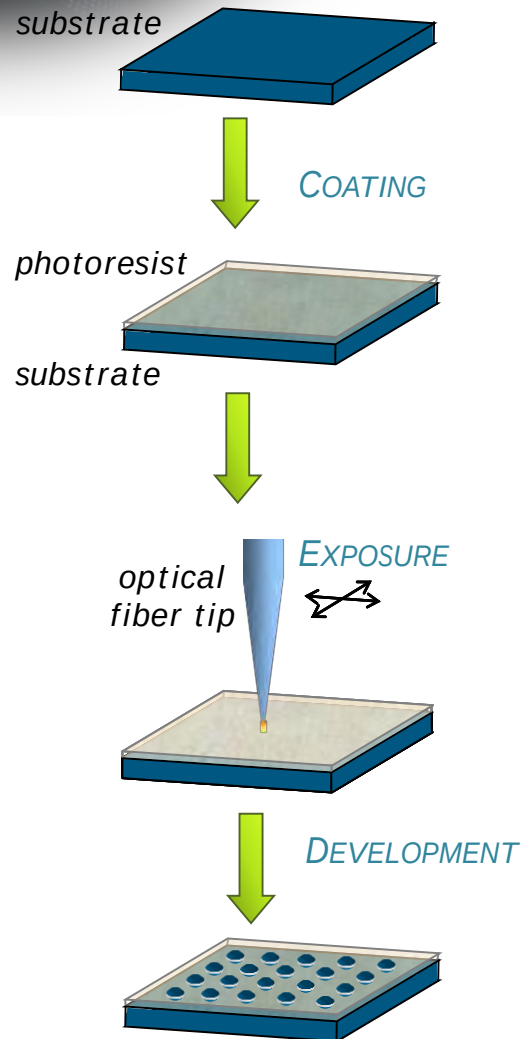
AFM povrchu tvarovanej LED



NSOM obrázky







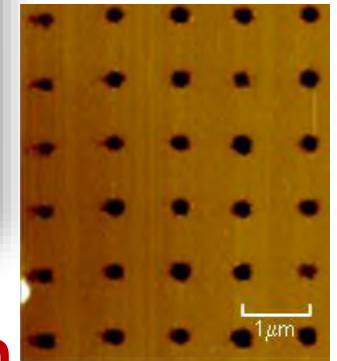
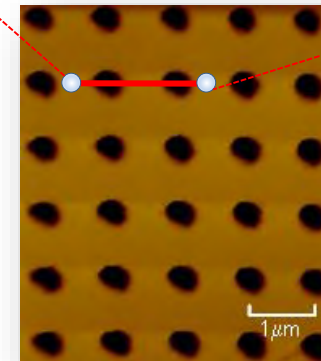
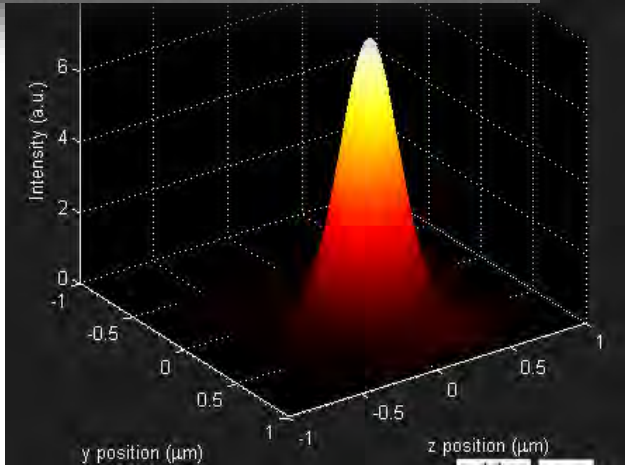
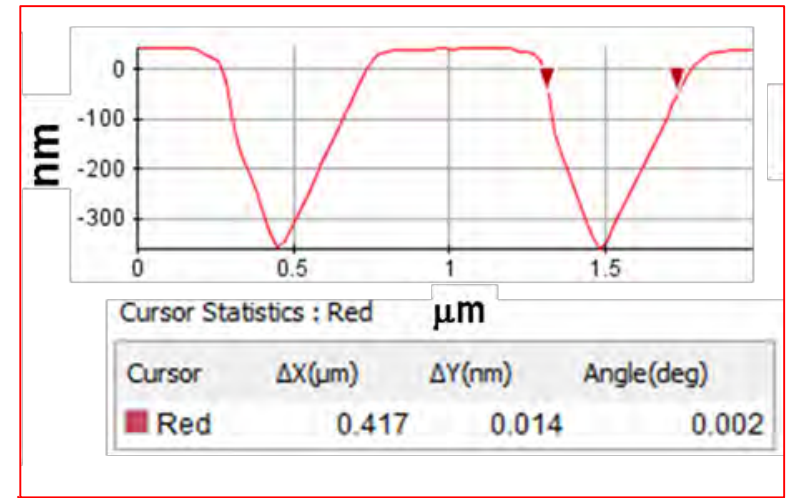
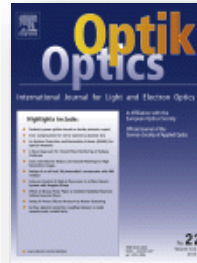
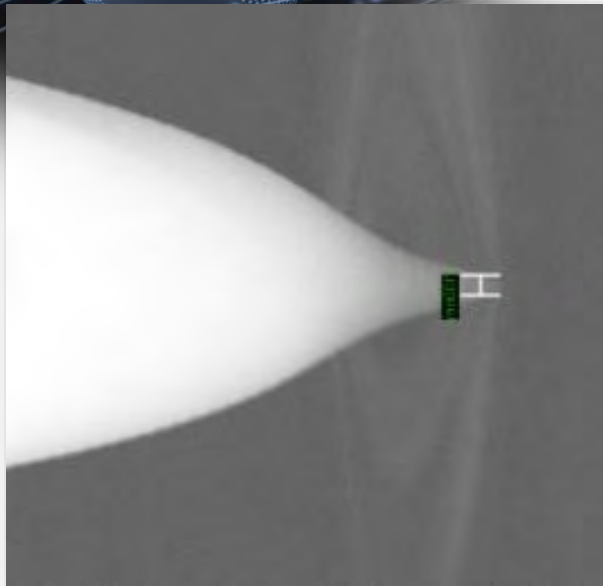
*Polomer krivosti hrotu
(sondy) < 500 nm*

Vlnová dĺžka 473 nm

*fotorezist: AZ 5214 E
hrúbka 450 nm*

*vývojka: AZ 400K
30 s čas vyvolávania*

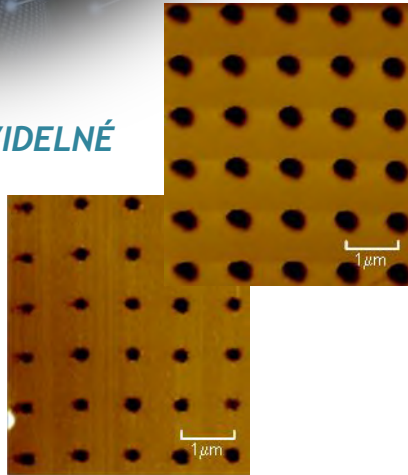
Riadenie expozície pomocou PC



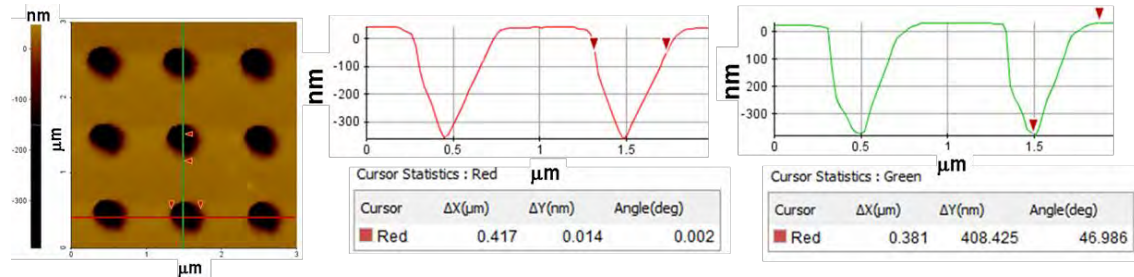
< 300 nm

I. Kubicova, D. Pudis, et al. Optik 124 1971-1973 (2013)

PRAVIDELNÉ

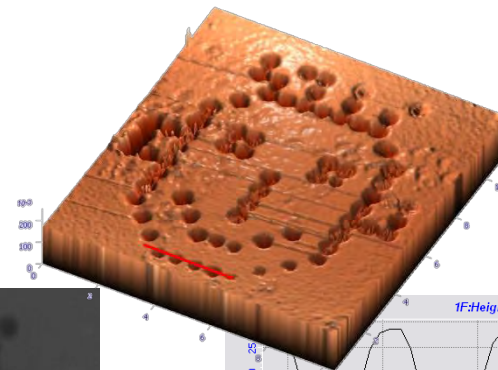
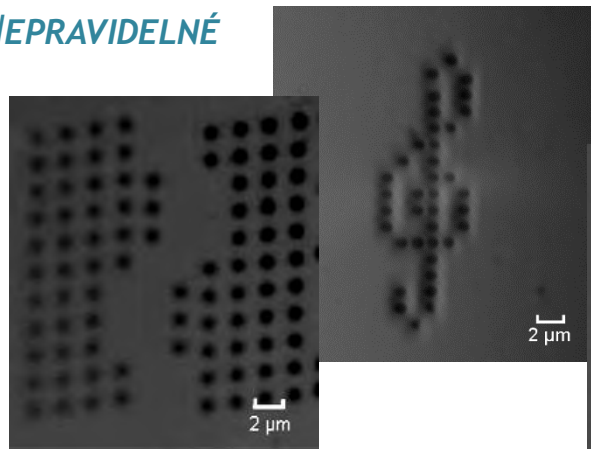


AFM OBRÁZKY A PROFIL

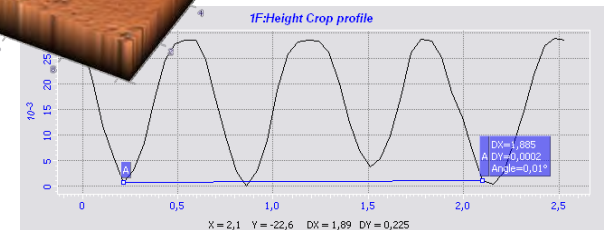


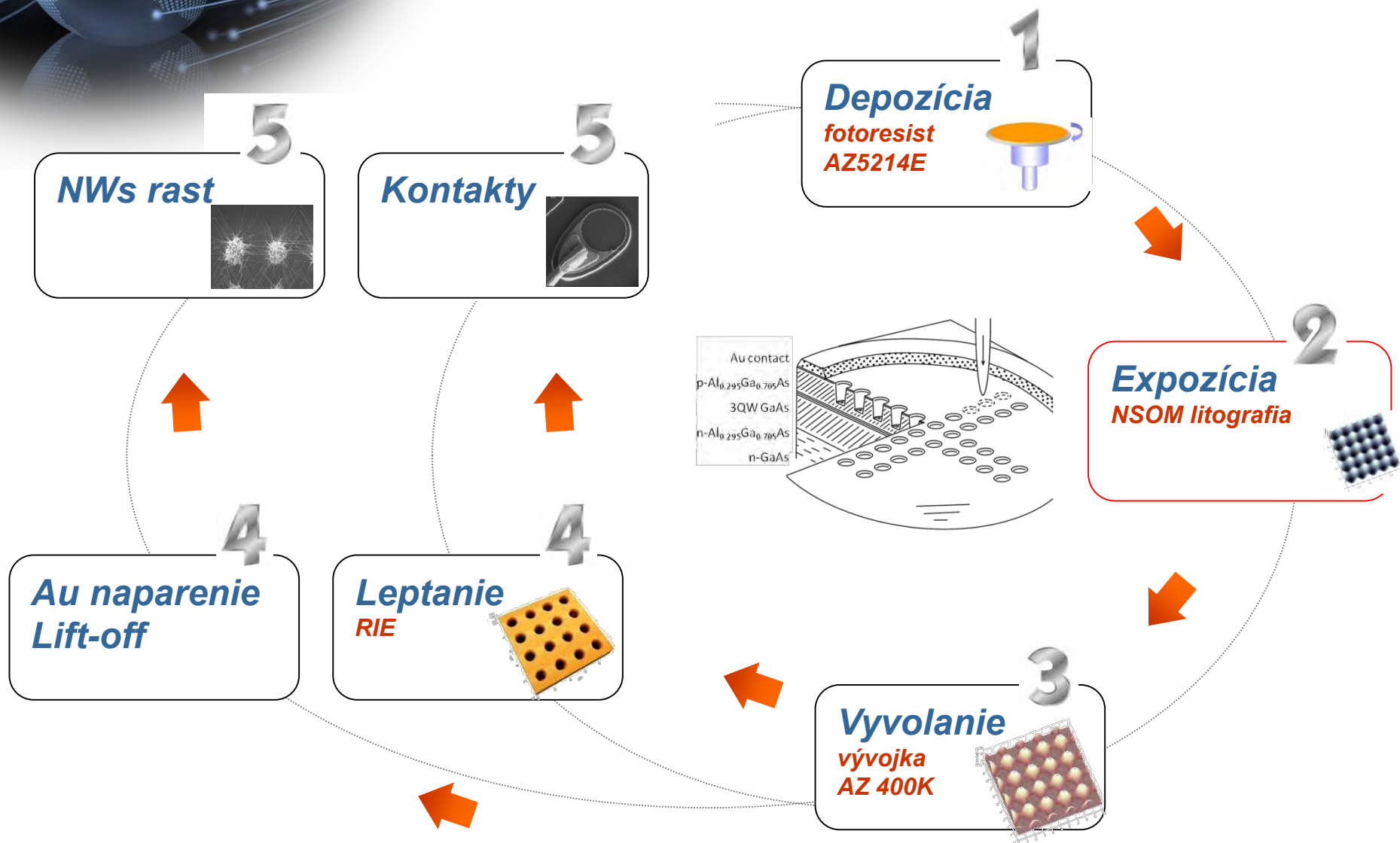
OPTICKÝ MIKROSKOP - OBRÁZKY

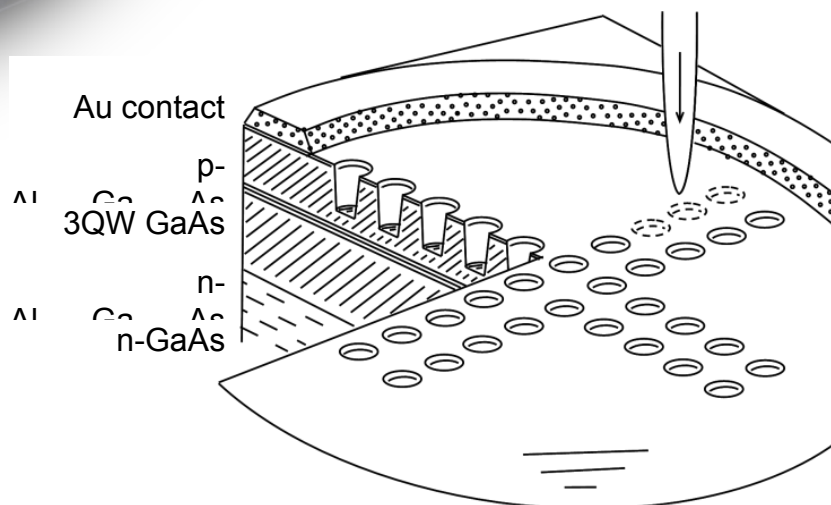
NEPRAVIDELNÉ



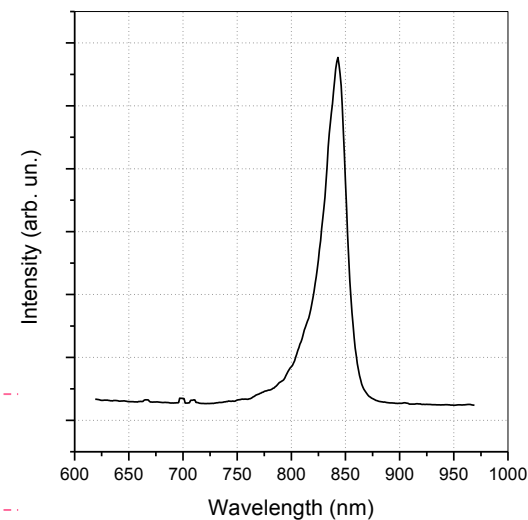
AFM OBRÁZOK
A PROFIL





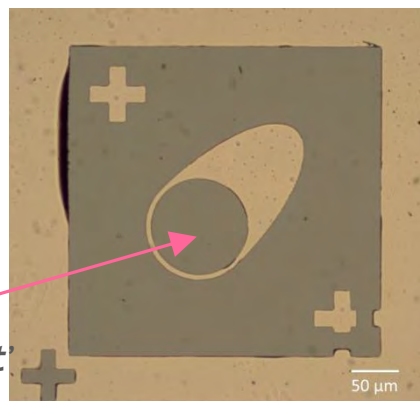


SPKTRÁLNA CHARAKTERISTIKA LED



$$\lambda = 845 \text{ nm}$$

OBRÁZOK Z OPT. MIKROSKOPU



Emitujúca časť

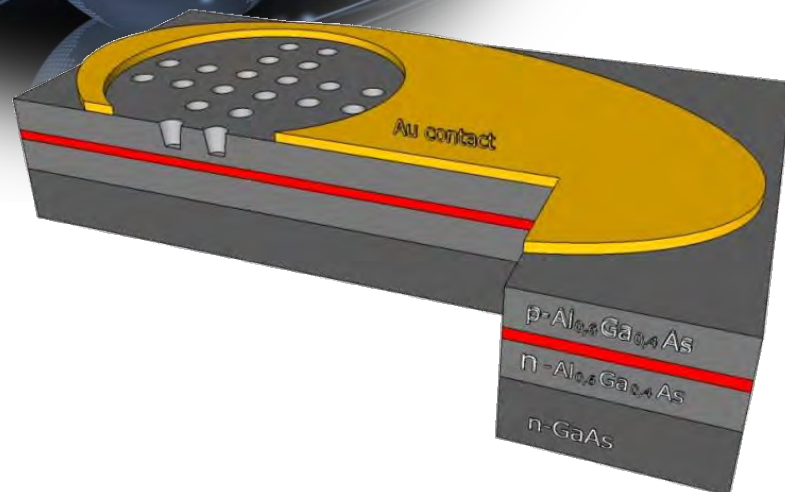
fotorezist: AZ 5214 E
Hrúbka 450 nm

vývojka: AZ 400K
30 s čas vyvolania

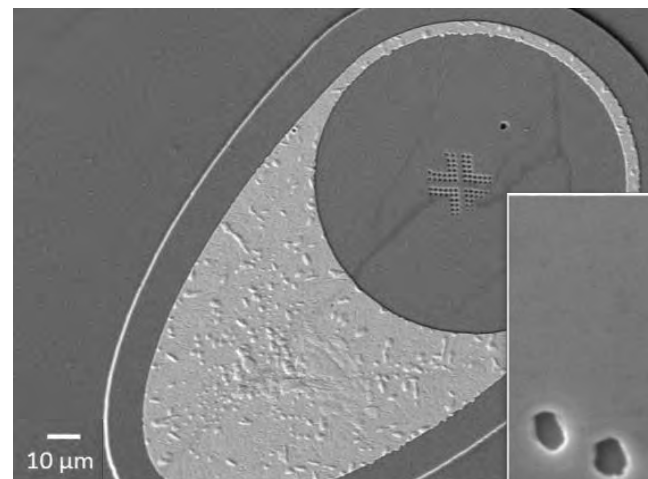
exposure control by PC

20x20 μm plocha

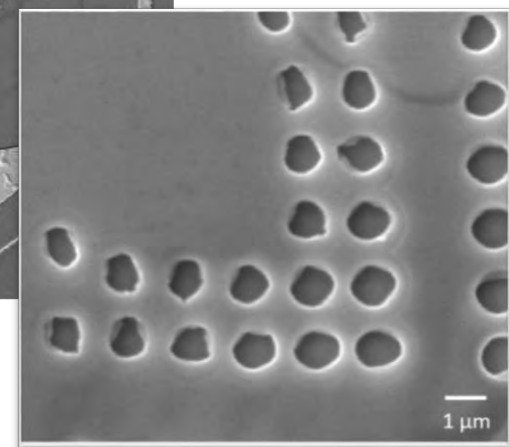
Ľubovoľný dizajn



LED s tvarovaným povrchom

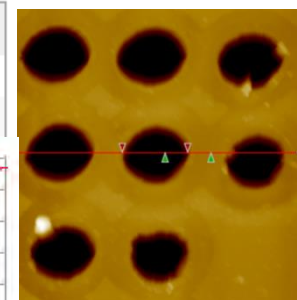
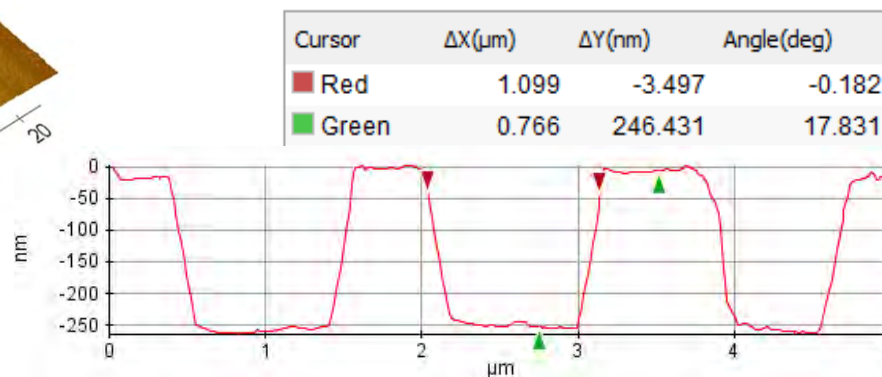
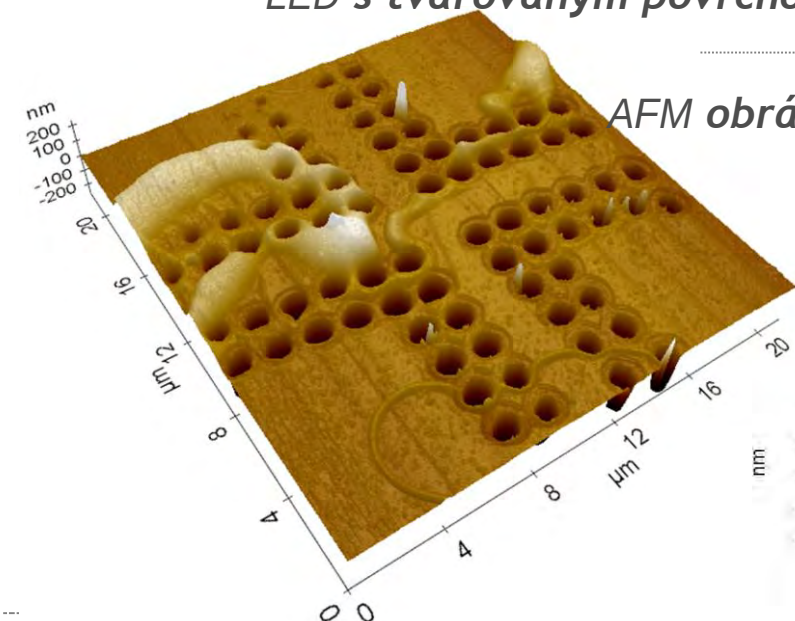


SEM obrázky



AFM obrázok

AFM profil

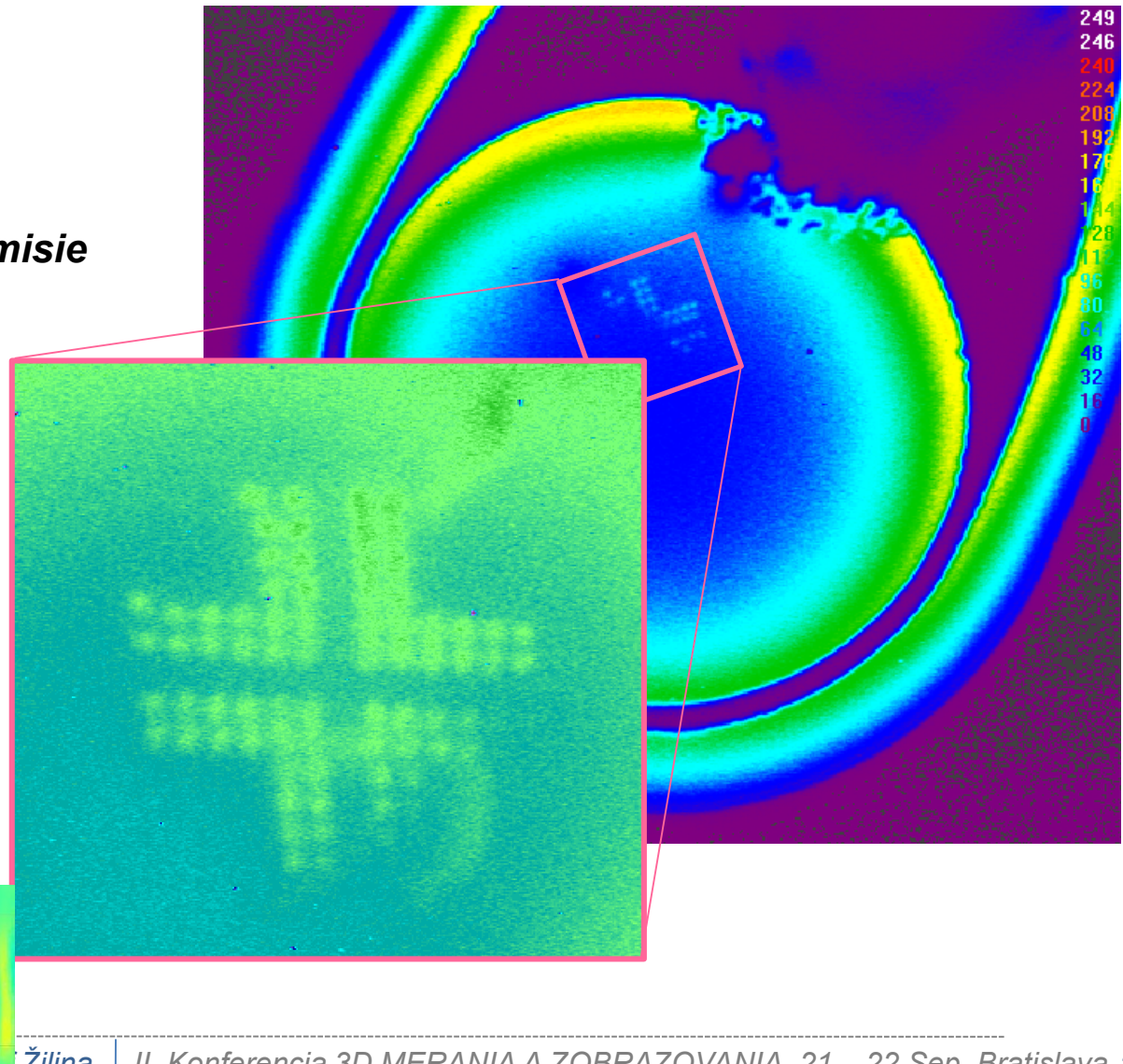
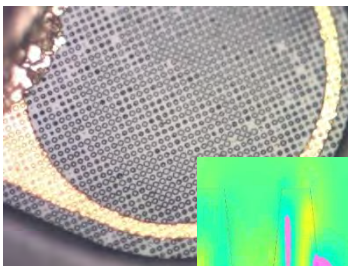


LED pri prúde 6 mA

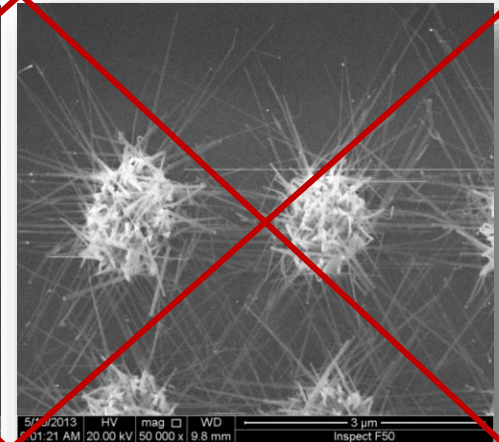
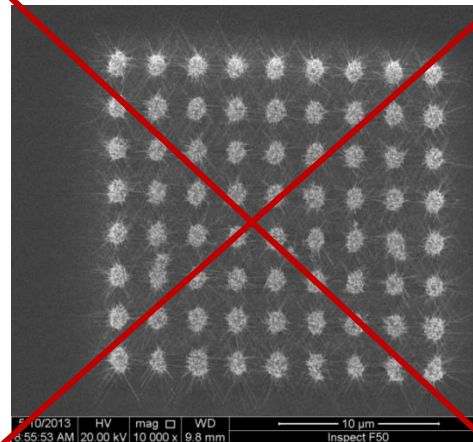
Lokálne zvýšenie emisie

$\sim 1.4 - 1.6 \times$

Porovnateľné s
pravidelnou štruktúrou

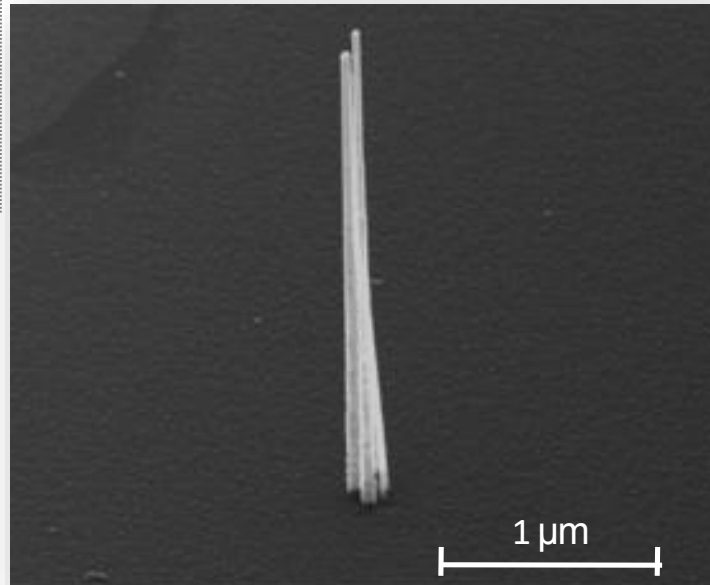
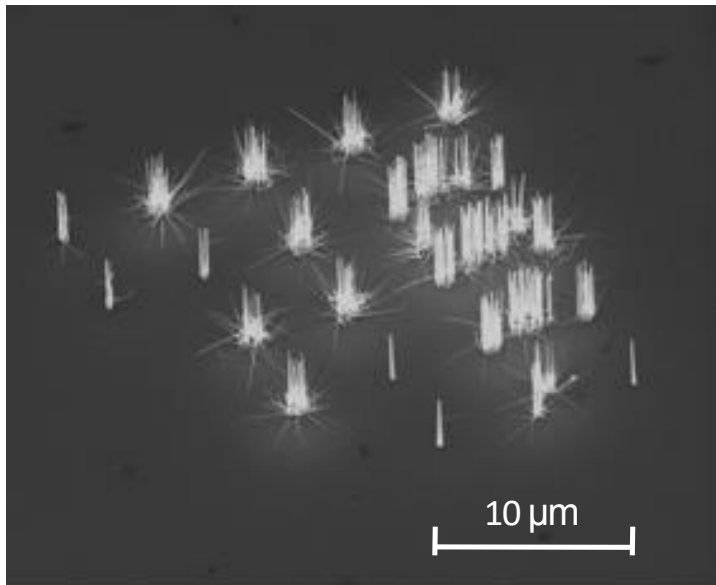


Hedgehog-like structures

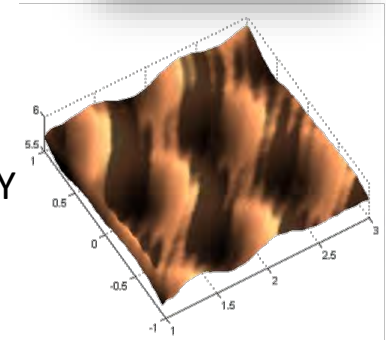
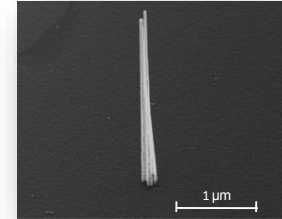
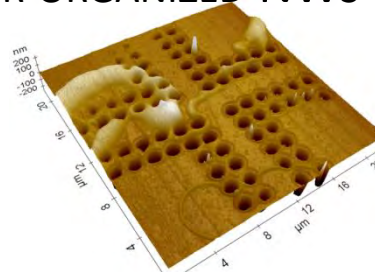


Organized NWs

Small stack of NWs



- PATTERNING USING NSOM LITHOGRAPHY
- 2D PREDEFINED STRUCTURES FOR ORGANIZED NWs GROWTH
- LED STRUCTURE PATTERNING
- NEAR-FIELD CHARACTERIZATION USING NSOM MICROSCOPY



NSOM - HIGH RESOLUTION LITHOGRAPHY AND MICROSCOPY < 200 nm

Described research was supported by the Slovak National Grant Agency under the projects No. VEGA 1/0491/14 and 1/0278/15 and the Slovak Research and Development Agency under the project No. APVV 0395-12.

PERFORMANCE IN NANOSPACE

Hana Tesařová¹

¹ Tescan Orsay Holding a.s., Brno

Abstract

TESCAN is one of the global suppliers of scientific instruments. The company is building its reputation and brand name in the field of designing and manufacturing scanning electron microscopes and system solutions for different applications. With many important patents and innovations some unique solutions and applications were established with the Scanning electron microscopes and Focused ion beam scanning electron microscopes.

PERFORMANCE IN NANOSPACE

**3D Measurement and Imaging – Imaging and Advanced Diagnostic Methods in
Industrial Practice**

Hana Tesařová, Ph.D.

Head of Global Materials Science Applications

TESCAN – Timeline of growth and expansion



• TESCOAN, s.r.o. established

• MIRA Schottky FE-SEM introduced

• Chinese branch established

• FERA3 and TIMA introduced
• 1000 SEM installed & ISO certification

• Merger of TESCOAN and ORSAY PHYSICS resulted in TESCOAN ORSAY HOLDING, a.s.
• TESCOAN-UK Ltd. established

• XEIA3 and Q-PHASE introduced
• TESCOAN Benelux + TESCOAN Do Brasil established

• S8000G introduced

1991

1999

2005

2007

2009

2010

2011

2012

2013

2014

2015

2016

2017

• VEGA SEM introduced

• LYRA FIB-SEM introduced

• Acquisition of TESCOAN USA
• Third generation of TESCOAN SEMs introduced

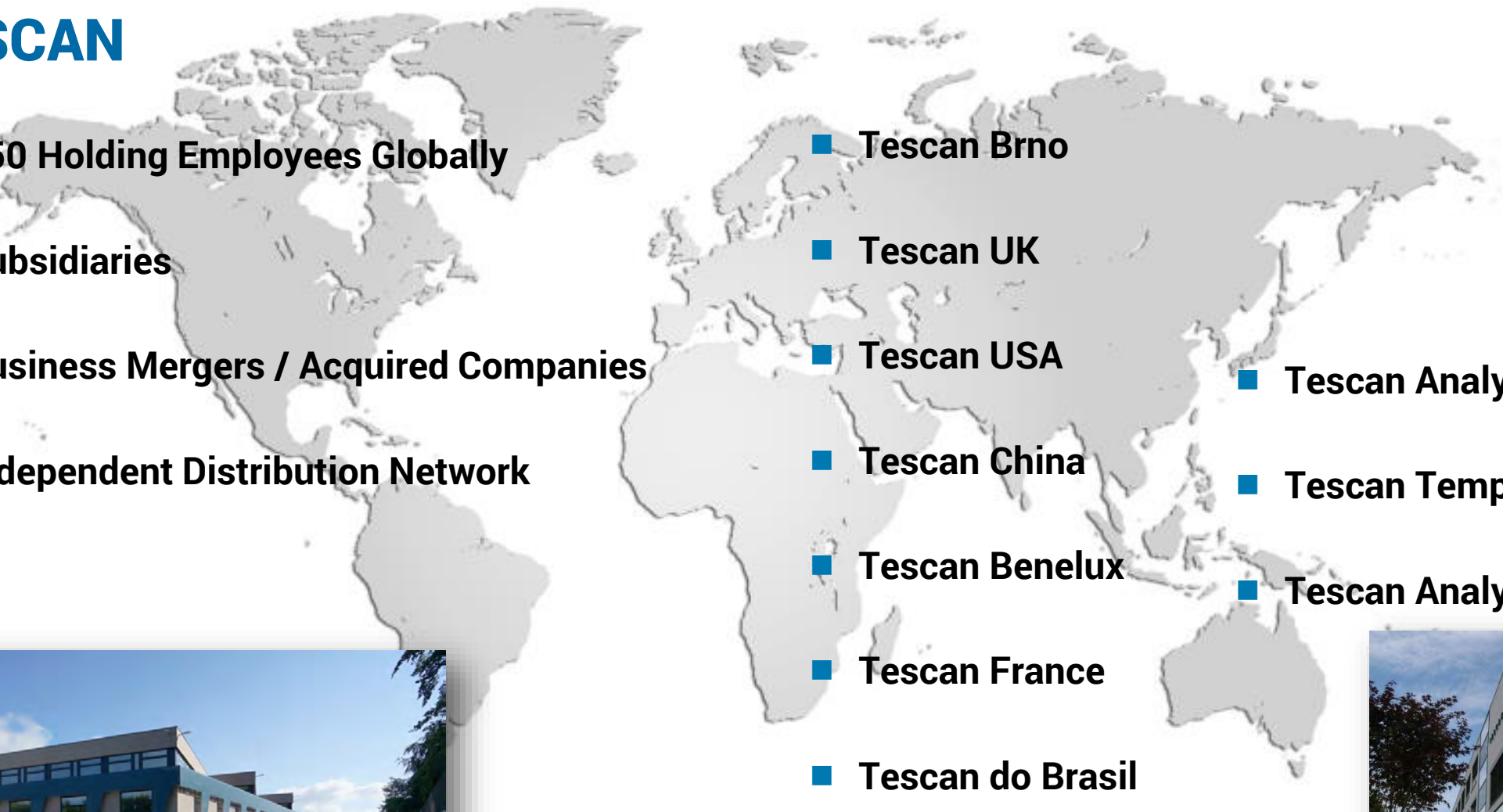
• MIRA3 AMU introduced

• Acquisition of App Five
• GAIA3 and RISE introduced

• NEW UHR Series Triglav™



TESCAN

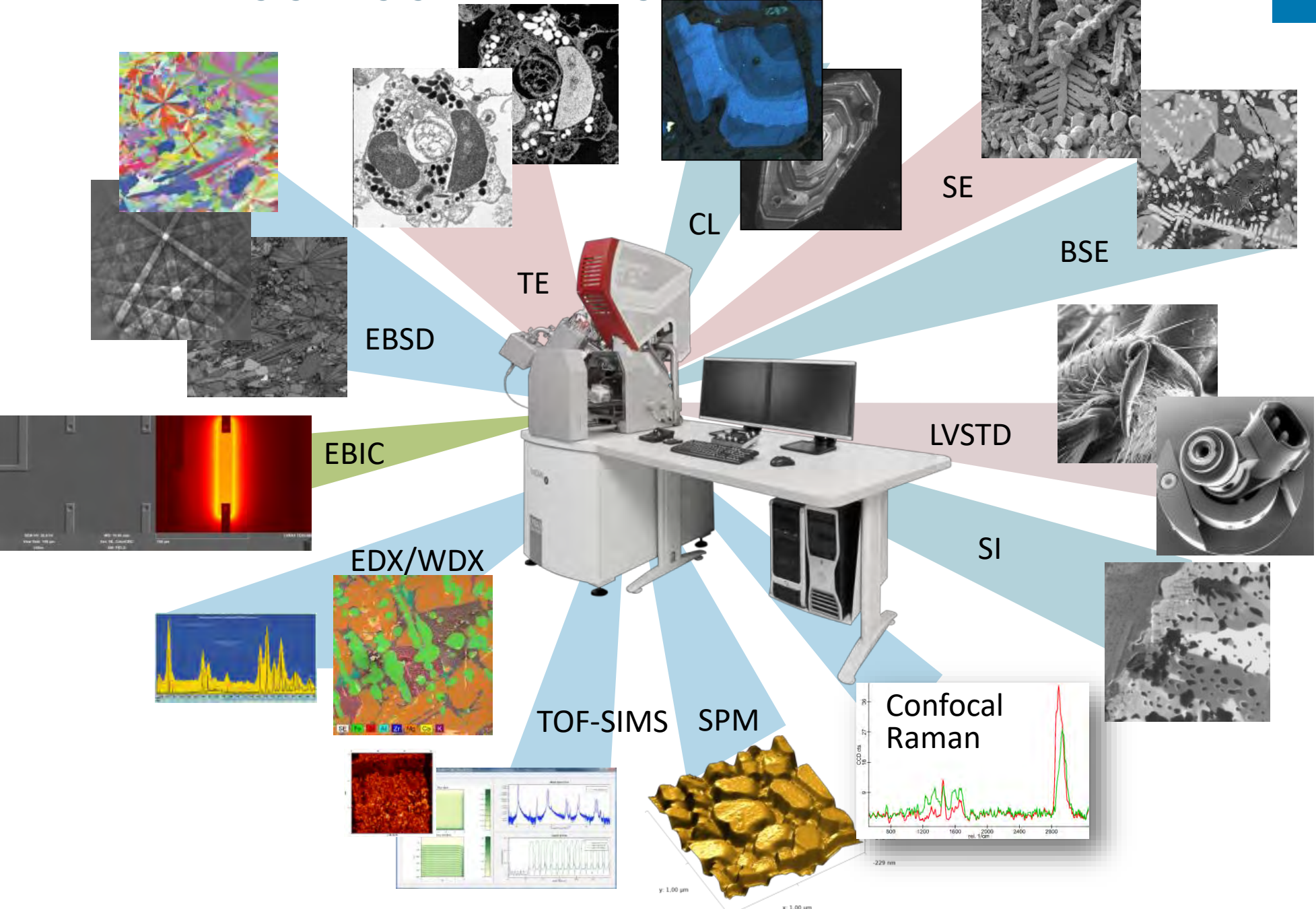
- 450 Holding Employees Globally
 - Subsidiaries
 - Business Mergers / Acquired Companies
 - Independent Distribution Network
- 
- A world map with blue squares indicating the locations of Tescan subsidiaries. The locations are: Tescan Brno (Czech Republic), Tescan UK (United Kingdom), Tescan USA (United States), Tescan China (China), Tescan Benelux (Benelux region), Tescan France (France), Tescan do Brasil (Brazil), Tescan Analytics (Japan), Tescan Tempe (USA), and Tescan Analytics (Australia).
- Tescan Brno
 - Tescan UK
 - Tescan USA
 - Tescan China
 - Tescan Benelux
 - Tescan France
 - Tescan do Brasil
 - Tescan Analytics
 - Tescan Tempe
 - Tescan Analytics



TESCAN Brno, s.r.o.

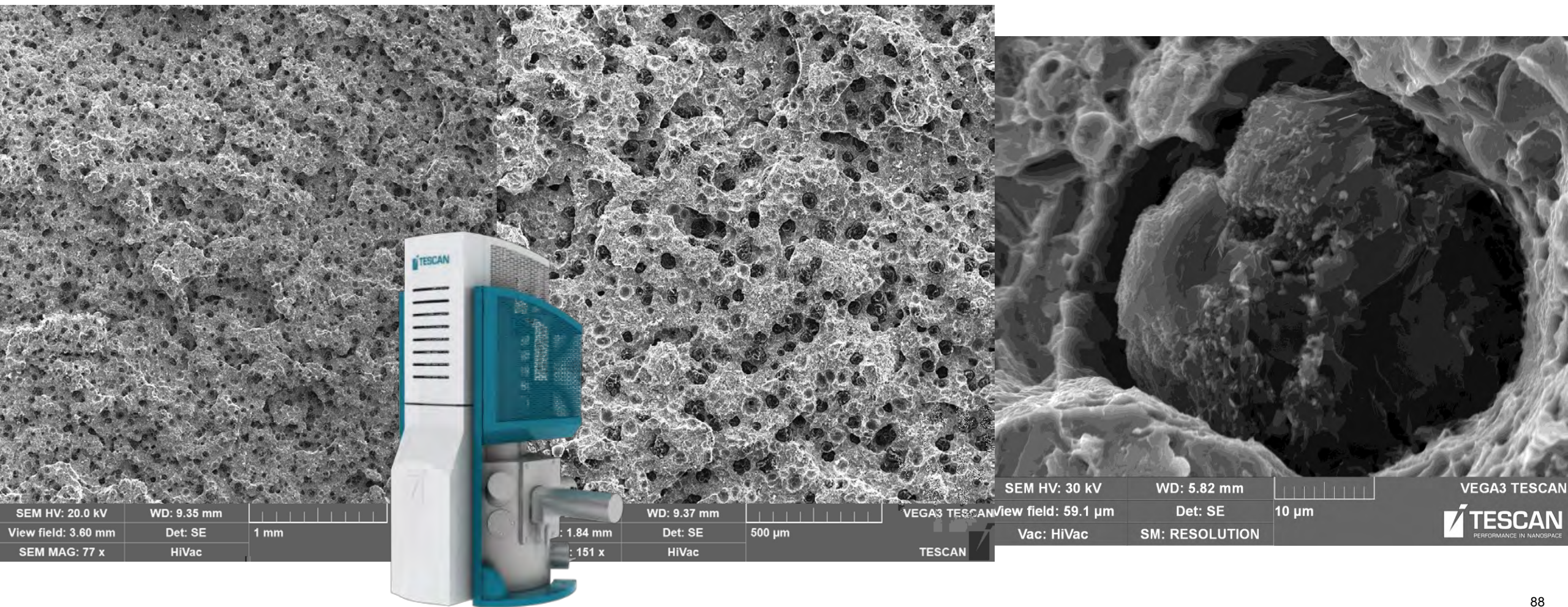


TESCAN ORSAY HOLDING, a.s.



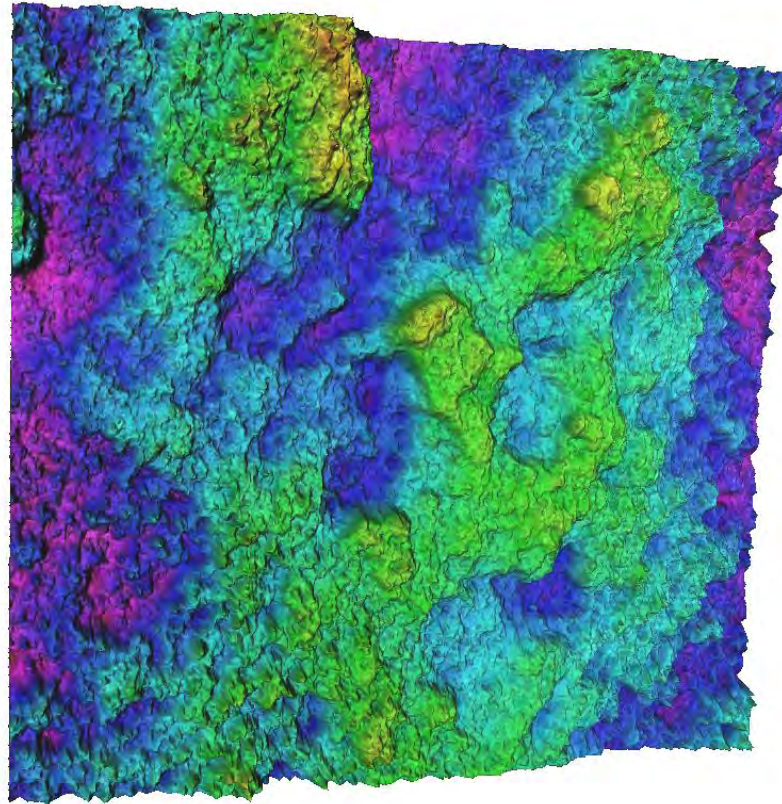
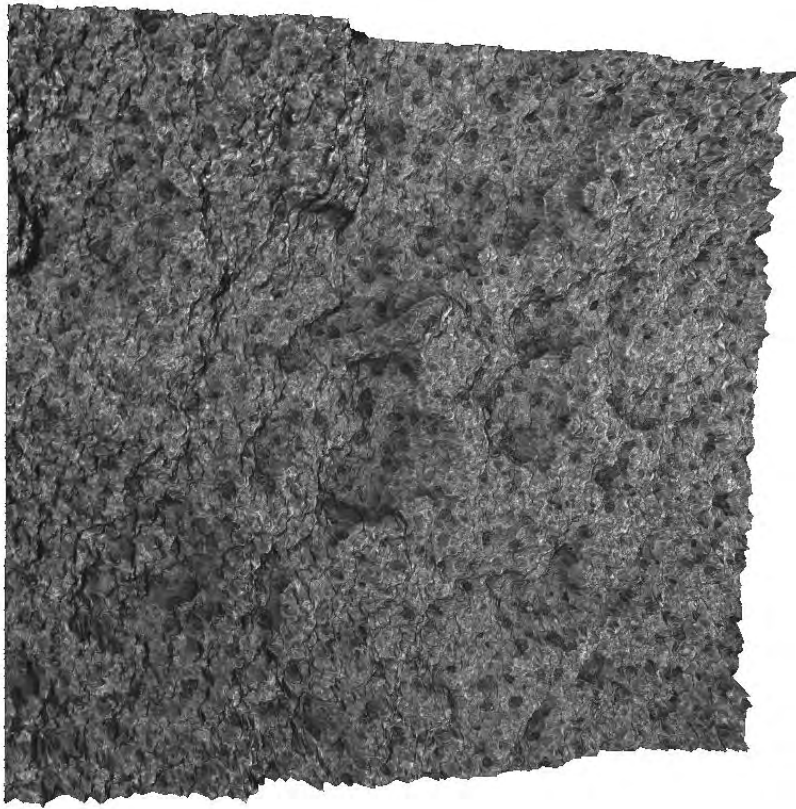
VEGA – Application Examples

■ Austempered Ductile Cast Iron – Fracture Surface

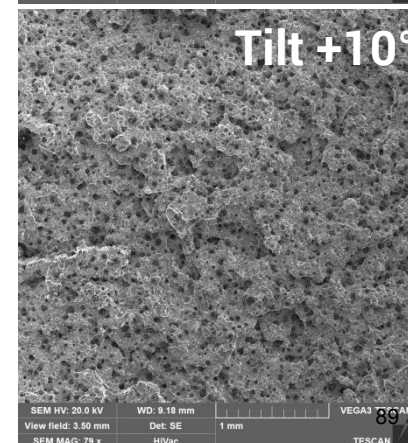
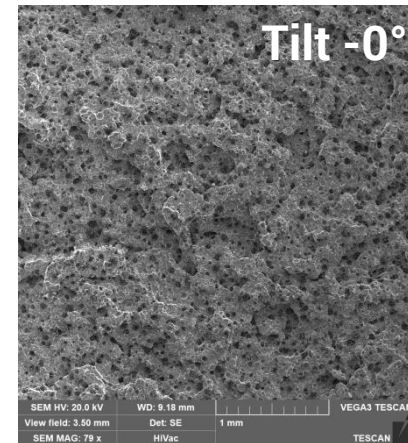
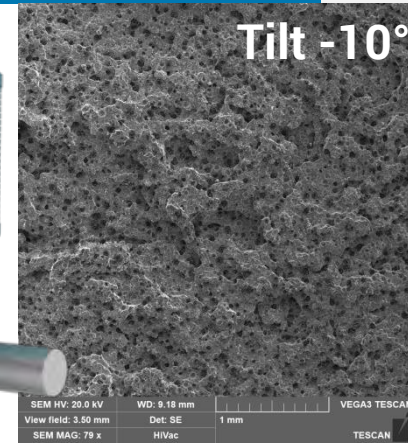


VEGA – Application Examples

■ Austempered Ductile Cast Iron – Fracture Surface

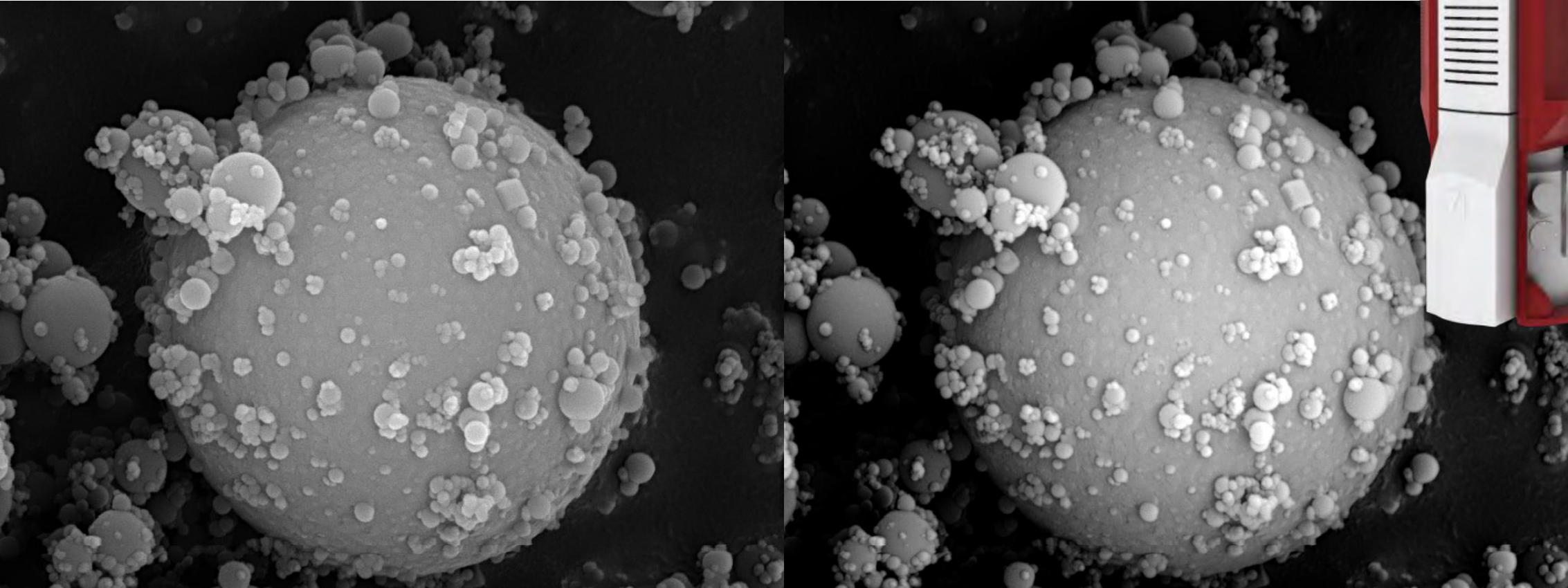


**TESCAN with MEX
software**



MIRA – Application Examples

- Silica powder



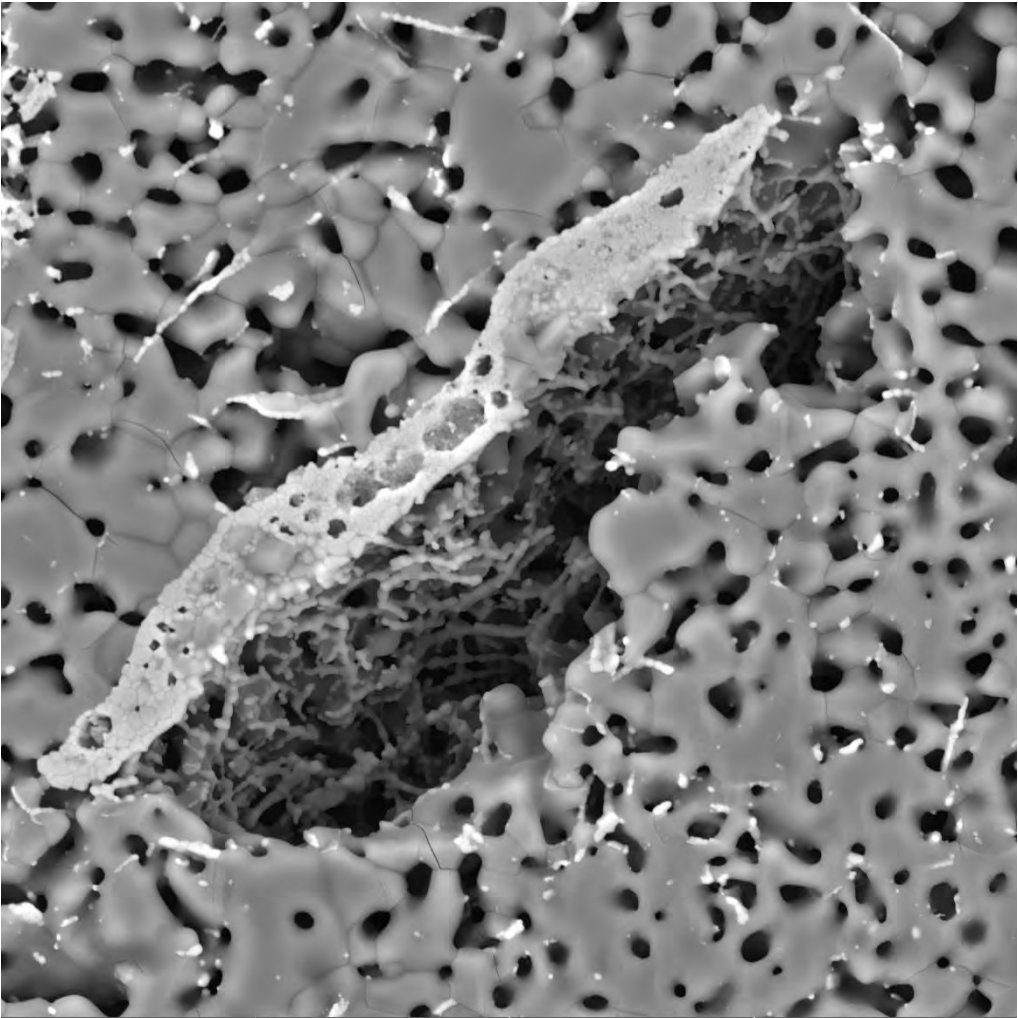
SEM HV: 20.0 kV	WD: 8.03 mm
View field: 3.43 µm	Det: SE, BSE
HiVac	SM: RESOLUTION



MIRA3 TESCAN

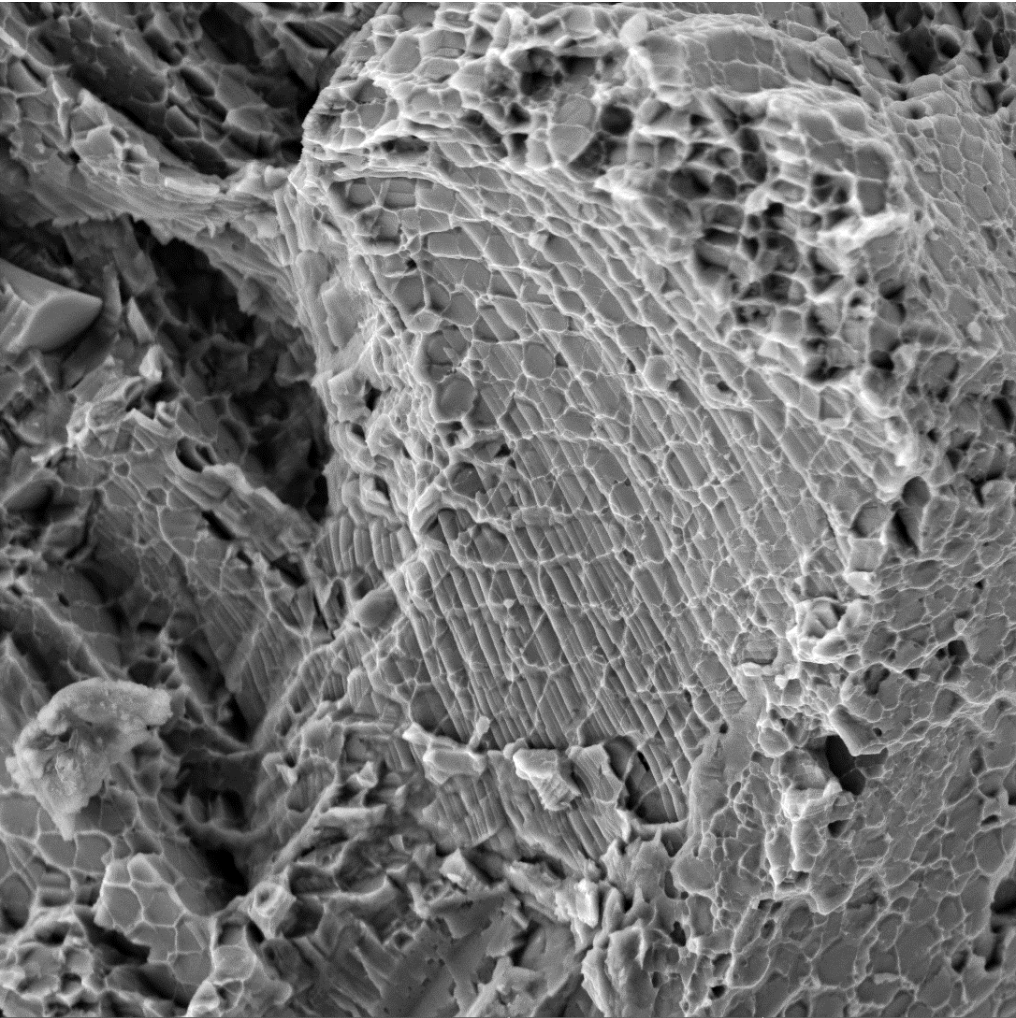
MIRA – Application Examples

■ Ceramic sample – ZrO2 wires



SEM HV: 15.0 kV	WD: 7.51 mm	MIRA3 TESCAN	
View field: 41.5 µm	Det: SE + BSE	10 µm	
SEM MAG: 10.0 kx	HiVac	Performance in nanospace	

■ Inconel – Fracture surface

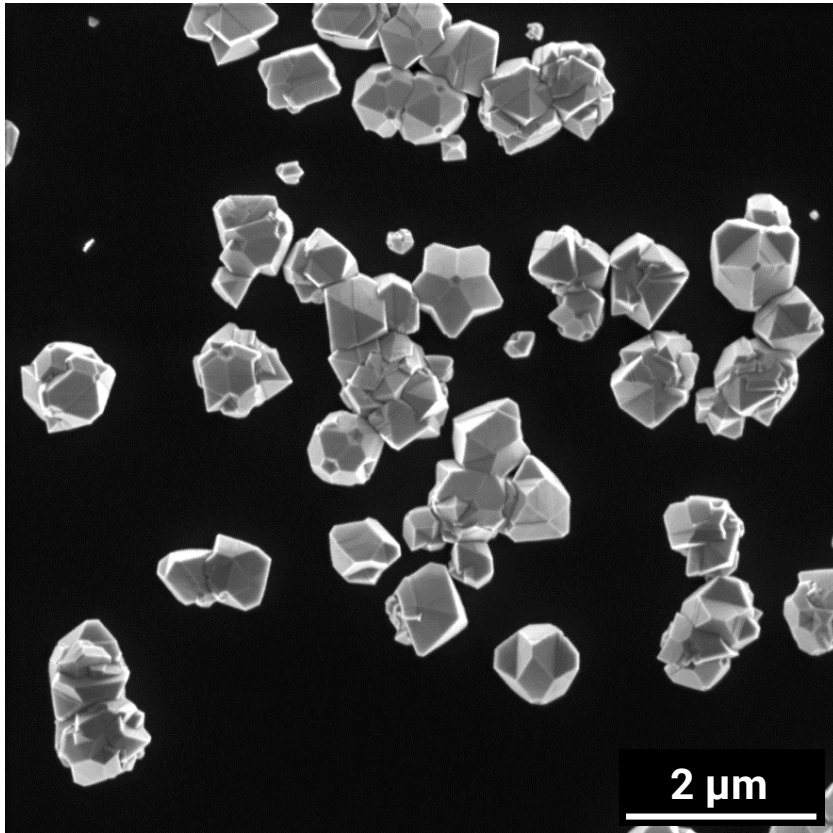


SEM HV: 10 kV	WD: 5.88 mm	MIRA3 TESCAN	
View field: 20.0 µm	Det: SE	5 µm	
Vac: HiVac	SM: RESOLUTION	TESCAN PERFORMANCE IN NANOSPACE	

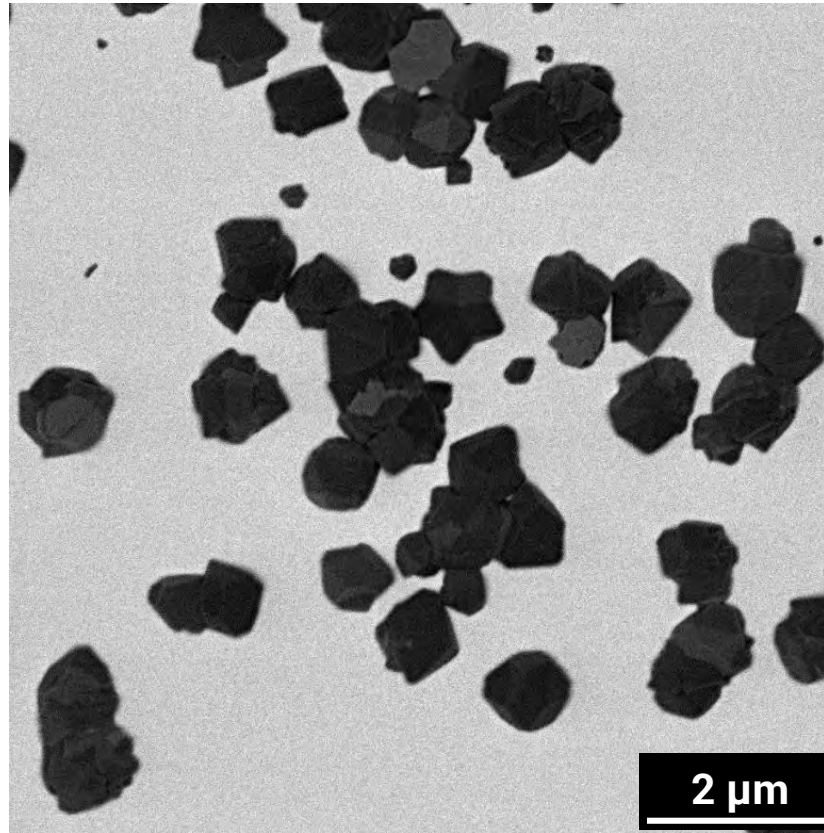


MAIA – Application Examples

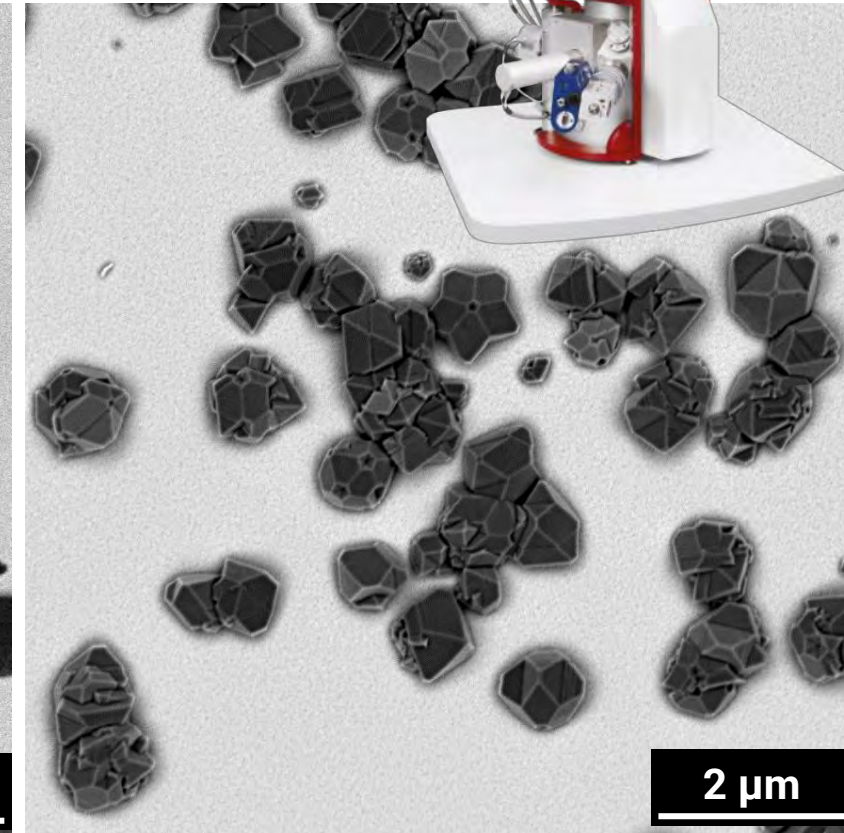
■ Silicon substrate with nanocrystalline diamonds with Si vacancies



In-Beam SE detector for high topography contrast (2 kV).



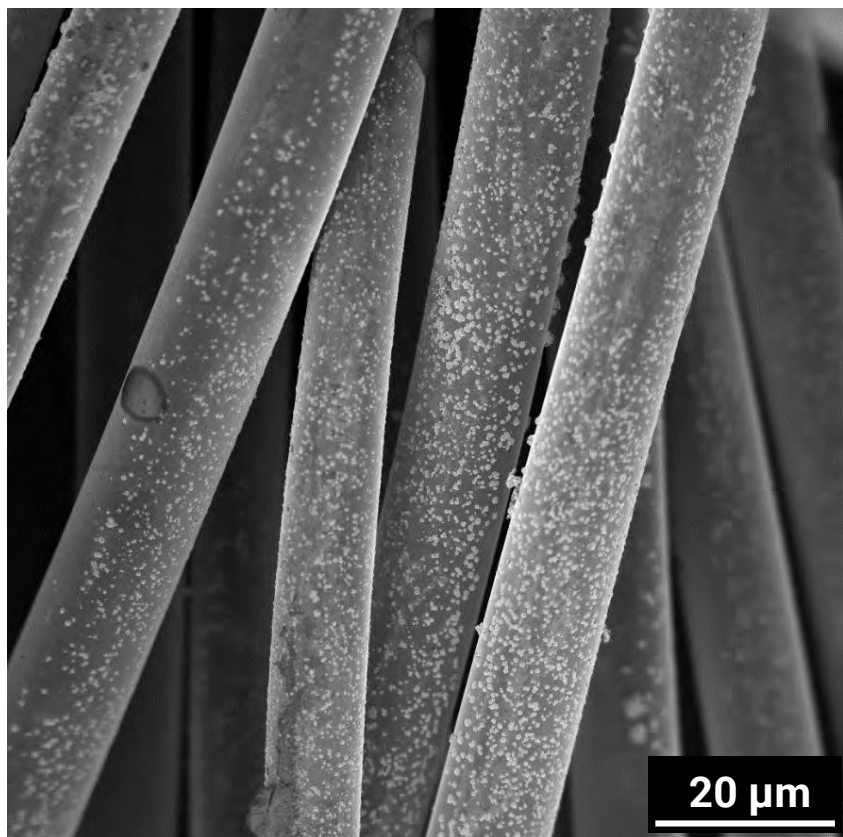
In-Beam BSE detector for pure material contrast (2 kV).



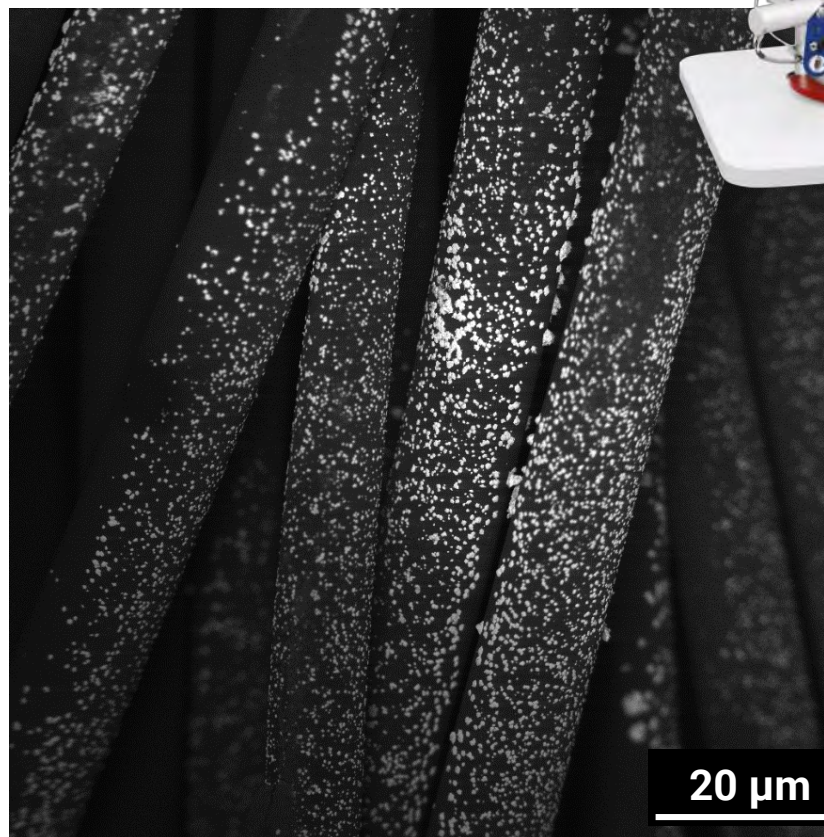
Mid-Angle BSE detector for both material and topographical contrast (2 kV).

MAIA – Application Examples

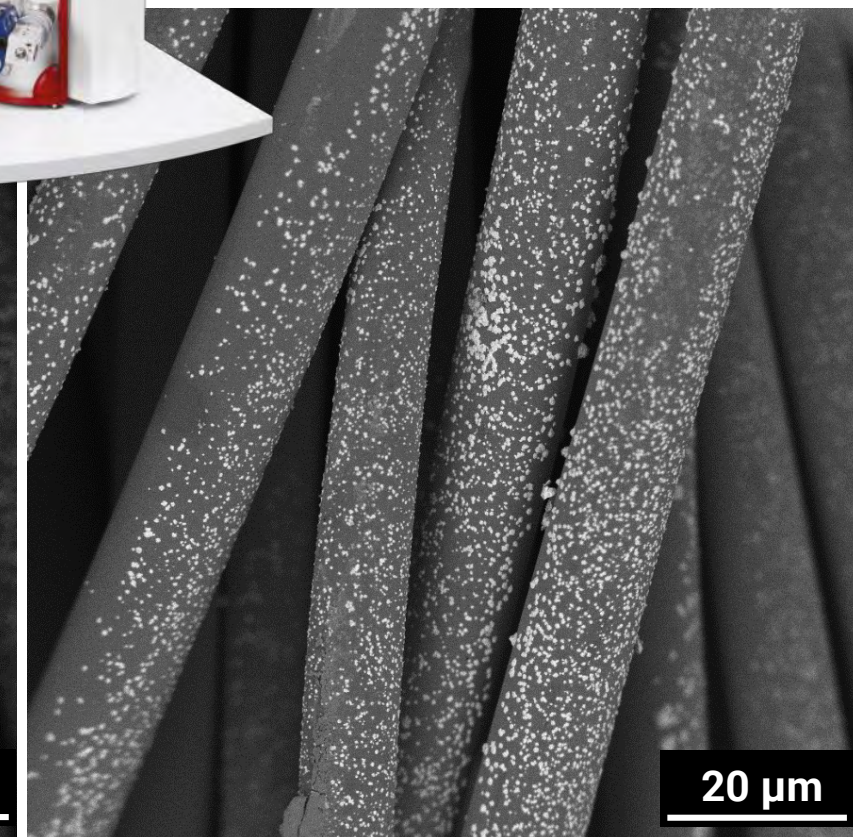
■ Carbon fibers with silver nanoparticles



In-Beam SE detector for high topography contrast (1 kV).



In-Beam BSE detector for pure material contrast (1 kV).



Mid-Angle BSE detector for both material and topographical contrast (1 kV).

S8000G Excellent FIB-SEM

Orage™ FIB column

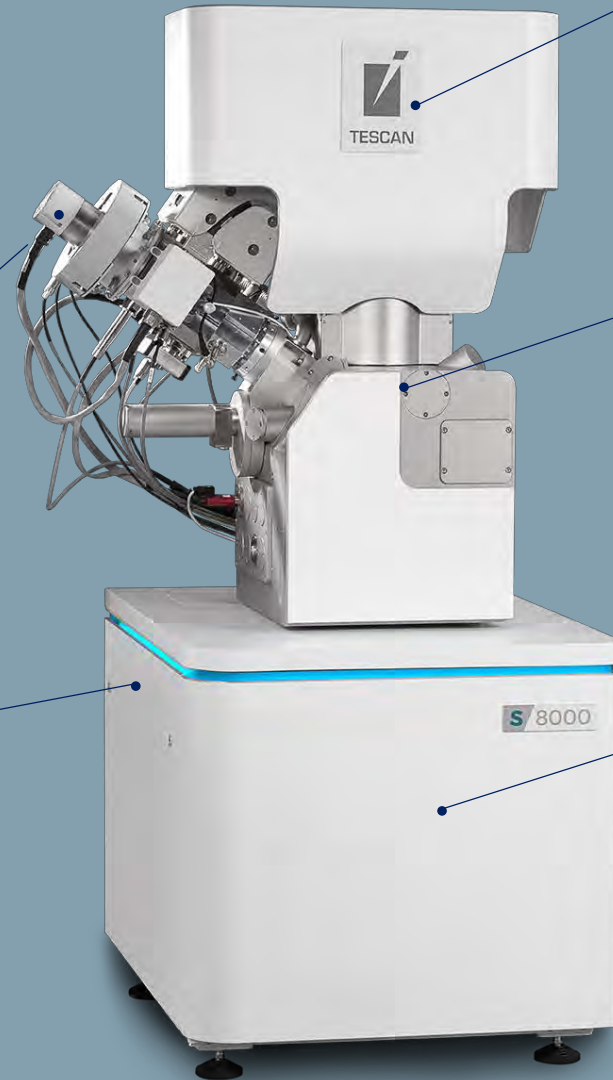
BrightBeam™ SEM
column

In-Beam detector system

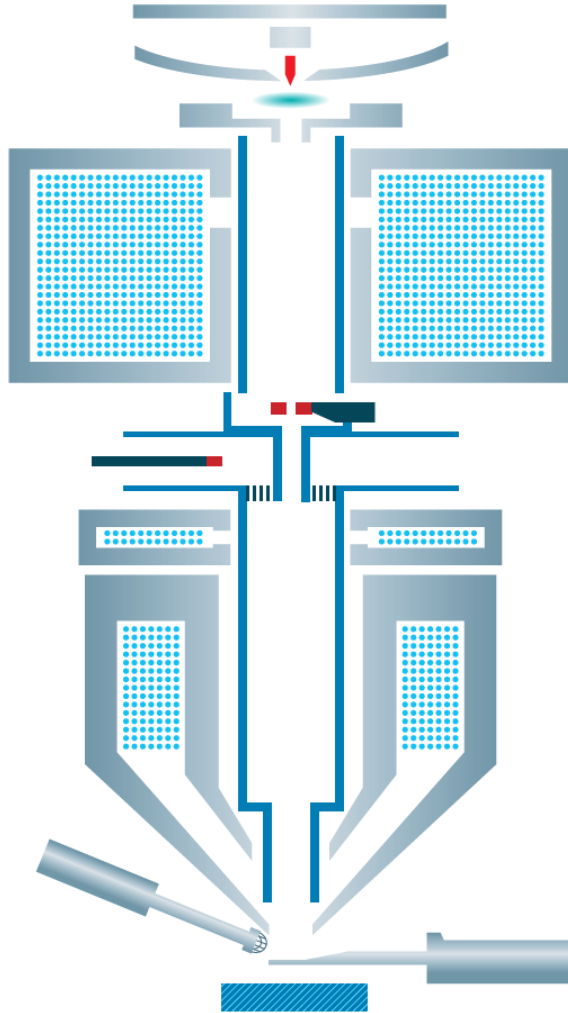
New HW

TESCAN Essence™ SW

New design



S8000G – BrightBeam™ SEM Column



- **Ultra High Resolution Field-Free SEM**
 - Excellent imaging at low energies
- **High Performance Field-emission Electron gun**
 - 10x faster changes of acceleration voltage
 - Probe current up to 400 nA
- **EquiPower™ Technology**
 - Constant power dissipation for high stability
- **In-Flight Beam Tracing™**
 - Accurate real-time computation of optical parameters
- **Wide Field Optics**
 - Variety of imaging modes
 - Large field of view imaging

S8000G – High Resolution Imaging at Low kV

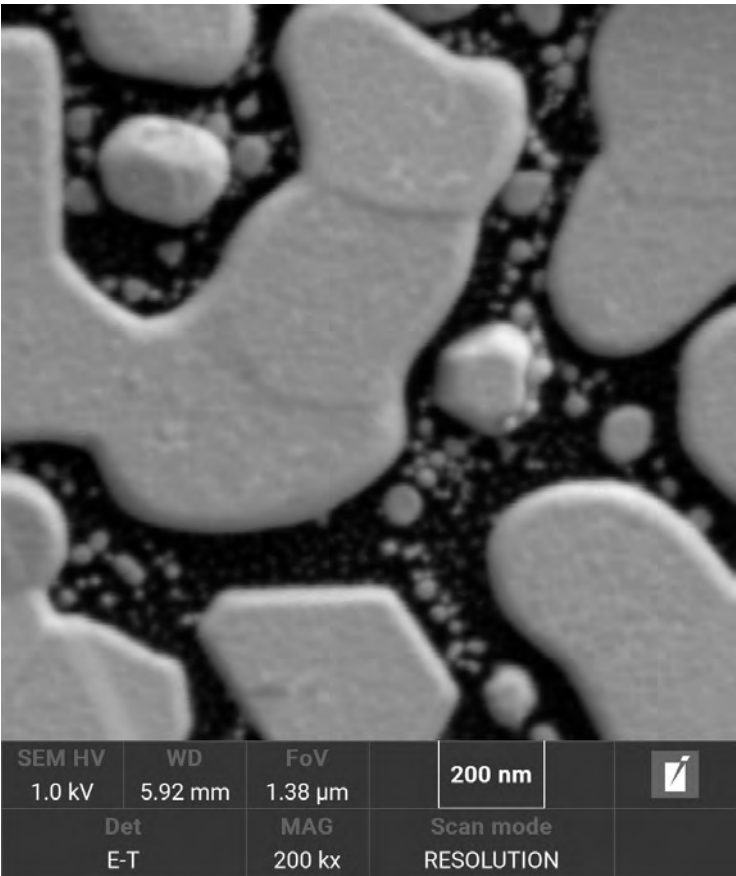
Combined electrostatic-magnetic lens enables **field-free ultra-high resolution imaging**

Resolution specs:

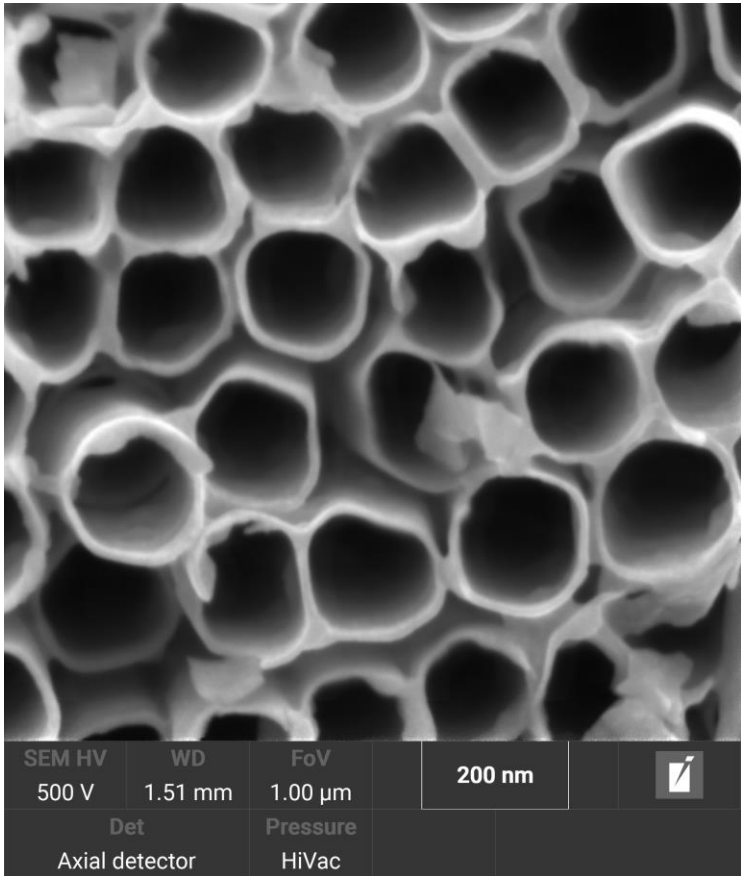
15 kV	0.9 nm (field-free)
1 kV	1.7 nm (field-free)
1 kV	1.4 nm (BDM)

Electron Beam Energy:

50 eV to 30 keV
down to 0 eV with manual BDM



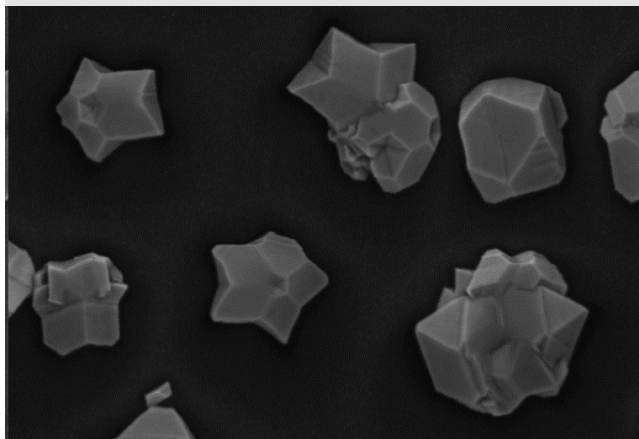
Au on C, 1kV, field-free



TiO₂ nanotubes, 500 V field-free

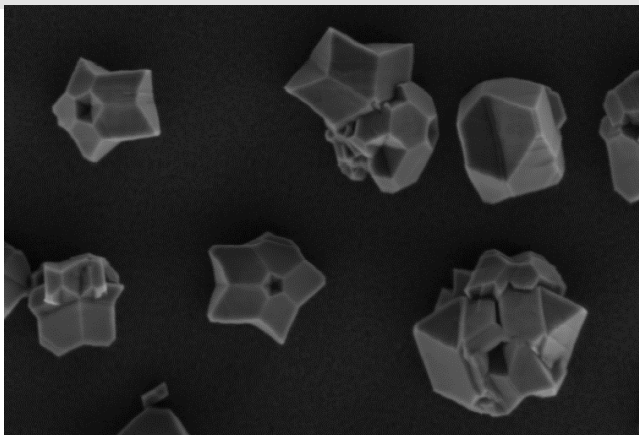
S8000G – Detection system

Axial Detector

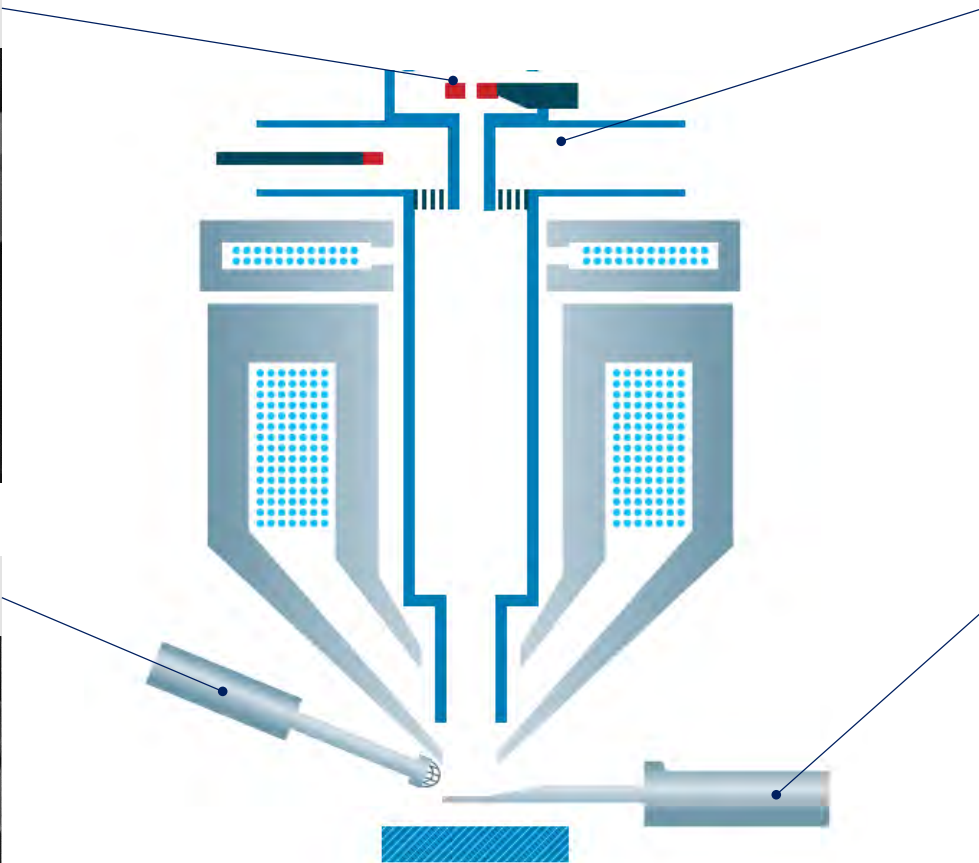


SE (BDM), SE

E-T detector

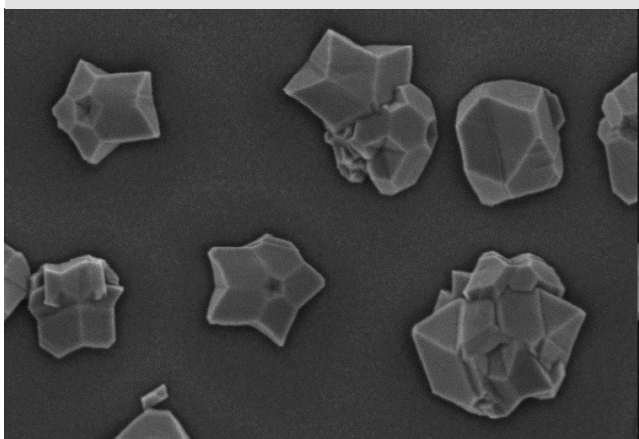


Topographical BSE SE (booster off)



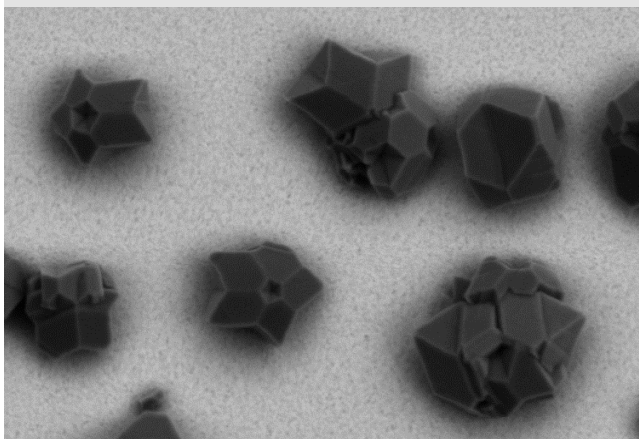
4 detectors and 9 signals to explore!

Multidetector



Filter Grid - SE x BSE

BSE-LE detector

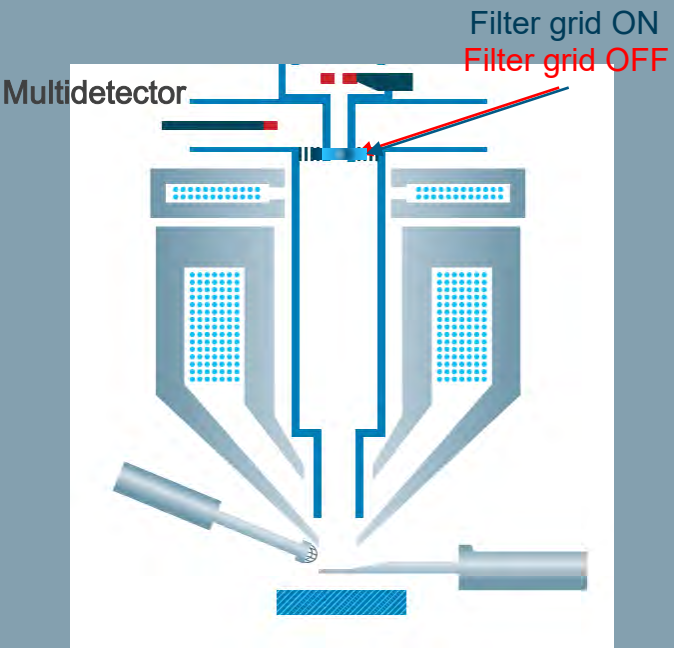


Wide-angle BSE

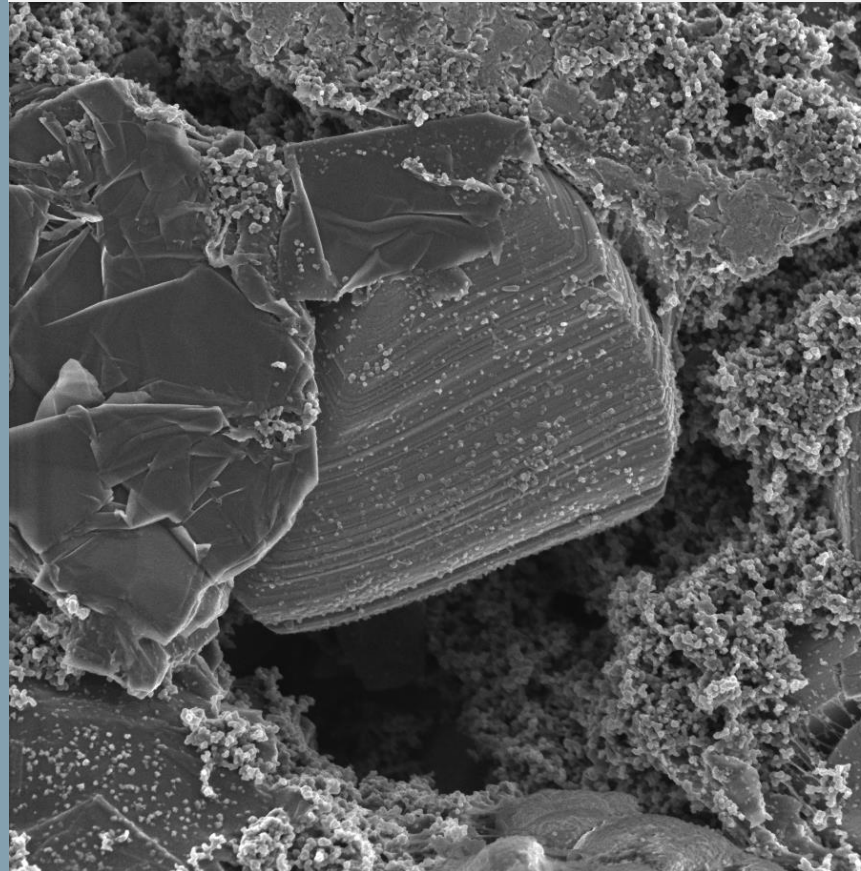
Detection system

SE and BSE SELECTION BY FILTERING WITH A MULTIDETECTOR

Li battery cathode

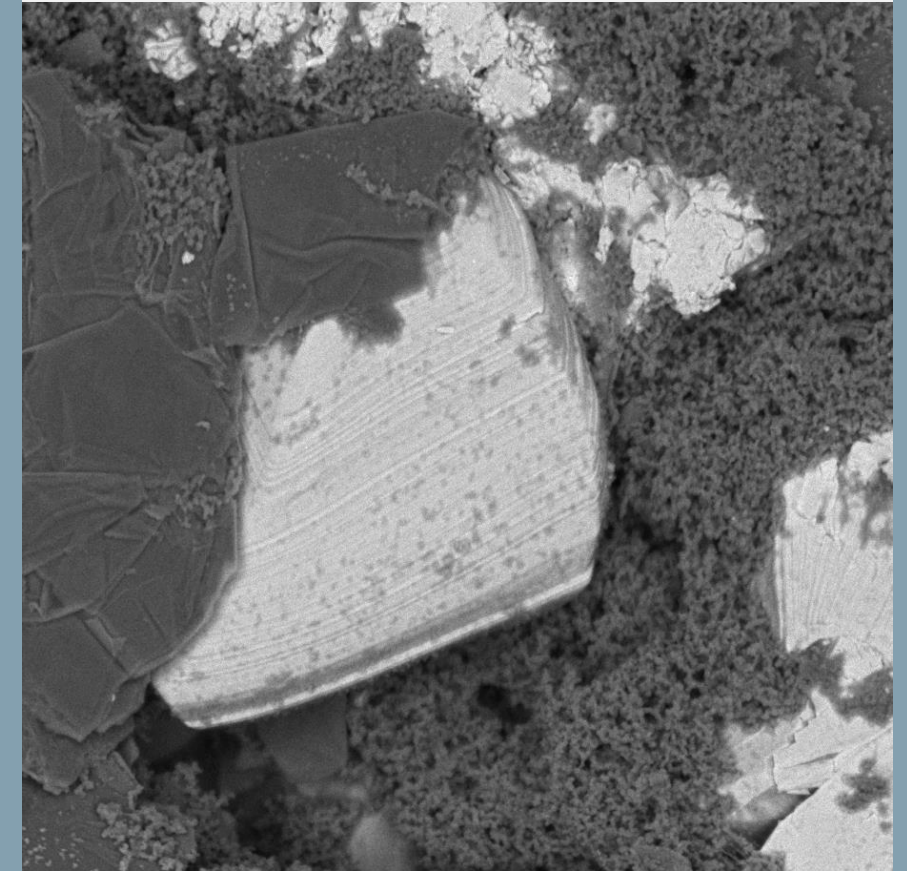


Grid **OFF** = SE signal



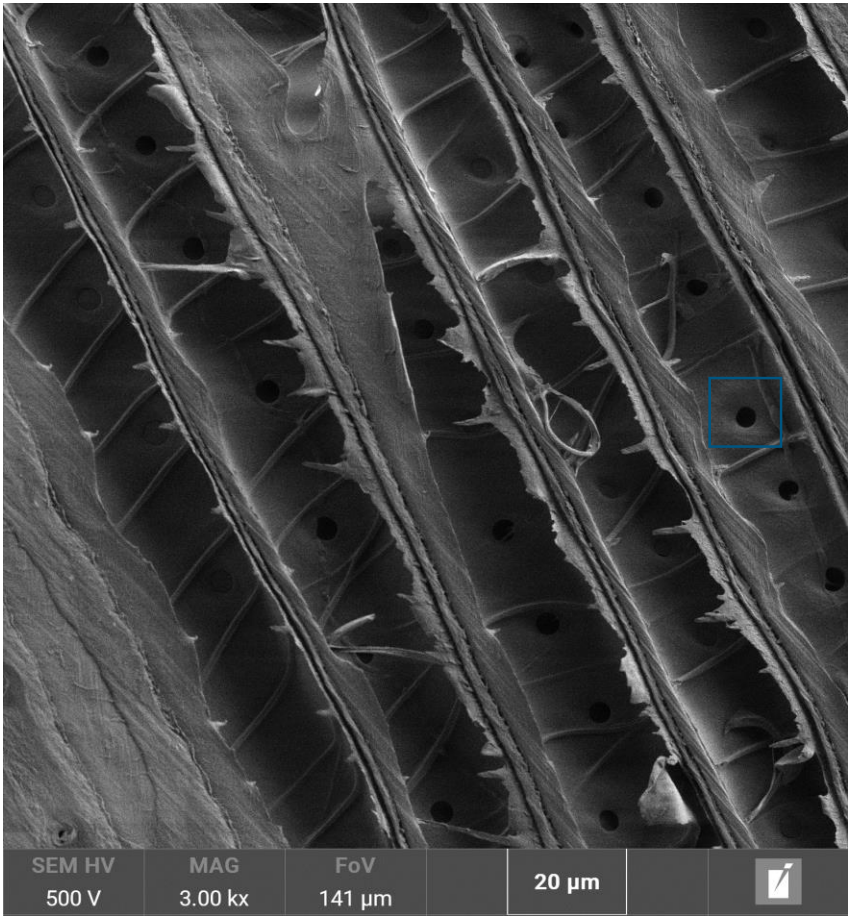
Resolution, topography,
typical edge contrast

Grid **ON** = BSE signal

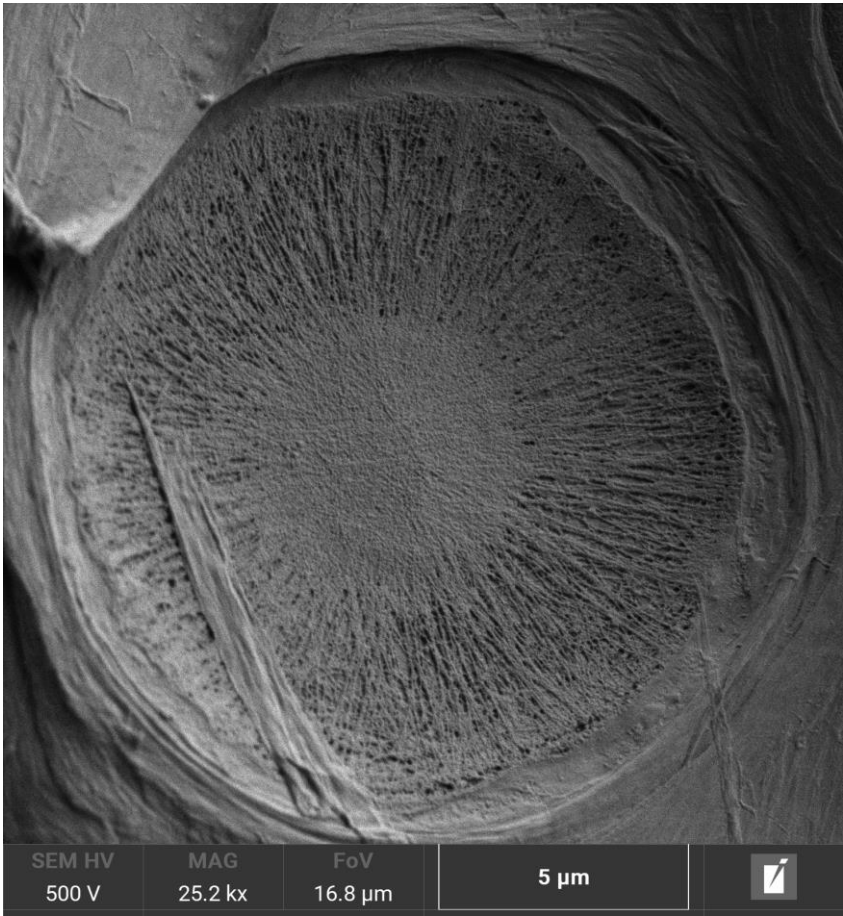


Material contrast

S8000G – Wood - Taxus



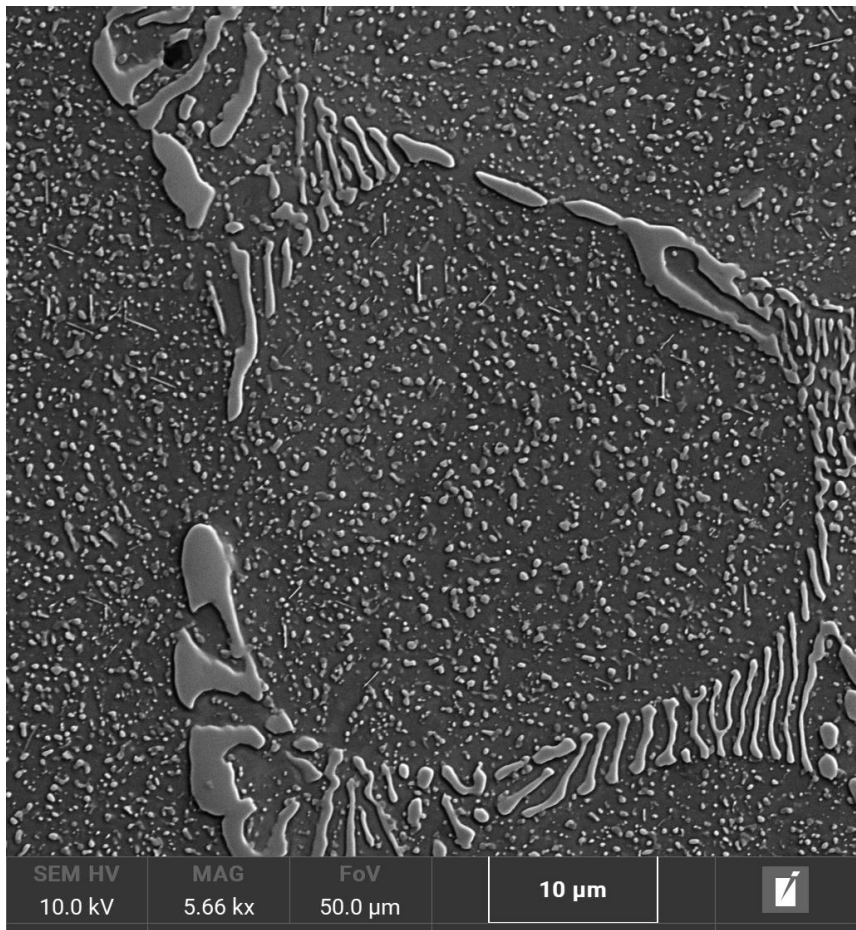
500V E-T Detector



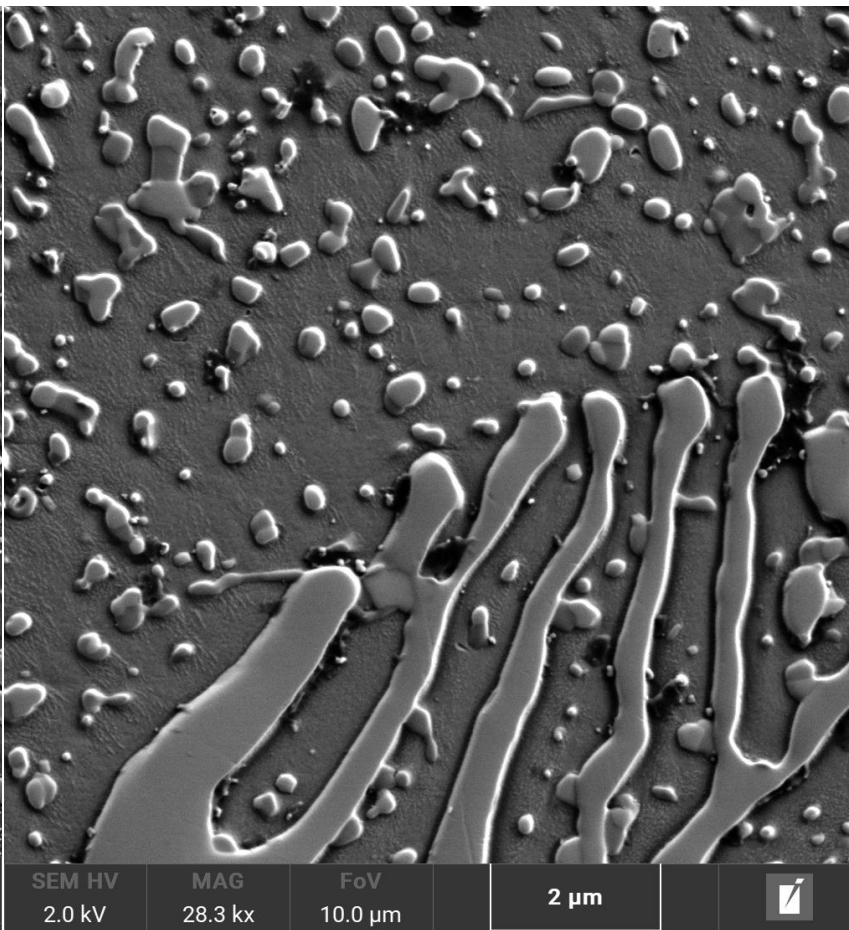
500V E-T Detector



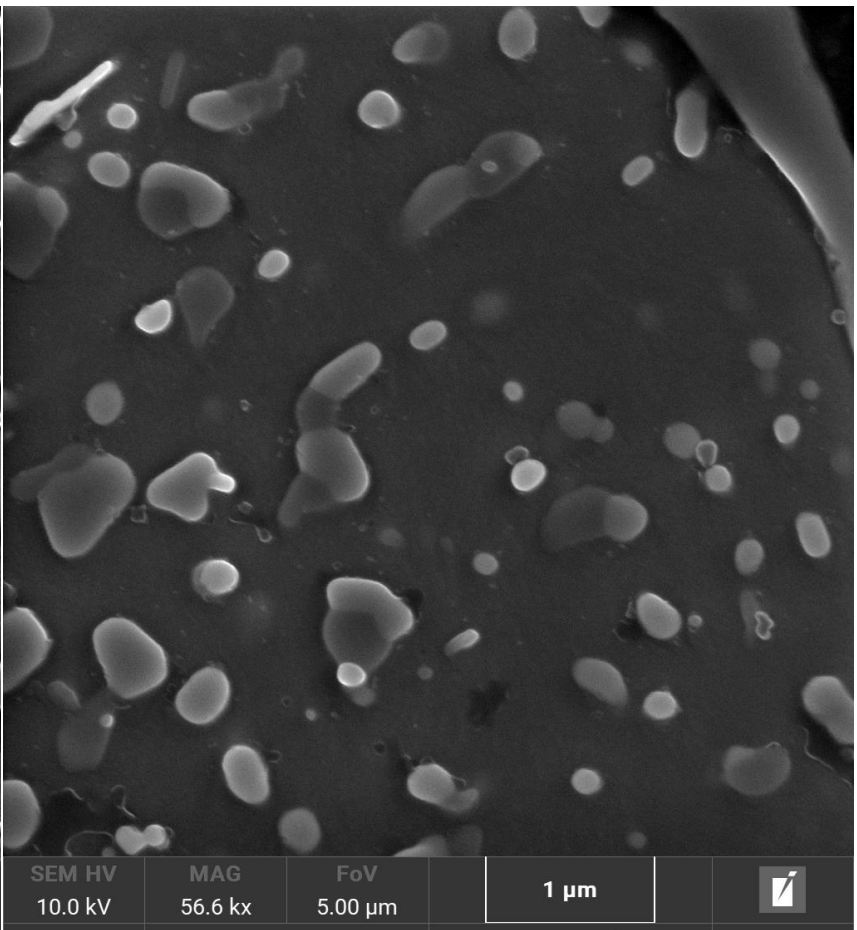
S8000G – High-Speed Steel – Ferromagnetic sample



10kV E-T Detector

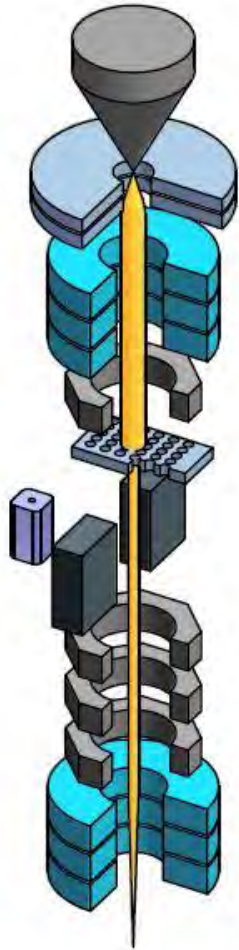


2kV E-T Detector



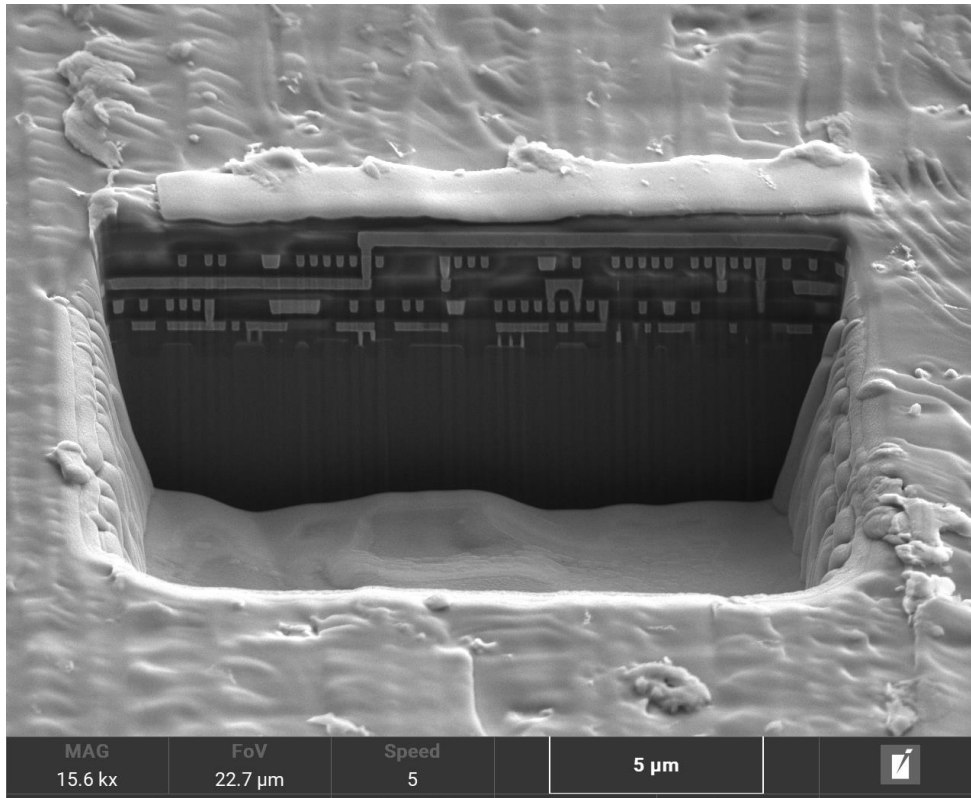
10kV Multi-Detector

S8000G – Orage FIB Column

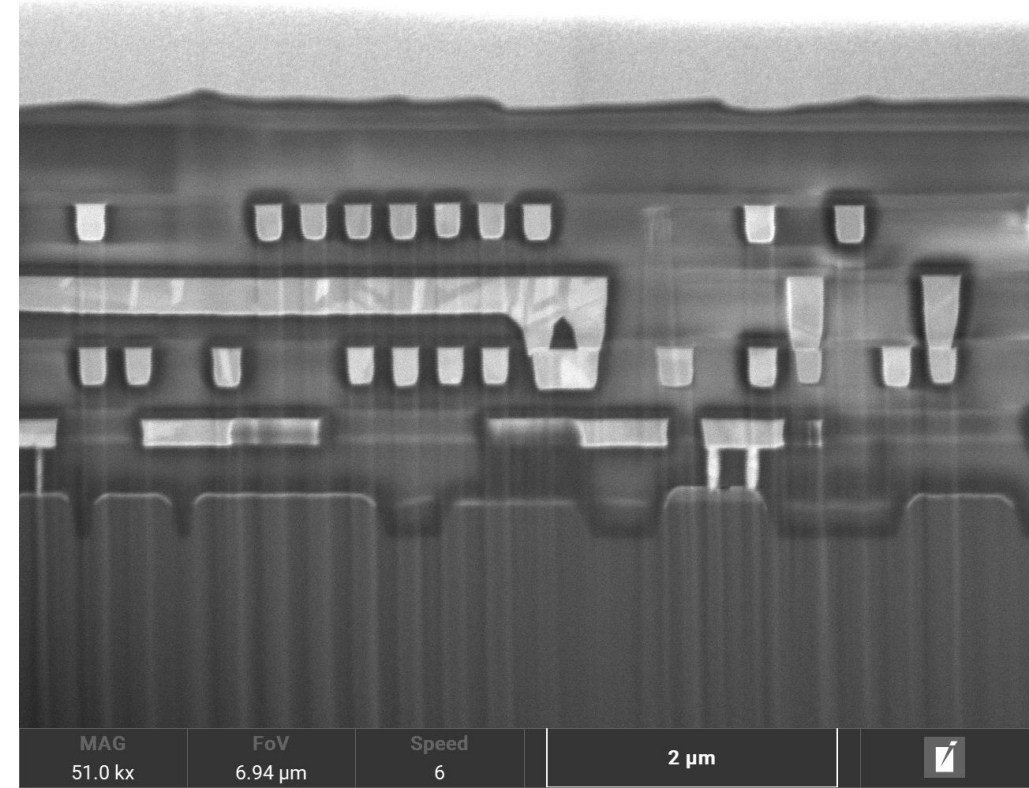


- **Next Generation FIB Column Design**
- **Improved low energy resolution for ultra-fine machining**
- **Beam current up to 100 nA for large volume milling**
- **Smart column alignment**

Integrated Circuit - 15 μm Polished Cross-Section (done in 4 minutes)



5kV E-T detector



2kV E-T detector

S8000G – Iron Powder – High Speed Crosssection

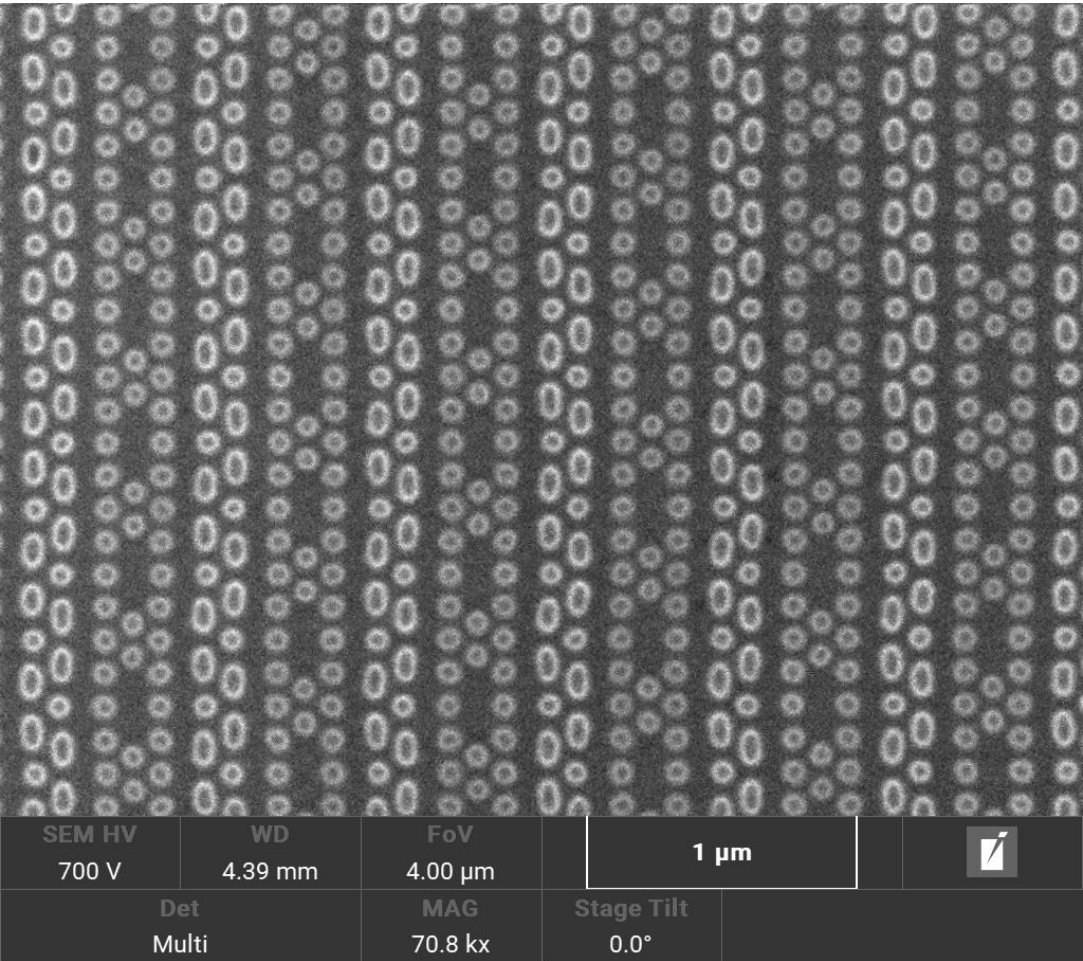


30kV FIB Image E-T detector



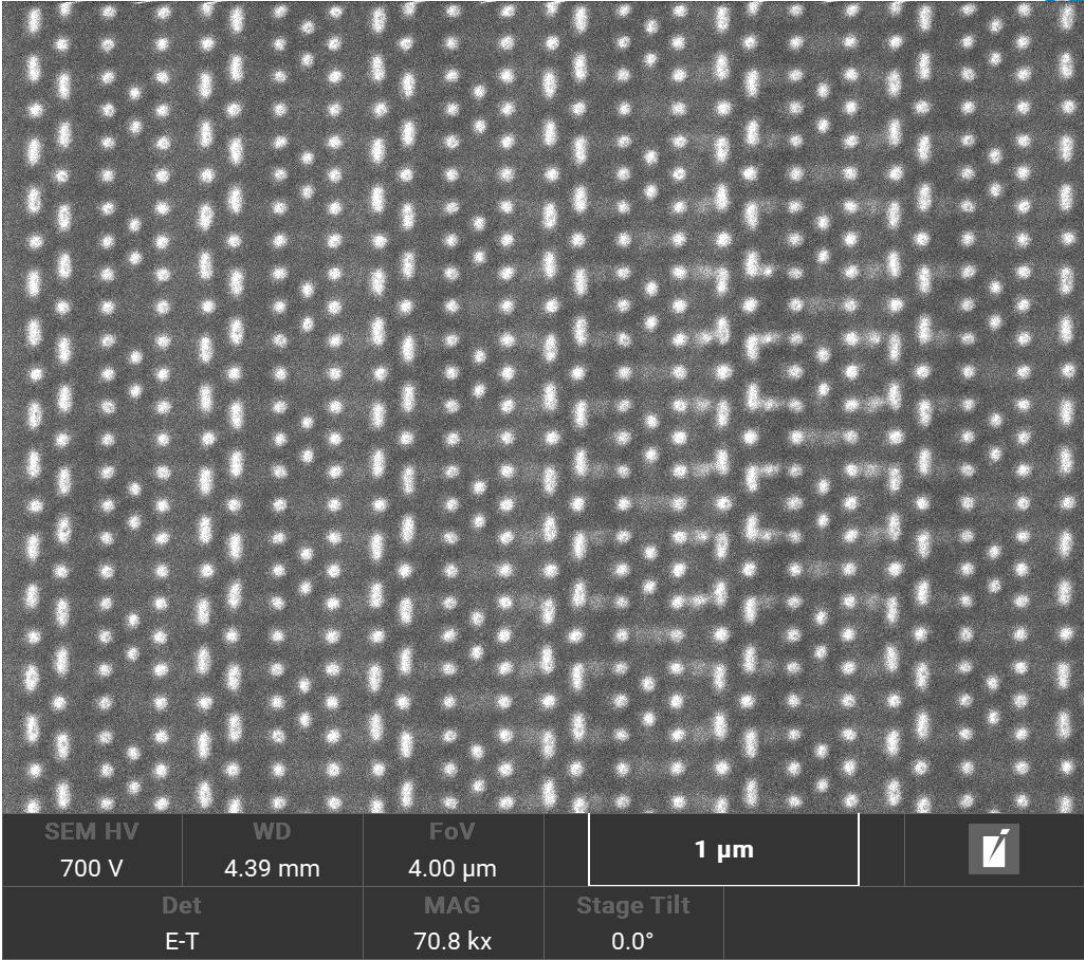
30kV FIB Image E-T detector

S8000G – Inspection after delayering: Imaging at 700 V



700V Multi detector

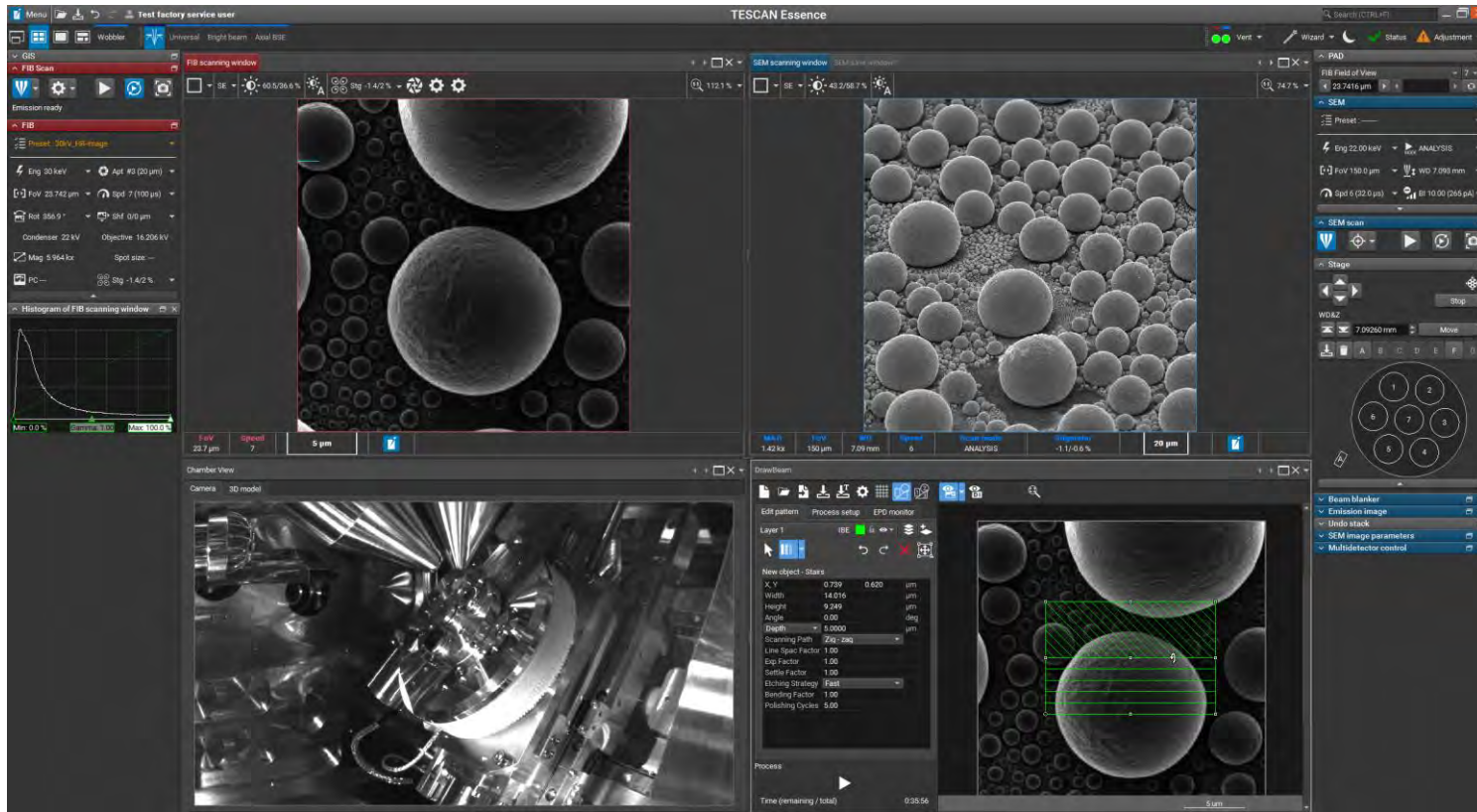
Voltage contrast



700V E-T detector

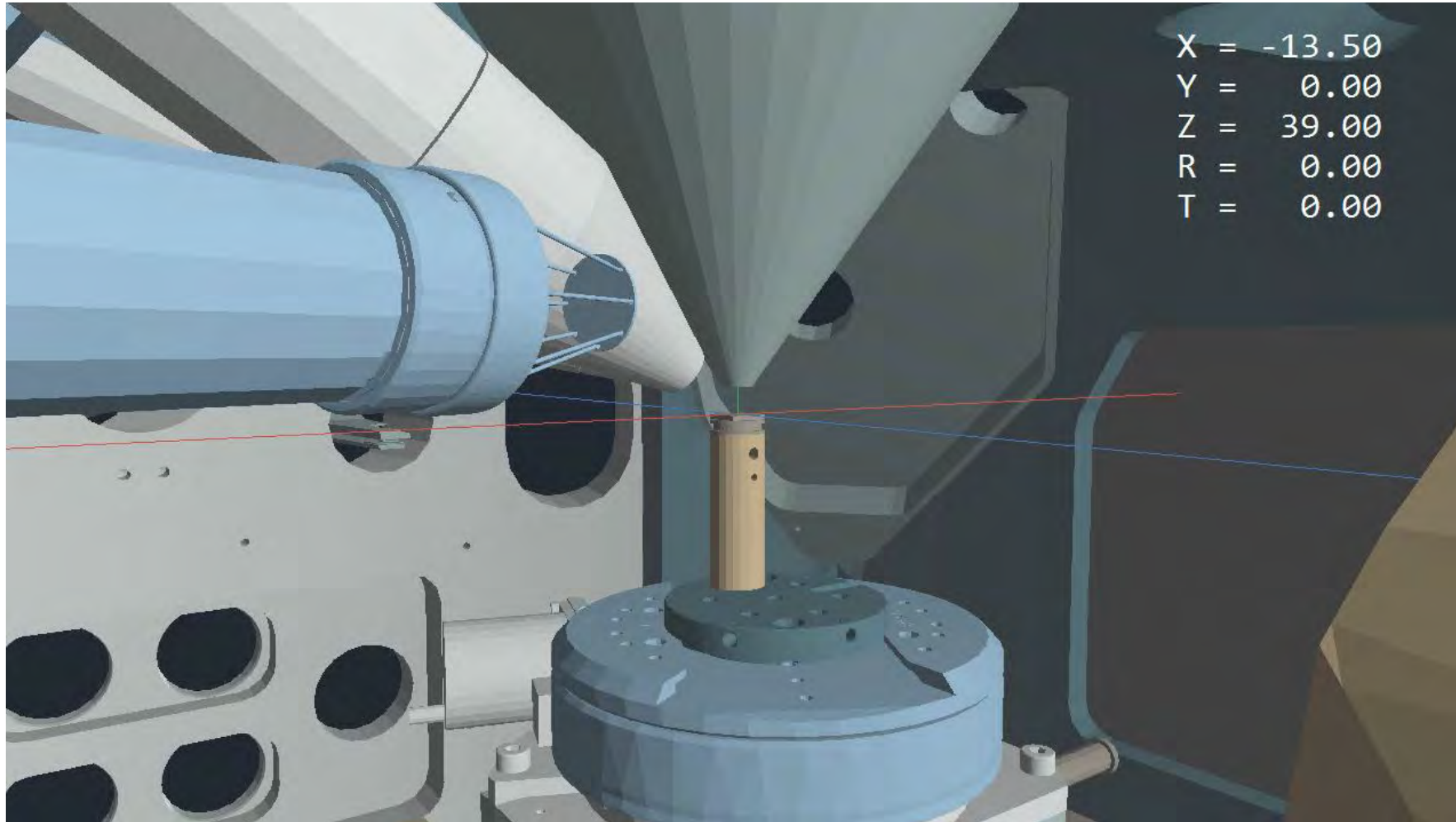
Topography: residual of the previous layer

TESCAN Essence™ software



- Simplified GUI
- Application specific layout
- Layout manager for image windows
- Workflow-oriented wizards
- DrawBeam for live & static window
- Chamber view
- 3D collision model
- Quick search box
- SEM/FIB undo-redo
- Report template editor
- Easy-to-learn for all users

TESCAN Essence™ software



DUAL BEAM SYSTEMS

Dual Beam Systems – Ga⁺, Xe⁺

COBRA FIB column

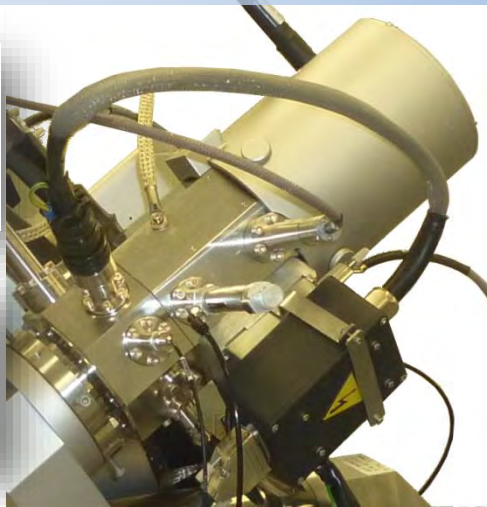
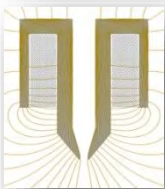
Analytical Performance

1.2 nm at 15 kV



High Resolution

0.7 nm at 15 kV



- Ga⁺ ions
- High resolution: 2.5 nm @ 30 kV
- In-Flight Beam Tracing
- Probe current control
- Spot size computation

iFIB plasma column

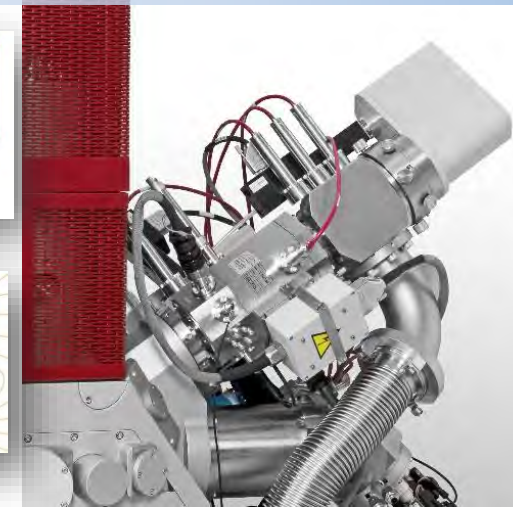
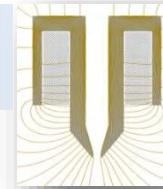
Analytical Performance

1.2 nm at 15 kV



High Resolution

0.7 nm at 15 kV



- Xe⁺ ions
- High resolution: 15 nm @ 30 kV
- Continuously adjustable current up to 2 uA
- Probe current control
- Spot size computation

Ga⁺, Xe⁺

Project

View

Edit

Objects

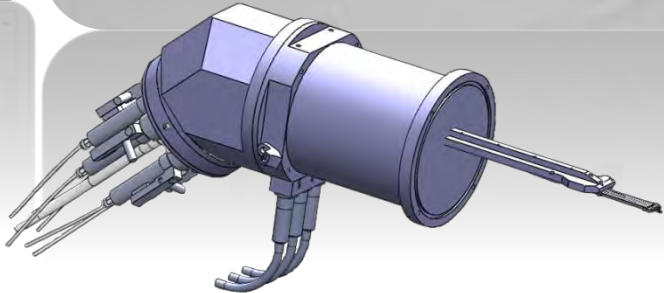
Selection properties

X, Y	1.27; -7.06	μm
Width	14.20	μm
Height	0.82	μm
Angle	0.0	°
Depth	2.0000	μm
Scanning Path	Zig - zag	
Exp Factor	1.00	
Settle Factor	1.00	

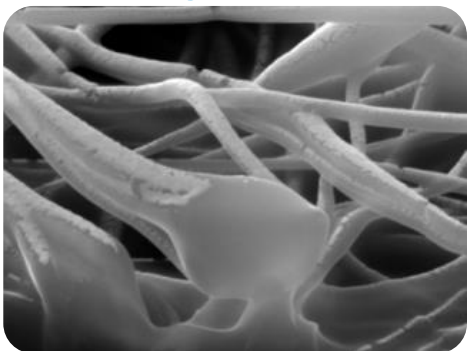
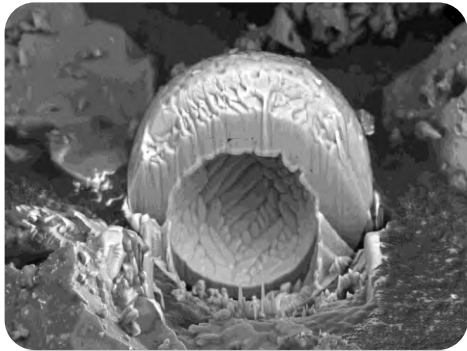
polishing IBE

Objects Layers

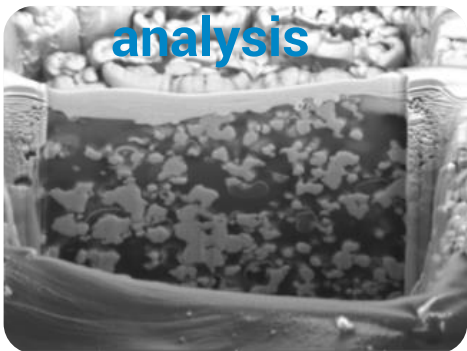
rough milling	IBE	
polishing	IBE	
undercut	IBE	
tip attachment	IBD	
final cut	IBE	
grid attachment	IBD	
polishing top	IBE	
polishing bottom	IBE	



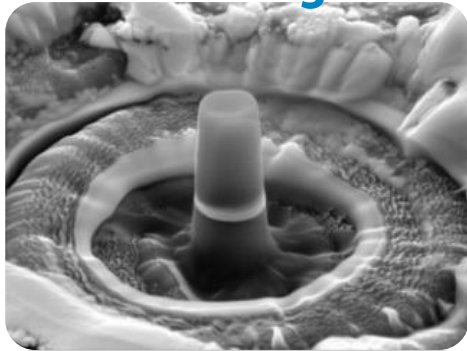
Cross-sectioning



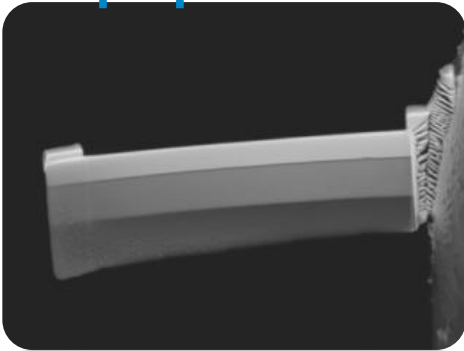
Volume analysis



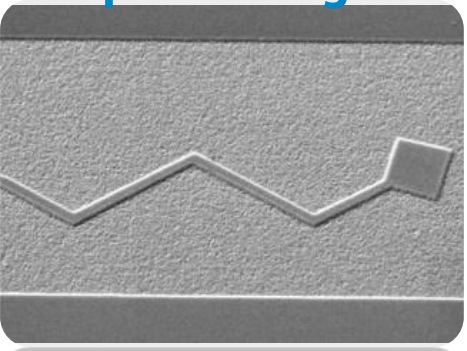
Pillars for mechanical testing



TEM lamella preparation

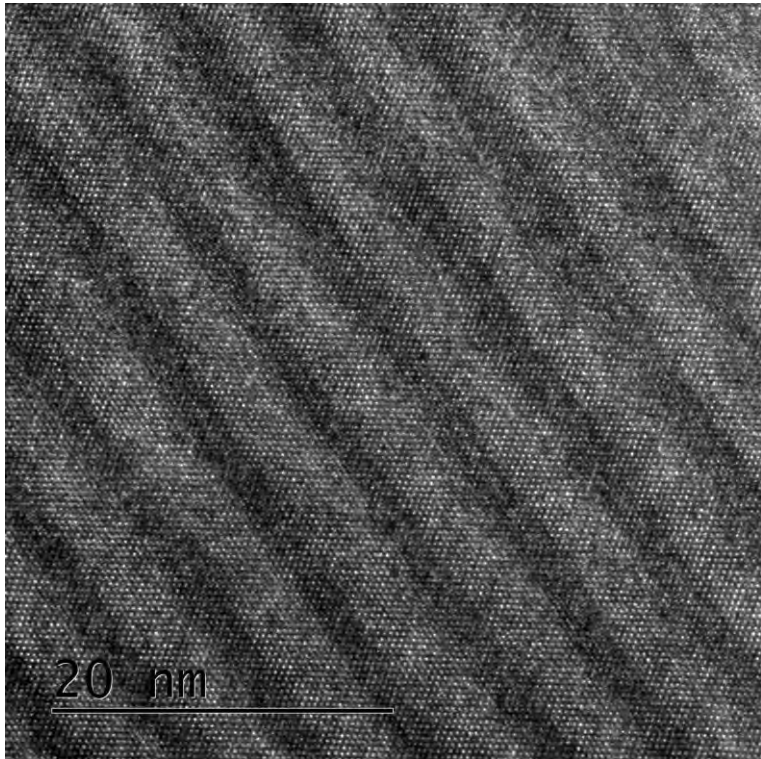
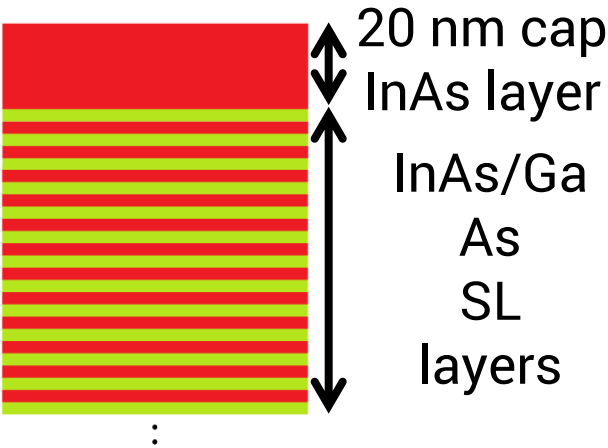
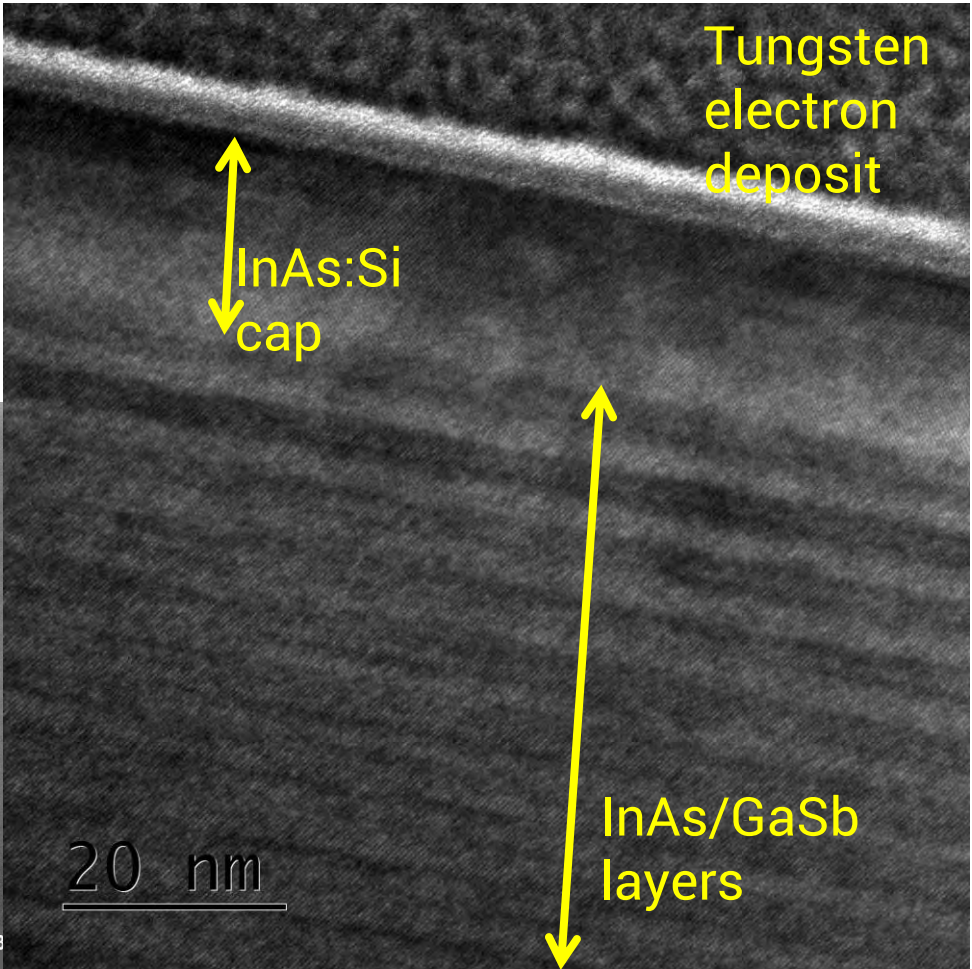
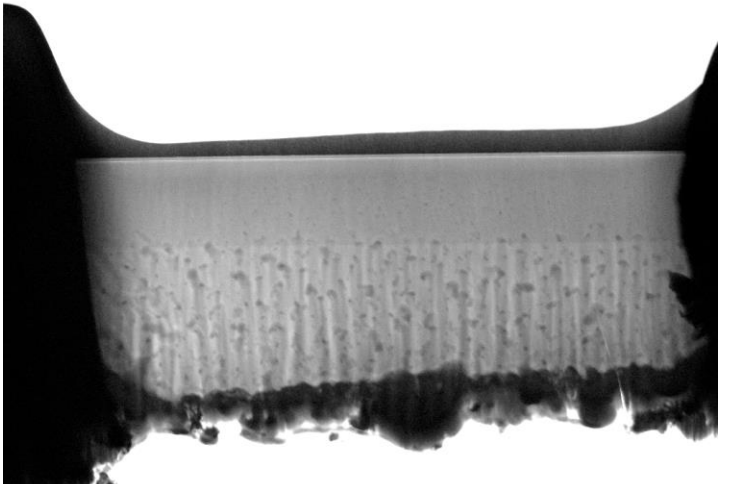


Ion Beam patterning



Xe⁺

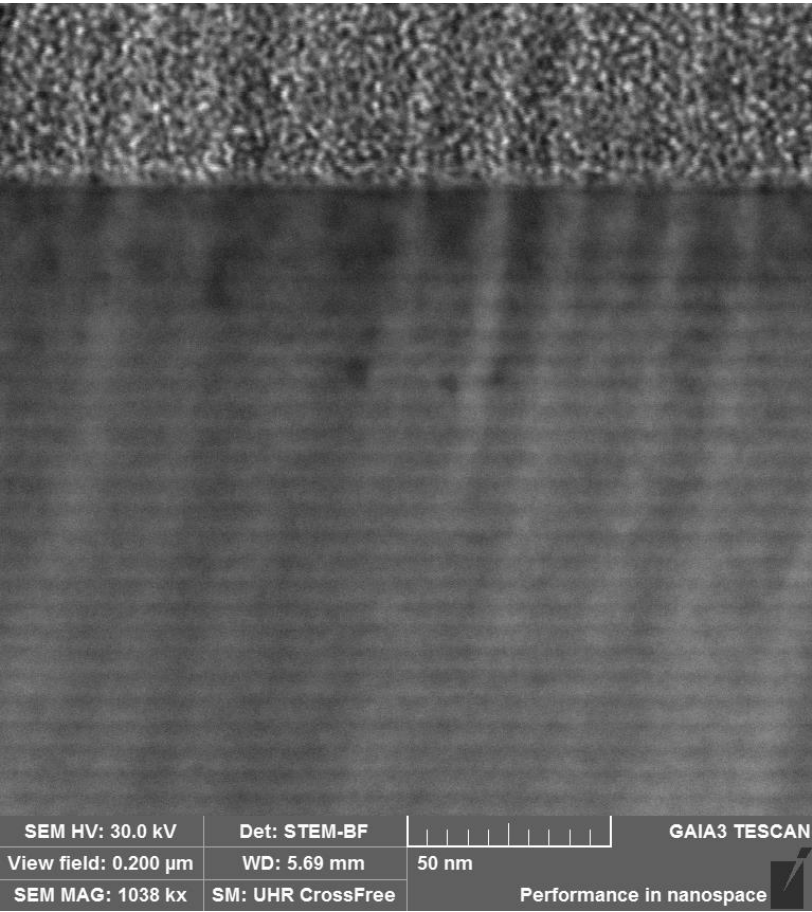
■ **II InAs/GaSb superlatice (T2SL) structure on GaSb substrate**



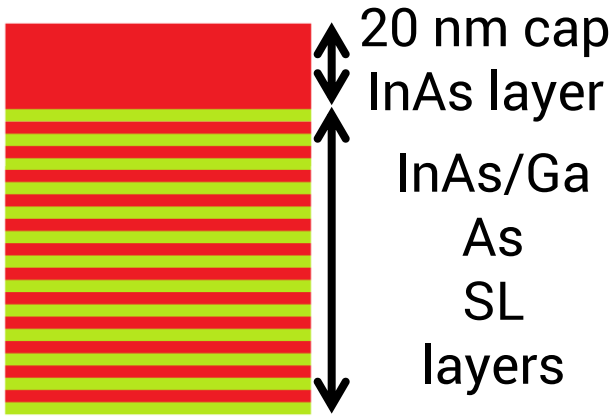
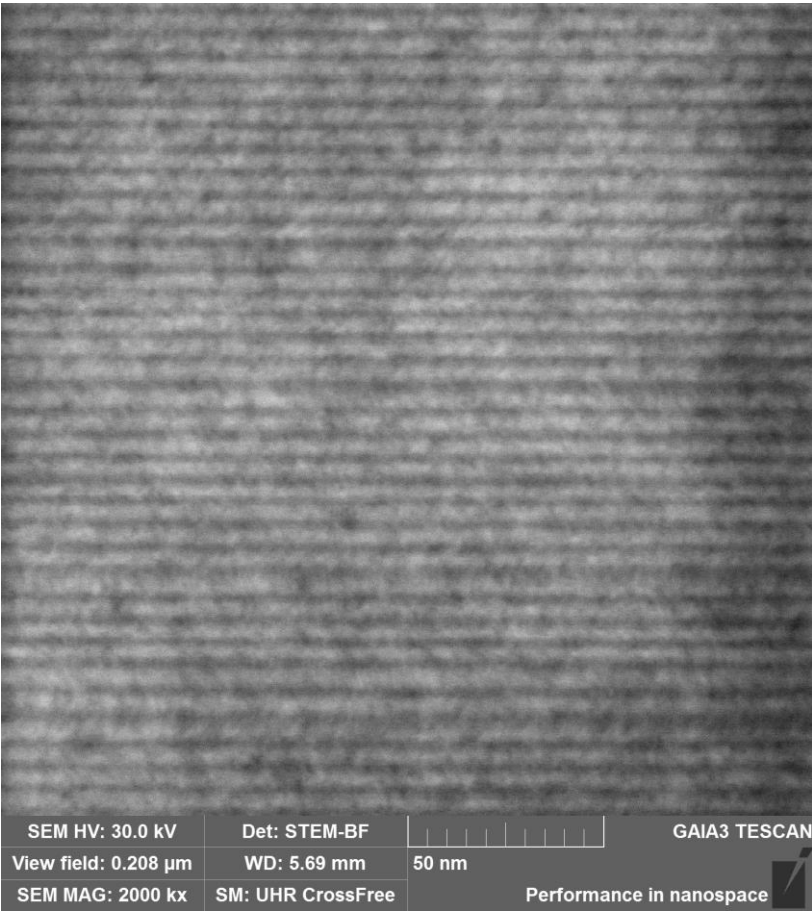
MAG: 1000 kx	Date(m/d/y): 10/17/16	FERA3
View field: 0.276 μm	XEIA3 GMU	Performance in nanospace

Ga⁺

■ **II InAs/GaSb superlatice (T2SL) structrure on GaSb substrate**



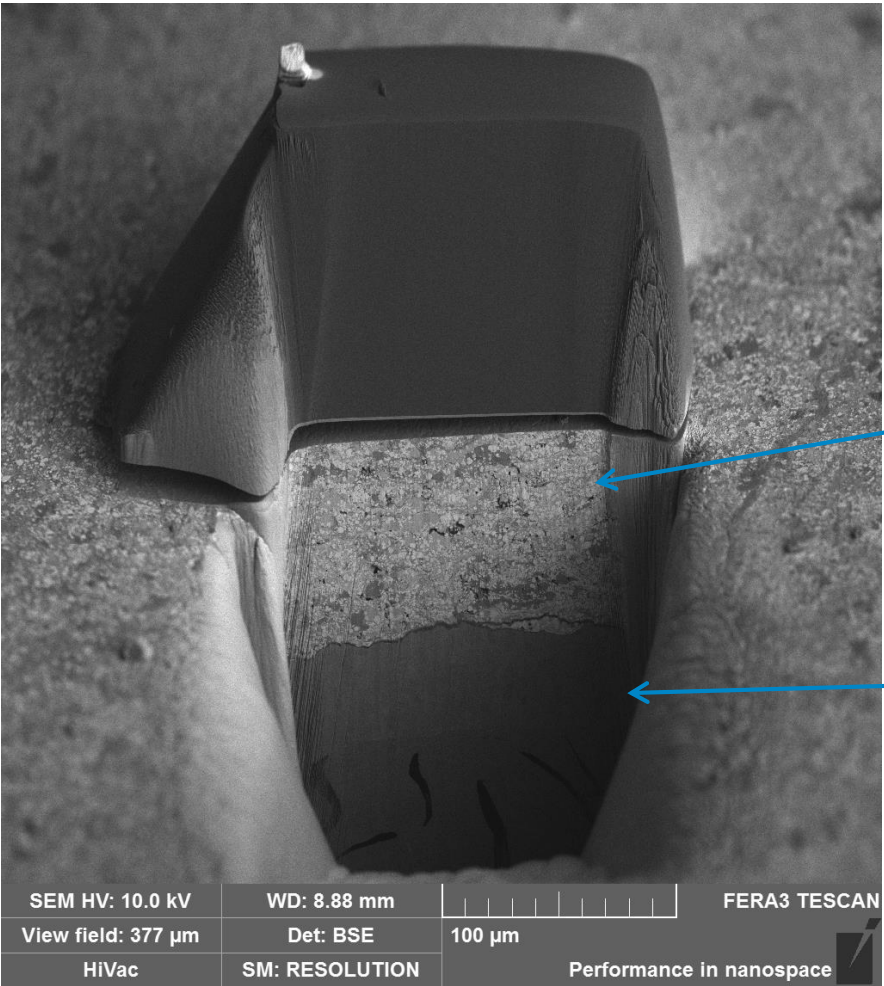
Ga⁺



20 nm	n-InAs:Si
x 40	i-GaSb (2.90 nm)
	n-InAs:Si (2.77 nm)
x 60	i-GaSb (2.90 nm)
	i-InAs:Si (2.77 nm)
x 40	p-GaSb:Be (2.90 nm)
	i-InAs (2.77 nm)
1000 nm	p-GaSb
500 nm	i-GaSb
2 inch GaSb substrate	

Xe⁺

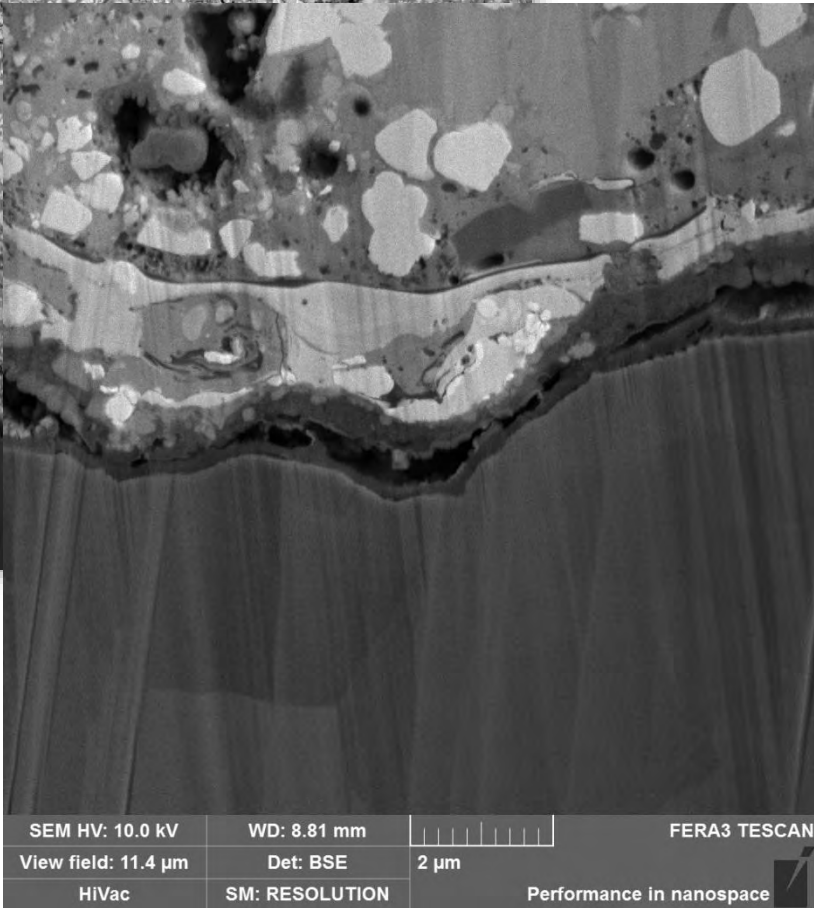
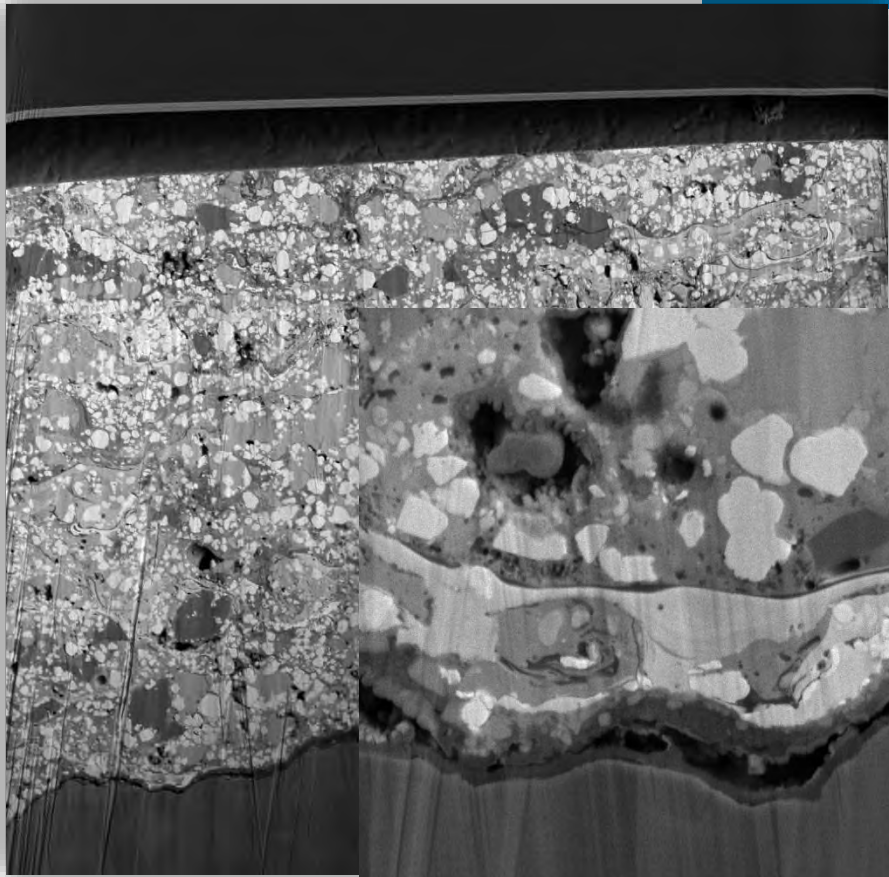
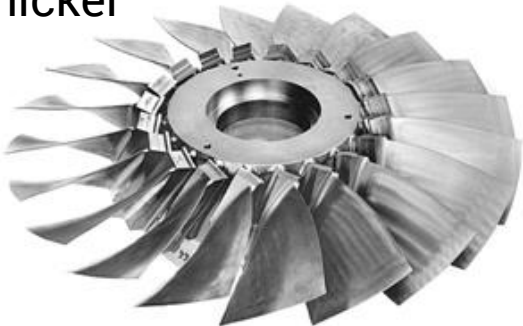
■ Hardcoating for aircraft turbine blade - cross-section



Hard material
layer on gray
cast iron

40 µm nickel

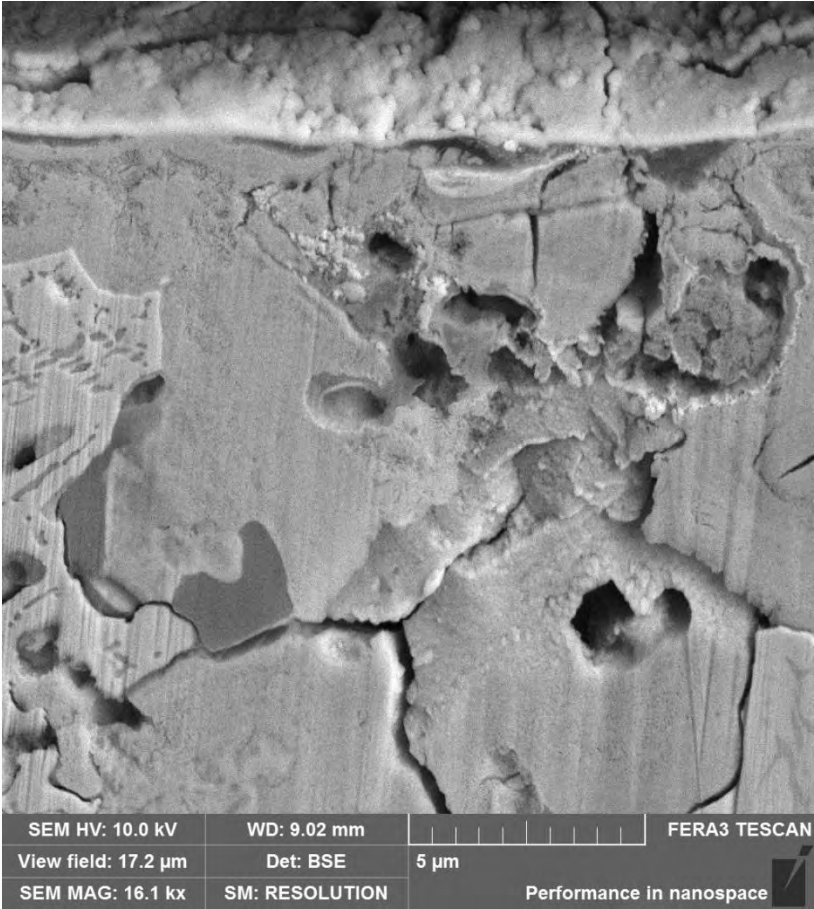
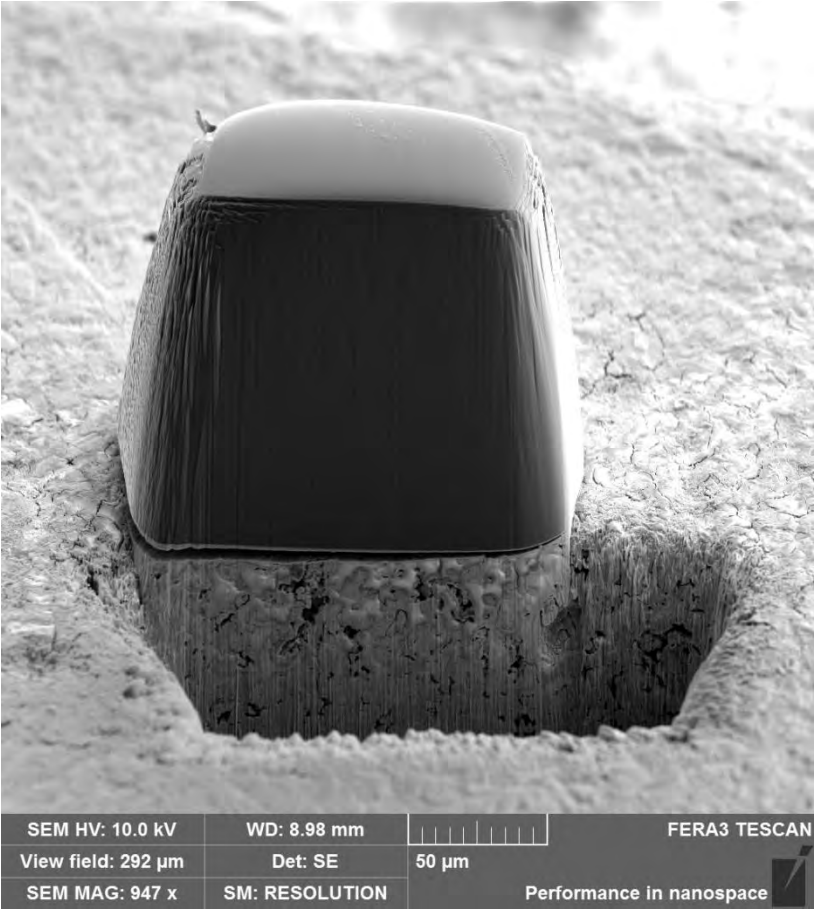
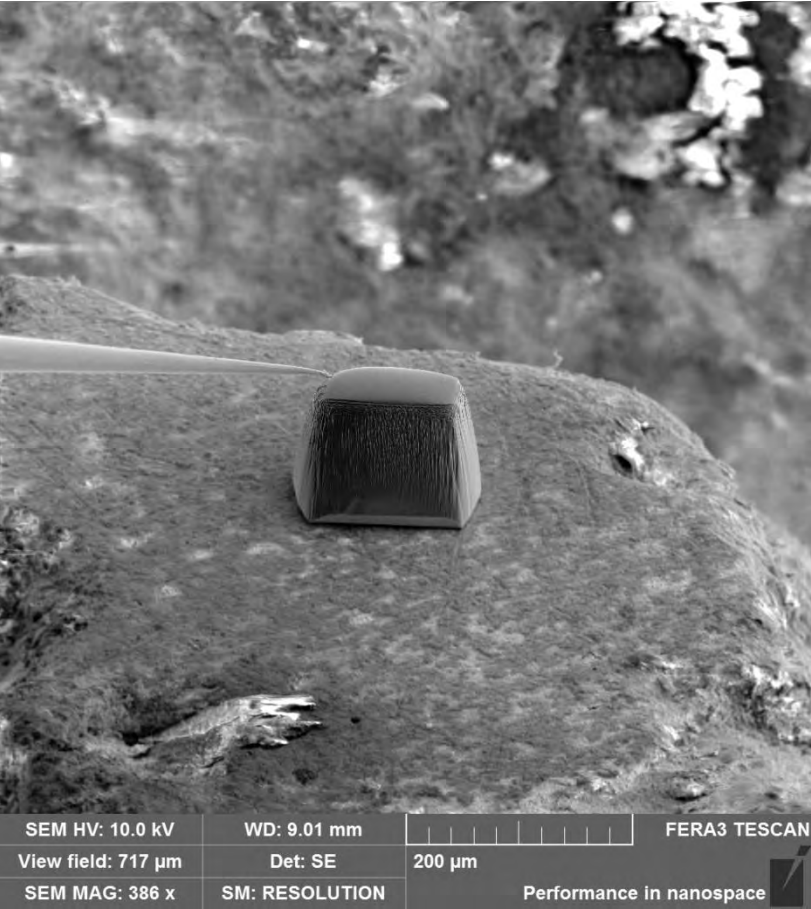
2 h



Detailed image of the hard coating

Xe⁺

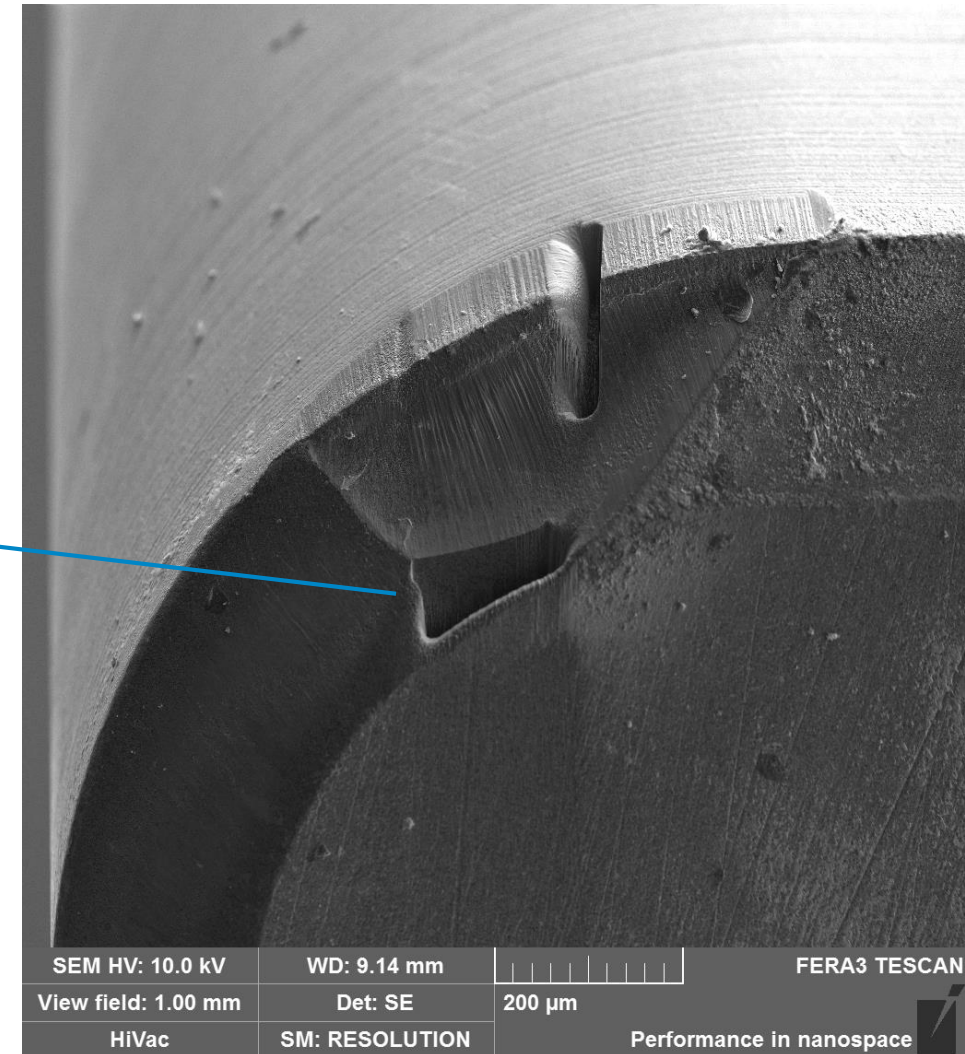
■ Cross-section of 2000 years old Romanian coin



■ Trench milling at 2 μA with silicon mask, 10 minutes

Xe⁺

- Cutting tool – boron nitride cross-sections

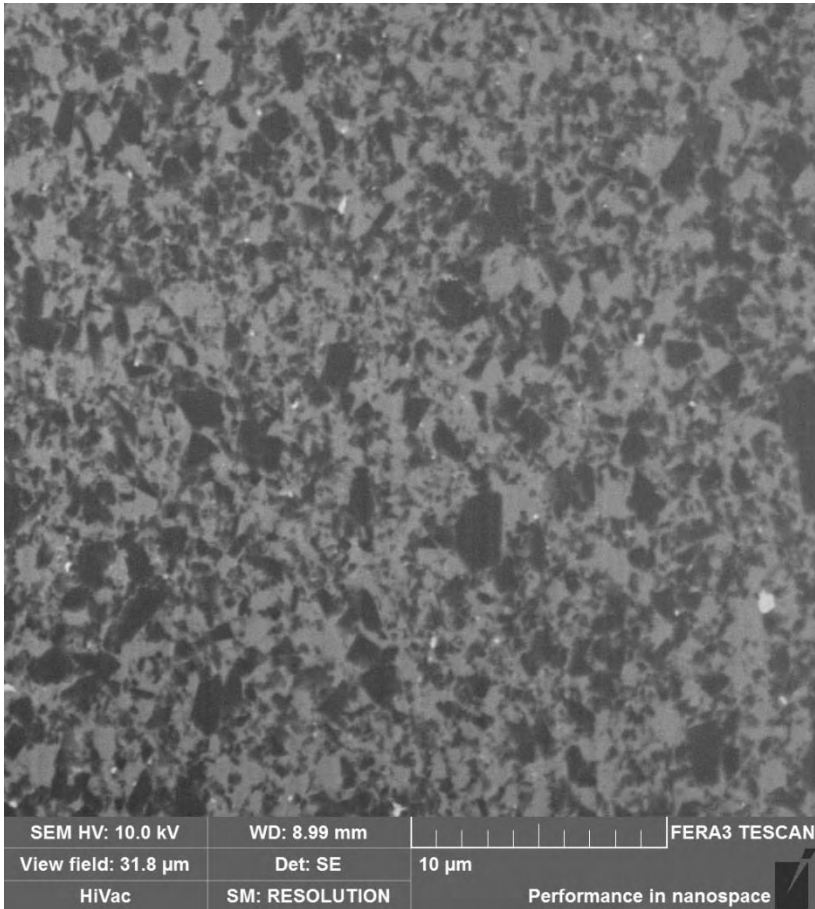
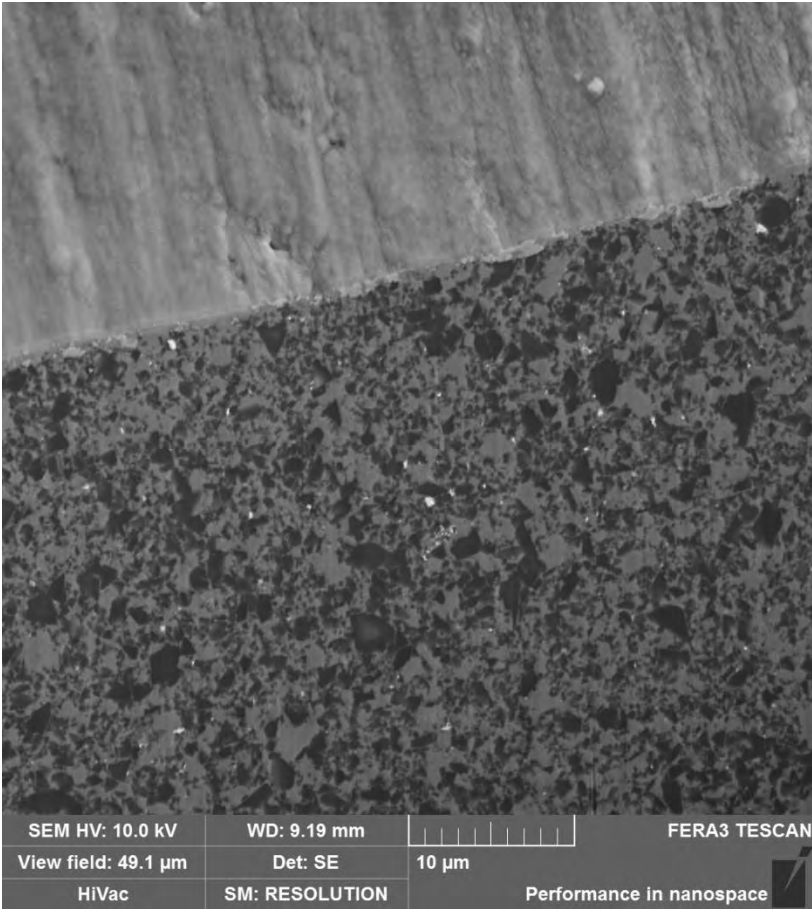
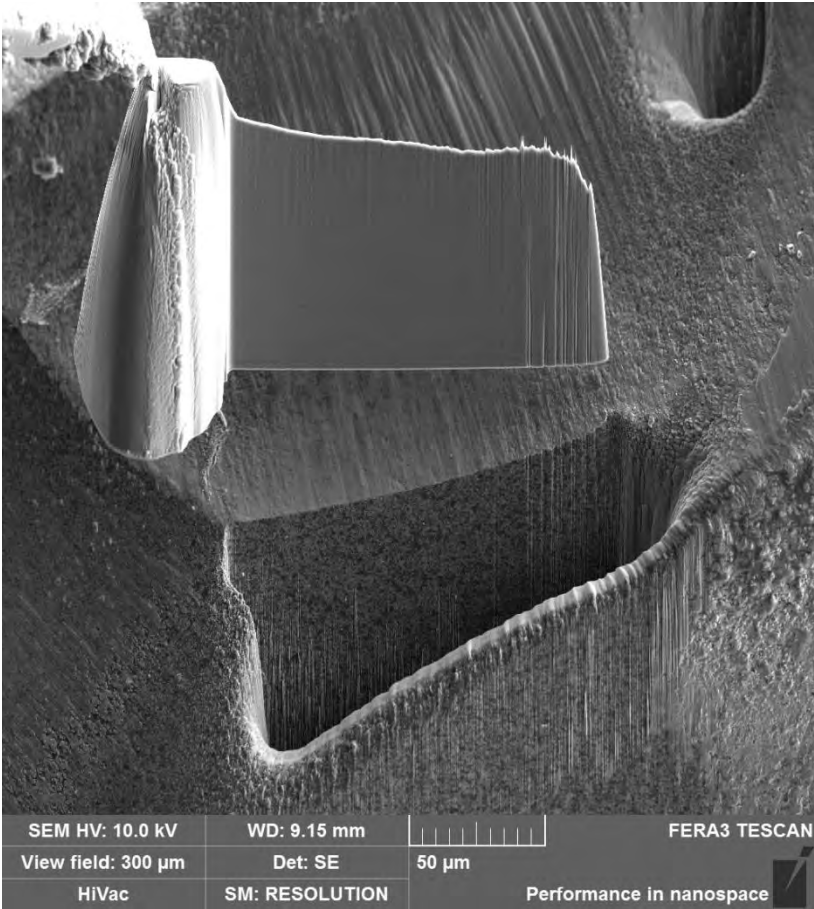


- Large delamination in cutting tool

- Trench milling – 15 minutes at 2 uA with the silicon mask
- Rough polishing – 25 minutes at 300 nA
- Final polishing – 20 minutes at 100 nA

Xe⁺

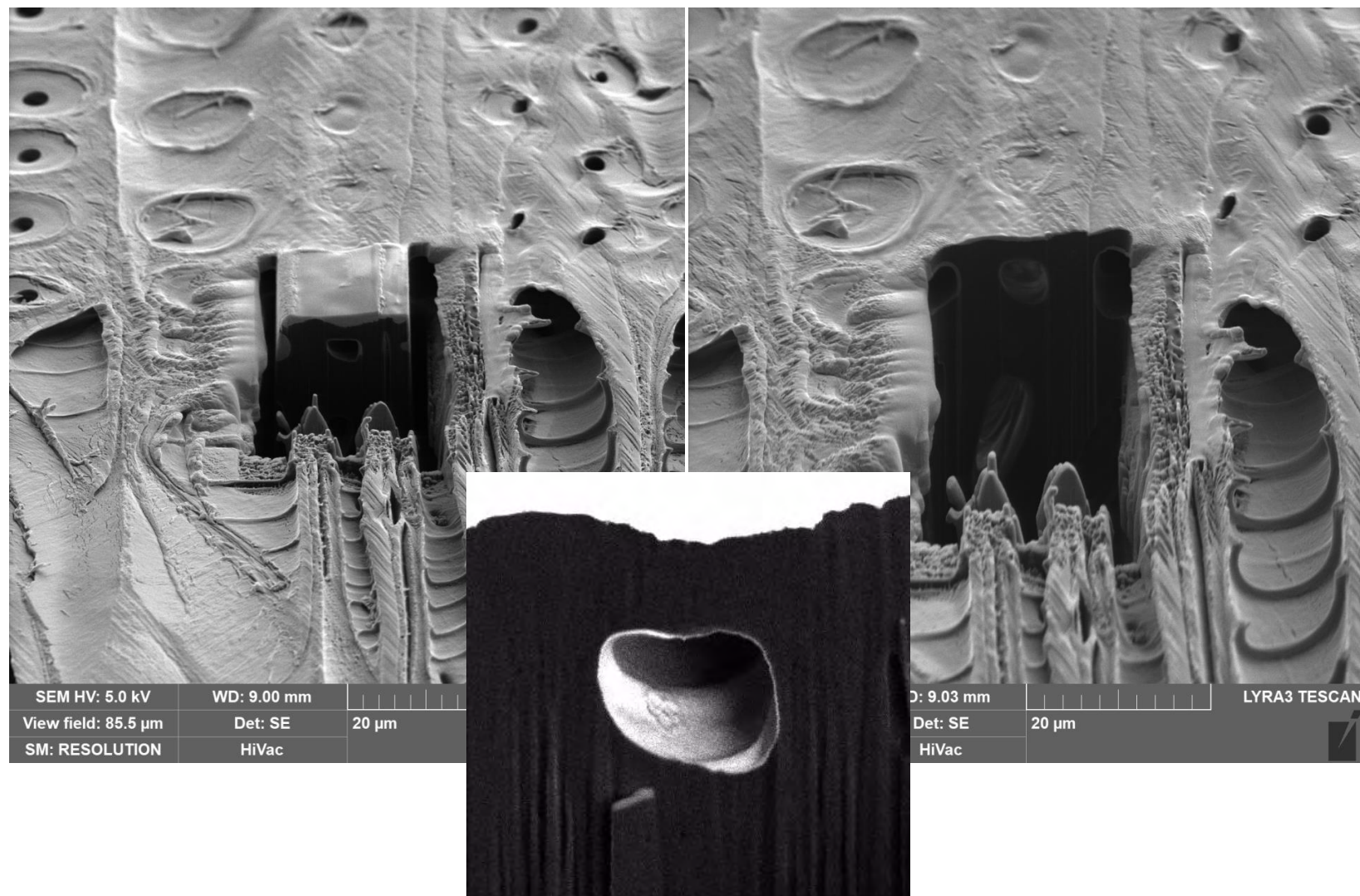
■ Cutting tool – boron nitride cross-section



Ga⁺

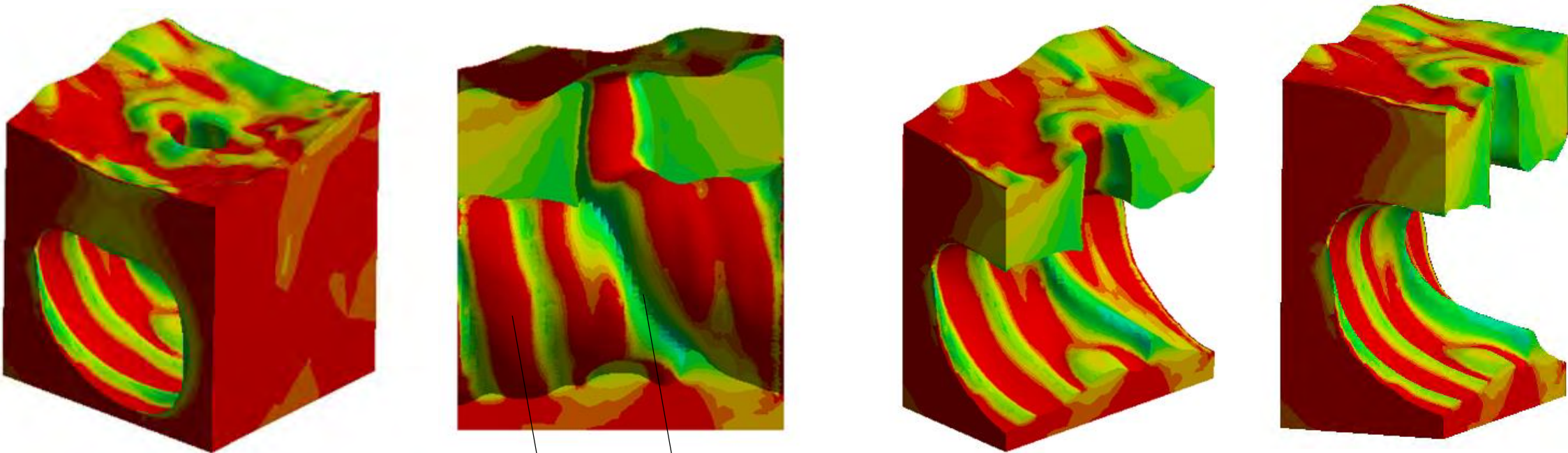
■ Wood - Taxus – 3D tomography

- 15×15×15 μm³ with 20 nm pixel size
- Trench: 17 nA current – 13 minutes
- FIB slicing: 820 pA – 1.52 hours
- SEM imaging 41 minutes
- Total time: 2.33 h



Ga⁺

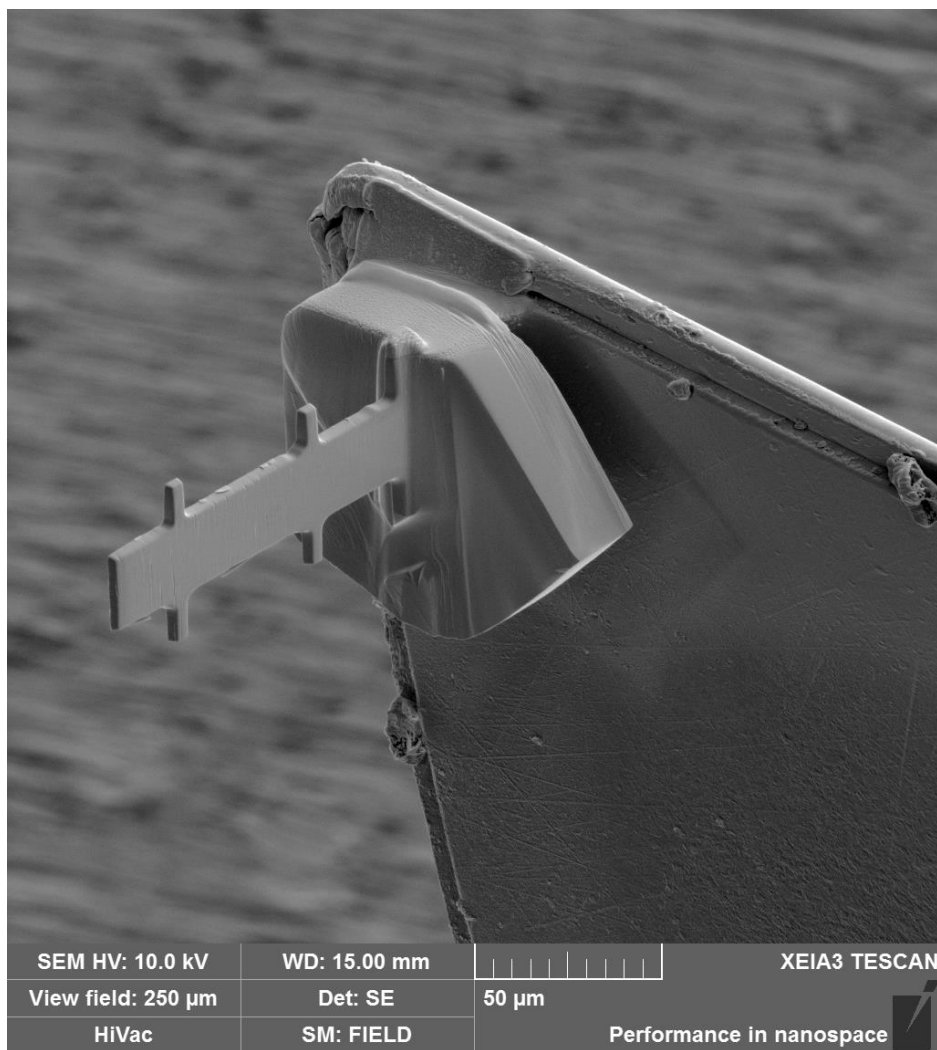
■ Wood - Taxus – 3D tomography



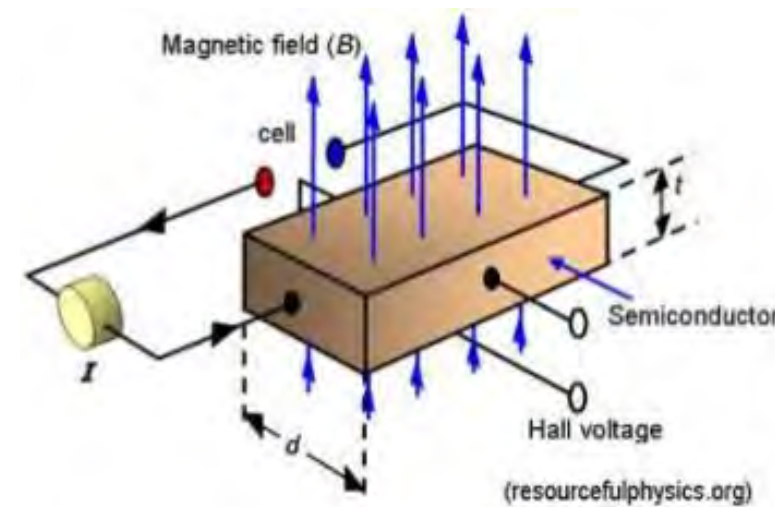
Max strain

Min strain



Xe⁺**■ Hall probe from planar lamella preparation**

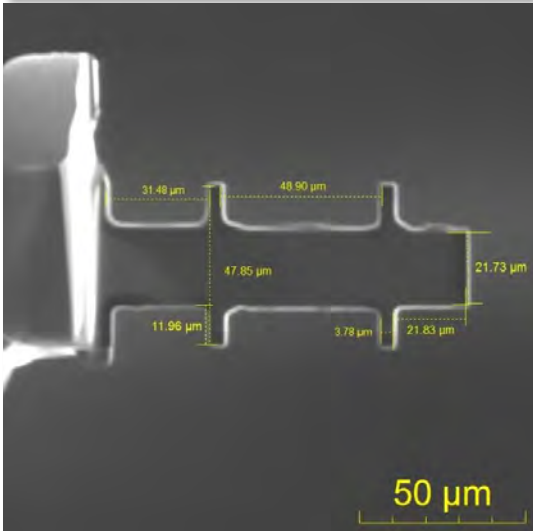
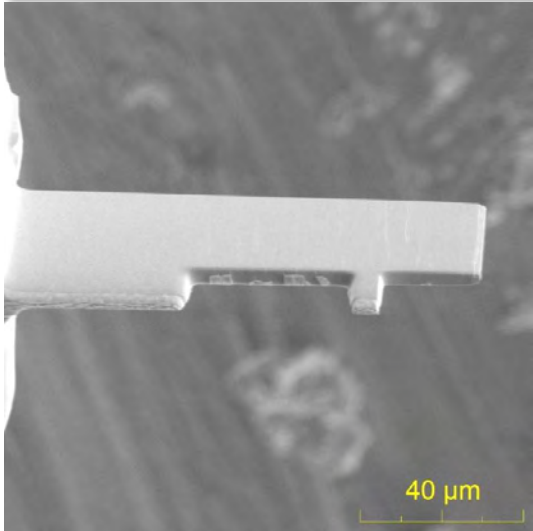
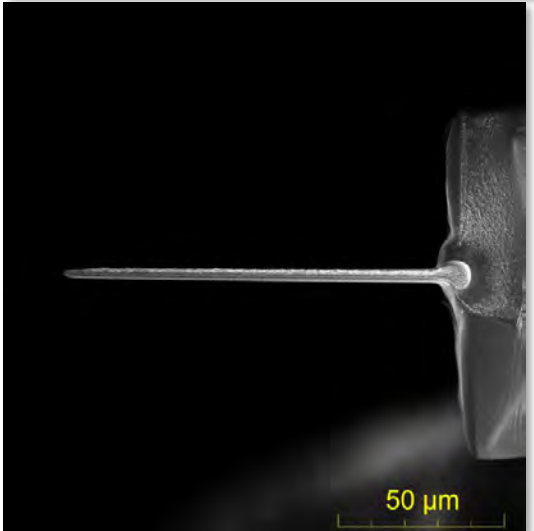
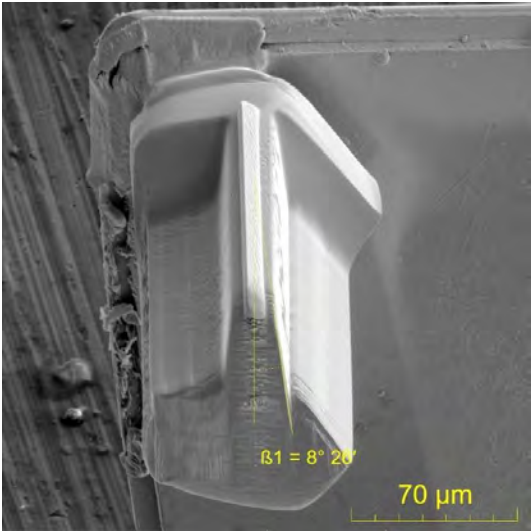
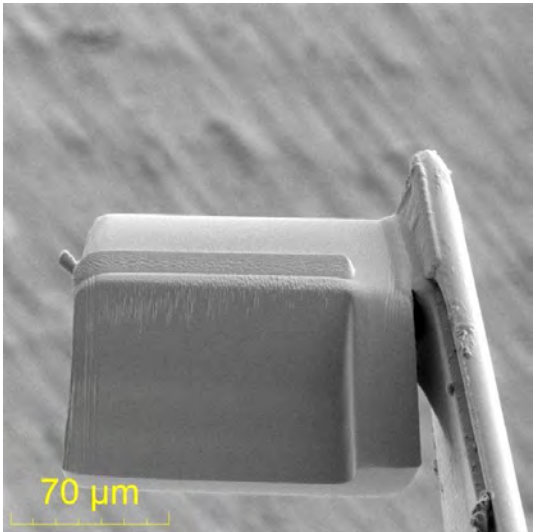
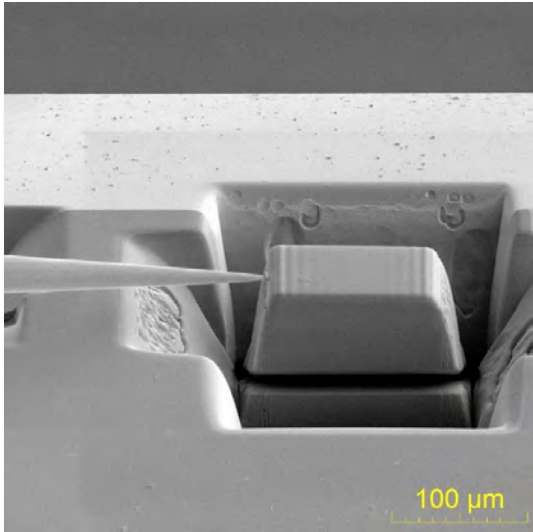
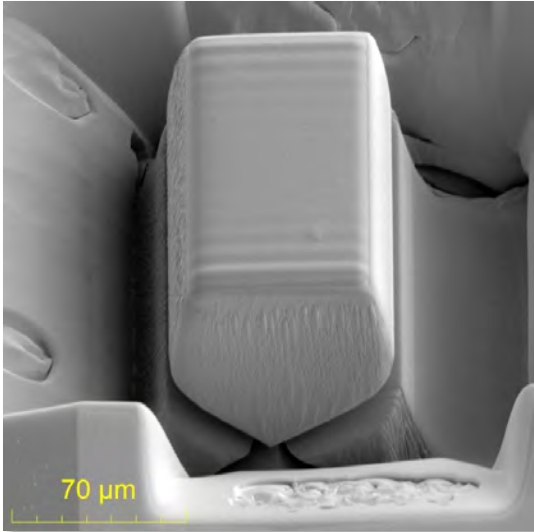
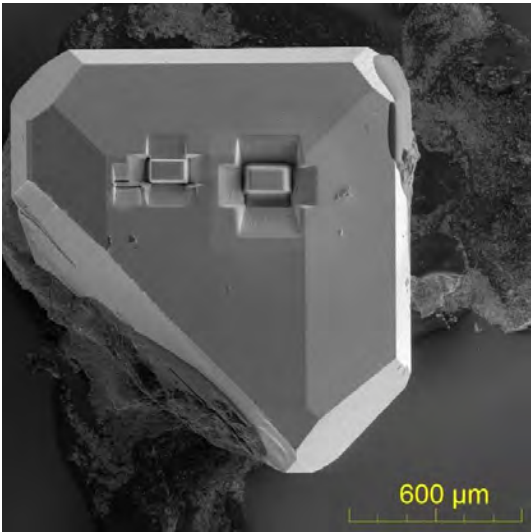
$$F = q[E + (v \times B)]$$



- Hall voltage is produced by charge accumulation on sidewalls
- Charge accumulation balances Lorentz Force
- Charge accumulation increases resistance
- Image of the Hall probe prepared by Plasma FIB.
Total preparation time: 3 hours

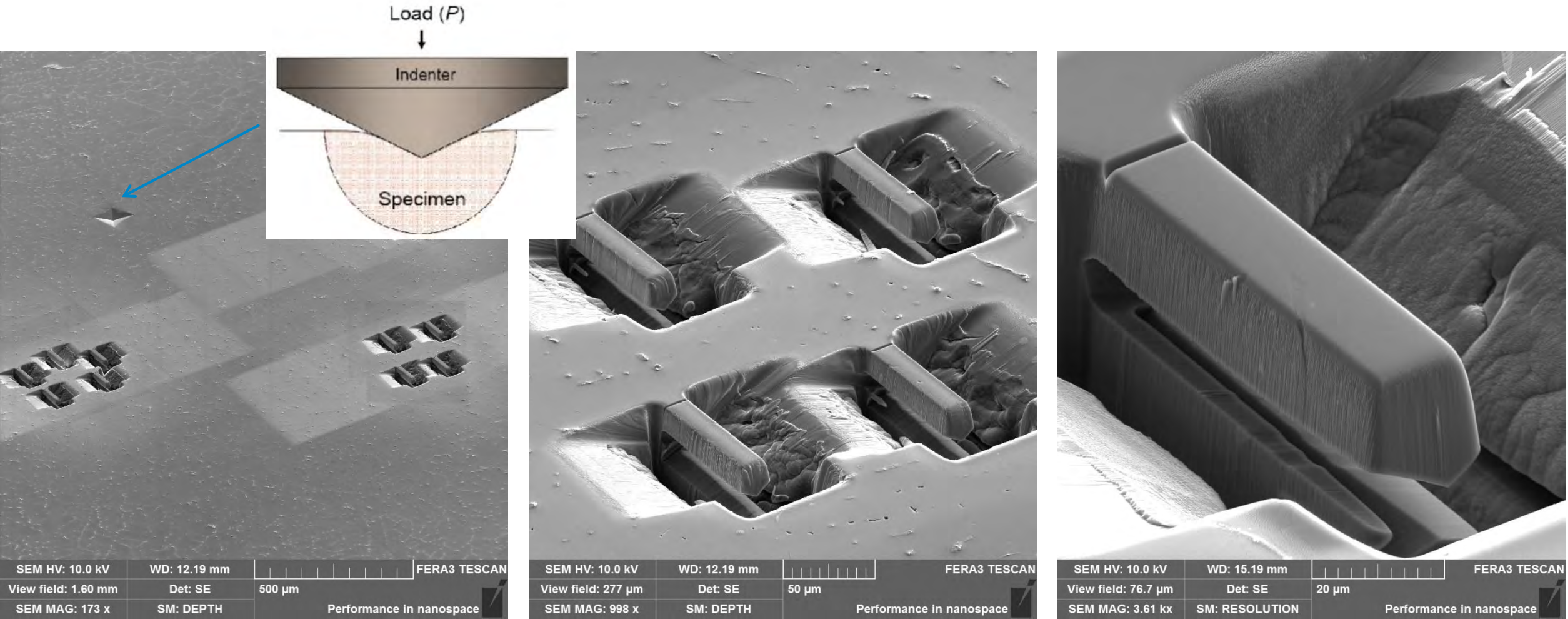
Xe⁺

■ Hall probe from planar lamella preparation



Xe⁺

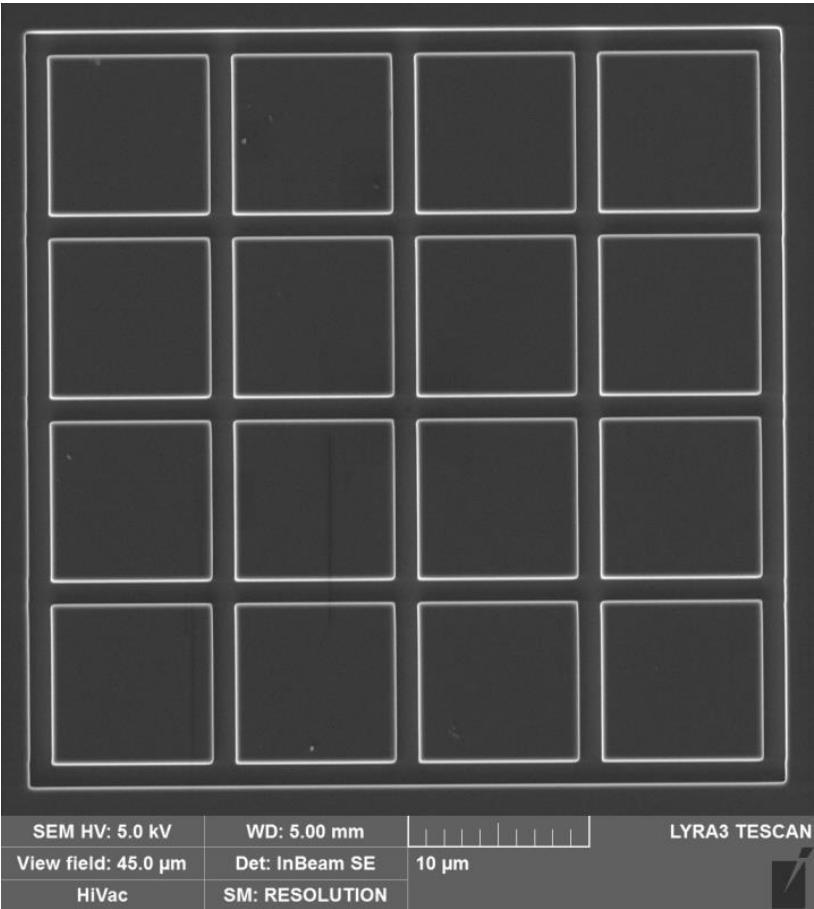
■ Array of identical micro-cantilevers for high temperature fracture testing



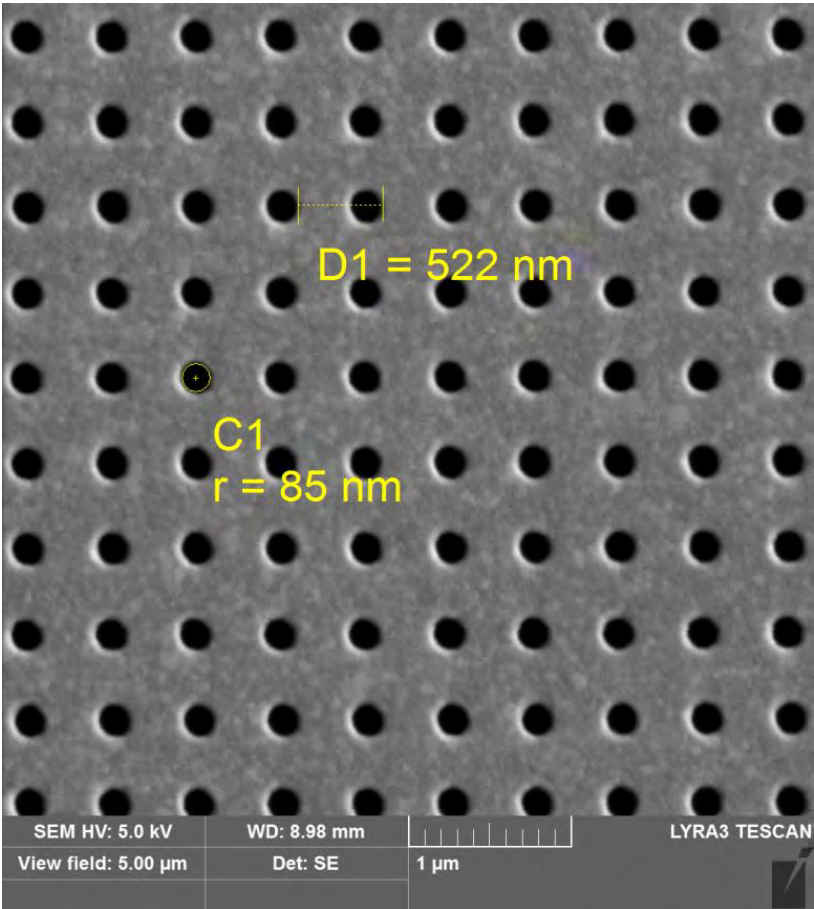
■ Magnesium sample

Ga⁺

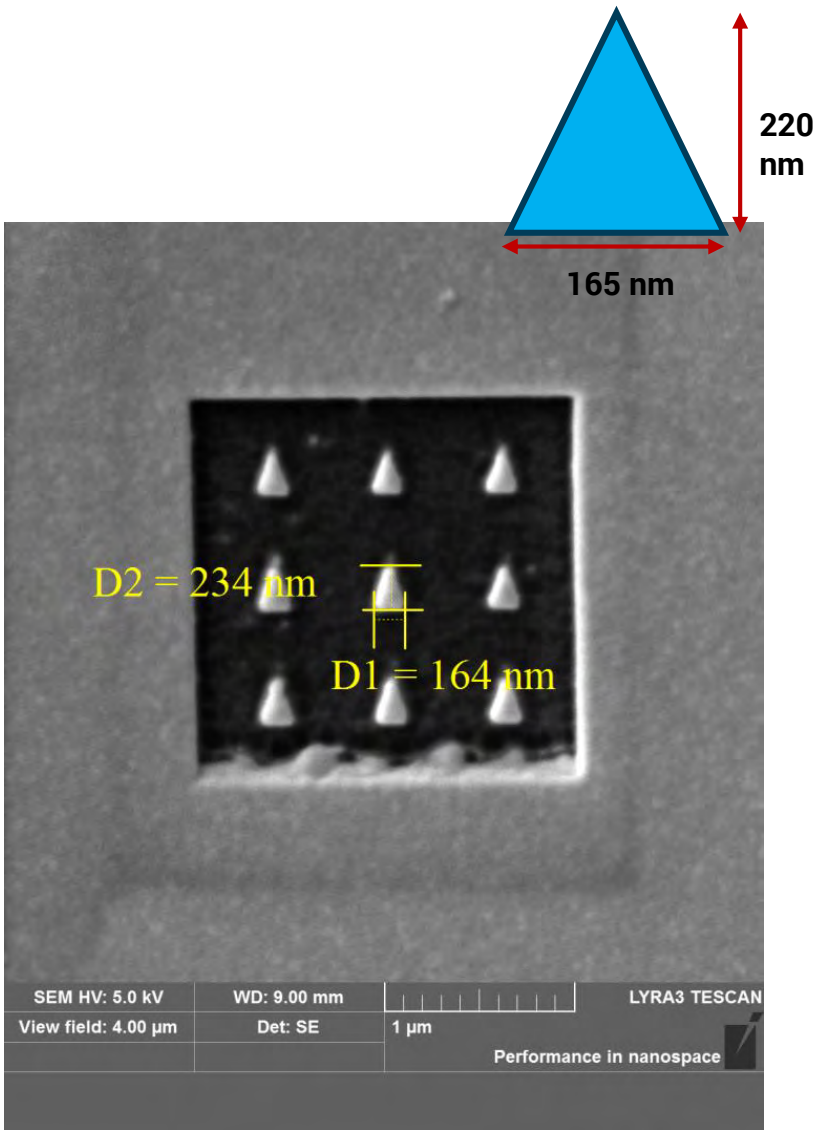
■ Micro/Nano Patterning



■ SiC Wafer



■ Glass substrate with Au



■ Glass substrate with Al

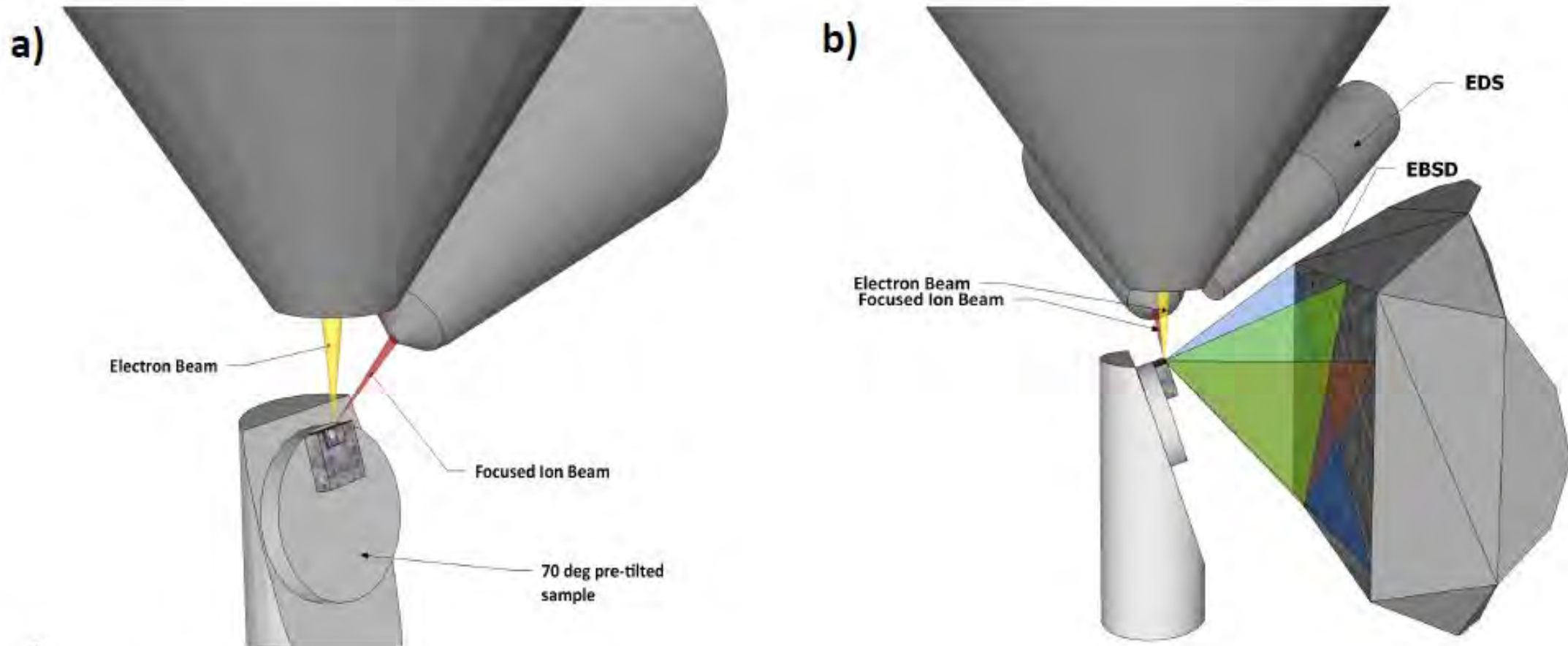
ADVANCED TECHNIQUES

3D EDX and EBSD

TOF-SIMS

AFM

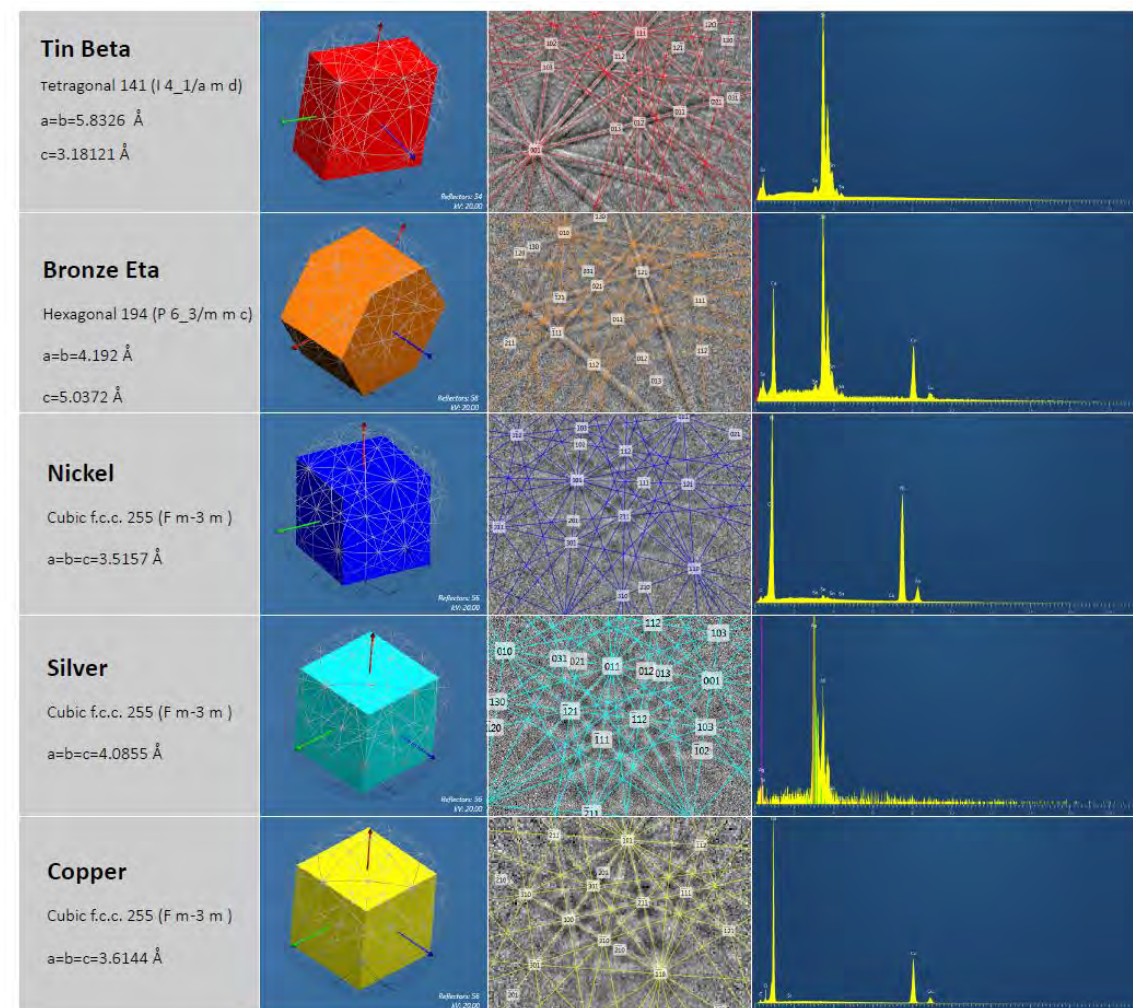
3D EDX and EBSD



TESCANs Unique Static 3D EBSD +3D EDS Acquisition

Advantages of Simultaneous EBSD+EDS (especially in 3D)

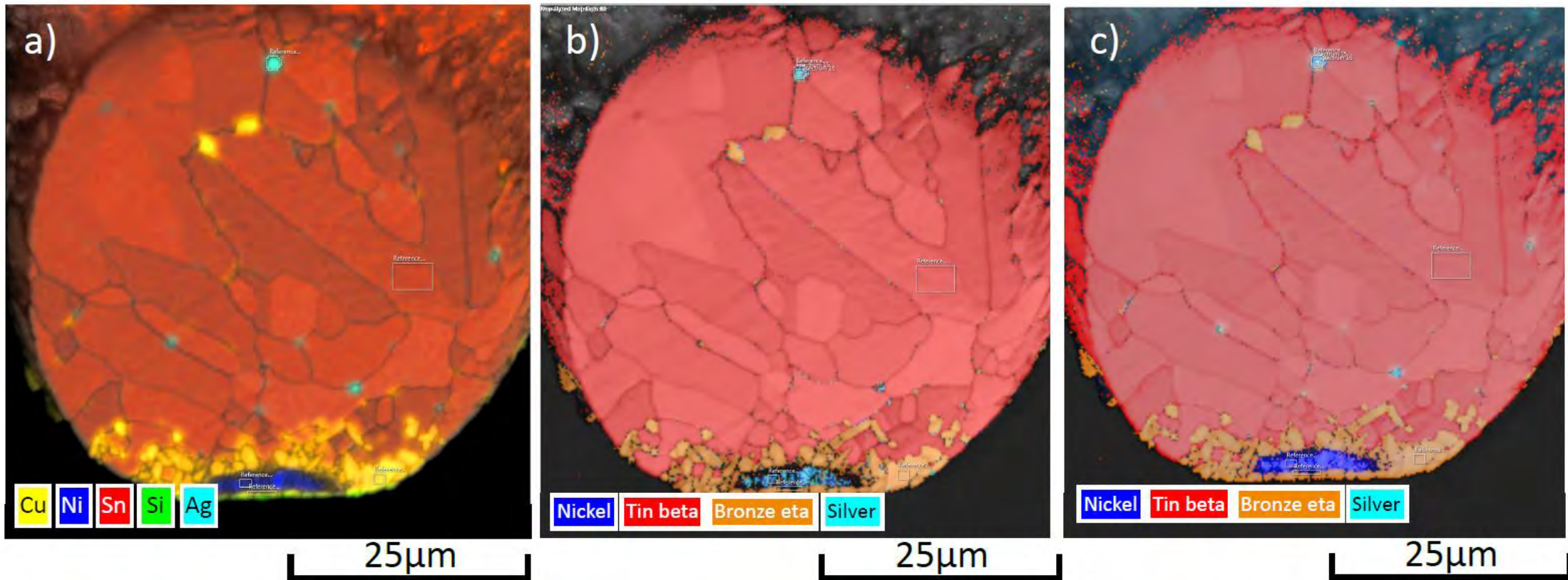
- Phases with similar crystal structure are sometimes difficult to distinguish only using EBSD
- EBSD phase identification with the help of EDS reference spectra can be set (OI TruPhase™)
- Online EBSD identification aid with the use of EDS data is beneficial especially for 3D EBSD
- EDS data can be stored together with EBSD for additional 3D data information



Example of possible phases in solder bump Cu and Nickel has similar f.c.c. grid

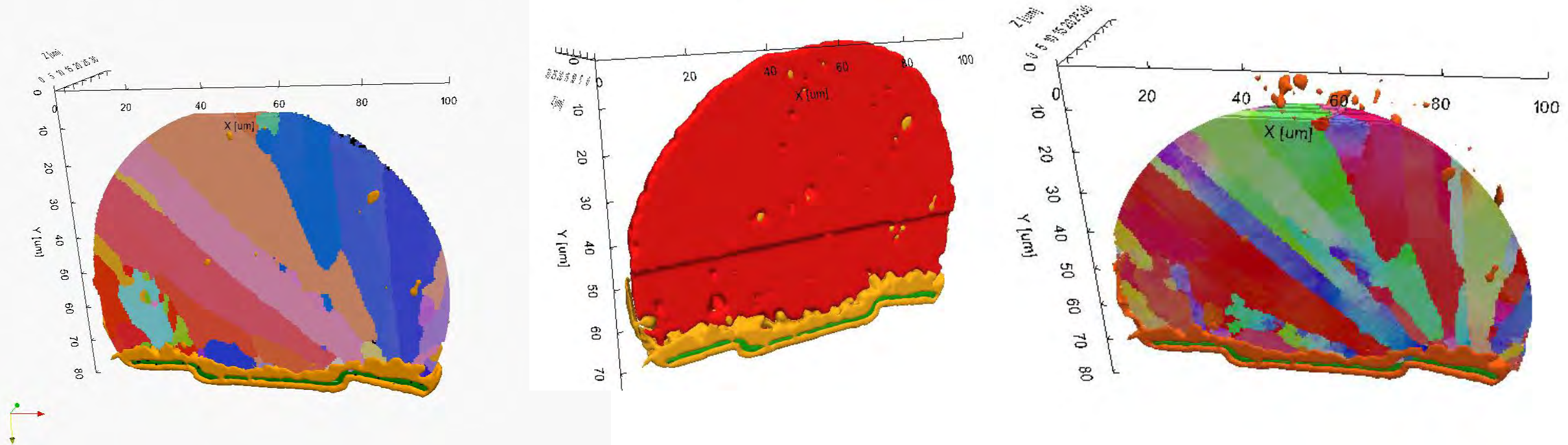
Simultaneous 3D EBSD + 3D EDS

■ Solder Bump



- Comparison of different phase analysis techniques: a) EDS map using TruMap™ deconvolution b) EBSD identification without using the EDS signal and c) TruPhase™ mapping result with reference spectra used for phase identification correction on phases with a similar crystal lattice

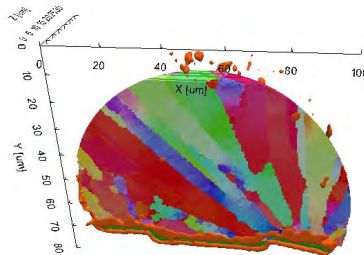
Simultaneous 3D EBSD + 3D EDS



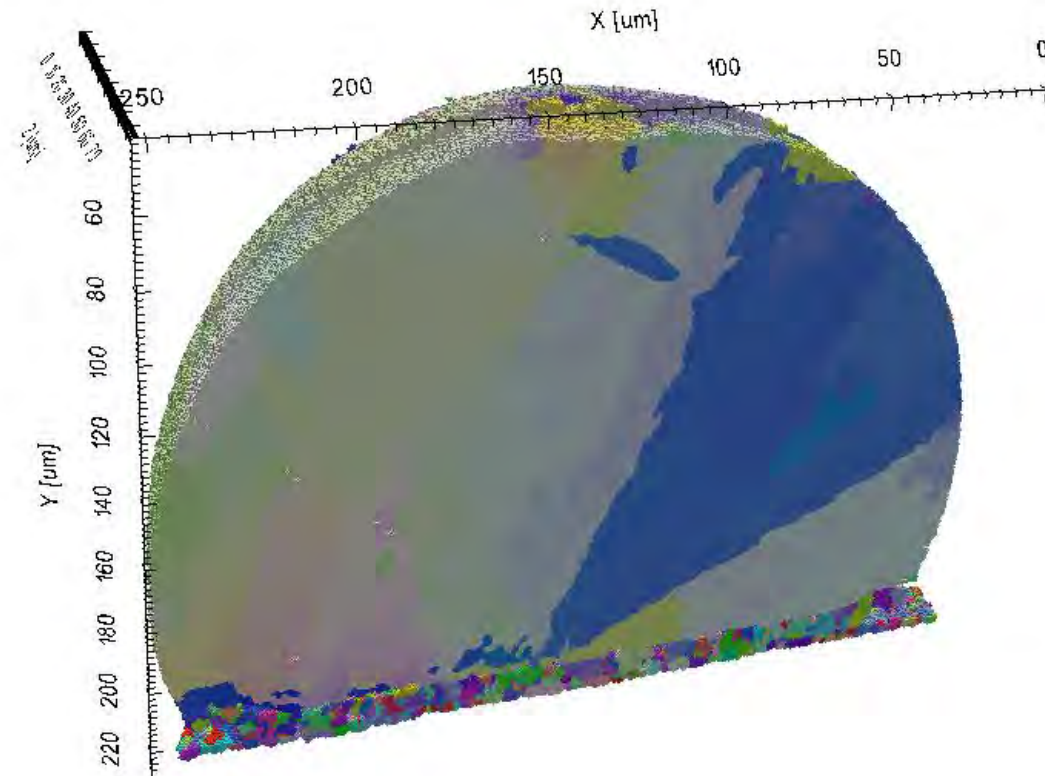
- Combined 3D EBSD and 3D EDS reconstruction of a 90 µm solder bump
- Tin phase shown in IPF-Z mapping (EDS - red), Copper (EDS - orange) and Nickel (EDS - green) isosurfaces extracted from 3D TrueMap™ data
- Visualized using ParaView

Ga⁺ FIB vs. Xe⁺ PFIB for 3D EDS and 3D EBSD

- What can be acquired in a reasonable amount of time?



- 3D EBSD of 90 µm solder bump acquired on Ga⁺ FIB (over a weekend)

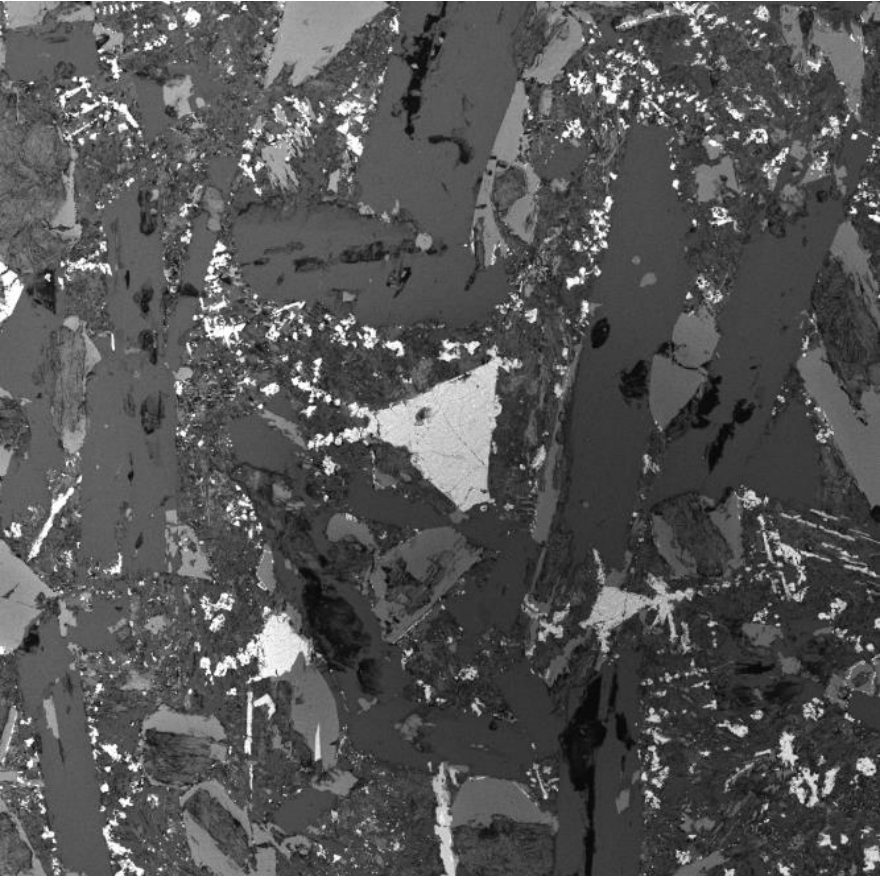


- 3D EBSD of 250 µm solder bump acquired on Xe⁺ FIB (over a weekend)

3D EDX

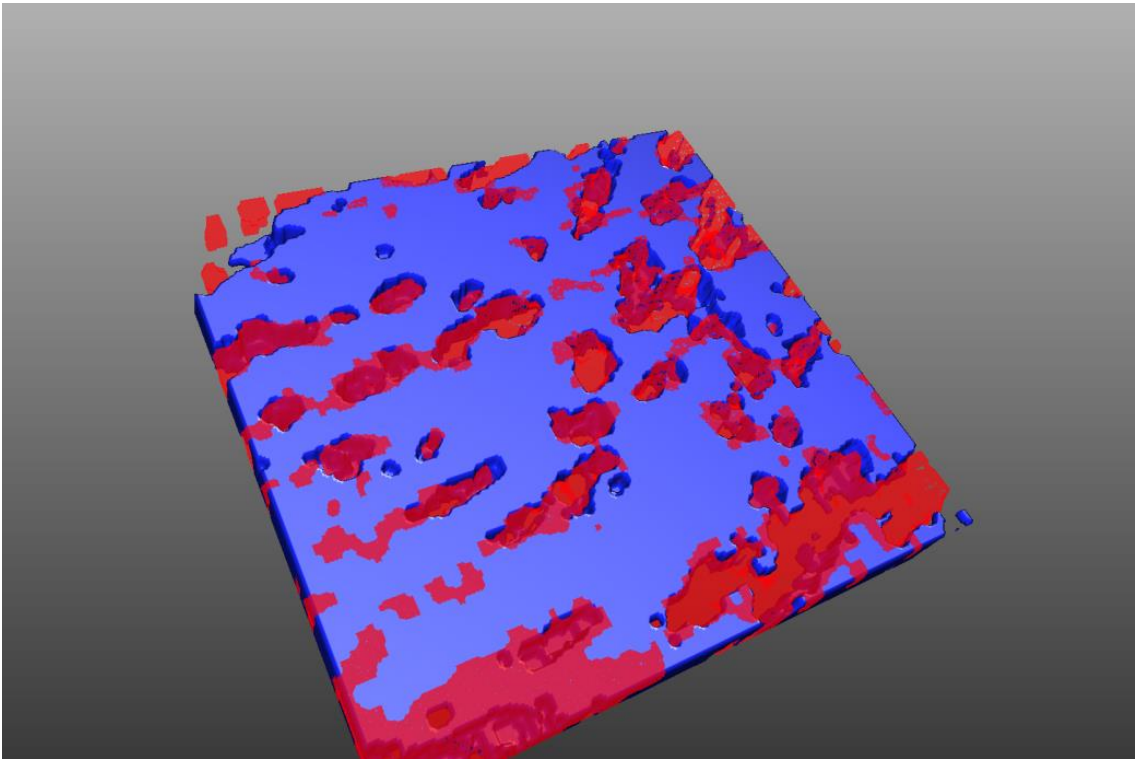
Ga⁺

■ Study of Volcanic Rock Sample

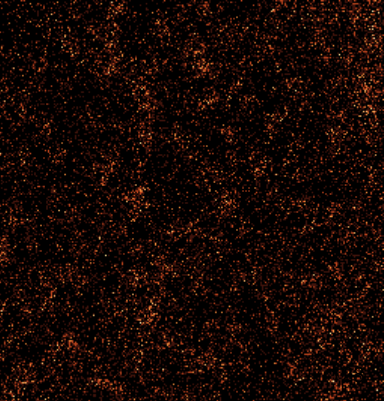
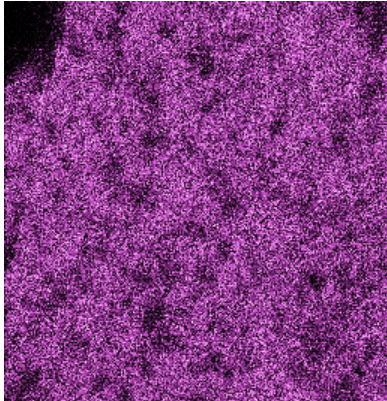
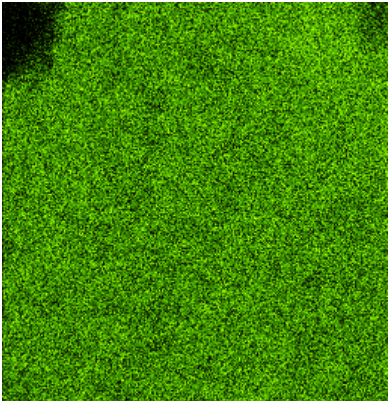
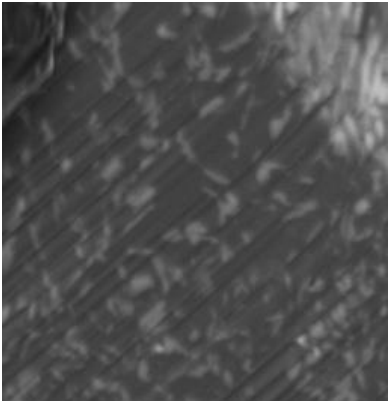


SEM HV: 10.0 kV WD: 8.99 mm LYRA3 TESCAN
SEM MAG: 1.21 kx Det: InBeam BE 50 µm
View field: 285 µm Date(m/d/y): 01/27/16 Jönköping University

**3D EDS Volume
Reconstruction:**
Volume: 20x20x2,1 µm
Slice thickness: 300 nm
Slice time: 7.5 min

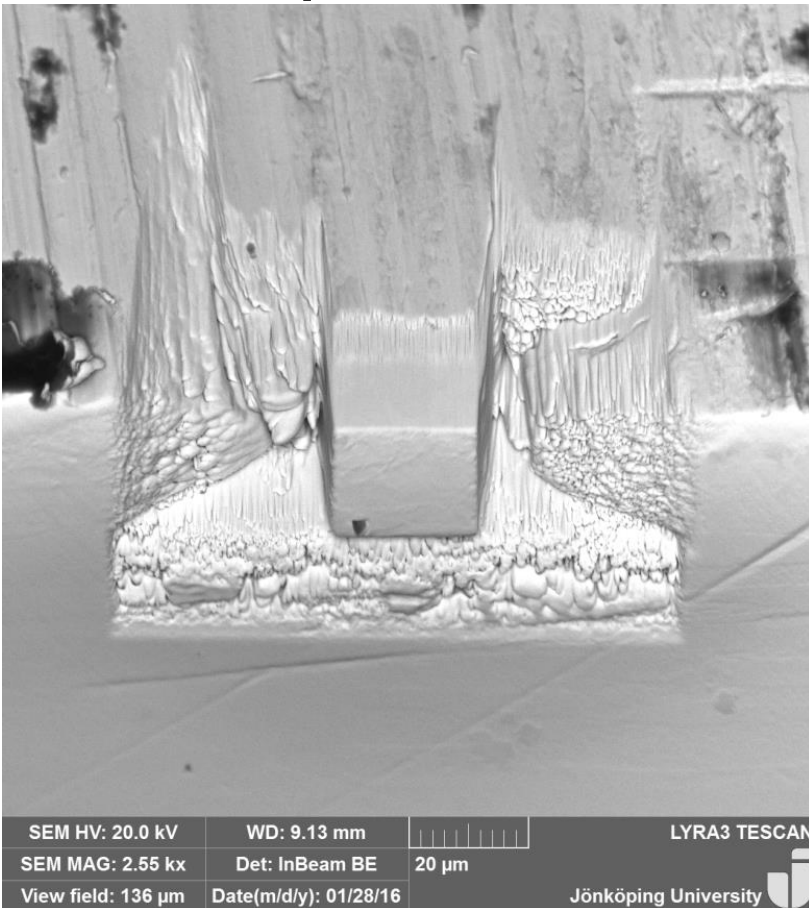


EDS map of a single slice 20x20 µm



3D EBSD

■ Duplex Stainless Steel



Pillar preparation – 1.5 hours
 with 23nA beam
 Pillar size 25x25x10 μm

Ga⁺

Slicing setup:

FIB current: 1.4 nA

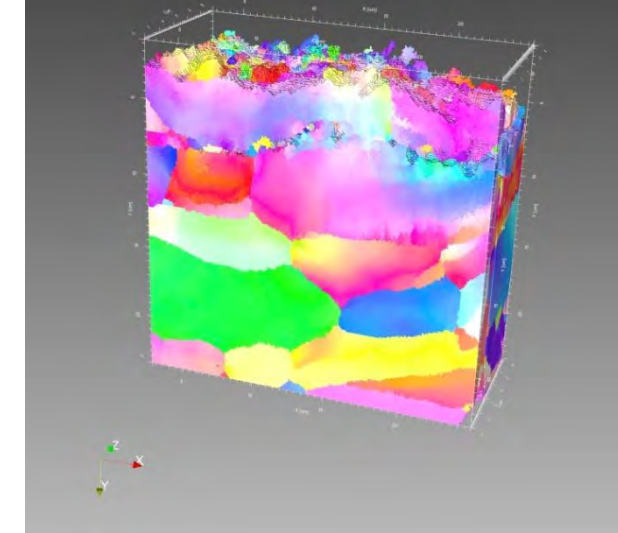
Slice thickness: 100 nm

Slicing time: 2.1 min

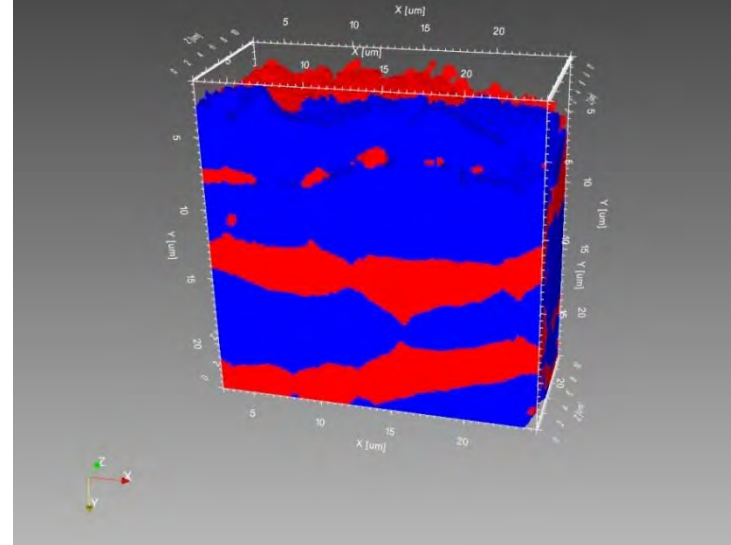
Number of slices: 100

Total acquisition time: 14.5 h

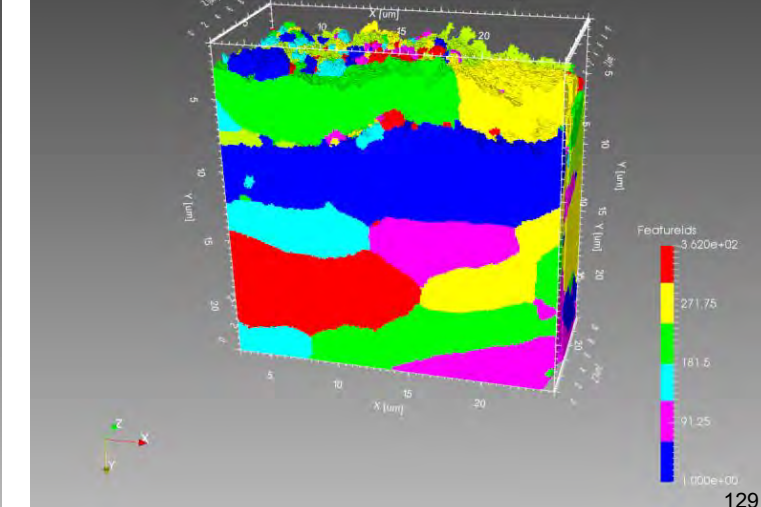
IPF-Z Maps



Phase map – red: Ferrite, blue: Austenite



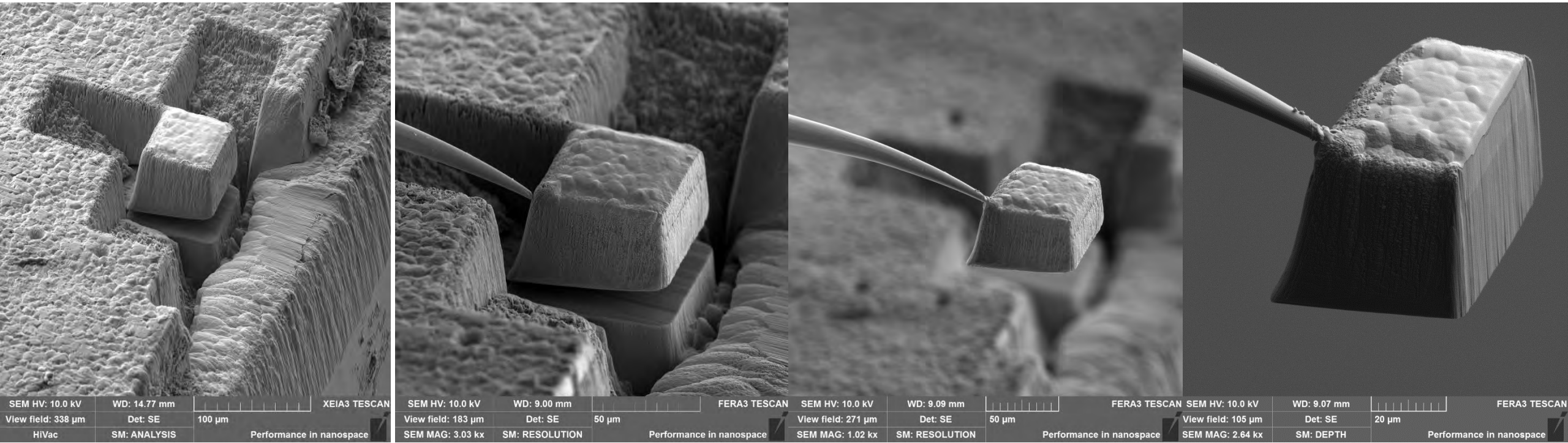
Grain representation
 Totally 362 grains found



3D EDX and EBSD

Xe⁺

■ Zn Coated Steel



- Tungsten deposition (50x50 µm²)
- Cubic sample was prepared by 3 trenches milling, undercut - 300 nA cca 1.5 hour

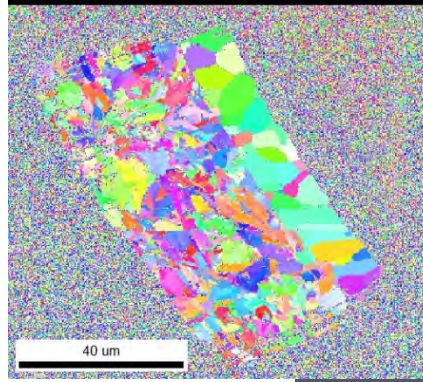
3D EDX and EBSD

■ Zn Coated Steel

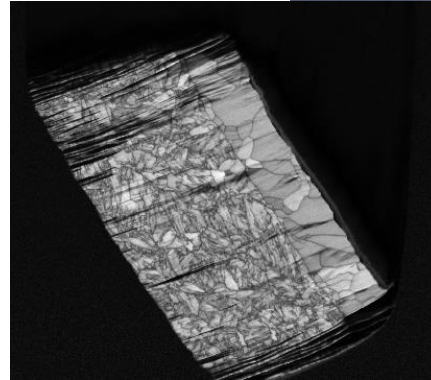
- SEM: (HV: 20 kV, Current: 6 nA)
- EBSD: (Step: 250 nm, Acquisition time: 10 min x 133 slices = 22 hours)
- 3D tomography process:
 - Number of slices: 133
 - Slice thickness: 100 nm
 - Total volume: 60x50x13 μm^3
 - Beam current for slicing: 30 nA
 - Time for FIB slicing: 30 s x 133 slices = 1 hour

Total acquisition time: 23 hours

IPF map



IQ image

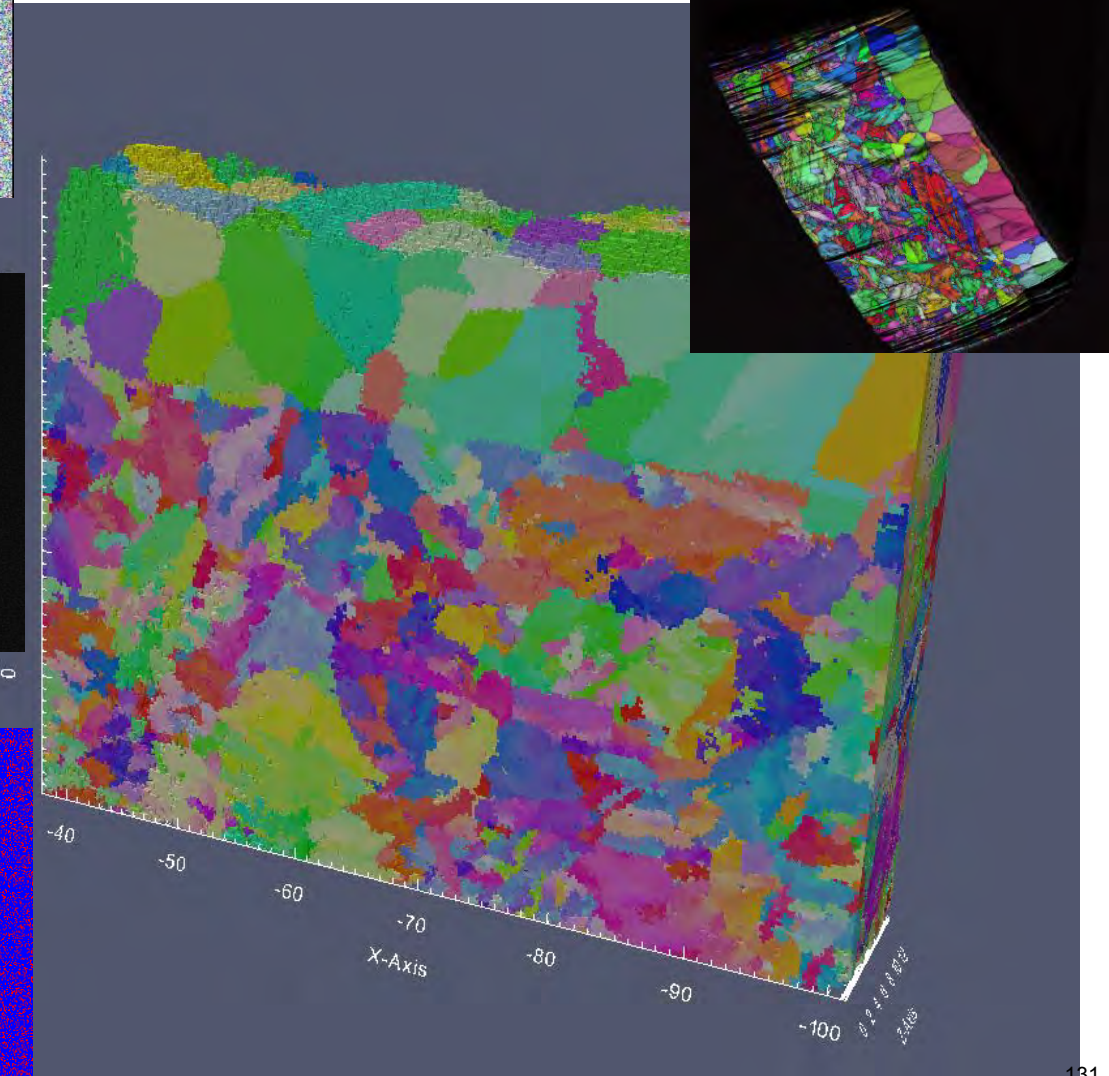
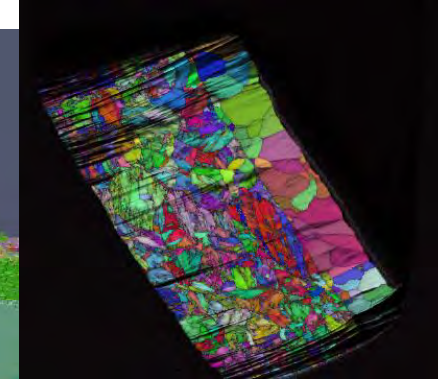


Phase map



Xe⁺

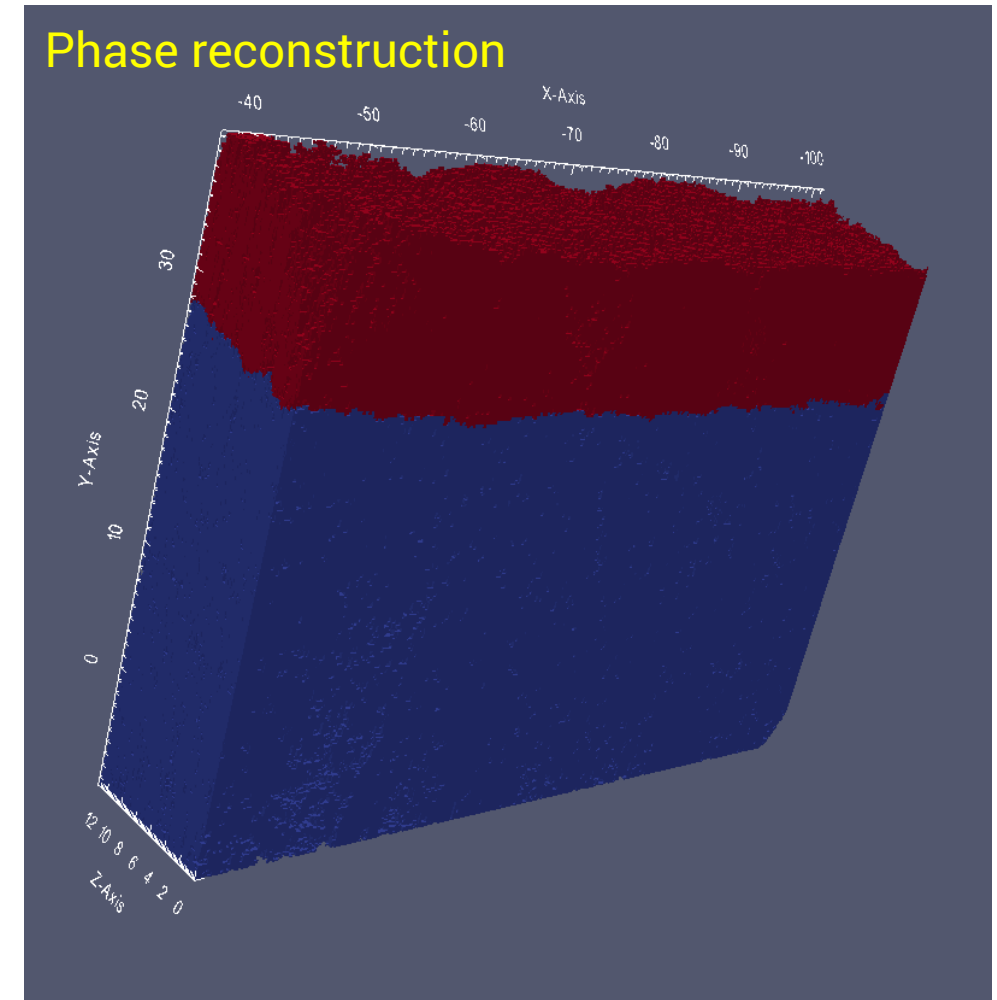
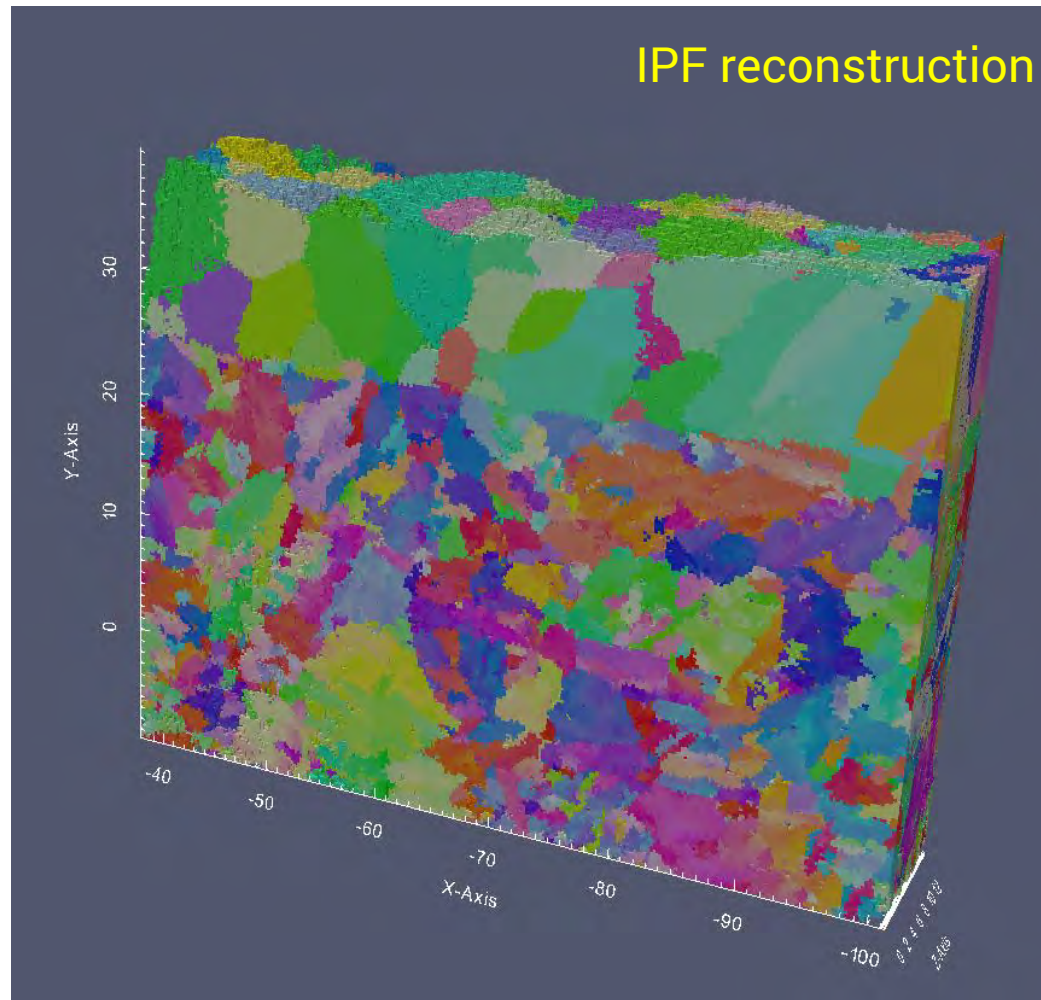
IPF+IQ map



3D EDX and EBSD

■ Zn Coated Steel

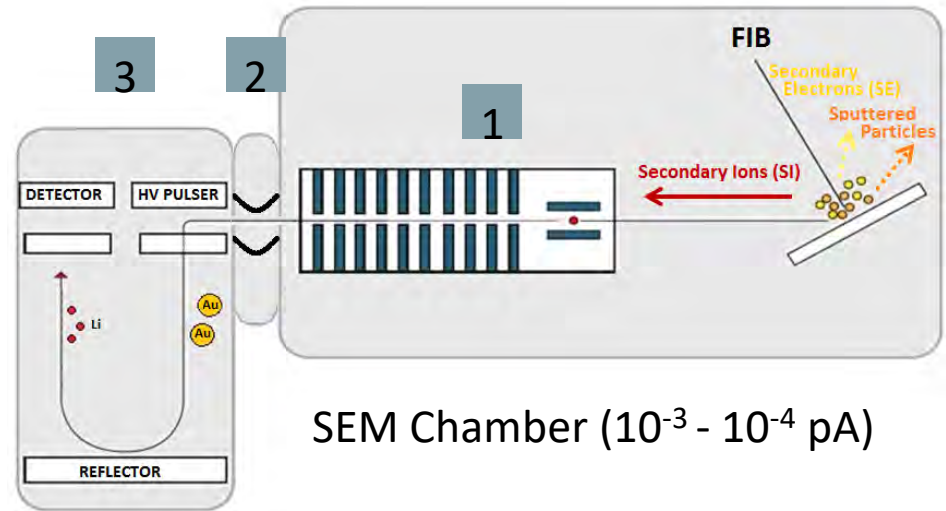
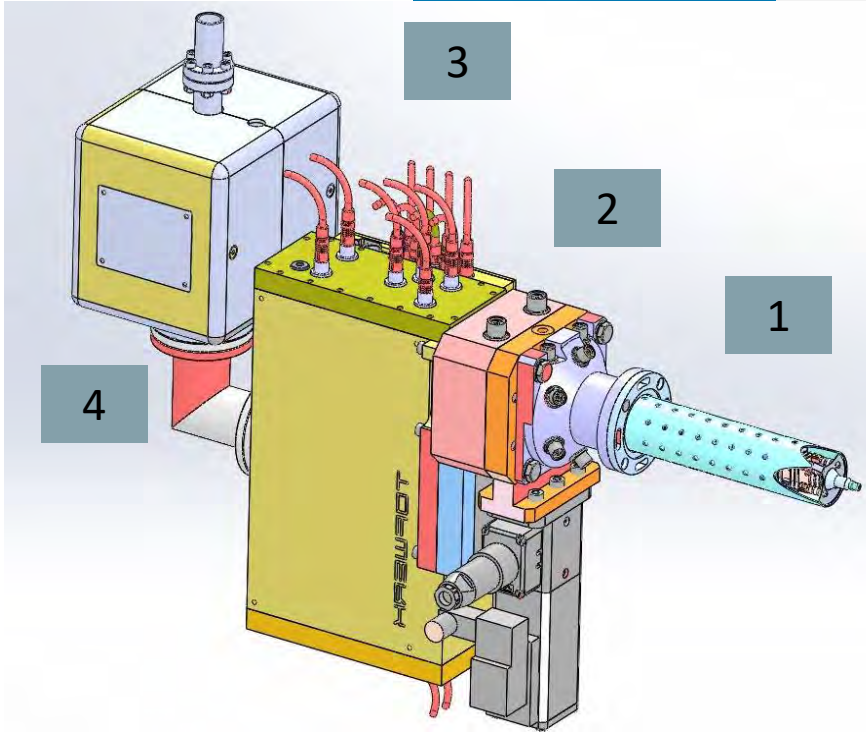
Xe⁺



– processed by Dream 3D and ParaView softwares

TOF-SIMS

- Ionisation by FIB (No need of another source)
- Secondary Ions are detected
- Ions are separated according to their m/Q
- Time of Flight is measured
- Positive or negative ion mode



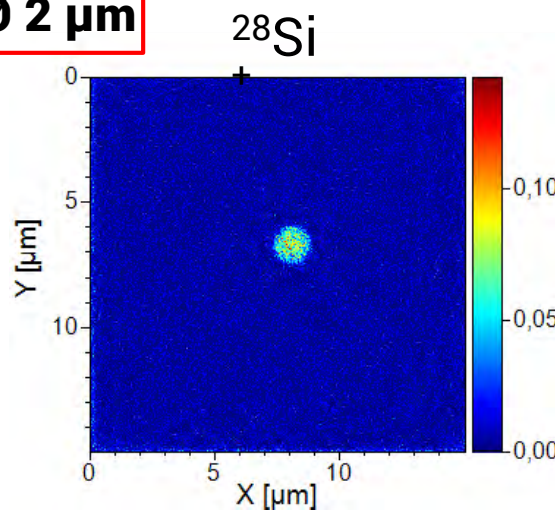
- 1 Ion Transfer Optics
- 2 Separating valve
- 3 TOF chamber
- 4 TOF ion pump

Lateral resolution	< 50 nm (Ga ⁺) < 60 nm (Xe ⁺)
Depth resolution	< 3 nm
Detection limit	< 3 ppm (Ga ⁺) < 1.5 ppm (Xe ⁺)
Mass resolution	> 800 (> 3500)

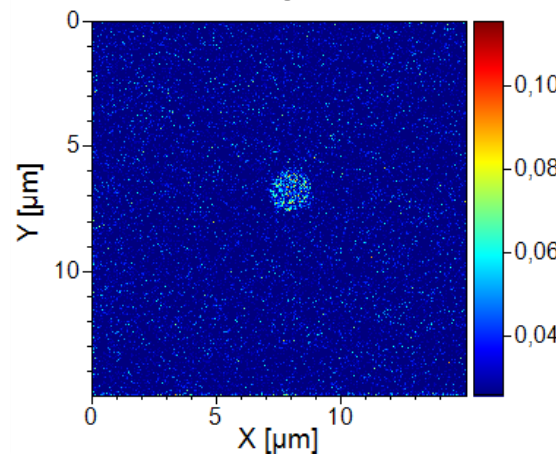
TOF-SIMS

- Micro- and nanoparticles analysis (Si, Al impurity on Si wafer)

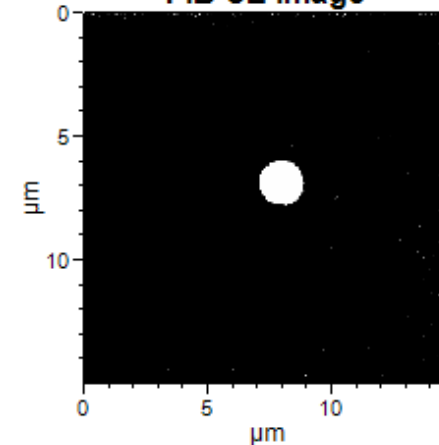
Ø 2 µm



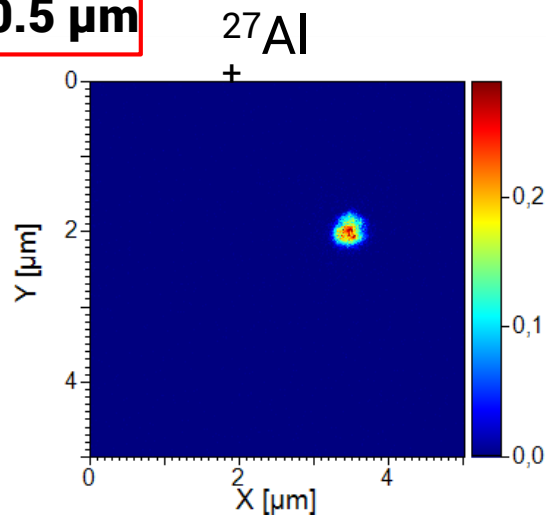
$^{16}\text{O}^-$



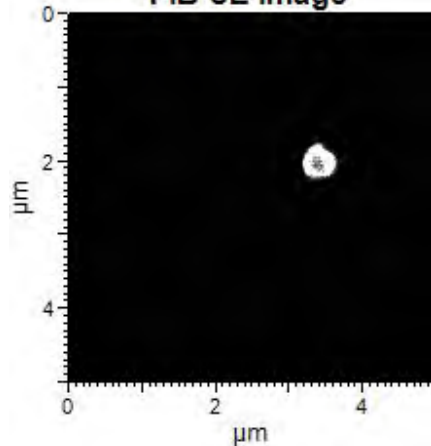
FIB SE Image



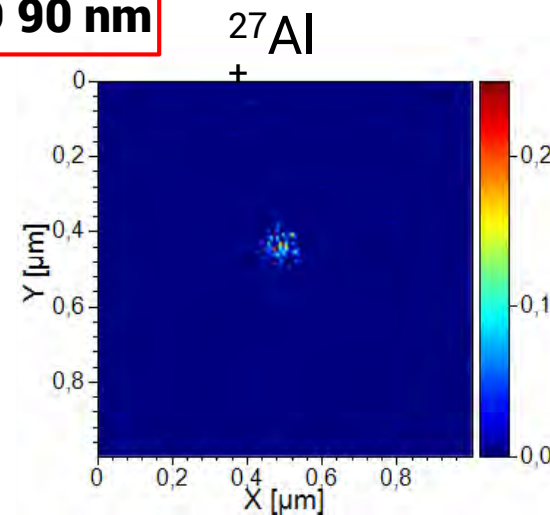
Ø 0.5 µm



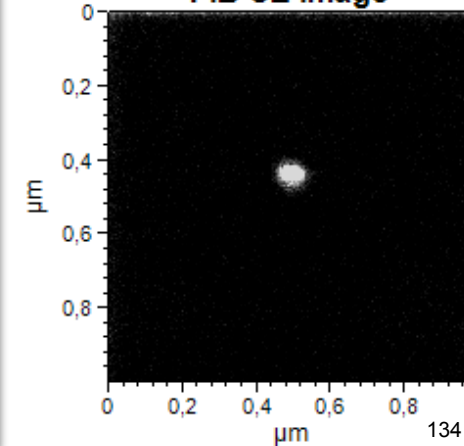
FIB SE Image



Ø 90 nm

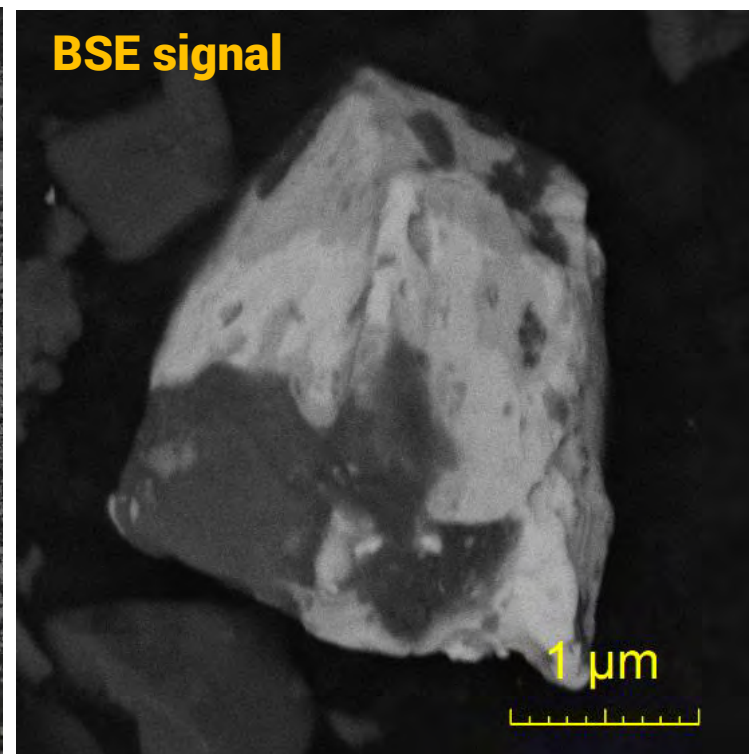
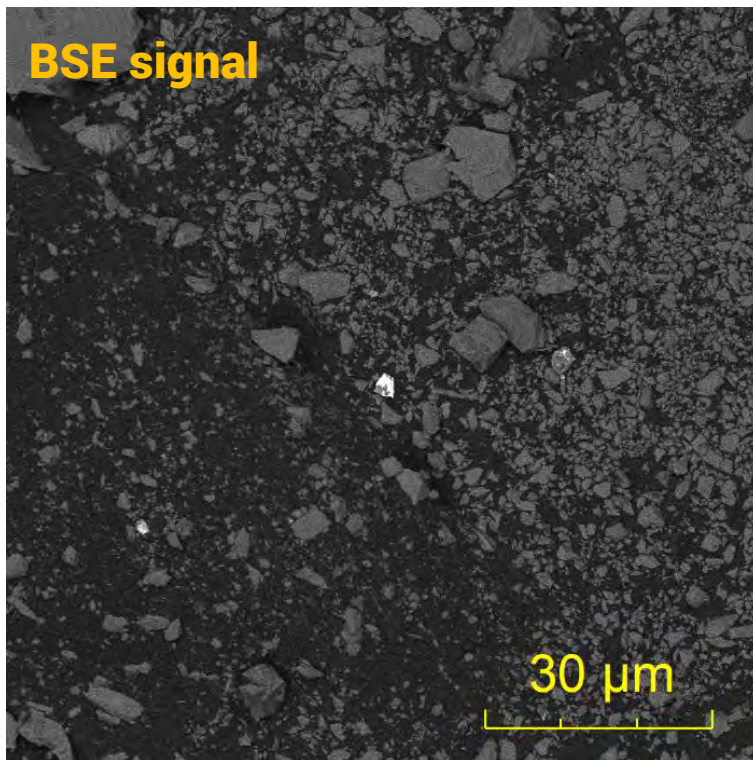


FIB SE Image

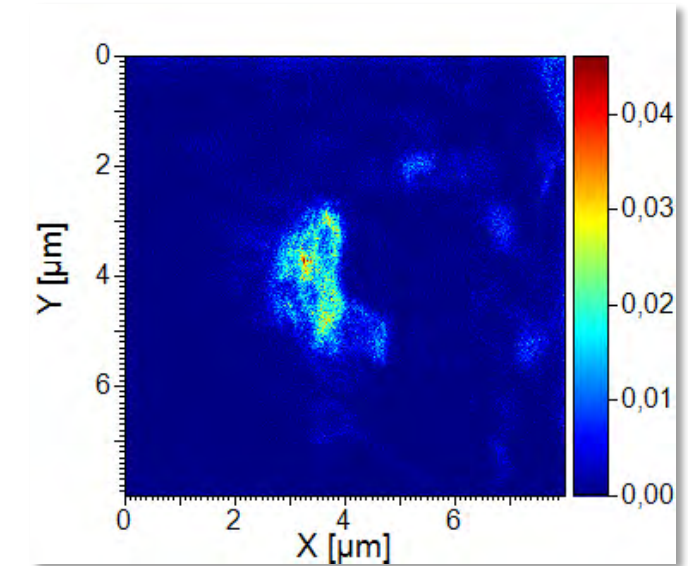


TOF-SIMS

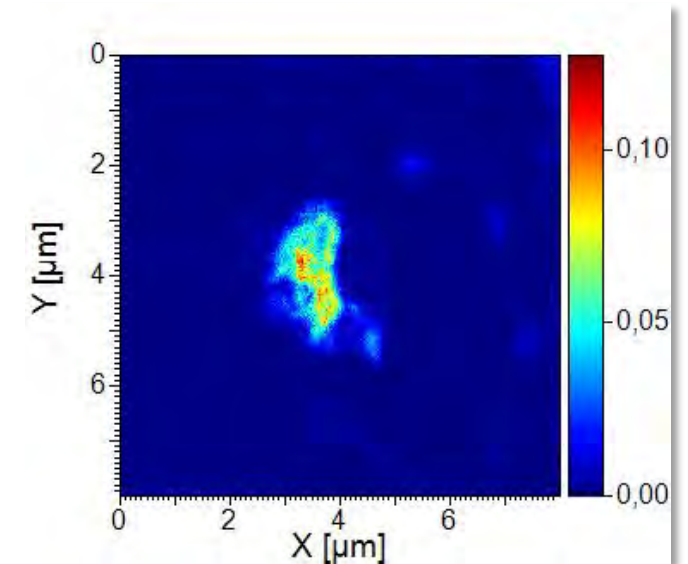
■ Micro- and nanoparticles analysis (U)



^{238}U
+

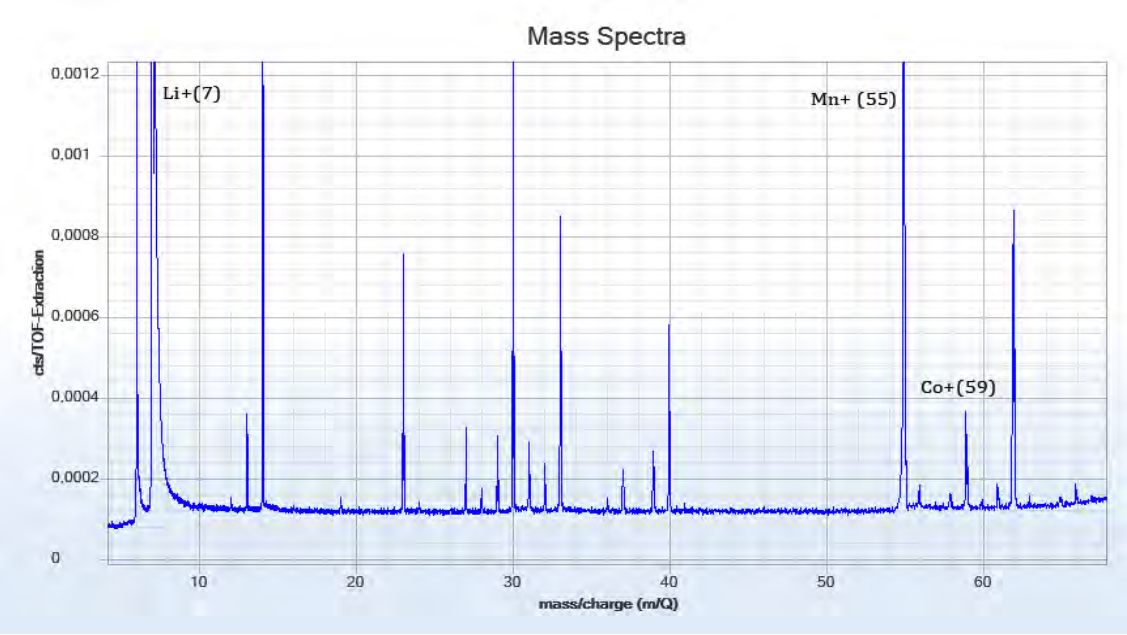


$^{238}\text{U}^{16}\text{O}$
+

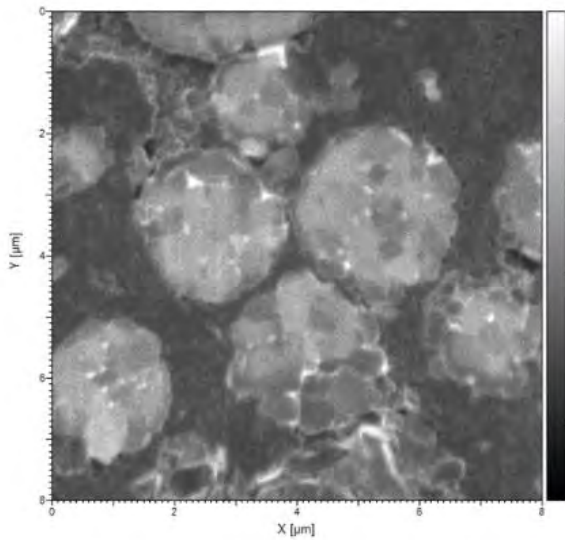


TOF-SIMS

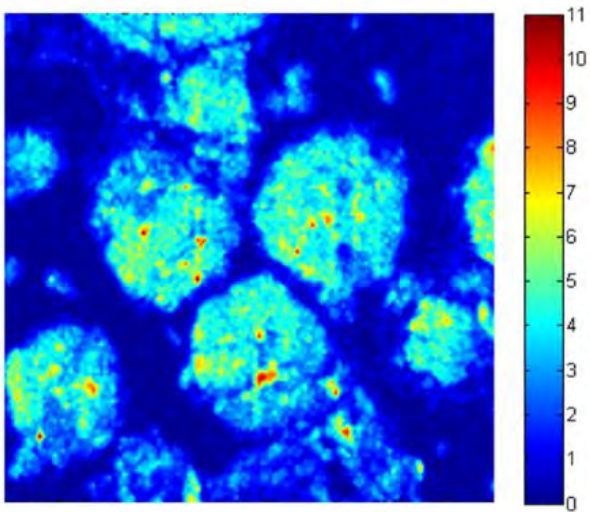
■ Li battery



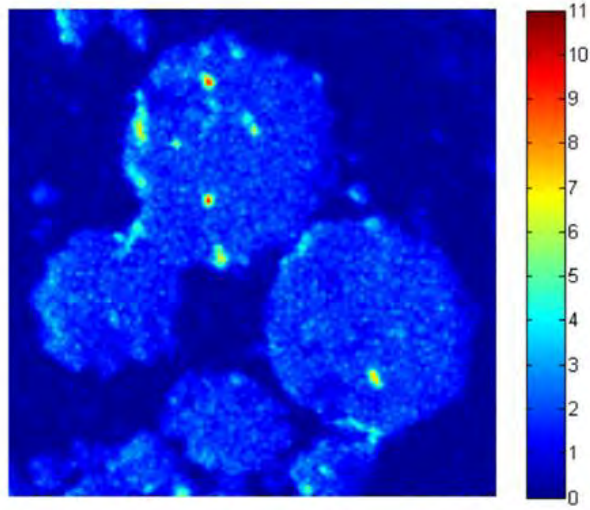
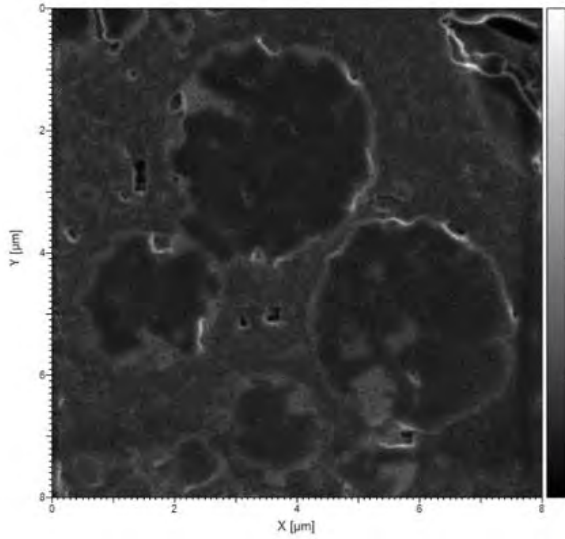
Fully Discharged



Li

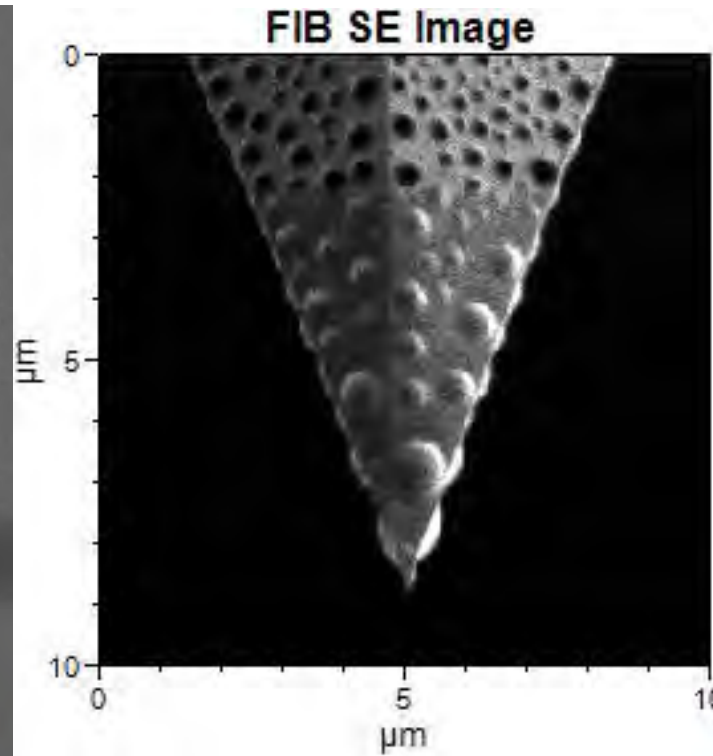
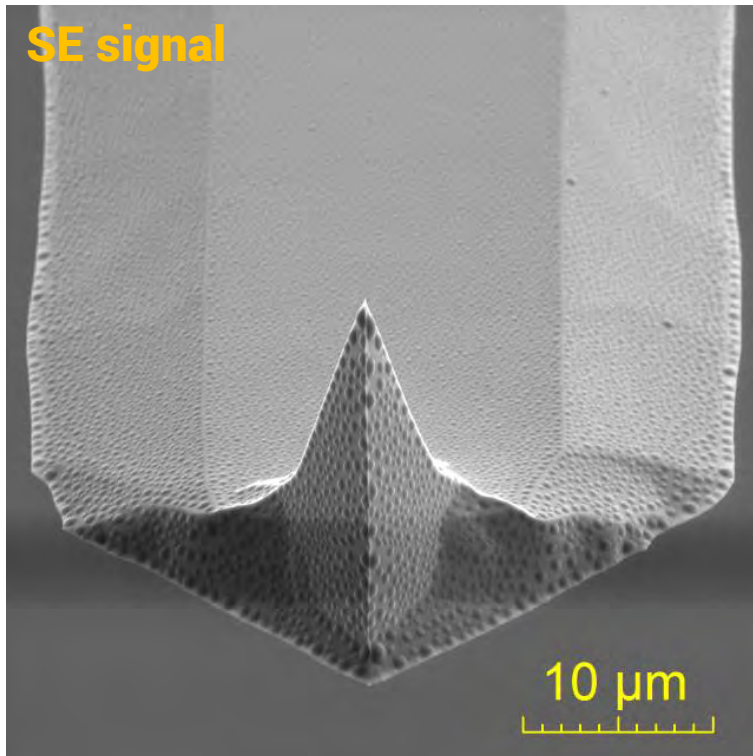
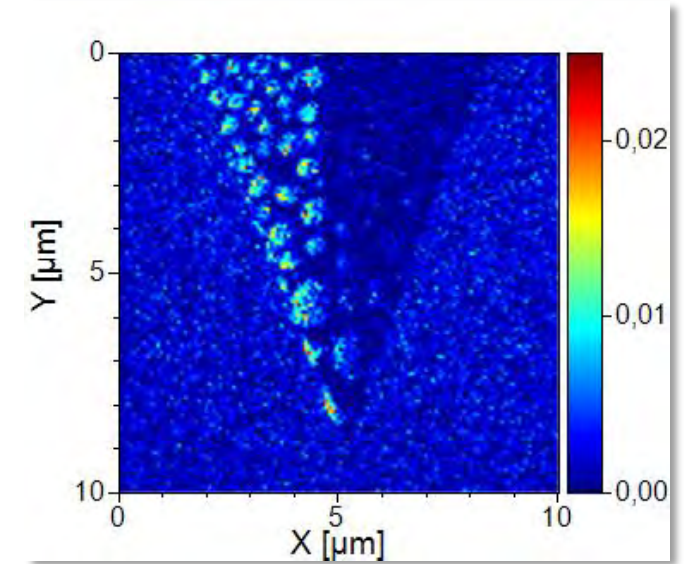
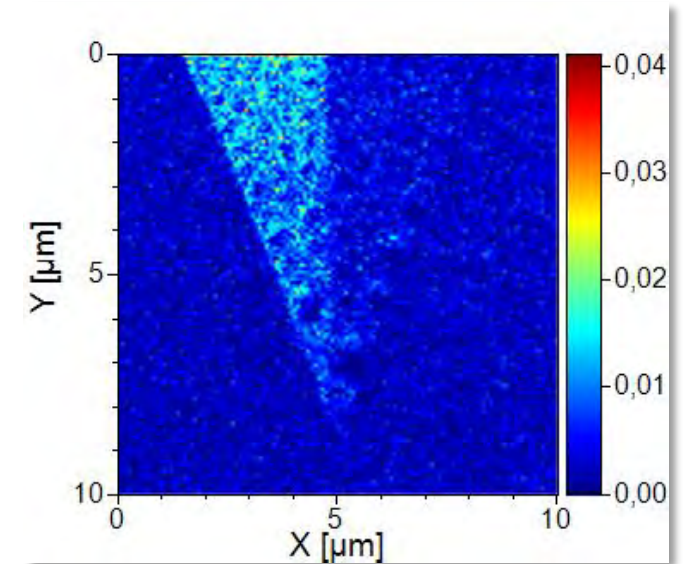


Fully Charged



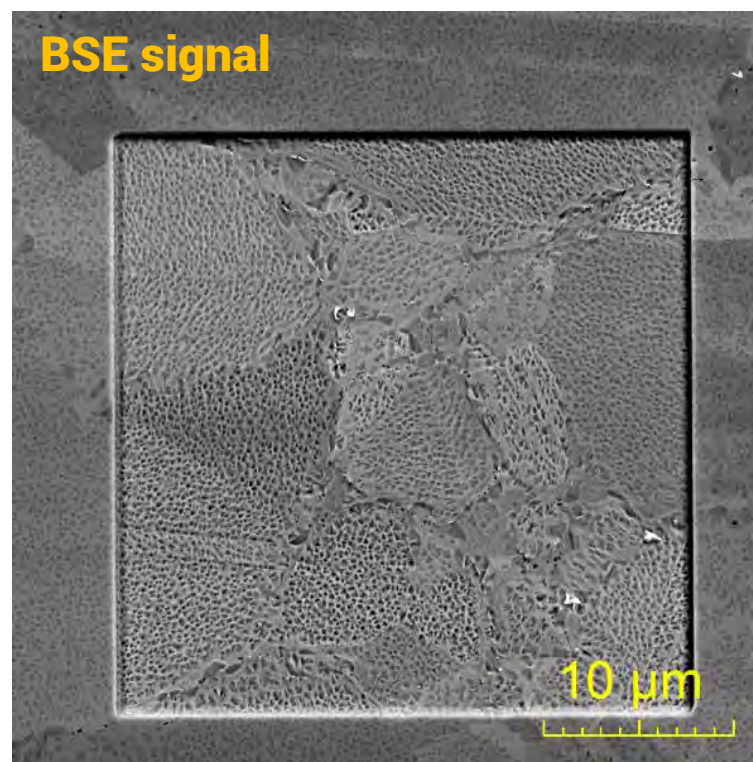
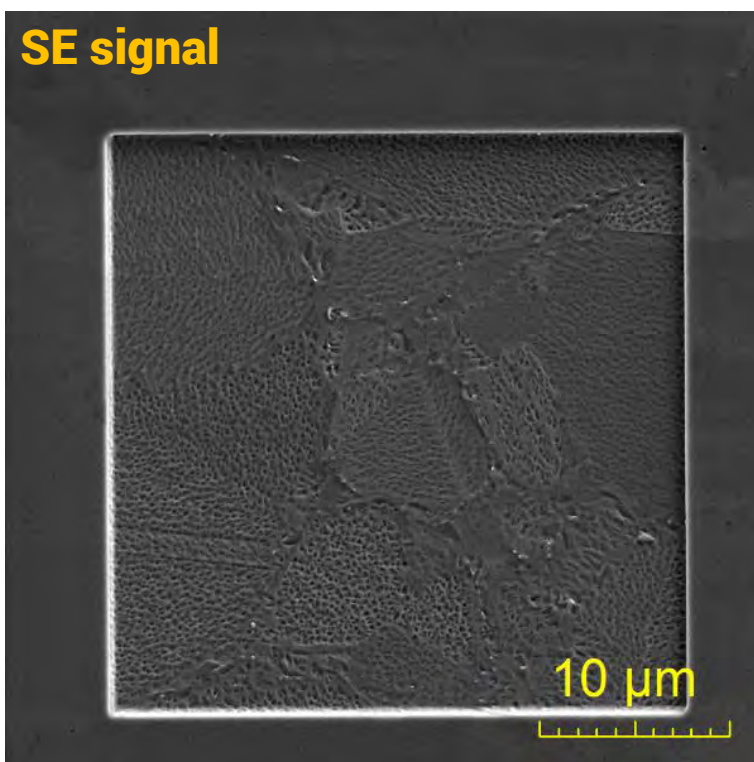
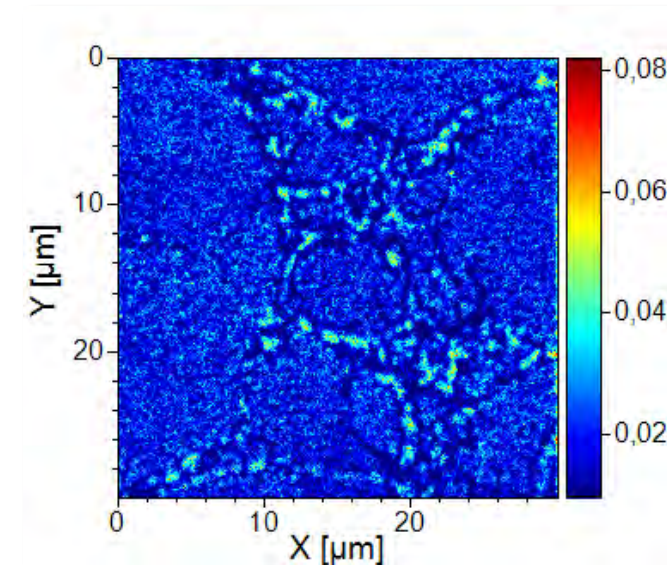
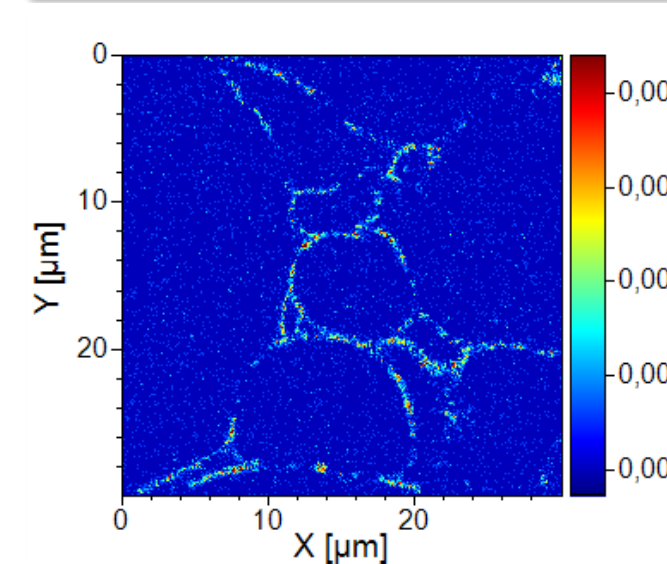
TOF-SIMS

■ Organic contamination on silicon AFM tip

 $^{12}\text{C}_2^-$  $^{16}\text{O}^-$ 

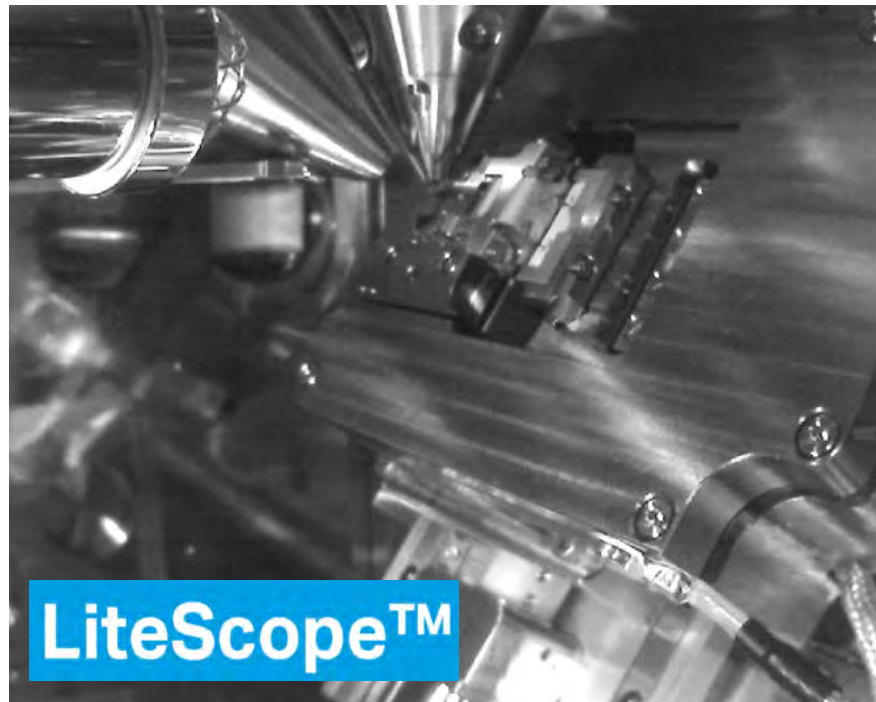
TOF-SIMS

■ Study of metal grain boundaries

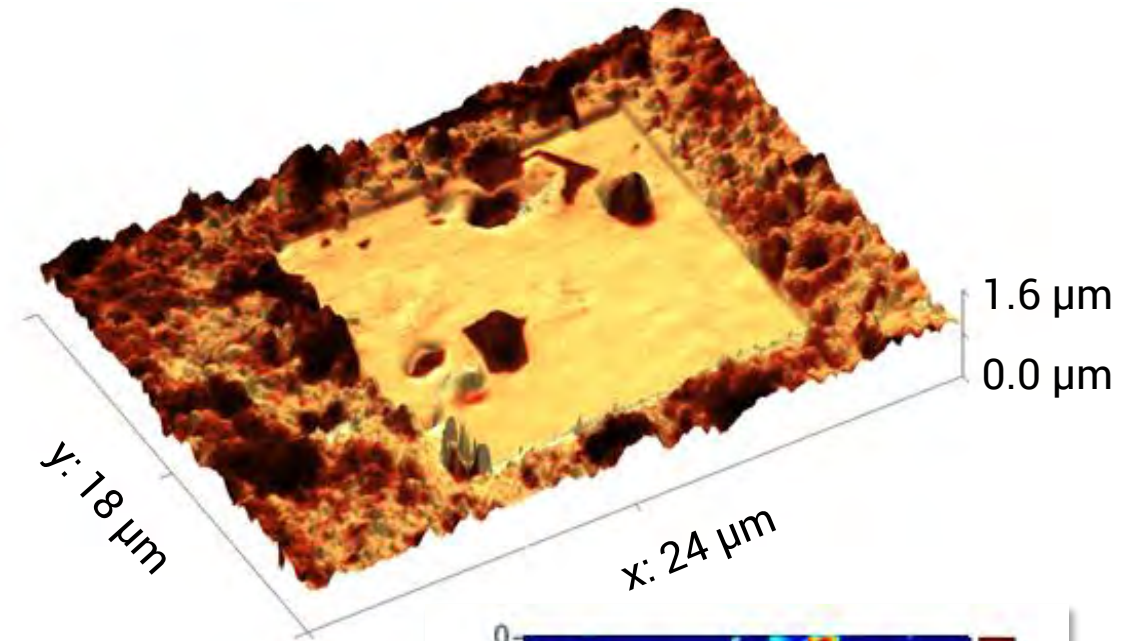
 $^{48}\text{Ti}^+$  $^{90}\text{Zr}^+$ 

TOF-SIMS

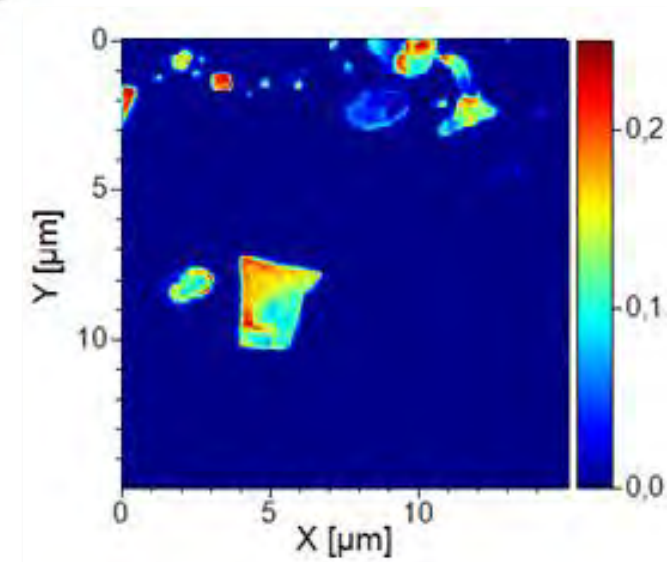
■ Topography measurement by AFM



CPEM (Topography + BSE)

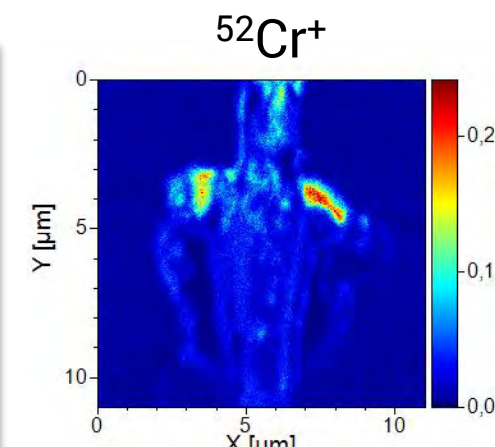
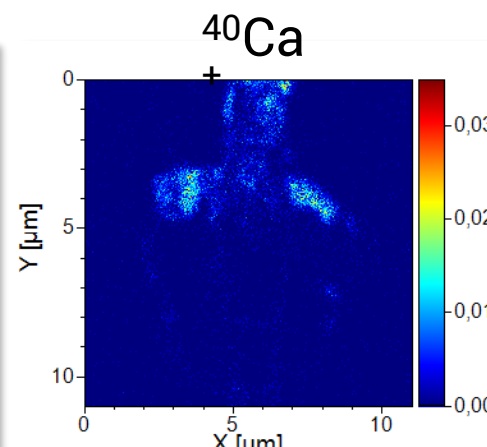
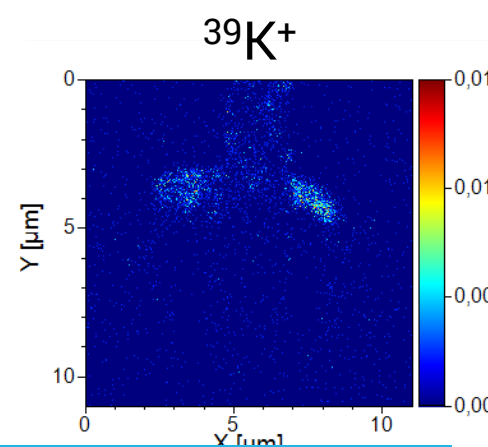
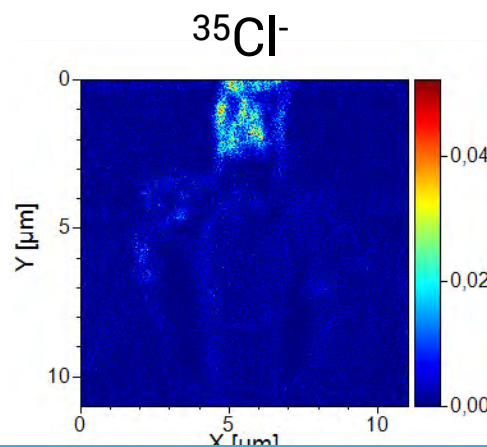
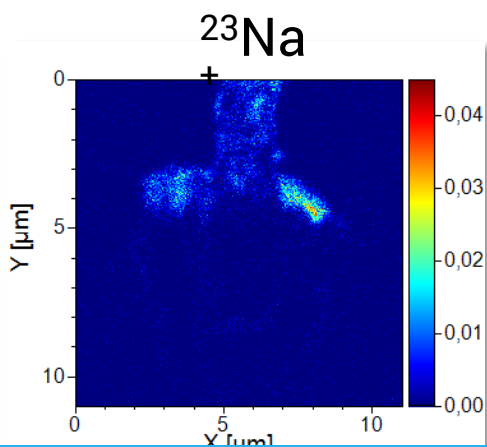
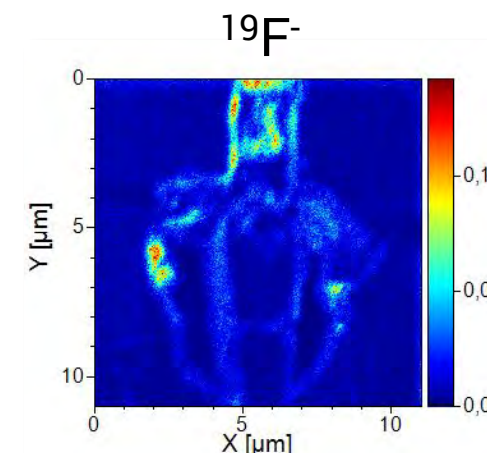
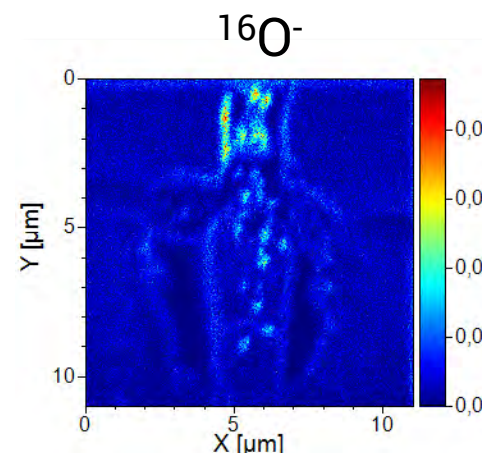
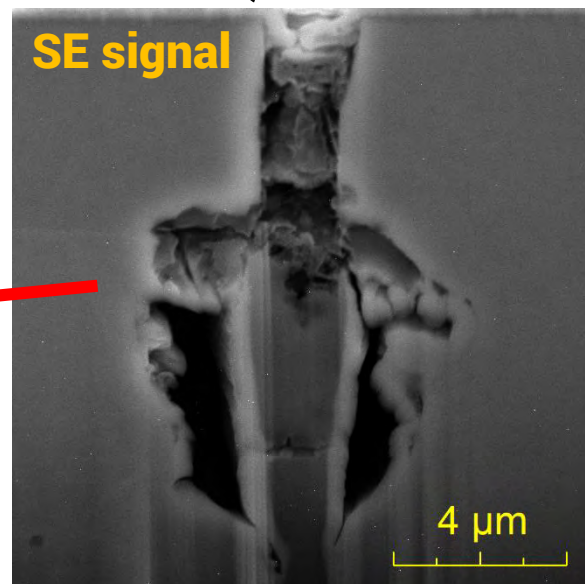
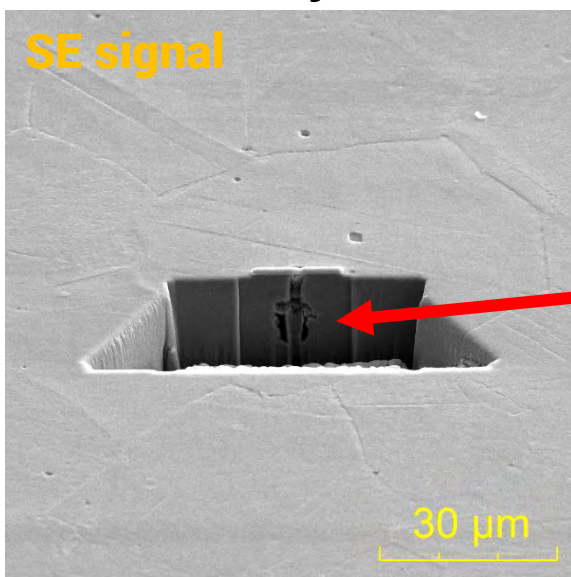


^{27}Al
+



TOF-SIMS

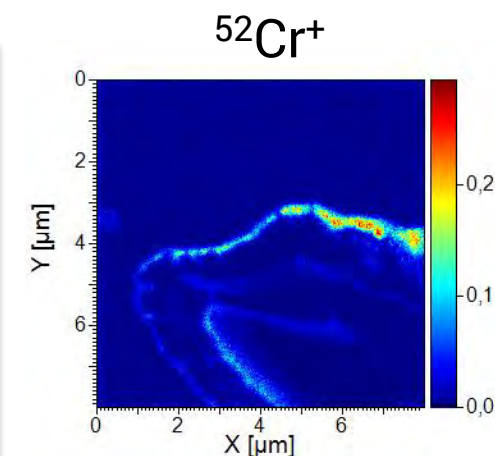
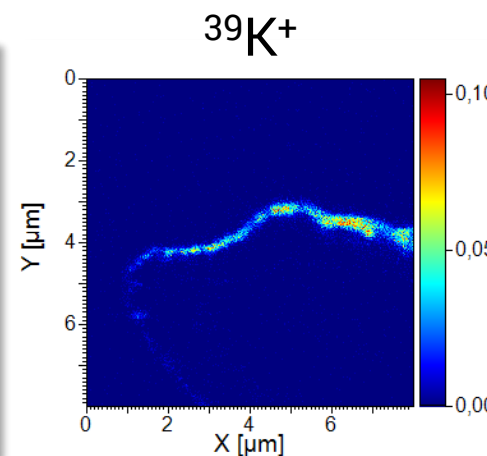
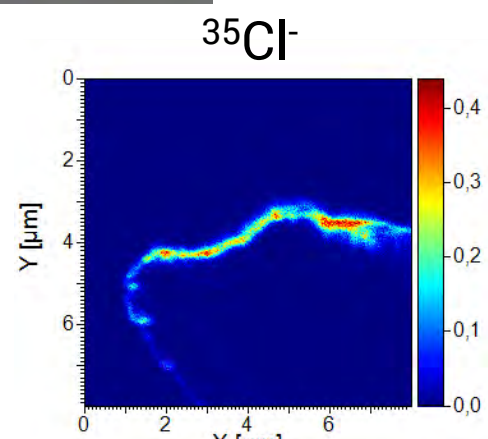
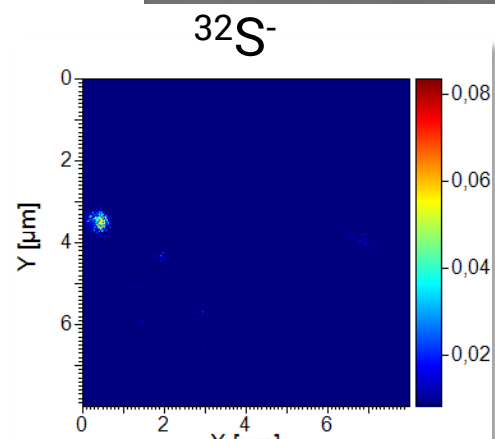
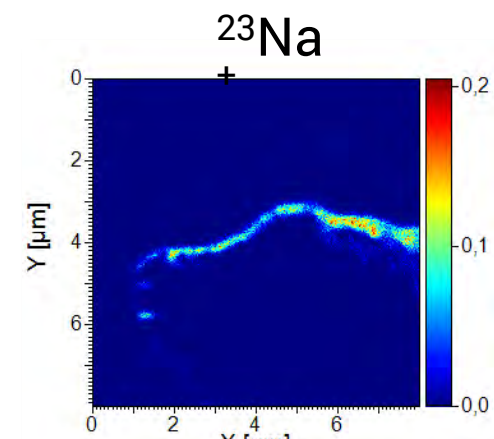
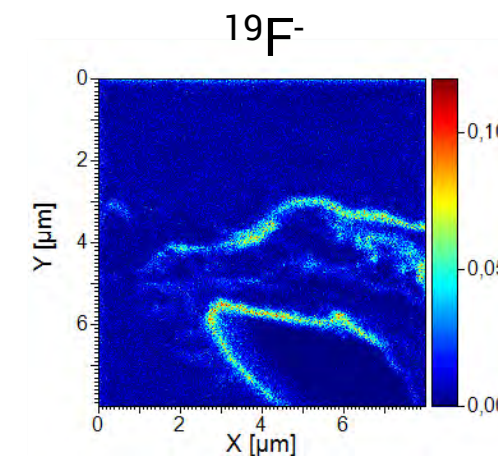
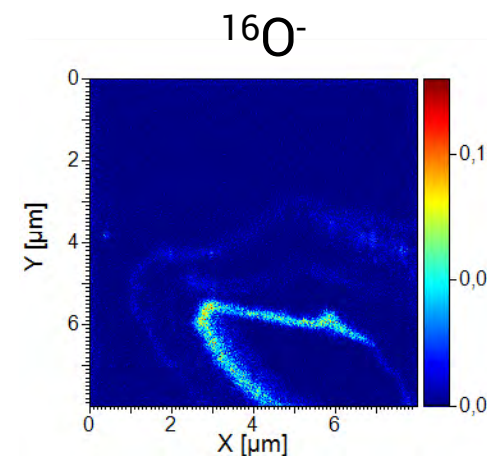
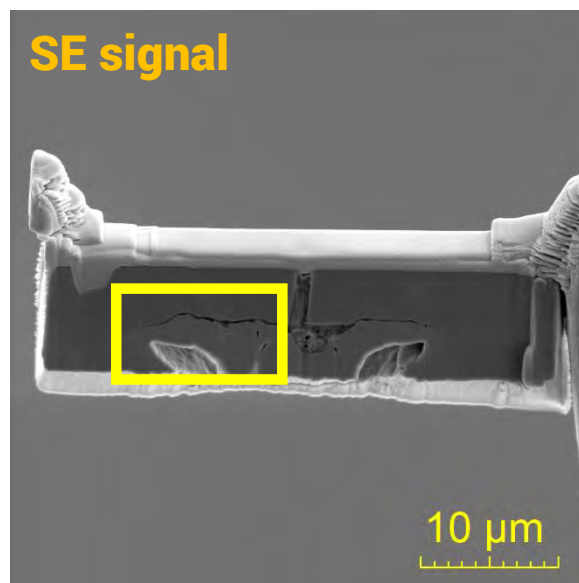
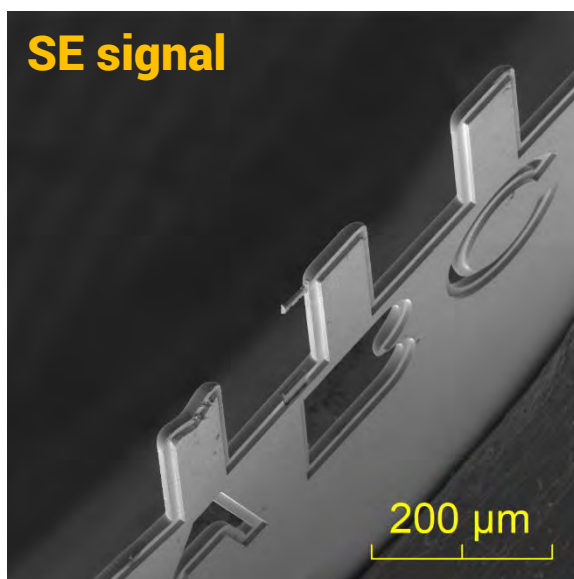
■ Analysis on cross-section (corroded inclusion in metal surface)



Many thanks to S. Simison, INTEMA CONICET UNMdP, Argentina

TOF-SIMS

■ Analysis on lamella (corroded inclusion in metal surface)



Thank you for your attention

COMBINED LASER AND PHOTOGRAMMETRIC MEASUREMENT FROM THE AIR AND FROM THE GROUND

Marko Paško ¹
¹ X3D

Abstract

Combined laser and photogrammetric airborne, mobile and terrestrial measuring

Author: Ing. Marko Paško, Expert_for_3D_Landscape, spol. s r.o., Slovakia, www.x3d.sk

Key words:

- Riegl LMS - airborne, mobile, UAS and terrestrial laser scanning and mapping systems
- Vexcel Imaging - airborne, mobile and terrestrial digital photogrammetry and mapping systems
- 3D mapping and data acquisition
- advantage of combination / data fusion from multiple sources,
- outputs from complex mapping systems,
- detailed high density data
- processing software

In this presentation will be provided answers to questions: - Why to use for 3D data acquisition or mapping the laser and photogrammetric technologies? - Why to combine laser and photogrammetric data acquisition? - Why to combine airborne and mobile data?

We will preview most advanced solutions in laser scanning and digital photogrammetry using examples of the newest products of Riegl Laser Measurement Systems and Vexcel Imaging. As conclusion we summarize most important factors for successful implementation of 3D mapping solutions in professional work.

Kombinované laserové a fotogrametrické meranie zo vzduchu a zo zeme



- laserové a fotogrametrické technológie na 3D meranie

RIEGL Laser Measurement Systems **VEXCEL** Imaging



- distribútor pre SR: Expert_for_3D_Landscape, spol. s r.o., www.x3d.sk

Témy:

1. Prečo využívať na zber priestorových dát, resp. mapovanie laserové a fotogrametrické technológie
2. Prečo kombinovať laserový a fotogrametrický zber dát
3. Prečo kombinovať dáta zo vzduchu a zo zeme
4. Riešenia Riegl
5. Riešenia Vexcel Imaging
6. Rozhodujúce faktory pre nasadenie v priemyselnej praxi



1. Prečo využívať na zber priestorových dát / mapovanie laserové a fotogrametrické technológie

- obe technológie
 - **vysoký potenciál automatizácie, bezdotykové**
 - **možnosť využitia dynamického snímania s časovou synchronizáciou**
 - **vysoká hustota + presnosť dát**
 - **kalibrovateľné**
- **fotogrametria**
 - tradičná mapovacia metóda dlhodobo, **plošné snímanie s prekrytom**
 - dobrá dostupnosť senzorov / digitálnych kamier, **lacnejšia**
- **laserové skenovanie**
 - novšia mapovacia metóda, **bodové snímanie lúčom s viacnásobným odrazom**
 - **vyššia cena** – rýchly pokrok vo vývoji, **viac robotizácie**

2. Prečo kombinovať laserový a fotogrametrický zber dát

- donedávna - 2D GIS, papierové mapy, digitalizované **staršie kartografické diela**
- bežné sú 3D rastrové dáta DTM/DHM s rastrom 100m, resp. **manuálne vyhodnocované** databázy budov
- dostupné dáta obsahovo nevyhovujú dnešným potrebám - **moderné priemyselné aplikácie** (autonómne dopravné systémy, monitoring kvality líniových stavieb, krízový management, ochrana životného prostredia, poisťovníctvo, kriminalistika) **potrebujú na automatizáciu procesov aktuálne a kvalitné dáta s vysokou hustotou**
- Zber dát má svoju cenu, preto by sa mal vykonávať efektívne:
 - **automatizovane, bezdotykovo** (jeden operátor namiesto stoviek meračov)
 - **v krátkom čase, najlepšie dynamicky** (skrátene trvania zberu dát)
 - **s vysokou hustotou + naraz viac senzorov / doplňujúcich sa technológií**
 - **s vysokou presnosťou, homogénne na kalibrovaných meracích systémoch**

3. Prečo kombinovať dáta zo vzduchu a zo zeme

- Kvôli potrebe viditeľnosti objektov z rôznych strán (z hora, zo zeme, znútra)
- Vzájomne prevrátená hierarchia medzi počtom daných typov nosičov a množstvom zameranej plochy:

špecializovaný merací nosič

Lietadlá: **málo** vhodných meracích lietadiel

Autá: meracie vozidlá **pomaly pribúdajú**, bude
v budúcnosti každé auto bude meracie vozidlo?

UAS: **rýchlo pribúda** počet meracích dronov

Človek: **teoreticky každý**, keď fotí, zbiera dáta

zamerané plocha

celoštátne, celé kraje, celé okresy, **veľkoplošný zber**

celé kraje, celé okresy, celé mestá, **líniový zber**

menšie mestá, lokality, **lokálny plošný aj líniový zber**

bodový **zber dát**, **menšia plocha vysoko detailne**

- Dôležité pre analýzu chýb a automatizáciu:

- redundantnosť dát
- treba kombinovať 2 vzájomne nezávislé metódy

4. Riešenia RIEGL Laser Measurement Systems



Všestranné riešenia:

* Terestrické:

- [VZ-400i](#) ... dosah 800m, presnosť 5mm, georeferencovanie v reálnom čase, cloud
- [VZ-2000i](#) ... dosah 2000m, presnosť 10mm

* Mobilné:

- [VMX\(450\)-1HA](#) ... mobilné presné skenovanie,
- [VMQ-1HA](#) ... light-verzia s 1 skenovacou hlavou

* Letecké + UAV:

- [VUX-1](#) ... 3 rôzne hlavy + [RiCopter](#) / [VP1](#)
- [VQ-880-G, -GH](#) ... topo-hydro mapovanie
- [VQ 1560i](#) ... city mapping, veľkoplošné mapovanie, duálny skener



<- už aj v SR



RIEGL LMS-Q1560

5. Riešenia Vexcel Imaging



- fotogrametrické technológie na 3D mapovanie - dôraz na fotogrametriu
- **Letecké riešenia:** – letecký zber dát špecializovaným meracím lietadlom
 - Flexibilné – vymeniteľné objektívy [UC Eagle Mark 3](#), najväčšia šírka záberu 26460 px
 - Šikmé snímkovanie – [UC Osprey Mark 3 Premium](#)
 - Konkurencia satelitným senzorom – [UC Condor Mark1](#) – 38000px
- **Mobilné riešenia:**
 - [UltraCam Mustang](#) – mobilný zber dát autom
- **Pochôdzne riešenia:**
 - [UltraCam Panther](#) – zber dát pešo človekom
- Jedno softvérové prostredie [UltraMap](#) – softvér na kompletne automatizované spracovanie zo všetkých druhov senzorov UltraCam



Minulý rok prezentované mobilné riešenie:
UltraCam Mustang

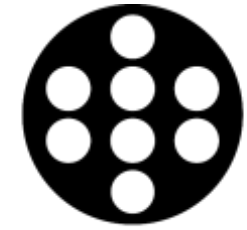
na pozemný mobilný zber
georeferencovaných obrazových dát



Konferencia 3D meranie a zobrazenie, Ing. Marko Paško,
Bratislava, 21.-22.9.2017 Expert_for_3D_Landscape, spol. s r.o.



UC Mustang



VEXCEL
IMAGING



- na **pozemný mobilný zber** georeferencovaných obrazových dát
- Max. **rýchlosť zberu až 120 km/h**
- **Panoramatické zábery 360° vo vysokom rozlíšení**
- **Presné vzájomné nadväzovanie** vďaka LiDARovým dátam
- **Presná poloha a náklony** vďaka integrovanému GNSS/IMU
- **Kompletne kalibrované**
- **Osvedčené a spoľahlivé riešenie** – už nazbieralo viac ako 5 miliónov km
- **Jednoduchý postprocessing v softvéri UltraMap** Terrestrial Essential

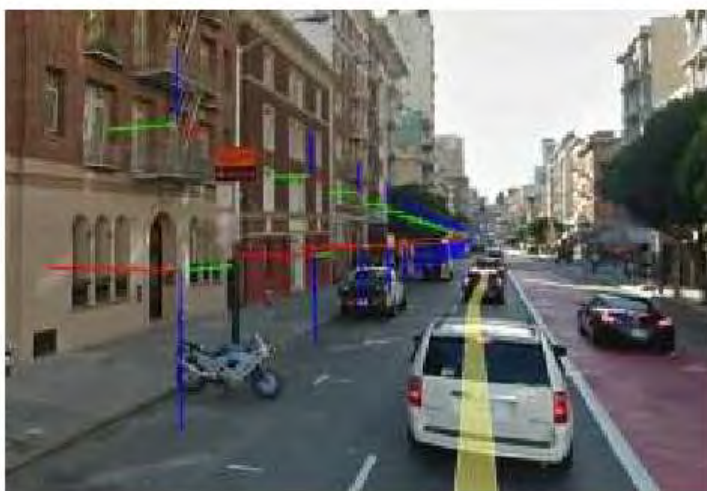
výstupy z UC Mustang

- Georeferencované **panoramatické snímky**
- Georeferencované **mračná bodov**
- Georeferencovaná **trajektória**
- **Kalibračné parametre**
- **Presnosť po postprocesingu +/- 2cm**
- Hustota obrazových dát **8 snímok za sekundu z 9 kamier, spolu 54 Mpix**
- Hustota laserových dát **700000 bodov za sekundu** zosynchronizovaných s obrazovými dátami

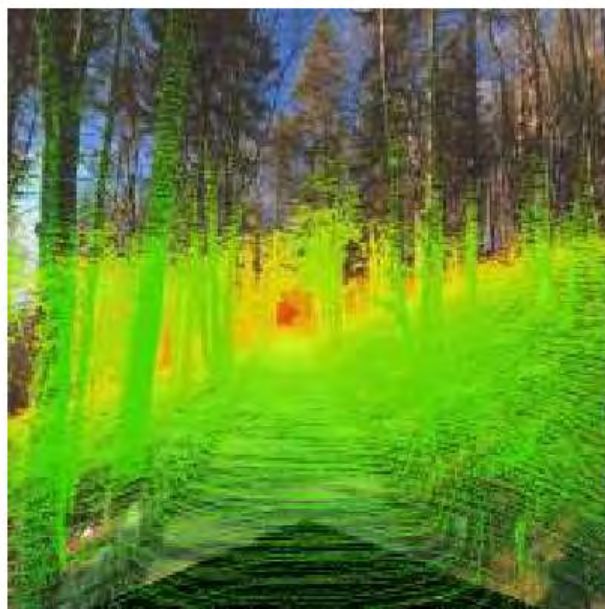




Dokonalé snímkové panorámy s vysokým rozlíšením, exportovateľné aj pre cave



Možnosť priameho 3D merania na presne georeferencovaných dátach



Konferencia 3D meranie a zobrazenie,
Bratislava, 21.-22.9.2017

Ing. Marko Paško,
Expert_for_3D_Landscape, spol. s r.o.





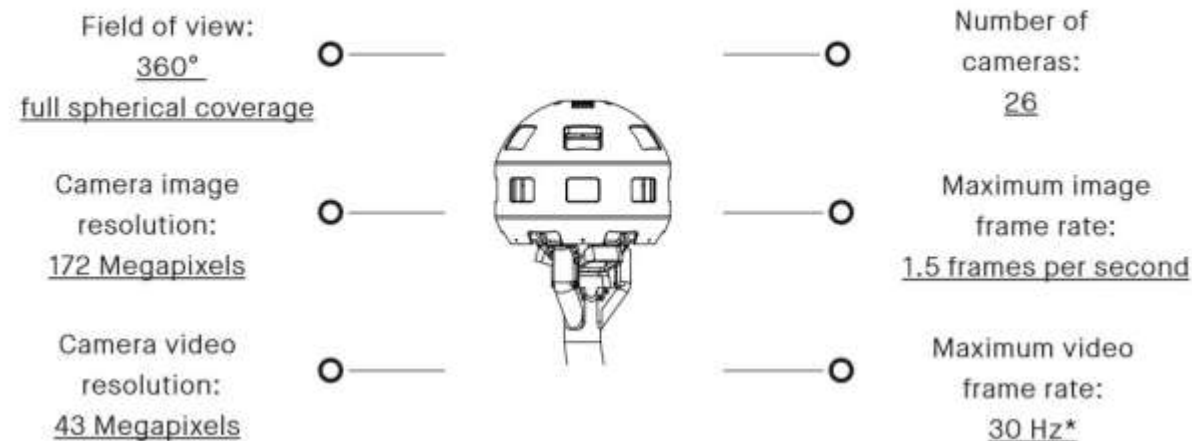
Novinka - pochôdzne riešenie:

UltraCam Panther

na pozemný zber

georeferencovaných obrazových dát

PANORAMIC HEAD



Príklad: ideálna kombinácia - spoločné využívanie zdrojových zariadení v lietadlách

- Riegl LMS [Q1560i](#) + Vexcel UltraCam [Eagle Mark 3](#)
- šetrí peniaze – časť technológií spoločne zdieľaná



6. Zhrnutie – rozhodujúce faktory pre úspešné nasadenie riešení v priemyselnej praxi

- Vyzretosť riešení – **skúsenosti založené na dlhodobom vývoji** HW a SW
- Možnosť **prepojenia s inými komplementárnymi štandardizovanými senzormi**
- Vysoká **automatizácia procesov** + naviac **kvalitné analytické nástroje** (one-click ale aj manuálne)
- **všestrannosť** technológie schopná spracovať **v jednej technologickej linke** dáta získané **všetkými 3 zdrojmi** – letecky, autom a aj peši

To všetko spĺňajú riešenia RIEGL LMS a VEXCEL Imaging.

Ďakujem za pozornosť. Viac na www.x3d.sk

CHALLENGES IN 3D SCANNING

Ján Žižka¹

¹ CEO, Photoneo - Focused on 3D

Abstract

The ability to accurately localize objects in an observed scene in 3D is critical precondition for many practical applications including automatic manufacturing, quality assurance, or human-robot interaction. We discuss why localization in 3D is hard and show several real-life examples.

Photoneo

Why localization in 3D is hard

Photoneo - Intro

- Slovak based company
- 4 years old
- Manufacturing 3D Scanners
- Developing 3D Camera
- 3D processing software
- Focus on automation



Our team: 46 people

Jan



CEO

PhD in Machine
Vision

Tomas



CTO

Computer Vision
guru

Michal



COO

PhD in
AI/Machine
Learning

Brano



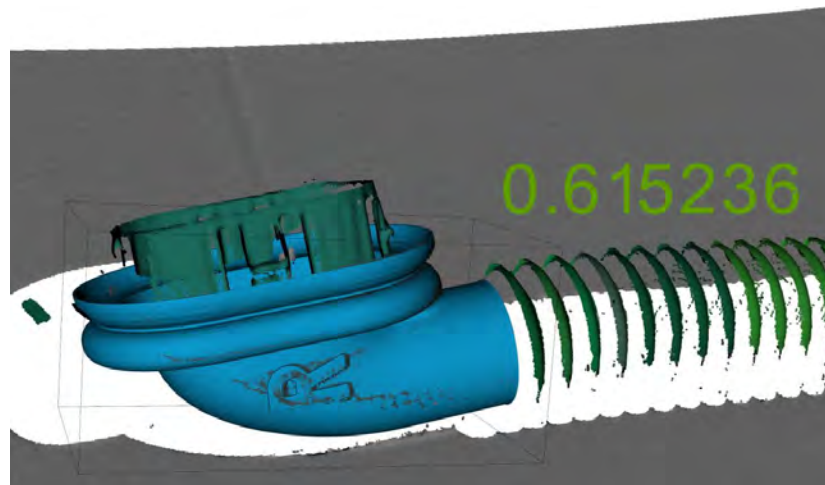
Business Director

Six Sigma Black Belt
& Sales master



Localization - definition

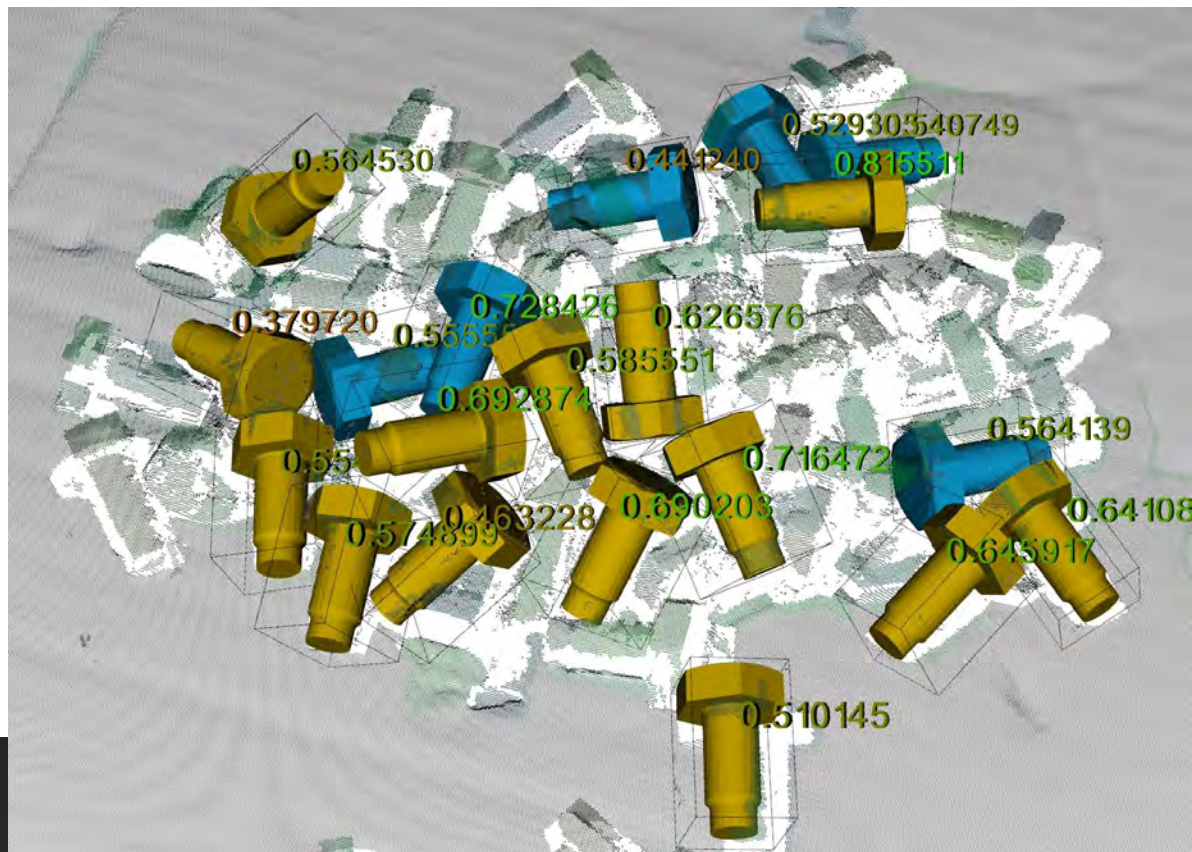
- Input
 - Pointcloud
 - CAD model of the part
 - Or 3D scan
- Task
 - Exact location & orientation of the object
 - Rigid vs Non-rigid



Examples - metal sheets



Examples - screws



Applications

Bin Picking

- Randomly placed & crowded
 - Occlusions
 - Collision detection
-
- Gripper design
 - Robot path planning



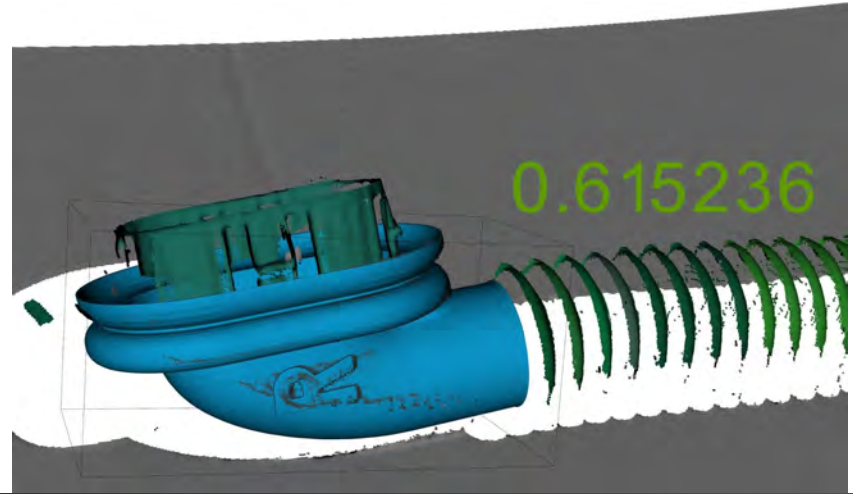
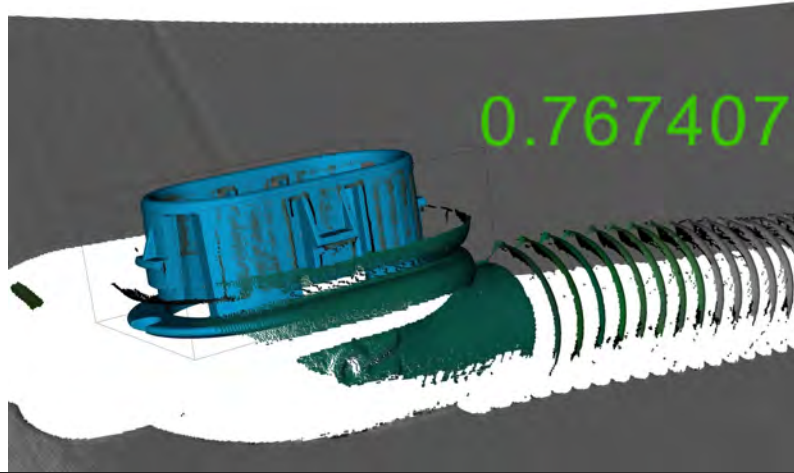


Alignment / Relative position

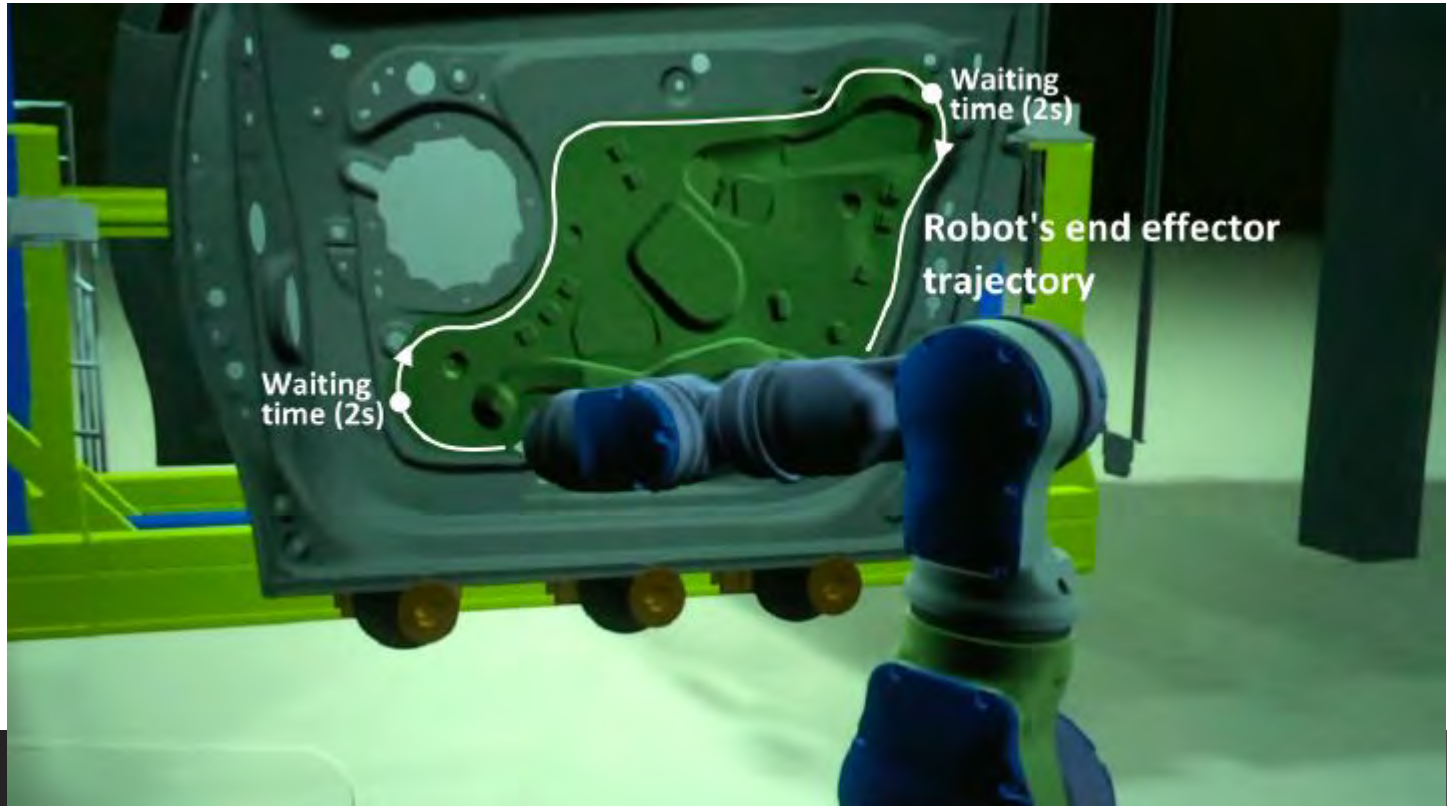


Alignment / Relative position

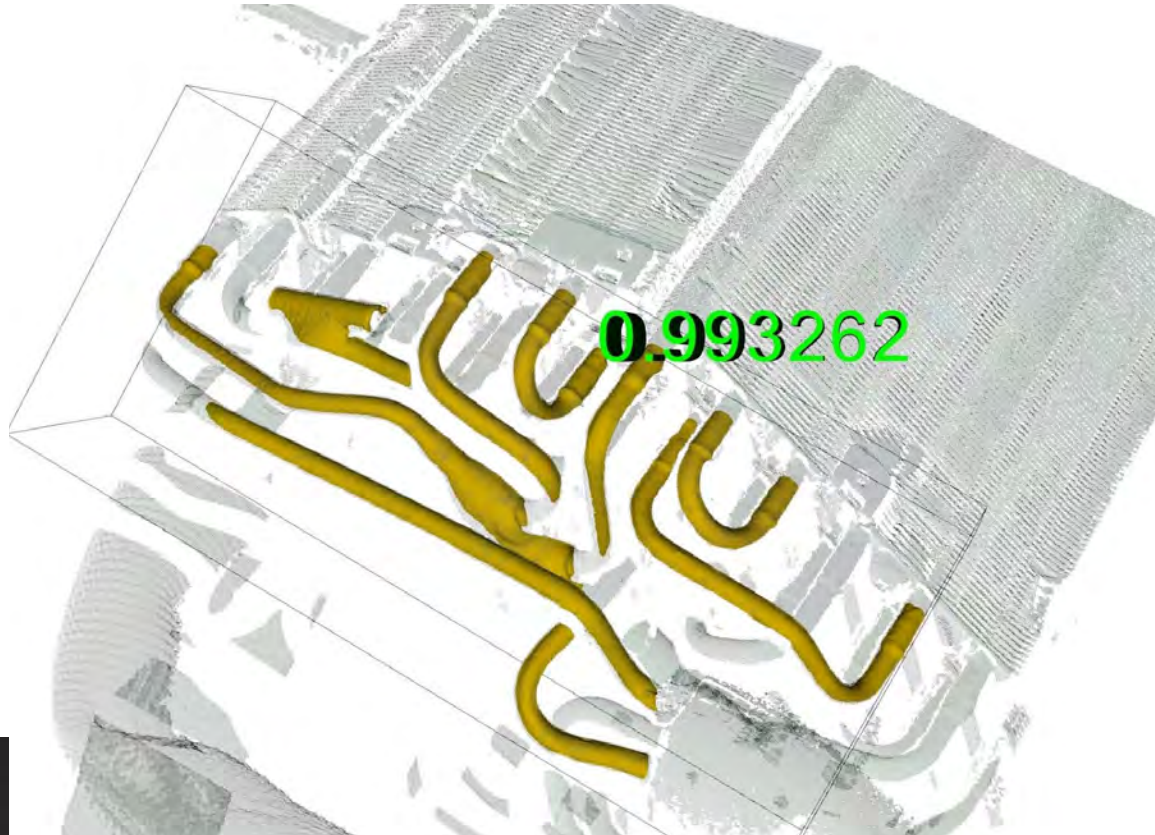
- Locate A
- Locate B
- Check relative position & orientation



Robot Path Correction

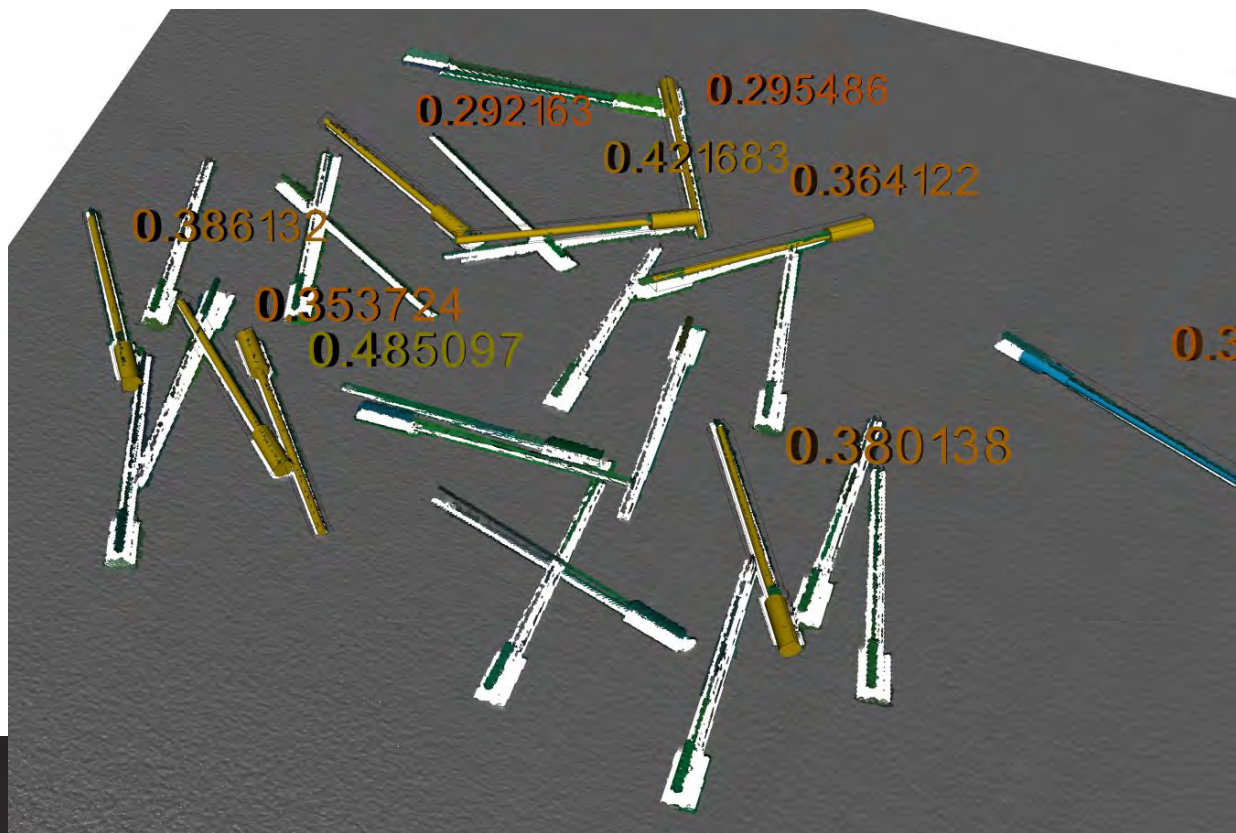


Robot Path Correction - Example



More applications

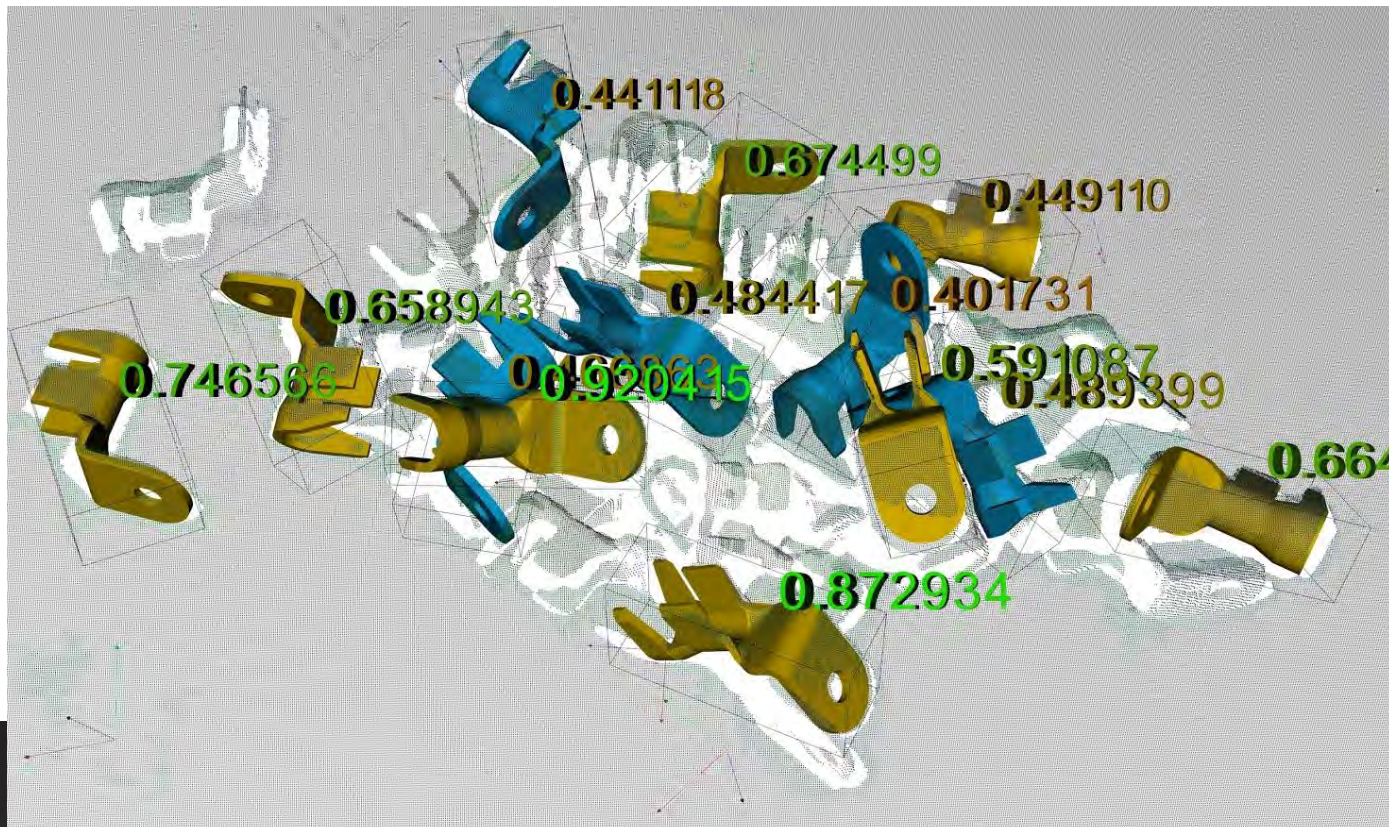
Examples - needles



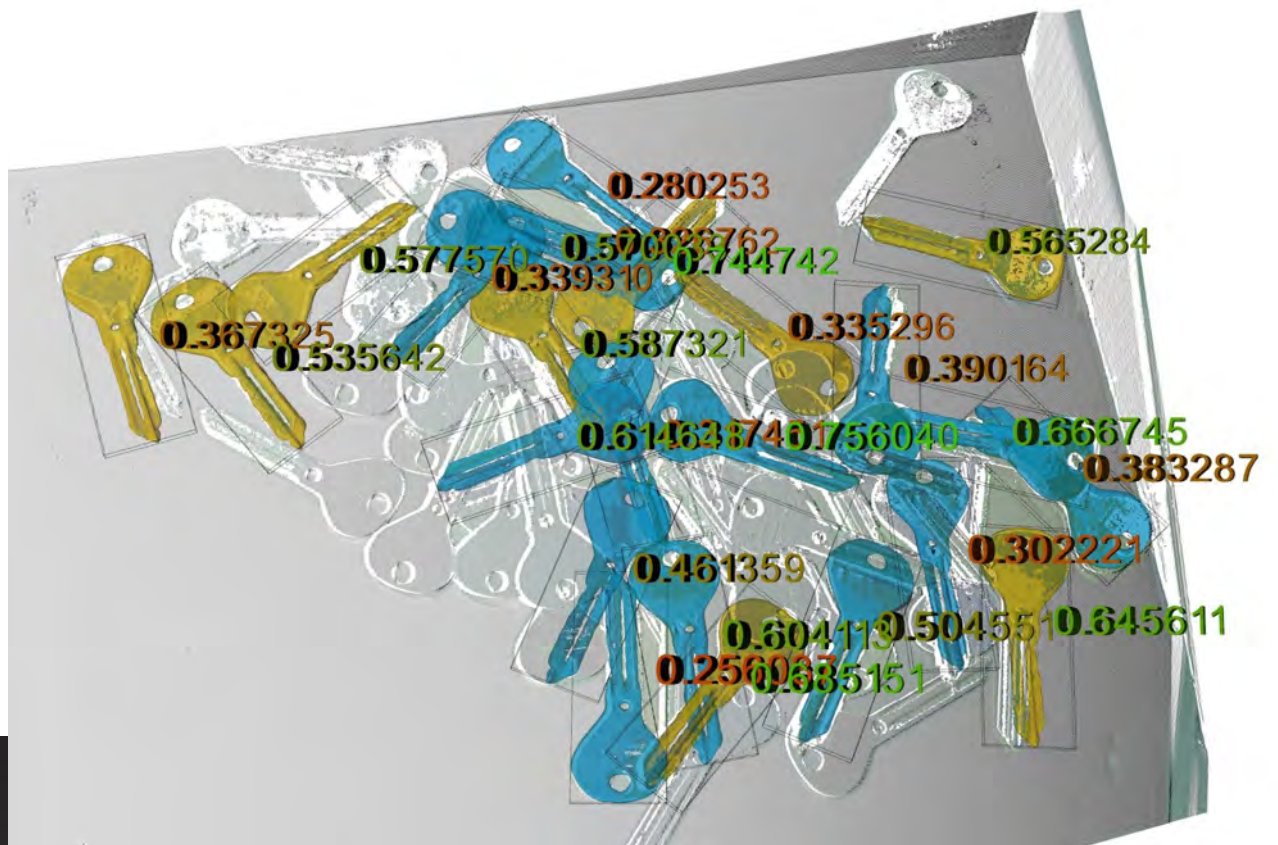
Examples



Examples



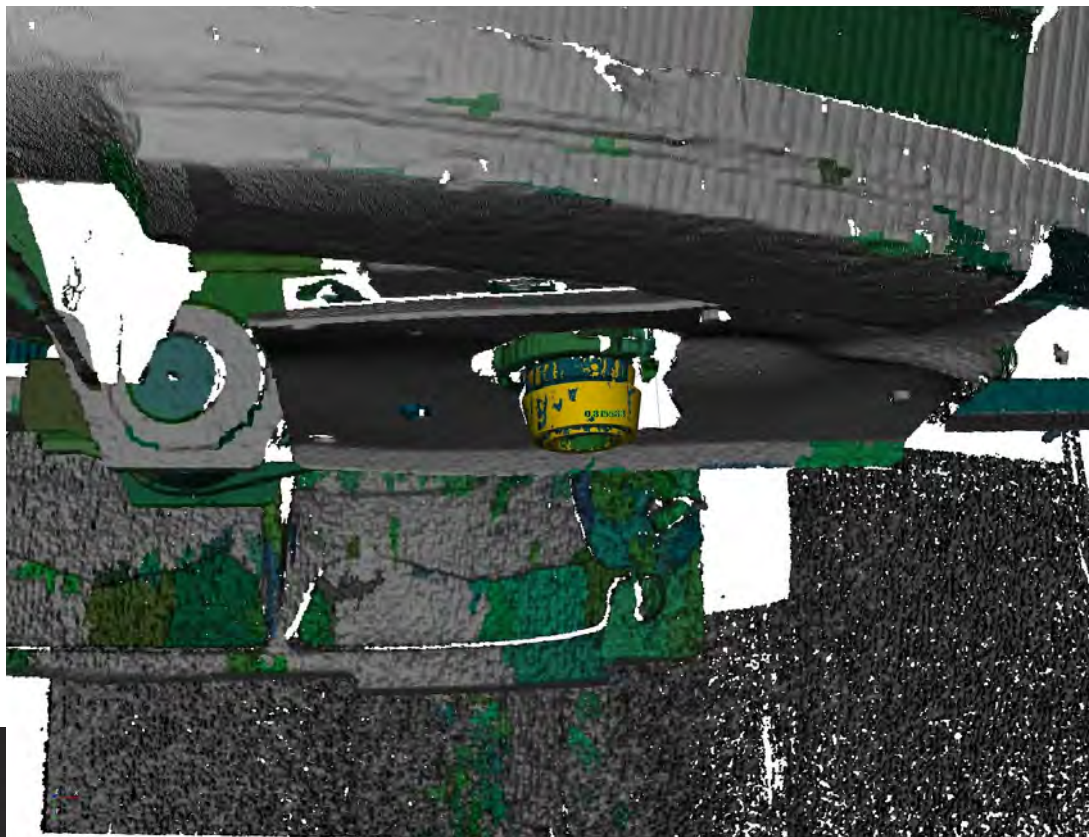
Examples



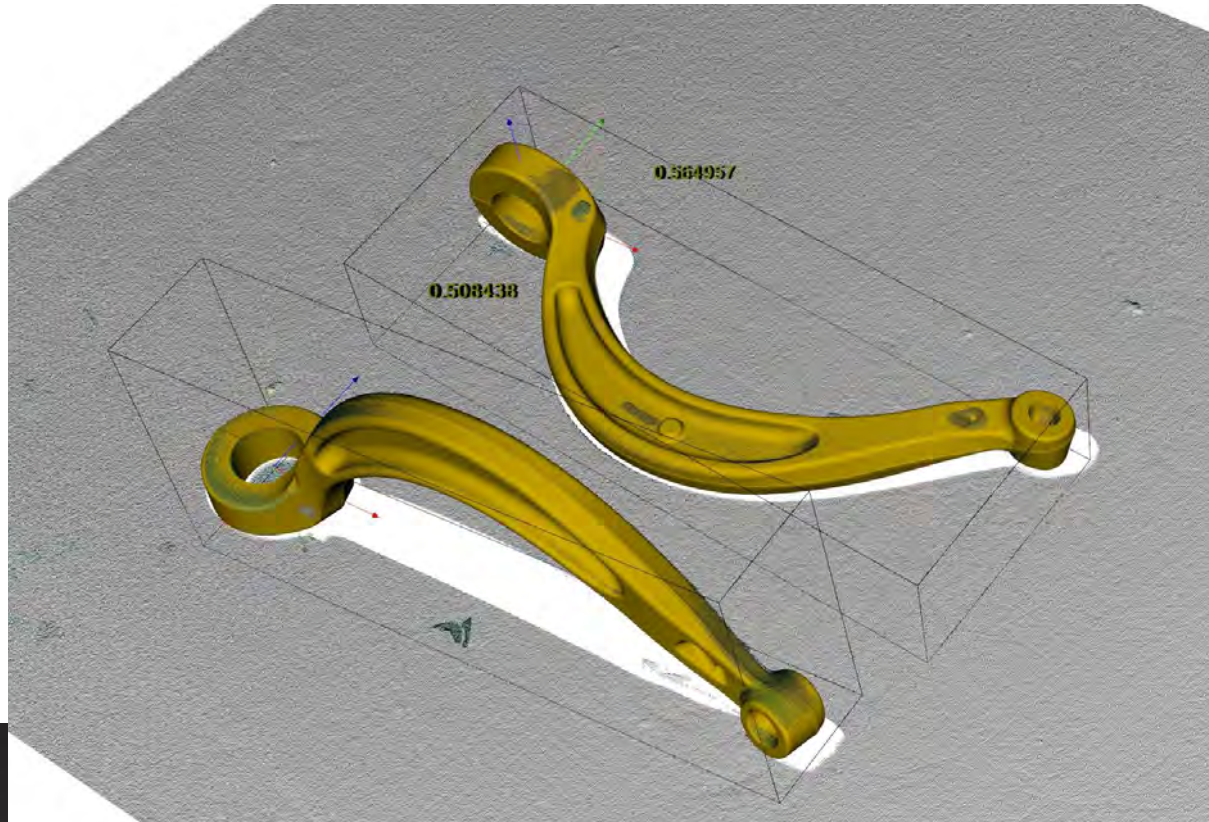
Examples



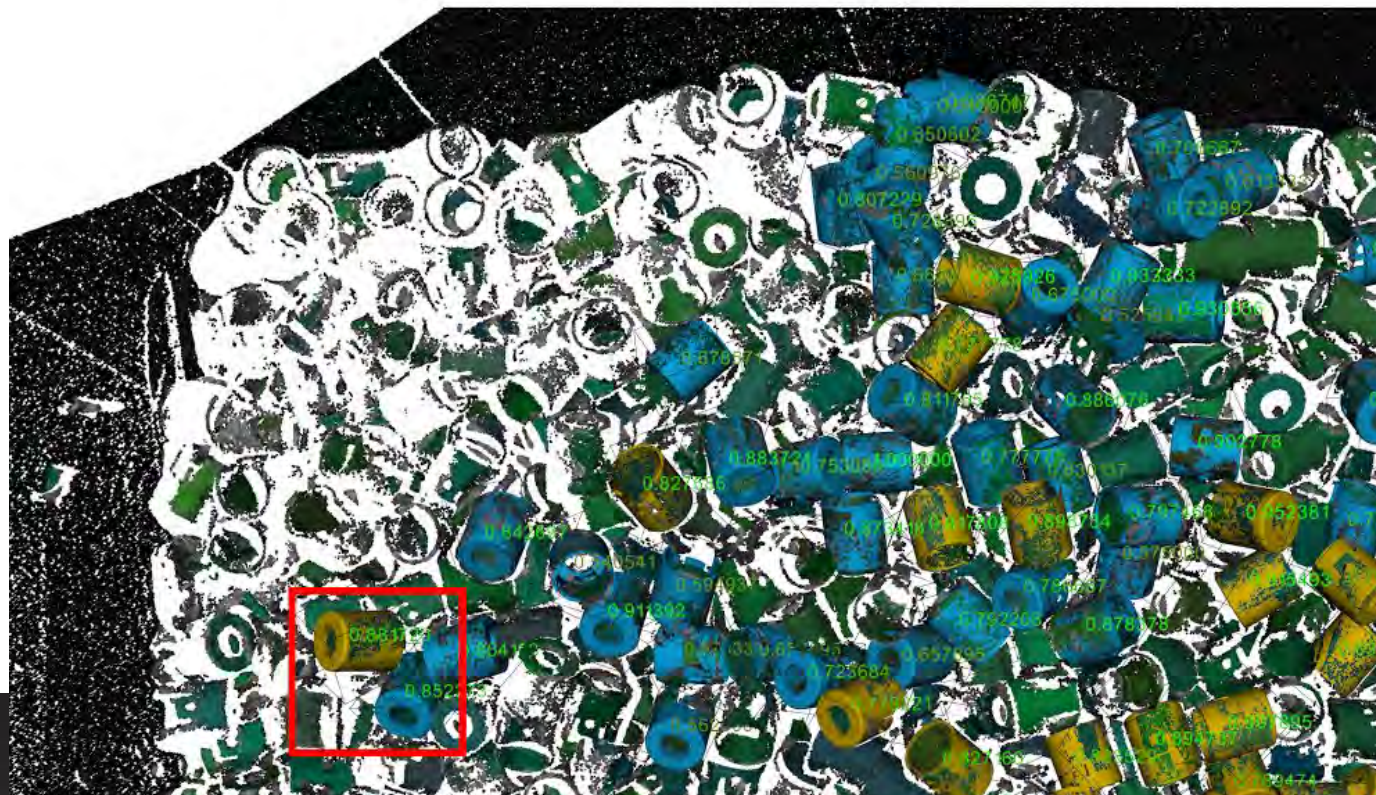
Examples



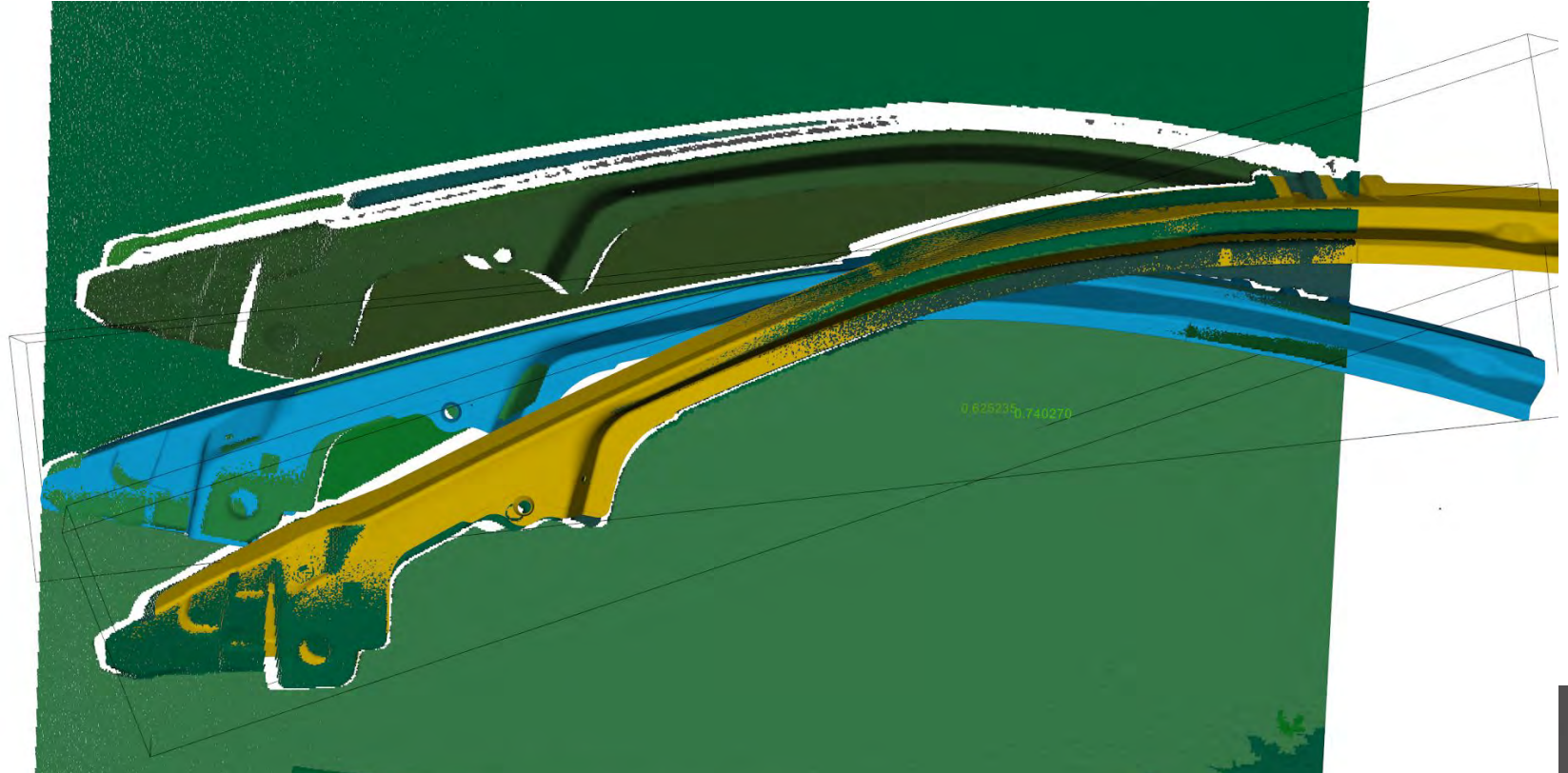
Examples



Limitations - Scan quality



Limitations - Bending



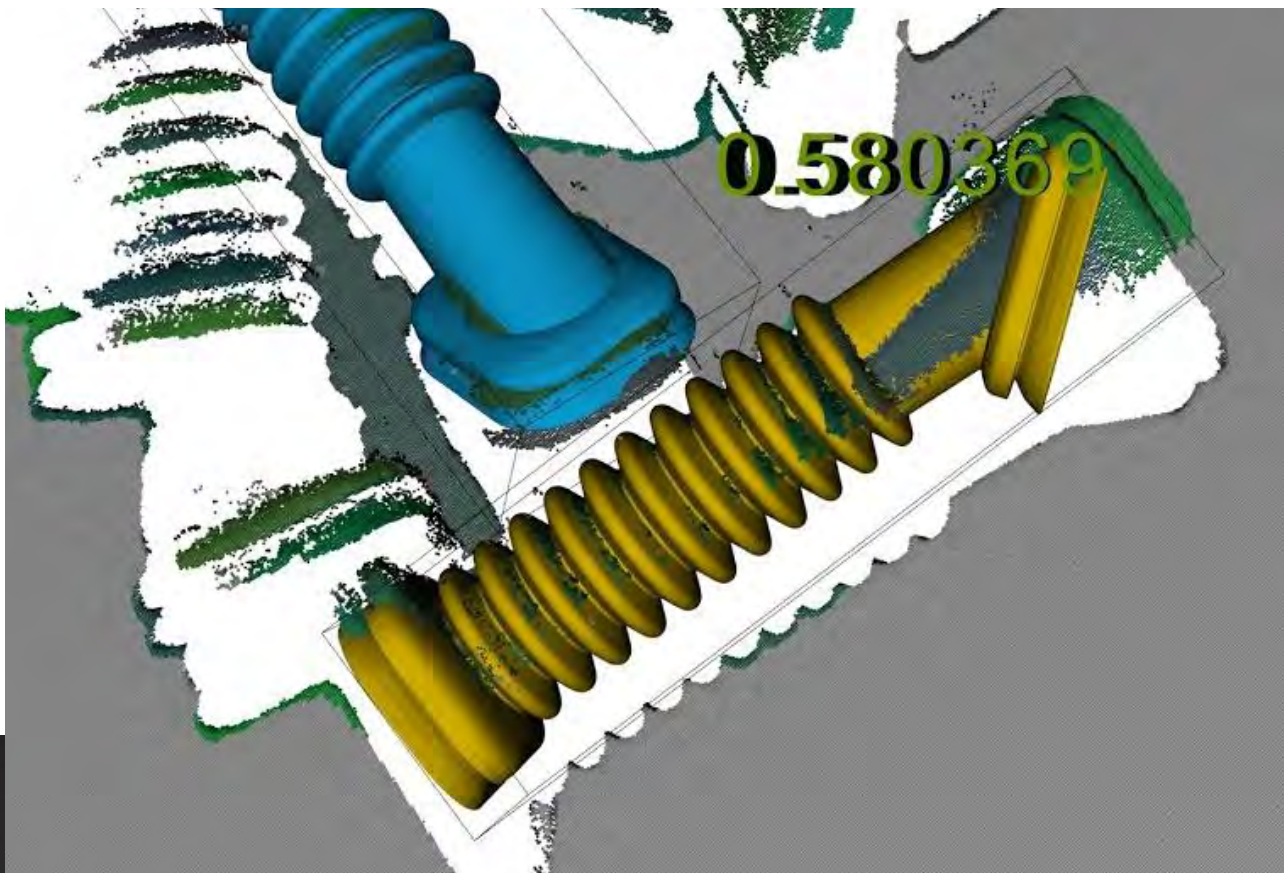
Limitations - Self similarity - translation



?



Limitations - Self similarity - rotation



Solutions

- Focus on **Surfaces**
- But also **Edges**



- Add **Machine Learning**
- Non-rigid alignment



Thanks

METHODS OF EXAMINING THE CONDITION OF WORKS OF ART IN THE CURRENT CONDITIONS OF COLLECTOR INSTITUTIONS

Veronika Gabčová¹, Branislav Horňák²

¹ SNG, Bratislava

² SNG, Bratislava

Abstract

Digital era use of current non-destructive methods in analysis of artwork condition. The application of research and the monitoring of the condition of artwork is essential in the practice of conservators, restorers, curators. From collected results we summarize the most important information about the artwork condition, so we can exactly define further professional procedures for research and protection. We will introduce you to our experience of using digital technology; the possibilities of methods and research are extensive, combined and interpreted.

SNG

Methods of examining the condition of works of art in the current conditions of collector institutions

akad. mal. Veronika Gabčová PhD.

Mgr. Branislav Horňák



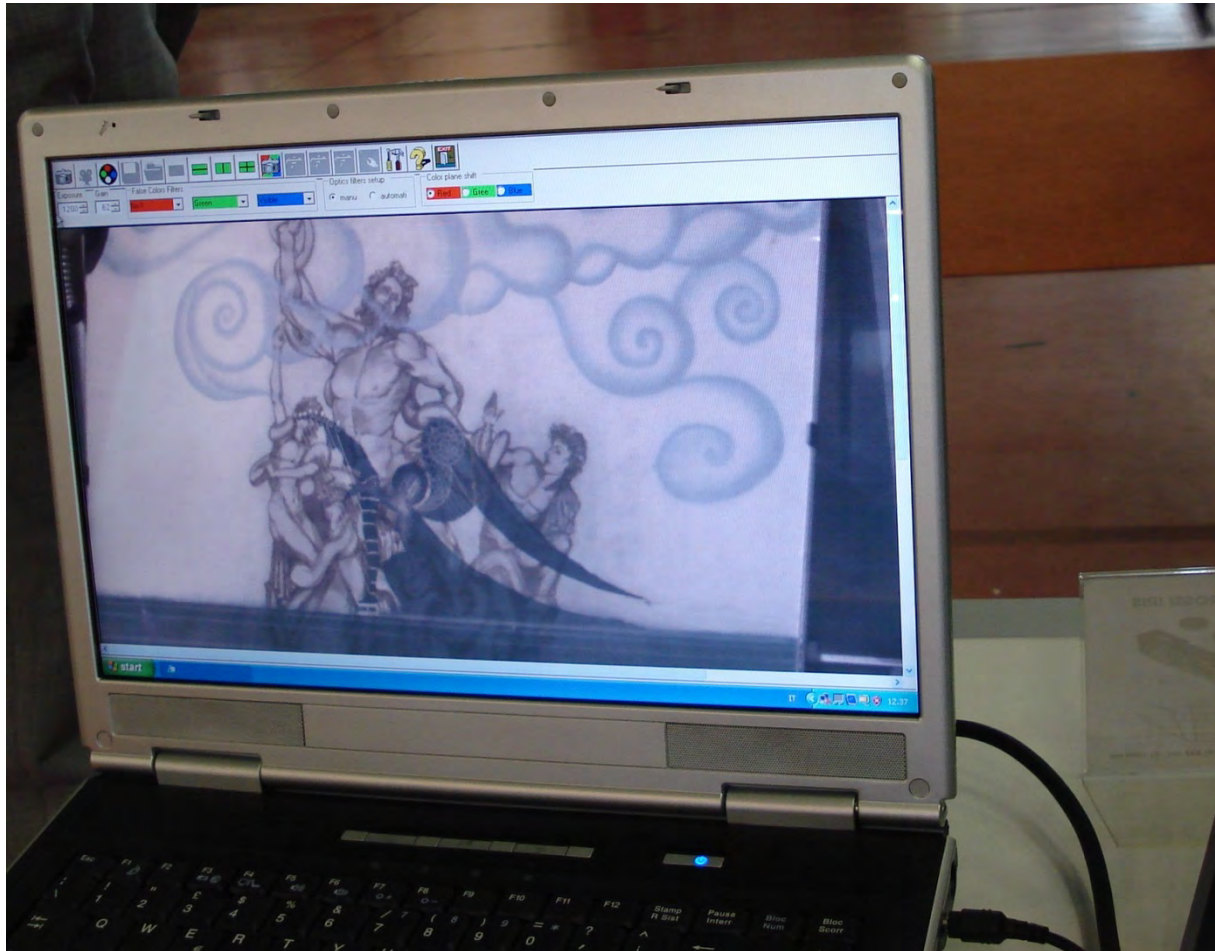
... how to use digital technology and data ...

... what reveals the digital era in the protection of cultural heritage ...

Digital era

- use of current non-destructive methods in analysis of artwork condition
- the application of research and the monitoring of the condition of artwork is essential in the practice of conservators, restorers, curators
- from collected results we summarize the most important information about the artwork condition, so we can exactly define further professional procedures for research and protection
- we will introduce you to our experience of using digital technology, the possibilities of methods and research are extensive, combined and interpreted

Development in everything



Optical instruments

Monitor microscopy 2007



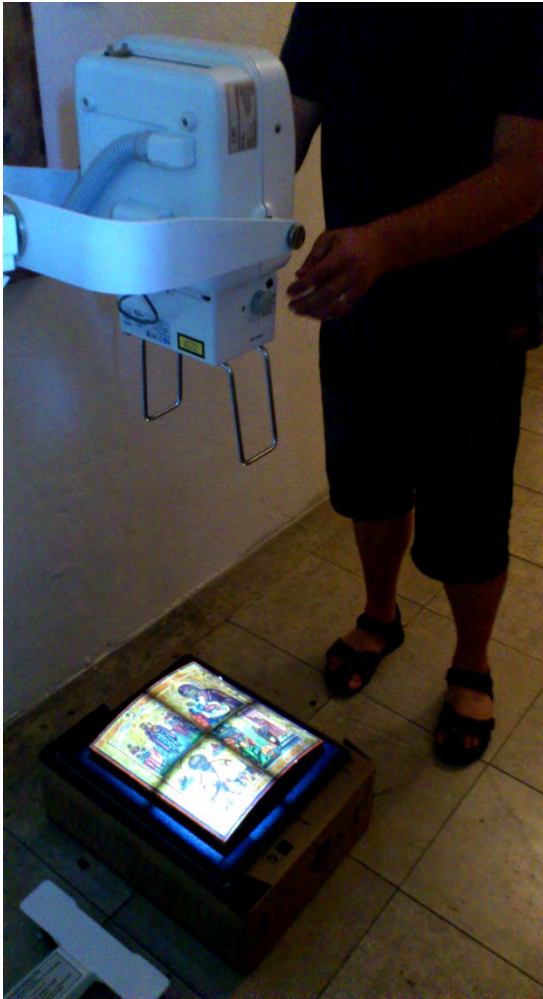
Monitor microscopy 2015



Optical instruments analysis



Instruments in the field of ionizing radiation



Research using X-ray



....immediate information...

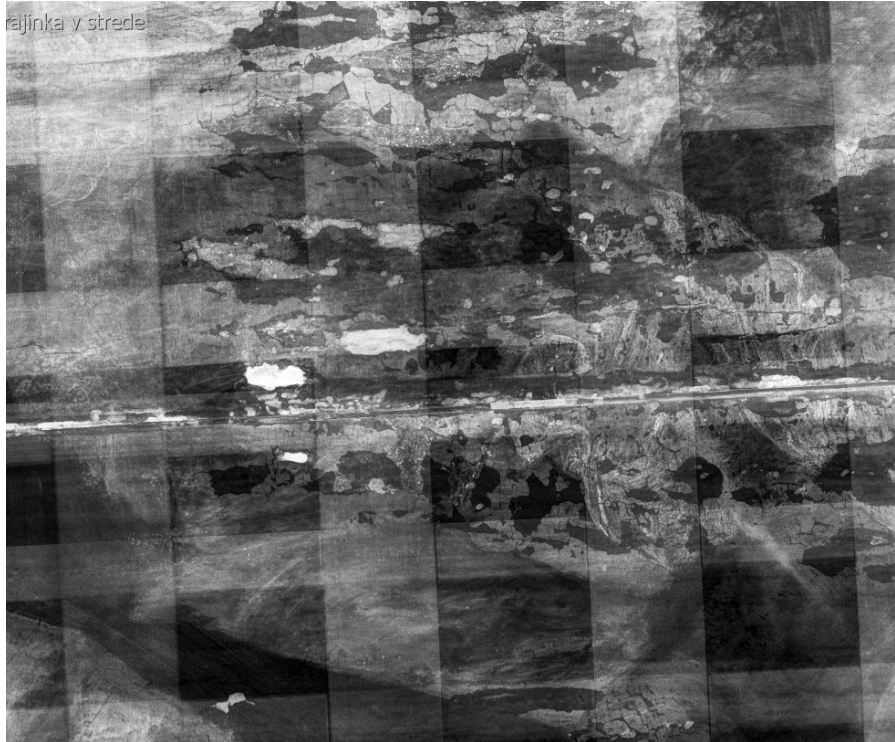


Immediate information

Non-destructive research



Mapping the research and the process of restoration interventions



Forensic diagnostics



Forensic diagnostics for screening on-site



Allows flexibility in on-site and off-site



Non-destructive research in the spectra

UV spectrum



Digital
post-processing



..... degradation of paper



... highly active mold visible to the
naked eye ...



Digitalization of 2D artwork



LARGE FORMAT SCANNER



Device parameters:

- trilinear sensor
- 14200 (x cca 47000) pixels
- 200 – 2000 ppi
- scan 1:1
- max. 1500 x 2500 x 200 mm
- changeable focus plane

Original Lighting System:

- **Real color**
 - the possibility of calibration and profiling
 - Parameter stability
- **variable lightning**
 - scattered light
 - directional light
 - variable angle of illumination



Symmetrical diffused light.
True colors at every point.



Directional light.
Capture of the surface structure.



JOHANNES KUPEZKI.

Dieser war seinem Vaterland nach ein Böhm, von wannen seine Eltern der Eifer für ihren Gottesdienst wegtrieb, und sie nach den Ungarischen Gränzen, nach Pefing brachte, wo er 1667. geboren ward. Er hatte noch drey Brüder, Jurga, Ferenz, und Martin, und eine Schwester Maria.

Seine Erziehung war nach dem Verhältniß seines Standes nicht unglücklich, bis ihn sein Vater zwingen wollte das Handwerk eines Webers zu lernen, wovon ihm ekelte. Da er seinen Vater unbeweglich fand, entschloß er sich in einem Alter von 15. Jahren davon zu gehen. Jetzt mußte er betteln; doch blieb er unerschüttert und kam von der Vorsicht geleitet zu dem Schloß eines Grafen von Czerh. Hier ward dieses von einem

FULL IMAGE

Original size – 106 x 162 mm

Mahler



DETAIL

Scan resolution – 2000 ppi

Scan Result - MASTER

MASTER

- unedited scan
- without additional edits
- advisory scales
- identifier

Technical parameters:

- TIFF uncompressed
- RGB 48 bit
- 1:1 at given resolution
- embedded device profile
- scanner settings saved in metadatas



Enhanced Surface Capability ...



High-dynamic-range Imaging

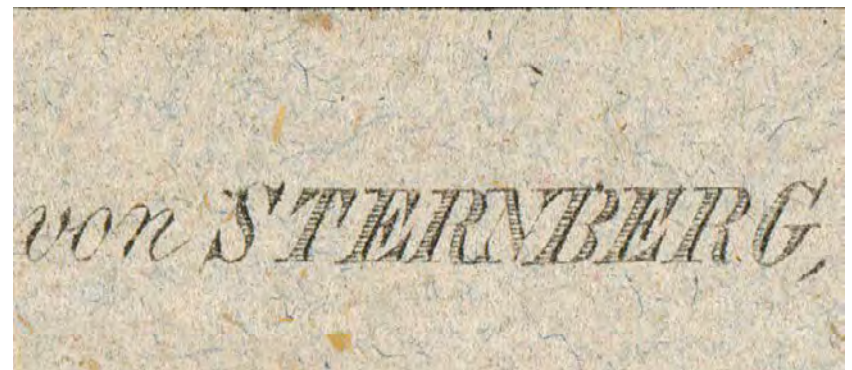
- color

Multi-light Imaging

- surface structures

Ideally, using a large-format scanner to maintain the benefits of scanning before a digital photo.

Readable details







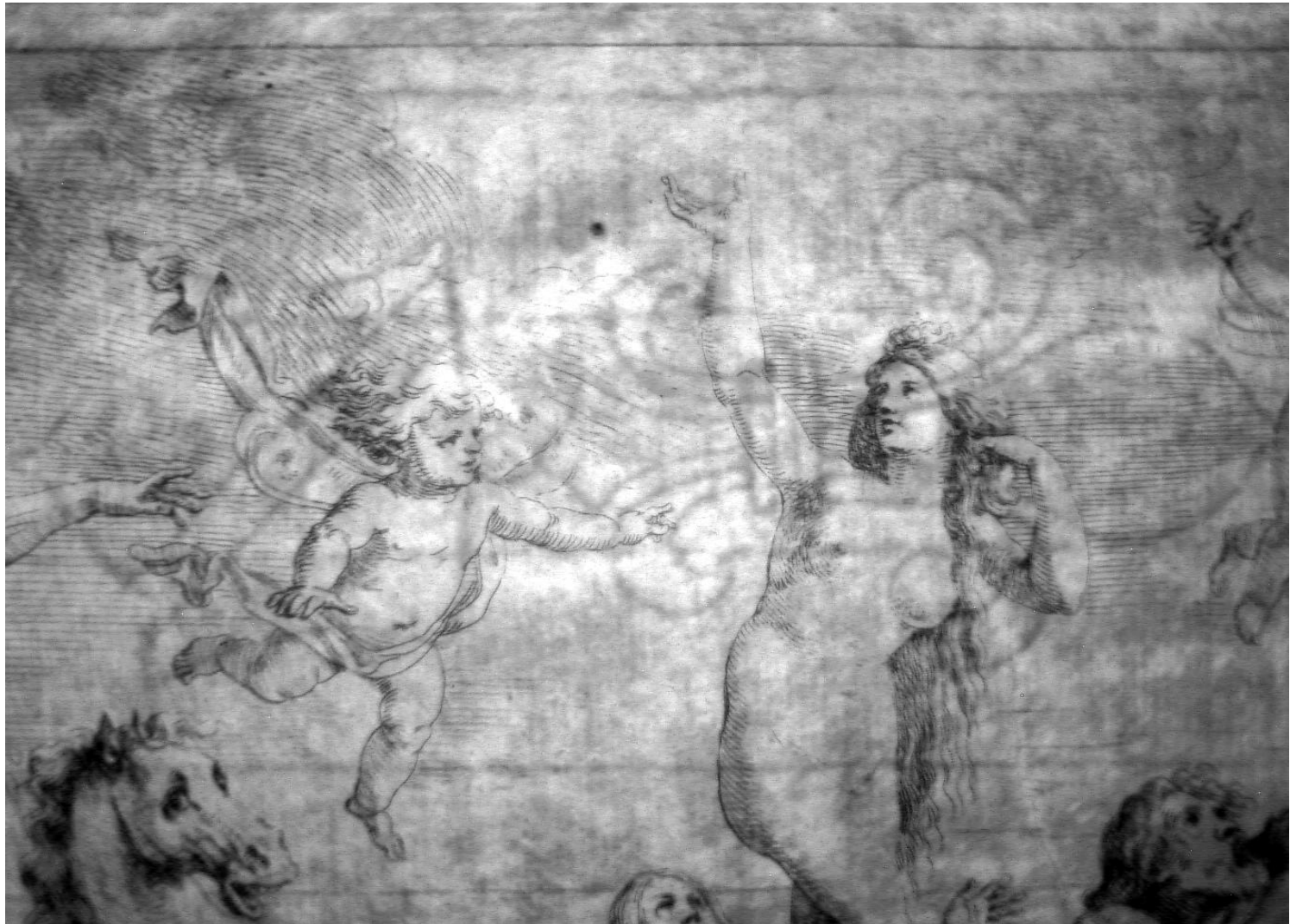


Digital technology helps to identify specific details of artwork





WATERMARK



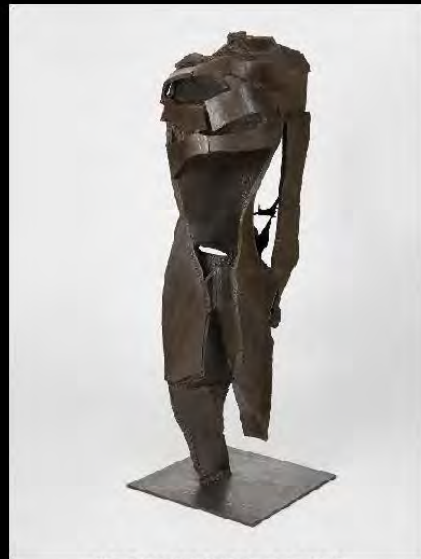
Digital zoom of the scan detail reveals
the print raster



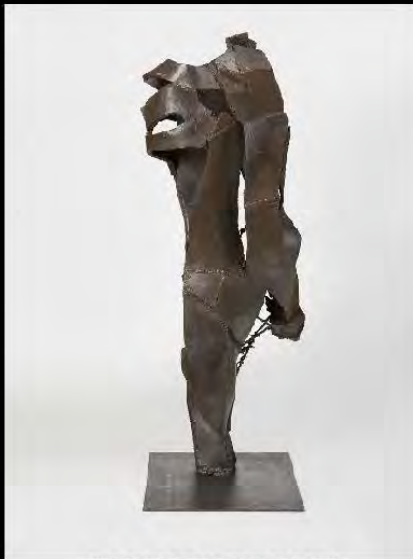
...use with 3D objects...



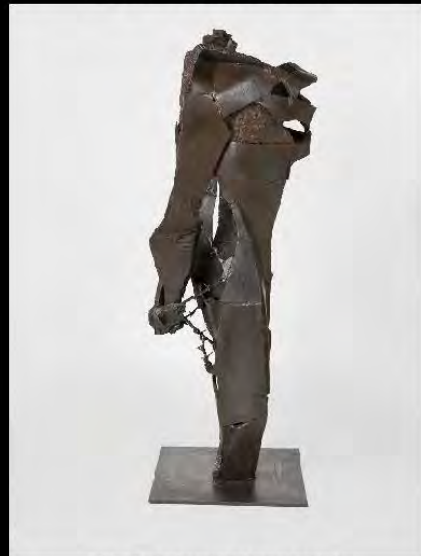
3D Objects - The current state of digital documentation



SNG-P_802-2_6-2015_01_26-LP_A4.tif



SNG-P_802-3_6-2015_01_26-LP_A4.tif



SNG-P_802-5_6-2015_01_26-LP_A4.tif



SNG-P_802-6_6-2015_01_26-LP_A4.tif

2D images from 6 points of view, additional images (important detail, moving parts ...) scanned with a control color scale.

Mid-format digital camera,
60 Mpx,
6708 x 8956 pixels

Documentation of artwork condition, presentation and publishing purposes. Limited professional use.

Documentation and planning of restoration interventions, other specific needs - the need to create separate digital records, still 2D.

3D Objects - Requirements for digitalization



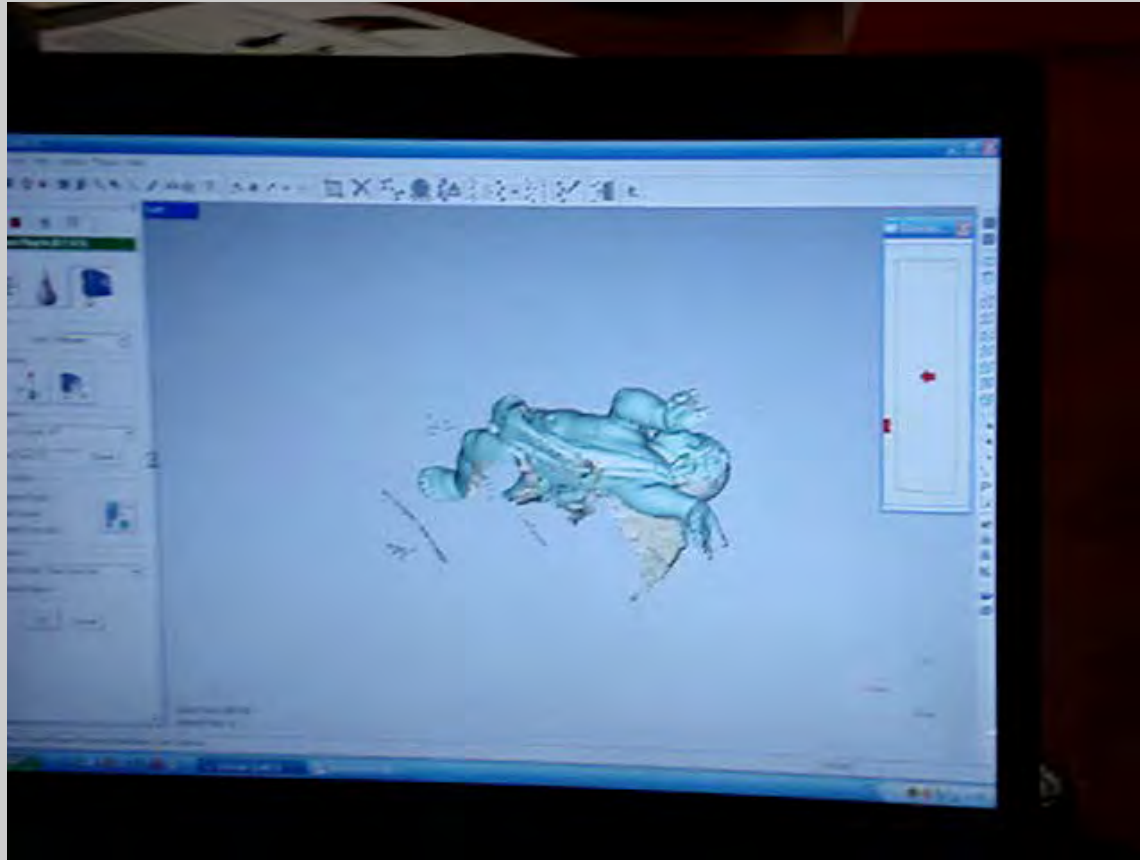
- Accuracy and resolution of a 3D model;
- Real color fidelity and high texture resolution;

3D Objects - Requirements for digitalization



- Dealing with problematic patterns (high gloss / gold, dark surfaces, broken objects / jewelry ...)

3D Objects - Requirements for digitalization



- acceptable difficulty of post-processing of the data obtained;
- the ability to work with a digital model on common devices;

Current possibilities in SNG

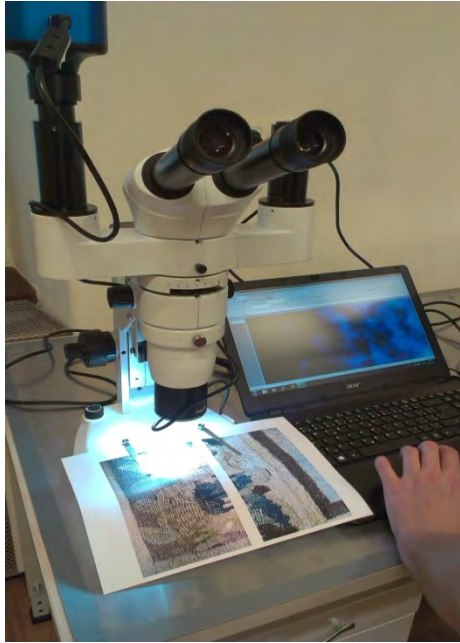
Our orientation in the development of artworks

- UV, IR, RTG, SKEN, forensic diagnostics, monitor microscopy, mass spectrometer, profilometry, other spectra - methods of non-destructive research
- specialized workplaces, natural sciences, technical character - laboratory of chemical technology optical instruments - analysis of sophisticated workplaces
- digital recording technology, recording, systematic database of on-site objects status

Specialized workplace

SNG Zvolen





...research,
analysis,
restoring...



The outputs of this three-dimensional research are:

- current records of our artwork condition and work on-site - external conditions
- procedures and conditions for manipulation with objects, recommendations for specialized professional activities eg. fumigation
- using the information of new digital technologies to evaluate the degradation process
- the methodology of other practical outputs for future use of digital photo data and scanning as a research material

What awaits us....

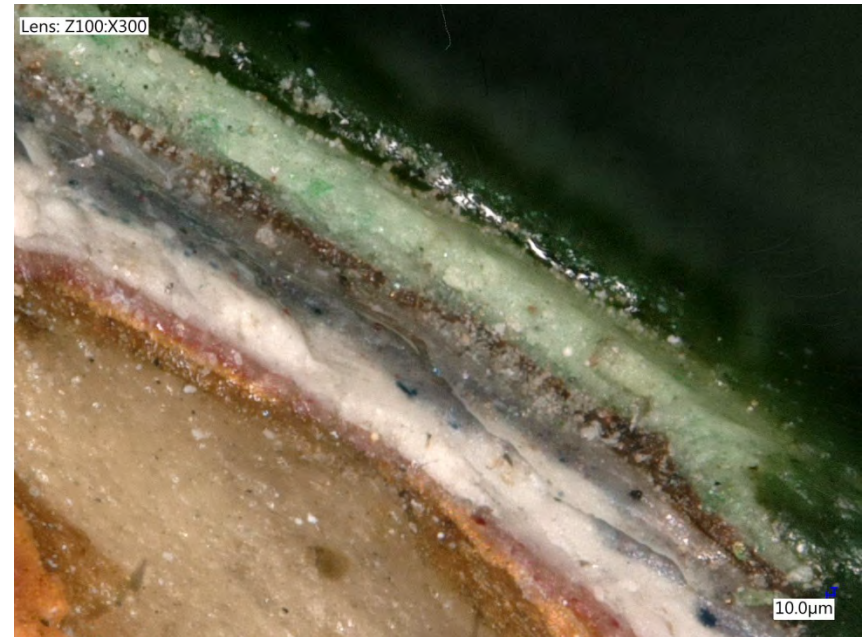
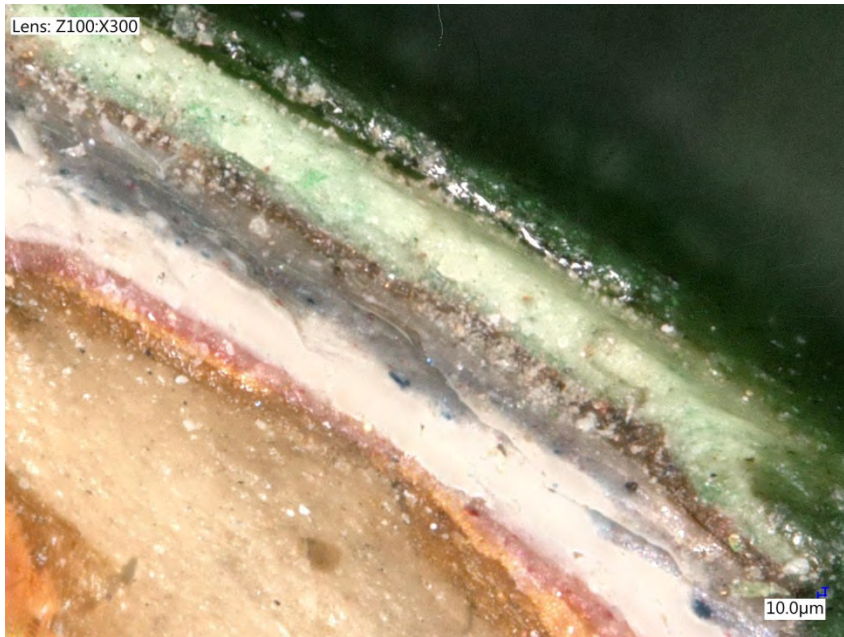
- Visions for the future of collector institutions and their target programs - prevention, protection, monitoring, presentation
- New procedures for data retrieval, storage, and presentation
- Interdisciplinary approaches and cooperation with specialized workspaces

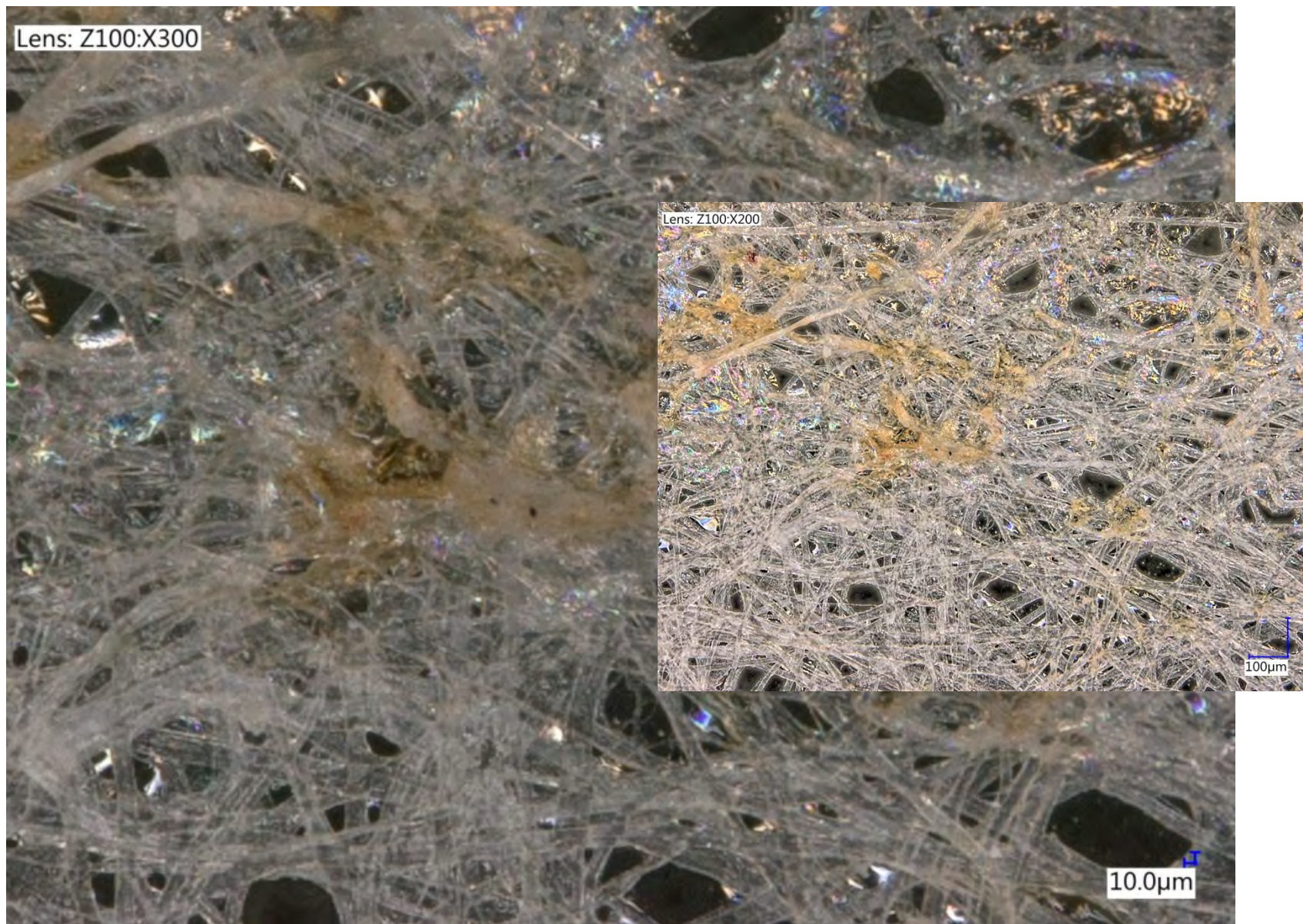
VHX-5000 DIGITAL MICROSCOPE

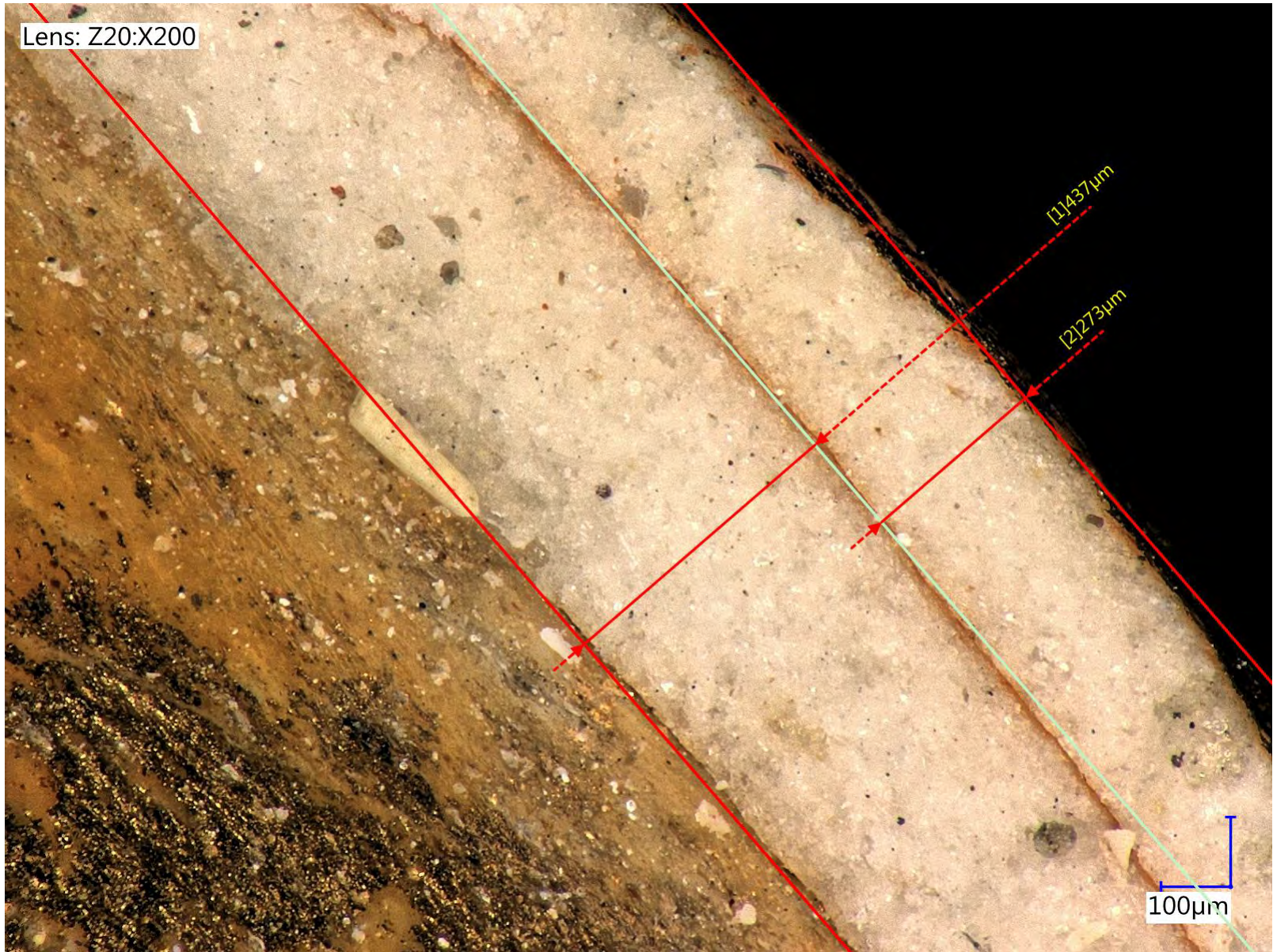
lens 300xmicro



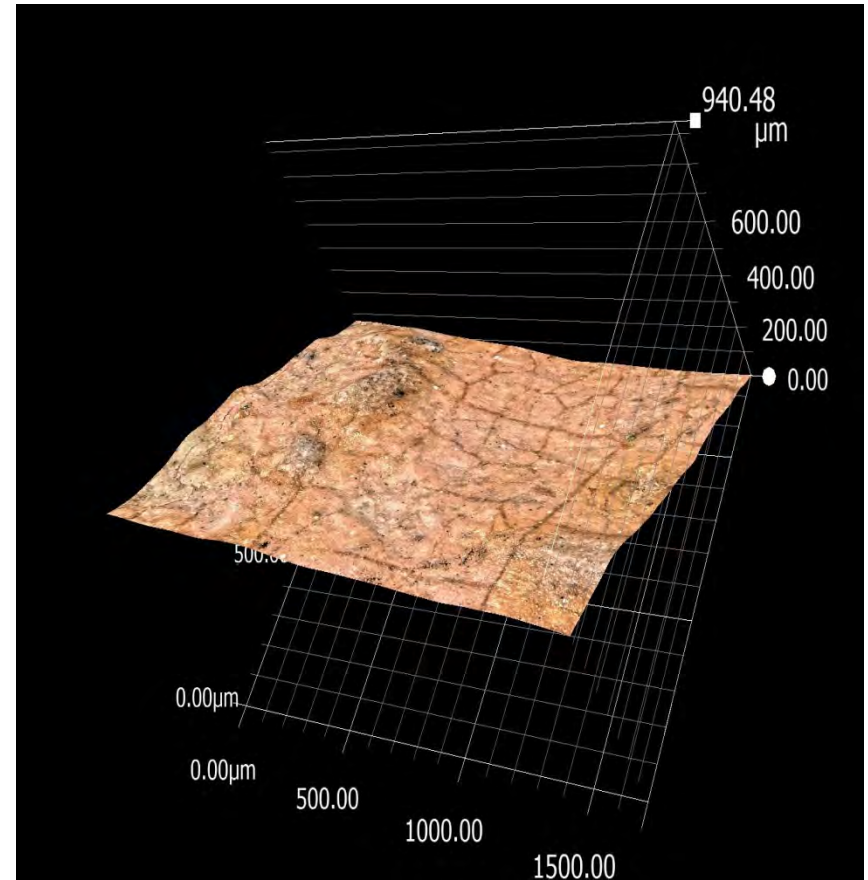
Non-destructive methods which allows us to see details of the damage

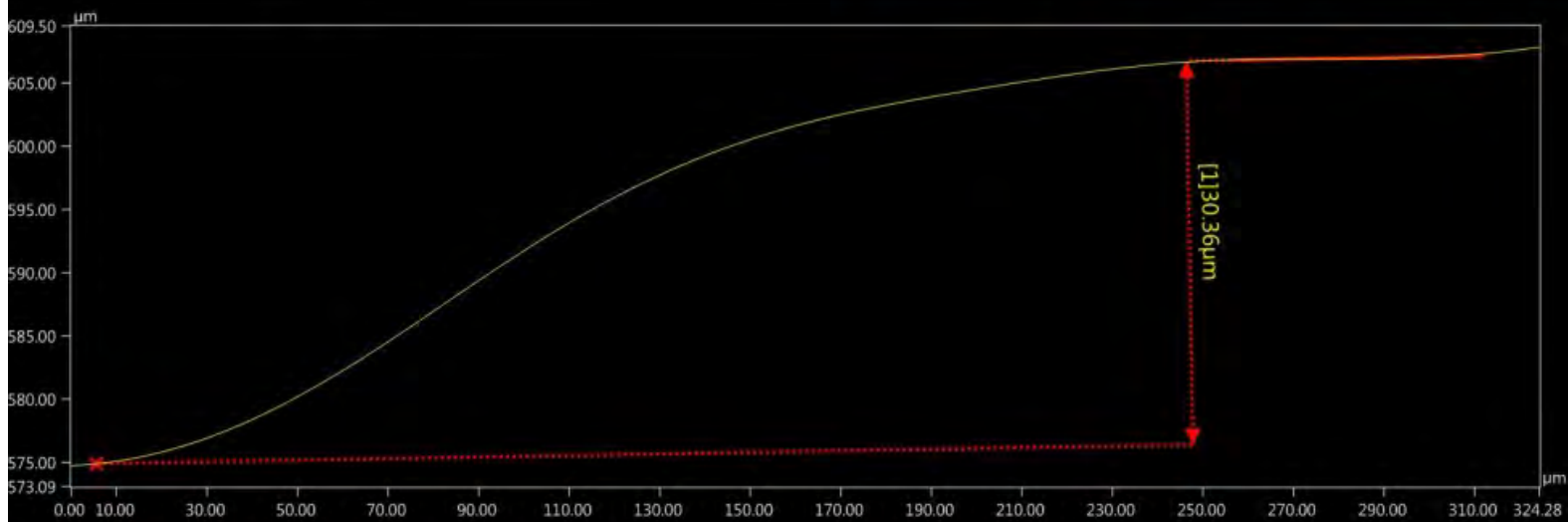
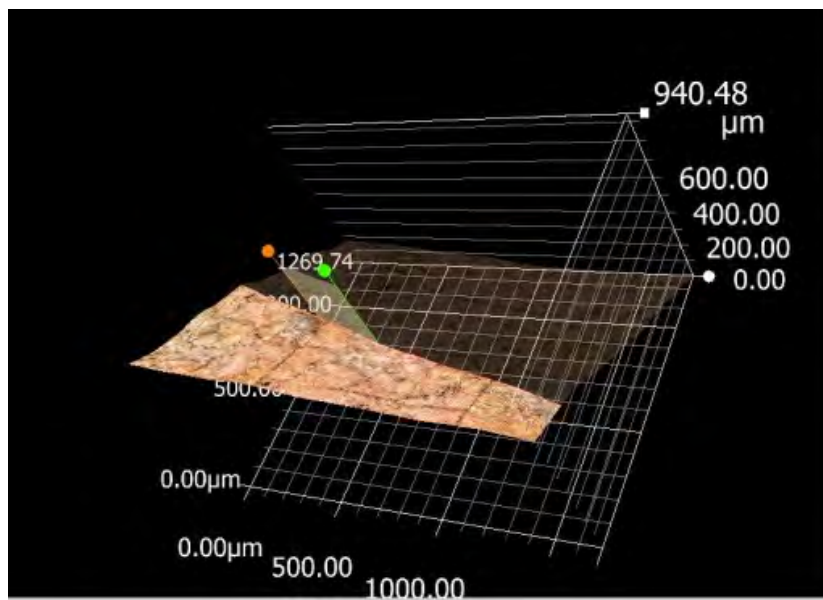






Topography of the surface from the image of the micro world





THANK YOU FOR YOUR ATTENTION

3D WOOD ANALYSIS USING ELECTRON MICROSCOPE

Miroslava Mamoňová¹

¹ Technical University in Zvolen, Slovakia

Abstract

The introduction of the lecture *Electron Microscopy and Study of Woody Structures* deals with the specific preparation of specimens for SEM (scanning electron microscopy) and with the major difficulties of this process, while the attention is paid to the uniquely developed preparation procedures of historical wood characterized by its fragility, limited amount of sampled material and various degree of degradation caused by fungi or insect. For degraded, as well as extremely hard wood specimen, the methodology using *Daucus carota* was suggested and verified.

Every preparation procedure is unique and developed in dependence upon the characteristics of the object of observation and requirement for the resulting scans to show the required information.

The lecture illustrates the color gallery of SEM scans of woody structures processed via ImageProcessing. Subsequently, the lecture discusses the research topics studied at the Workplace of electron microscopy of the Technical University in Zvolen, including a brief overview of studies using SEM Tescan Vega with a significant impact, whose results were published in prestigious scientific journals.

The core of the lecture includes new 3D SEM applications and images carried out in Tescan Orsay Holding, a.s. Brno, with following points being discussed:

1. 3D model of reconstructed brushed surface of a wood log house specimen, Nižná Boca, using software module Mex with FE-SEM Mira 3, Tescan. The measurement results of specimen profile are given.
2. High resolution imaging of tracheid pitting in radial walls of white fir wood (*Abies concolor* (Gordon) Lindl. ex Hildebr.) with the occurrence of warty layer (Magnification: 76400x) and taxodioid cross-field pits; bordered pit of Scots pine wood (*Pinus sylvestris* L.), while the InBean detector was used for imaging the microfibrillar structure in secondary wall of compression wood tracheids. We document also formation of gold granules on coated xylem specimens, which can hide the subtle finesses of nanostructures (Magnification: 84600x).
3. Cryo SEM imaging of cross-section break zone of tension wood fibres in *Fagus sylvatica* using SEM Tescan Lyra3. A visible lamella structure could be observed this way for the very first time.
4. Dual beam FIB-SEM (Focused ion beam scanning electron microscopy) system applied on libriform fibres and beech parenchyma cells of rays (*Fagus sylvatica* L.), scanned using LYRA3 Tescan equipped with ion-optics with highly stable Ga⁺ LMIS source (Cobra column).

The last part of the lecture is devoted to the results of material research into wood elements of structures in the National Cultural Monument Krásna Hôrka, the National Cultural Monument Lupčiansky hrad and historical roof frame structures in Premonstrat Monastery in Želiv, Czech Republic.

Acknowledgement:

This study was created thanks to the enthusiasm of Ing. Jana Havráňková and Ing. Kristína Rosíková, who were immensely helpful with applying individual methods of the company Tescan Orsay Holding, a.s. Brno.

I would like to thank also to the Department of Special Measuring Technology of the company Kvant, s.r.o. Bratislava, for general help and support.

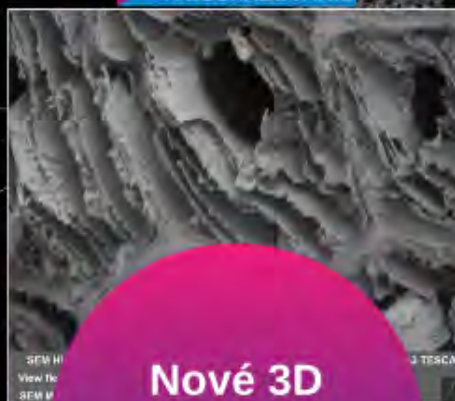
This lecture was funded by the following grants: the Scientific Grant Agency of the Ministry of Education SR and the Slovak Academy of Sciences (Grant No. 1/0822/17 "Surface modification of wood and coating materials in order to improve stability of the wood – coating material system."). This lecture has been included into the project APVV-16-0177 "Progressive modifications of the wood surface, film-forming materials and their interactions at the phase interface."

Elektrónová mikroskopia a štúdium drevných štruktúr

Ing. Miroslava Mamoňová, PhD.

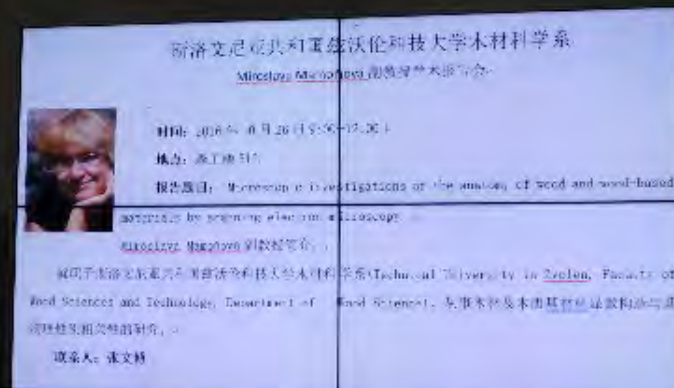
22. 9. 2017

Elektrónová
mikroskopia



Nové 3D
aplikácie
a zobrazenia

2. ročník 3D meranie a zobrazovanie
Zobrazovanie a moderné diagnostické metódy v priemyselnej praxi



Materiálový
prieskum
historických
objektov

SEM MAG: 4000 x DET: SE Detector 120 µm Vega©Tescan

Elektrónová mikroskopia a štúdium drevných štruktúr

Ing. Miroslava Mamoňová, PhD.

22. 9. 2017



斯洛文尼亚共和国兹沃伦科技大学木材科学系

Miroslava Mamoňová 副教授学术报告会



时间: 2016 年 10 月 26 日 9:00-12:00

地点: 森工楼 312

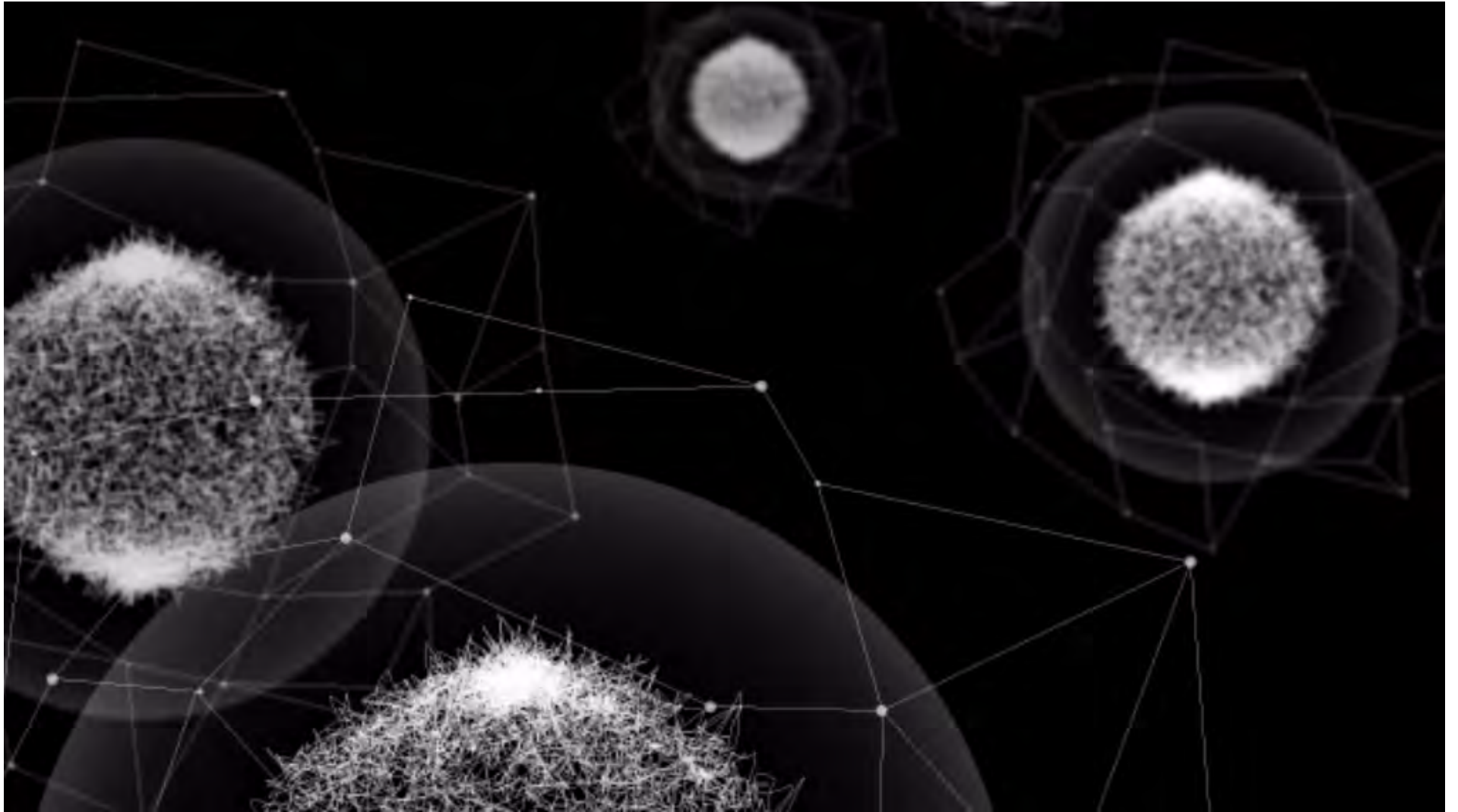
报告题目: Microscopic investigations of the anatomy of wood and wood-based materials by scanning electron microscopy.

Miroslava Mamoňová 副教授简介:

就职于斯洛文尼亚共和国兹沃伦科技大学木材科学系 (Technical University in Zvolen, Faculty of Wood Sciences and Technology, Department of Wood Science), 从事木材及木质基材料显微构造与其物理性质相关性的研究。

联系人: 张文博





Elektrónová mikroskopia

Drevo
–
anatomický
pohľad

Možnosti
zobrazenia
– SEM
Tescan
Vega

Špecifická
príprava
preparátov

Galéria

Predmet
skúmania

Elektrónová mikroskopia

- ➡ Drevo – anatomický pohľad
- ➡ Možnosti zobrazenia – SEM Tescan Vega
- ➡ Špecifická príprava preparátov
- ➡ Galéria
- ➡ Predmet skúmania

- ➡ **Nové 3D aplikácie a zobrazenia**
Tescan Mira3, FIB-SEM TescanLyra3
- ➡ Materiálový prieskum drevených prvkov konštrukcií
NKP Krásna Hôrka a NKP Slovenská Ľupča
- ➡ Materiálový průzkum krovových konstrukcí v Klášteře
premonstrátů v Želivě

Makrosvet dreva

- o **Drevo ako čierna krabička** – fyzici dreva, mechanici dreva
- o Drevo je **najuniverzálnejší materiál na zemi**
- o **Atribúty**, nielen vynikajúcich mechanických vlastností, ale pripisuje sa mu schopnosť dýchať v priestore, naše estetické cítenie je úzko späté s drevom – vnímame ročné kruhy, má teplé farebné odtiene

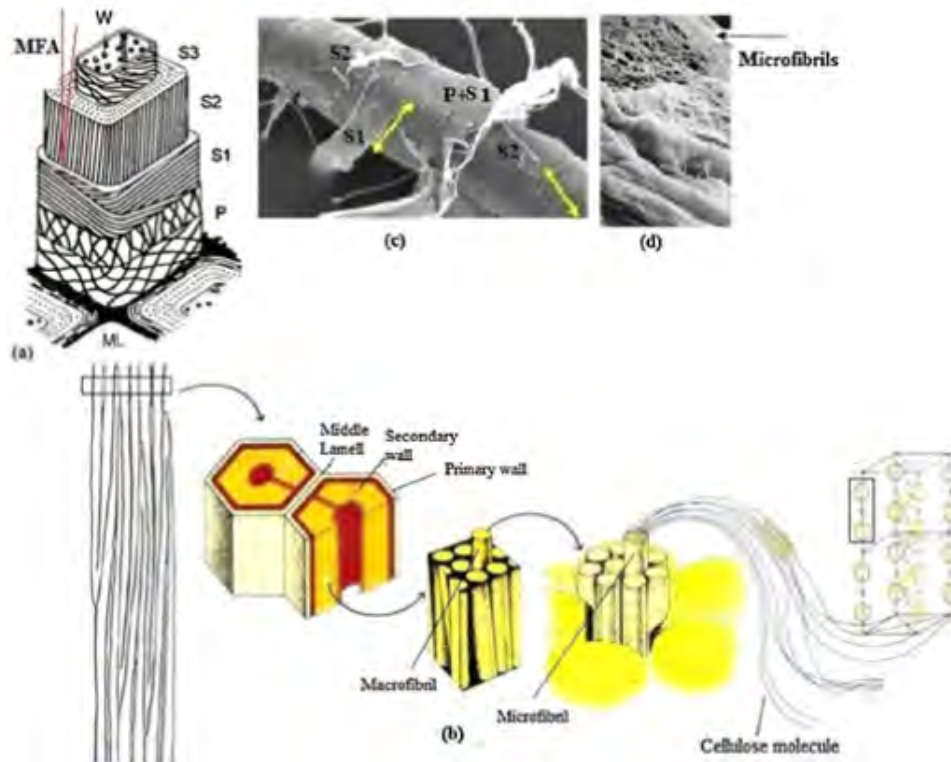




Mikrosvet dreva

- o **Z hľadiska anatomického** je najporozuhodnejším – **vlákno dreva** - dĺžka je 100 až 200 násobne dlhšie ako jeho pričné rozmery
- o Štruktúra steny vlákien - dlhé reťazce kryštalickej celulózy, ktorých zväzky sa nazývajú **mikrofibrily**.
- o **mikrofibrily** - vytvárané **rozetami** - na koncoch vlákien
Rozety sú vynikajúcimi príkladmi prirodzenej nanotechnológie
- o Fascinujúca tvorba stien vlákna - proces premenlivého uhla mikrofibríl nebol dodnes objasnený ► tri rozdielne vrstvy

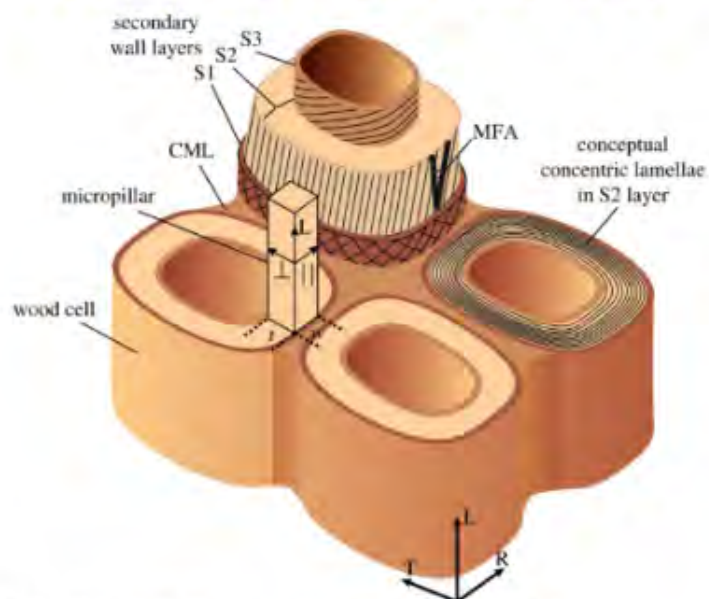
Mikrosvet dreva



Obrázok 1 Štruktúra vláknitej bunky dreva

- a) vrstvy bunkovej steny (stredná lamela /**middle lamella** (ML), primárna stena/ **primary wall** (P), sekundárna stena/**secondary wal** (S1, S2, S3), lúmen s bradavičnatou vrstvou/**warty layer** (W);
- (b) fibrilárna štruktúra bunkovej steny;
- (c) SEM obraz vrstiev bunkovej steny; d) SEM mikrofibríl

Mikrosvet dreva



Obrázok 2 Koncept koncentrických lamiel v S2

Uhol medzi celulóзовými fibrilami a pozdĺžnou osou bunky - uhol mikrofibríl, MFA

Fascinujúca tvorba stien vlákna - proies

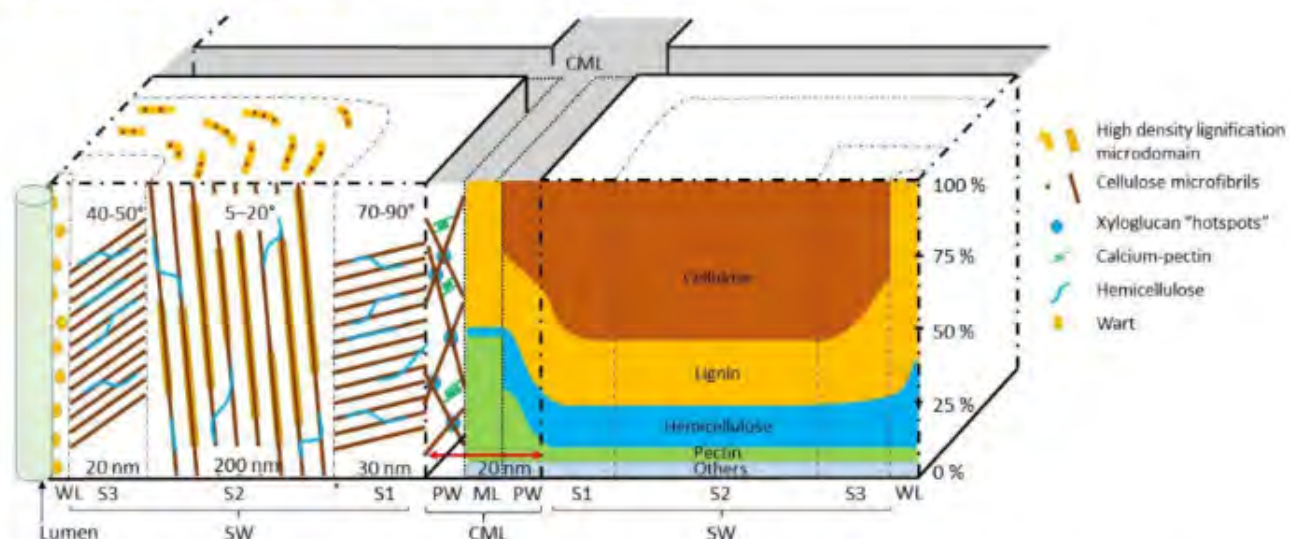
premenlivého uhla

mikrofibríl nebol dodnes objasnený ► tri rozdielne vrstvy

Vieme:

- stredná vrstva (**S2**) - **najhrubšia** a uhol mikrofibríl tejto vrstvy má dramatický vplyv na vlastnosti vlákien a dreva ► vplýva na pevnosť, pružnosť a zosychanie dreva
- **veľký uhol mikrofibríl** vrstvy bunkovej steny S2 - vlákno je pružné a tvrdé

Mikrosvet dreva



Obrázok 3 Model bunkovej steny vlákna listnatého dreva
od strednej lamely po lumen

Lignín a hemicelulózy - viažu mikrofibrily (a vlákna navzájom) a vytvárajú komplexnú štruktúru masívneho dreva

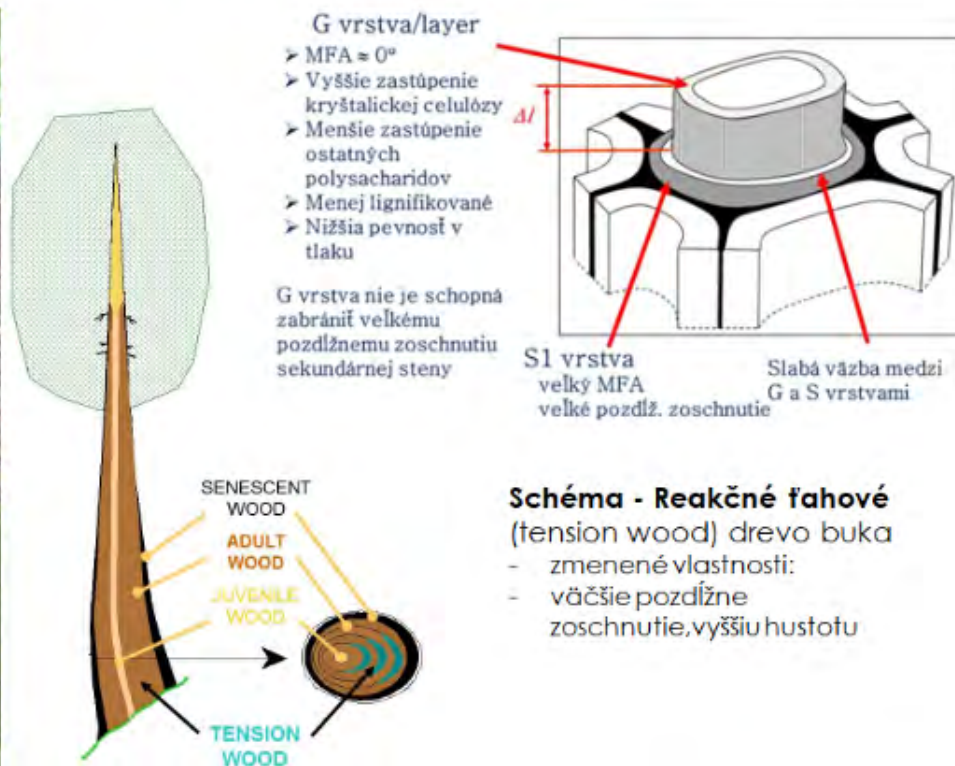
A teda čo je drevo?

- o vrstevnatý materiál, anizotropný – má smery, má rezy, má odlišne orientované pletivá
- o **rozmanitosť druhová:**
„Na svete je približne **25 000 až 30 000 druhov dreva**, ale len 3 000 – 5 000 sa hodí na priemyselné spracovanie a obchoduje sa len s **200 – 250** druhmi dreva“
- o nerovnorodá štruktúra, anizotropia, zmena jeho rozmerov a vlastností
- o **degradačné činitele:** huby, hmyz, bakteriologický rozpad – cez mikroštruktúru možno predikovať zmeny chemické, fyzikálne a mechanické
- o **anomálie rastu**





A teda čo je drevo?



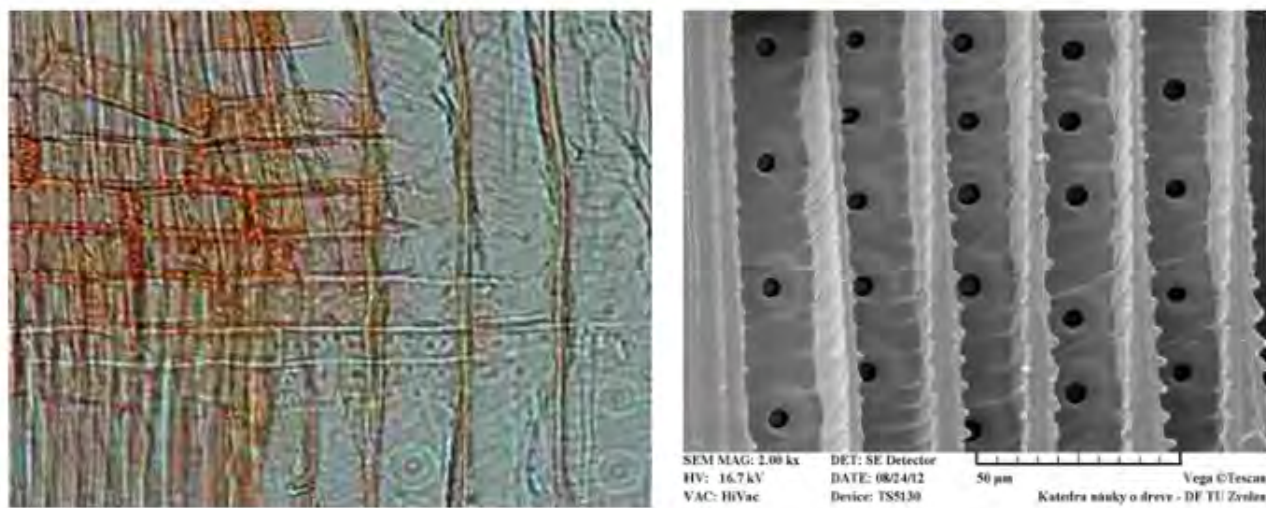
Skenovací elektrónový mikroskop (SEM)

- Prednosti zobrazenia v porovnaní s optickým mikroskopom
- Príprava preparátov pre SEM, hlavné úskalia tohto procesu

Odber vzorky, fixácia preparátov, dehydratácia a sušenie preparátov, lepenie vzoriek a ich pozlátenie

- **Aplikačné možnosti** využitia zobrazovania a analýz v drevárskych a lesníckych vedách

Obrázový výstup



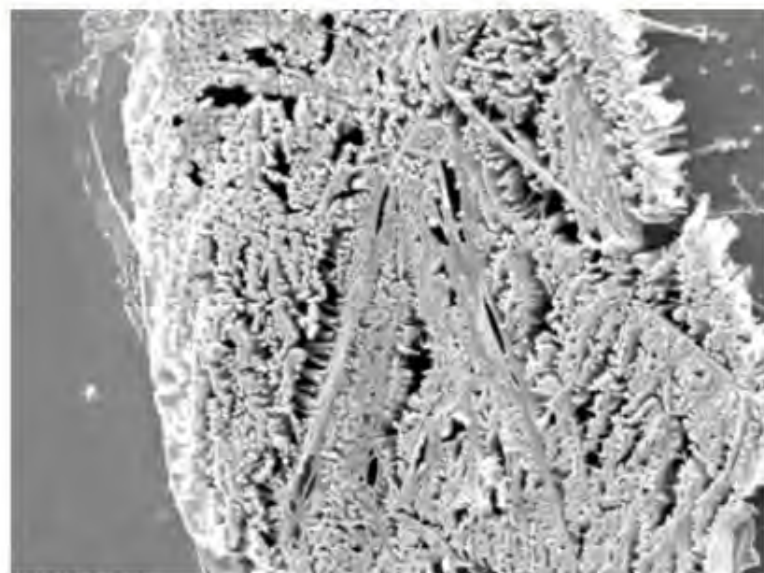
Obr. 5 Ilustračná fotografia z optického a skenovacieho elektrónového mikroskopu na podobnom preparáte dreva duglasky tisolistej *Pseudotsuga menziesii* (Mirbel) Franco.

Obrazový výstup – Tescan Vega

Zápis obrazu v digitálnej forme, najčastejšie vo formáte - **bitová mapa** (.bmp, **1024x864 pixels, o veľkosti 865kB**)

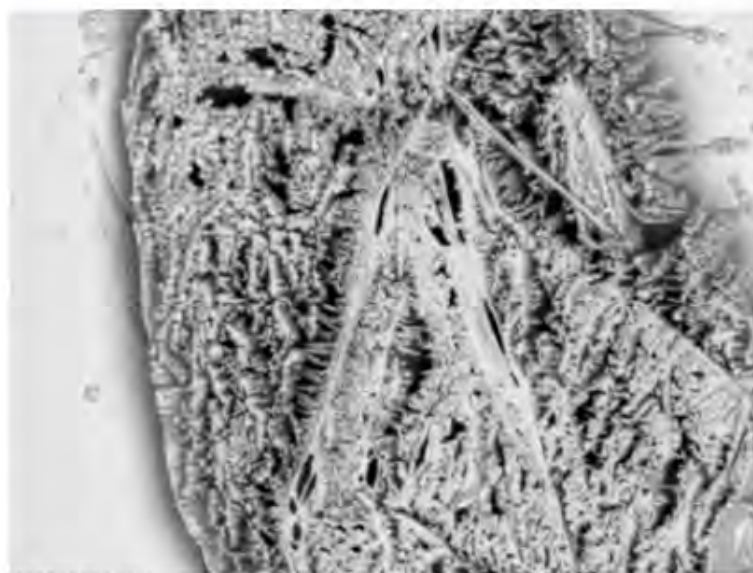
- **hĺbka ostrosti** – SEM fotografie - väčšia hĺbka ostrosti (3D)
 - Ideálne pre pozorovanie dôležitých diagnostických znakov - **špirálovitá výstuž, dvojbodky - anatomické detaily dreva**
- **preparáty** – pozorovanie živých a vodu obsahujúcich preparátov je pomocou SEM problematické (vysoké vákuum) – **riešením je enviromentálny mikroskop a Critical Point Drying (CPD)**
- **absencia farieb** – **256** stupňov intenzity sivej
- **SE** - zobrazenie **topografie** povrchu vzorky
- **BSE** - veľmi **citlivé na zmeny atómového čísla**

Výstup SE-BSE signálů



SEM MAG: 4.00 kx DET: SE Detector
HV: 15.0 kV DATE: 05/24/05 20 µm Vega ©Tescan
VAC: HiVac Device: TS5130 Katedra nauky o dreve - DF TU Zvolen

Pure protein-borate structure
a mixture of boric acid (5%) with
protein (2.5%)



SEM MAG: 4.00 kx DET: BSE Detector
HV: 15.0 kV DATE: 05/24/05 20 µm Vega ©Tescan
VAC: HiVac Device: TS5130 Katedra nauky o dreve - DF TU Zvolen

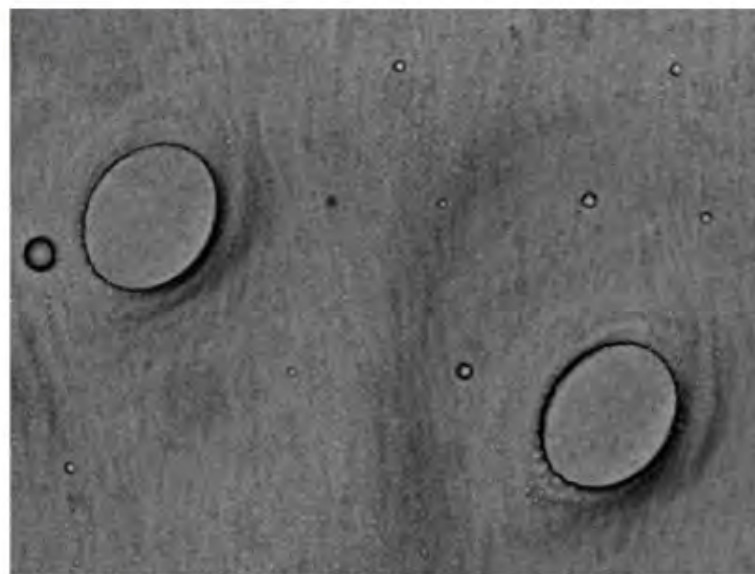
BSE Detector

Výstup SE-BSE signálov



SEM MAG: 8,00 kx DET: SE Detector
HV: 15,0 kV DATE: 06.08.05 10 µm Vega ©Tescan
VAC: HiVac Device: TS5130 Katedra náuky o dreve - DF TU Zvolen

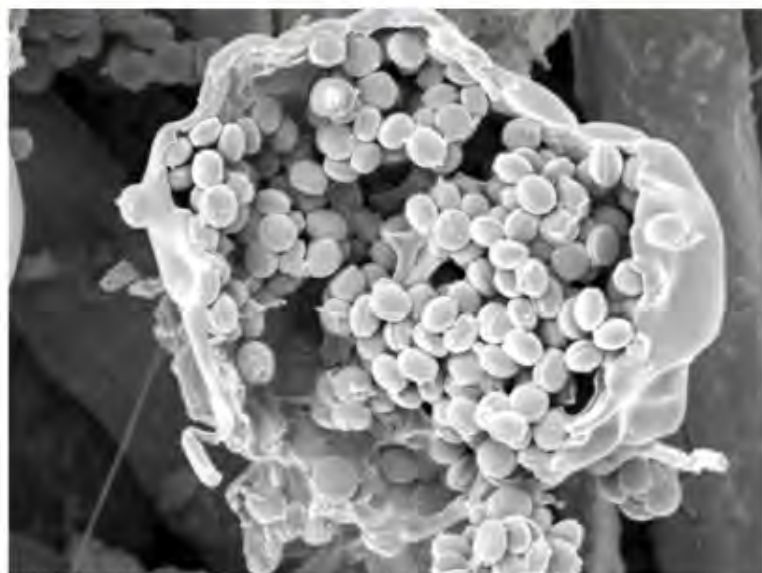
Solutein 1.0% vodný roztok,
dvojbodky na radiálnej stene jarnej
tracheidy *Pinus sylvestris*



SEM MAG: 8,00 kx DET: BSE Detector
HV: 15,0 kV DATE: 06.08.05 10 µm Vega ©Tescan
VAC: HiVac Device: TS5130 Katedra náuky o dreve - DF TU Zvolen

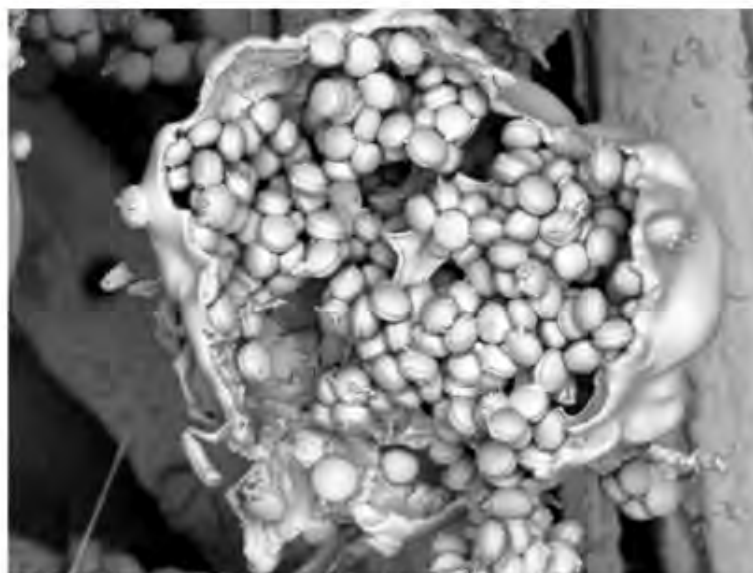
BSE Detector

Výstup SE-BSE signálov



SEM MAG: 3.00 kx
HV: 15.0 kV
VAC: HiVac
DET: SE Detector
DATE: 10/13/10
Device: TS5130
20 µm
Vega ©Tescan
Katedra nauky o dreve - DF TU Zvolen

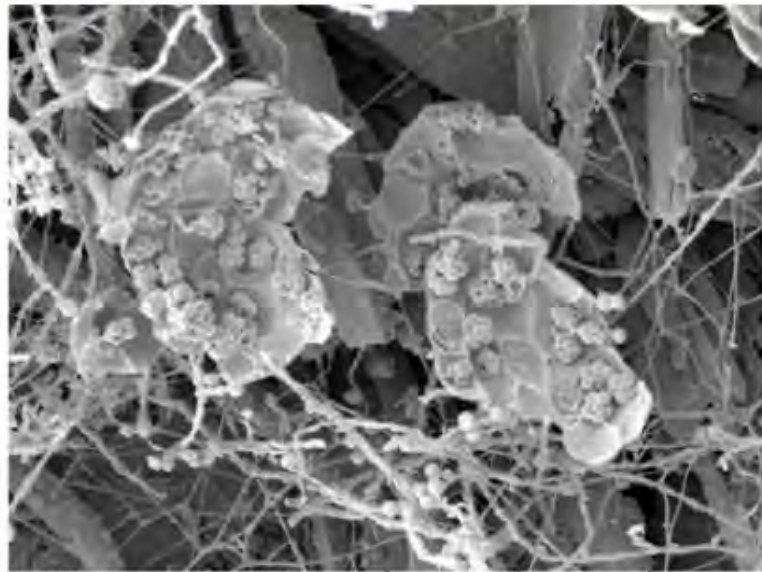
Spóry



SEM MAG: 3.00 kx
HV: 15.0 kV
VAC: HiVac
DET: BSE Detector
DATE: 10/13/10
Device: TS5130
20 µm
Vega ©Tescan
Katedra nauky o dreve - DF TU Zvolen

BSE Detector

Výstup SE-BSE signálov



SEM MAG: 1,00 kx
HV: 15,0 kV
VAC: HiVac
DET: SE Detector
DATE: 10/13/10
Device: TS5130
100 µm
Vega ©Tescan
Katedra nauky o dreve - DF TU Zvolen

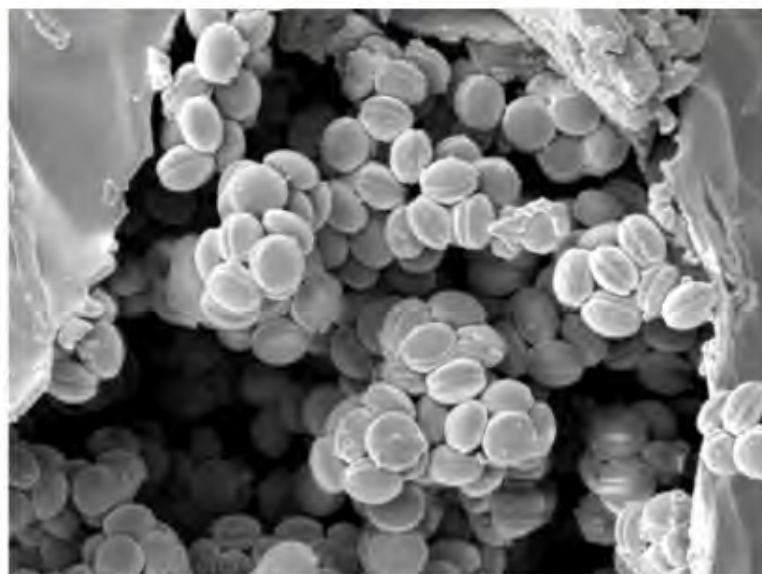
Spóry



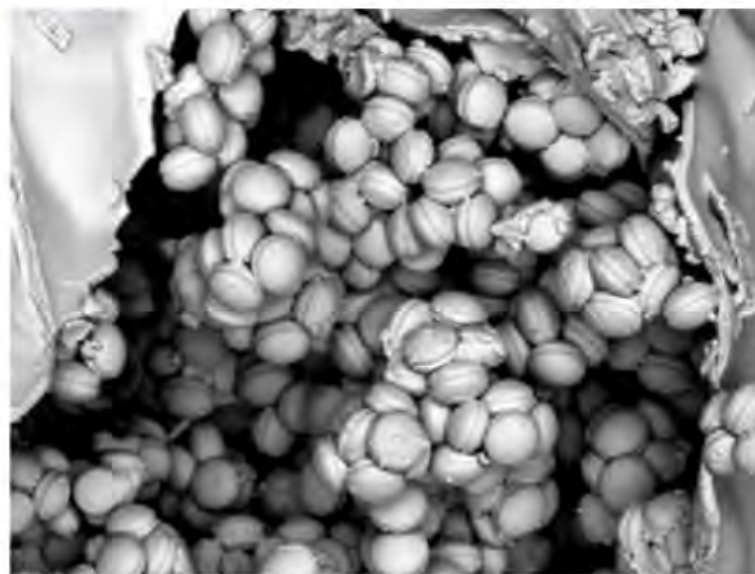
SEM MAG: 1,00 kx
HV: 15,0 kV
VAC: HiVac
DET: BSE Detector
DATE: 10/13/10
Device: TS5130
100 µm
Vega ©Tescan
Katedra nauky o dreve - DF TU Zvolen

BSE Detector

Výstup SE-BSE signálov



SEM MAG: 4.00 kx DET: SE Detector
HV: 15.0 kV DATE: 10/13/10
VAC: HiVac Device: TS5130
20 µm Vega ©Tescan
Katedra nauky o dreve - DF TU Zvolen



SEM MAG: 4.00 kx DET: BSE Detector
HV: 15.0 kV DATE: 10/13/10
VAC: HiVac Device: TS5130
20 µm Vega ©Tescan
Katedra nauky o dreve - DF TU Zvolen

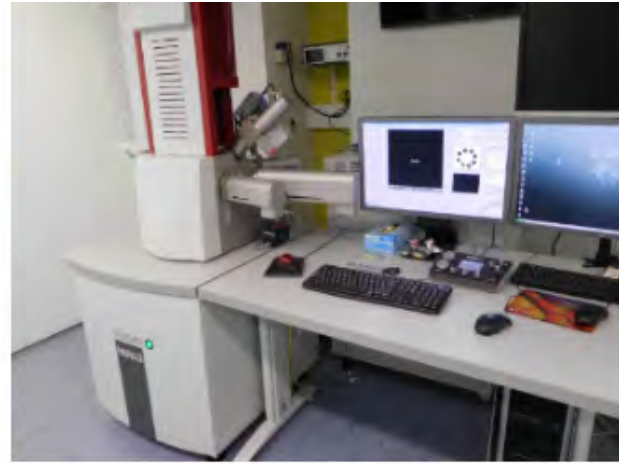
Pollen grains

BSE Detector

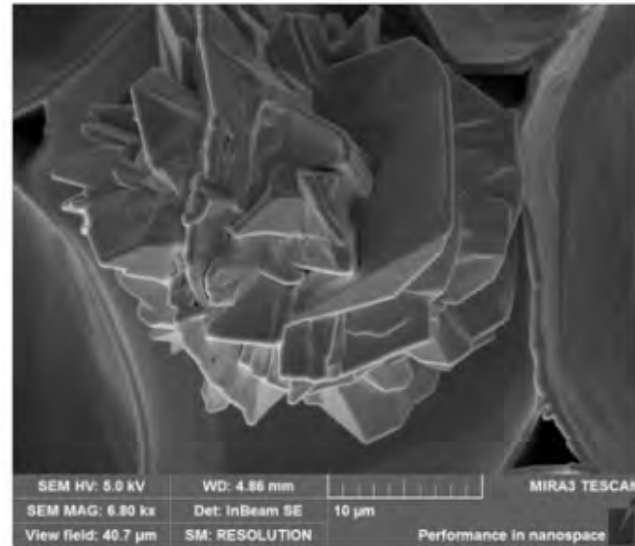
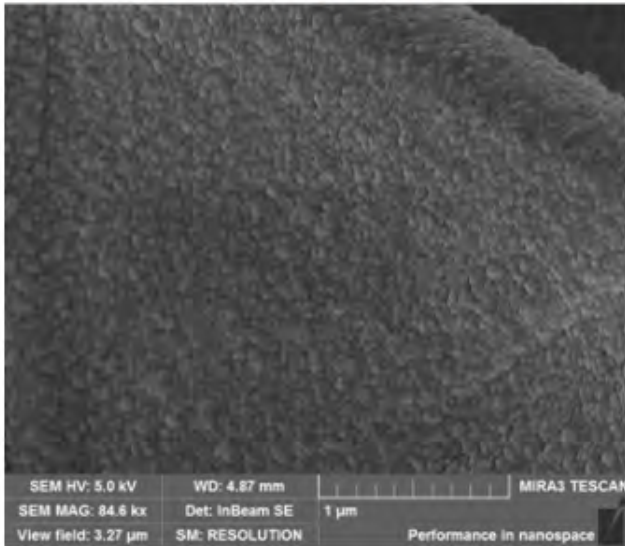
Možná kombinácia BSE+SE – mixed picture



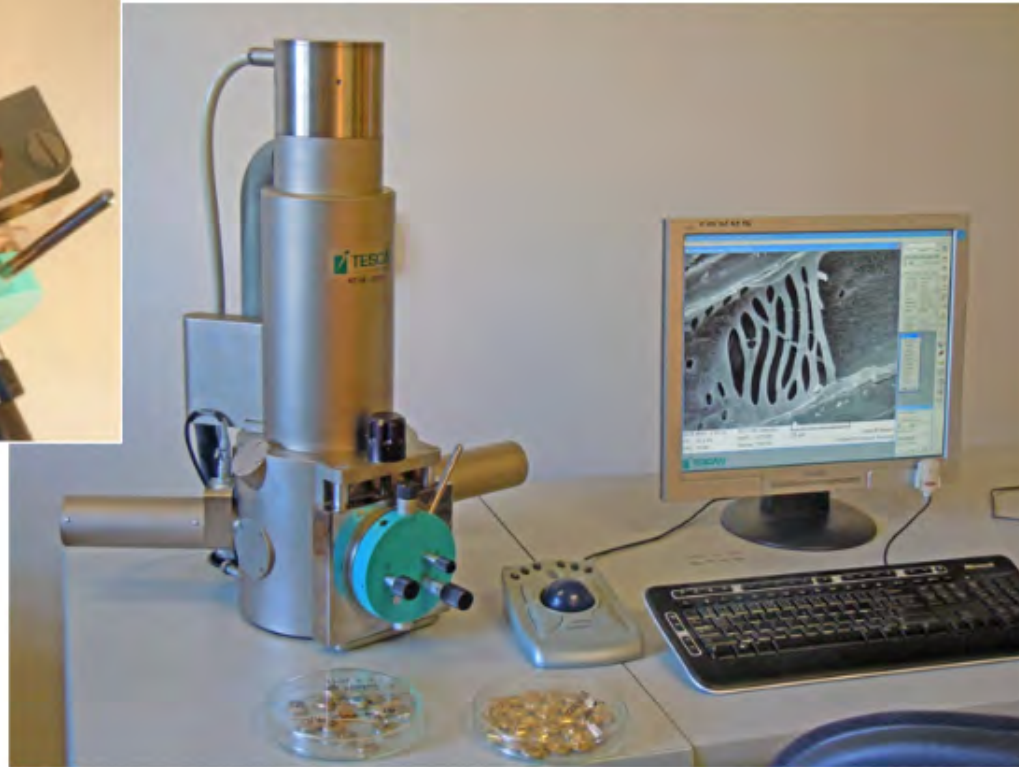
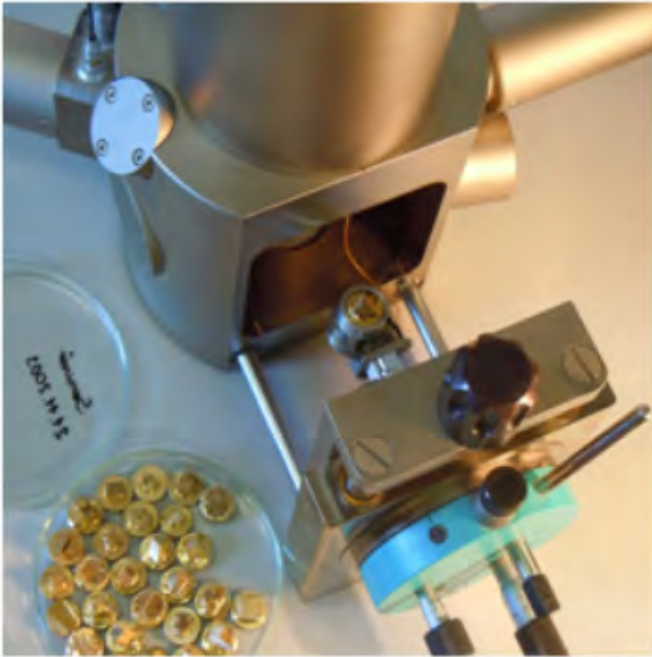
Tescan Orsay Holding, Brno (laboratóriá)



Tescan MIRA, Brno (2.3.2015)



Tescan VEGA TS 5130



Príprava preparátov pre SEM

Preparáty z drevných štruktúr pre SEM je vždy potrebné špecificky pripravovať a to z nasledujúcich dôvodov:

- pre vysokovákuový SEM vzorka **nesmie obsahovať vodu**
- musí byť stabilná pod zväzkom elektrónov
- vzorka by mala byť **elektricky vodivá**, aby sa nenabíjala záporne nabitými elektrónmi
- na povrchu vzorky by nemali byť prítomné **cudzorodé častice a nečistoty**

Každý postup prípravy je **jedinečný** a vyvinutý v závislosti na charakteristike objektu skúmania a požiadavke, aby výsledné snímky preukázali požadovanú informáciu.

Príprava preparátov pre SEM

Príprava preparátu **pre vysoké vákuum** v SEM mikroskope všeobecne zahŕňa nasledujúce kroky:

- **Odber prieskumných sond** (z krovu, tráv, dreveného artefaktu).
- **Vymanipulovanie preparátov** z odobratých sond - príprava **R a T štiepných plôch (čepielkou)**, ktoré budú **následne zrezané žiletkou** a **Pr** rezov; výška vzorky by nemala presiahnuť 5-6 mm.

- Pre degradovaný, ale aj extrémne tvrdý preparát xylému sme navrhli a overili - ***Daucus carota***,

následne ukotvíme do zveráčka a odoberieme žiletkou tenkú vrstvičku z radiálnej (tg) štiepnej plochy pre dosiahnutie ideálneho rezu.

- Každý preparát radiálneho rezu je zrezaný žiletkou taktiež **šikmým priečnym rezom** z dôvodu orientácie v oblasti jarného a letného dreva preparátu

Príprava preparátov z historického dreva pre SEM



Fotookumentácia
odobratých sond
A preparátov drevených
prvkov podľa
NKP Slovenská ľudia



Detaily vzoriek z hlavy (1) a z misy (2) plastiky Hlava Jána Krstiteľa

Limitne malé vzorky

- potrebné správne sa rozhodnúť aký rez vymanipulujeme
- najvýpovednejšiu hodnotu **pre ihličnaté drevo** má **rez radiálny** (pre listnaté drevo – tangenciálny rez)

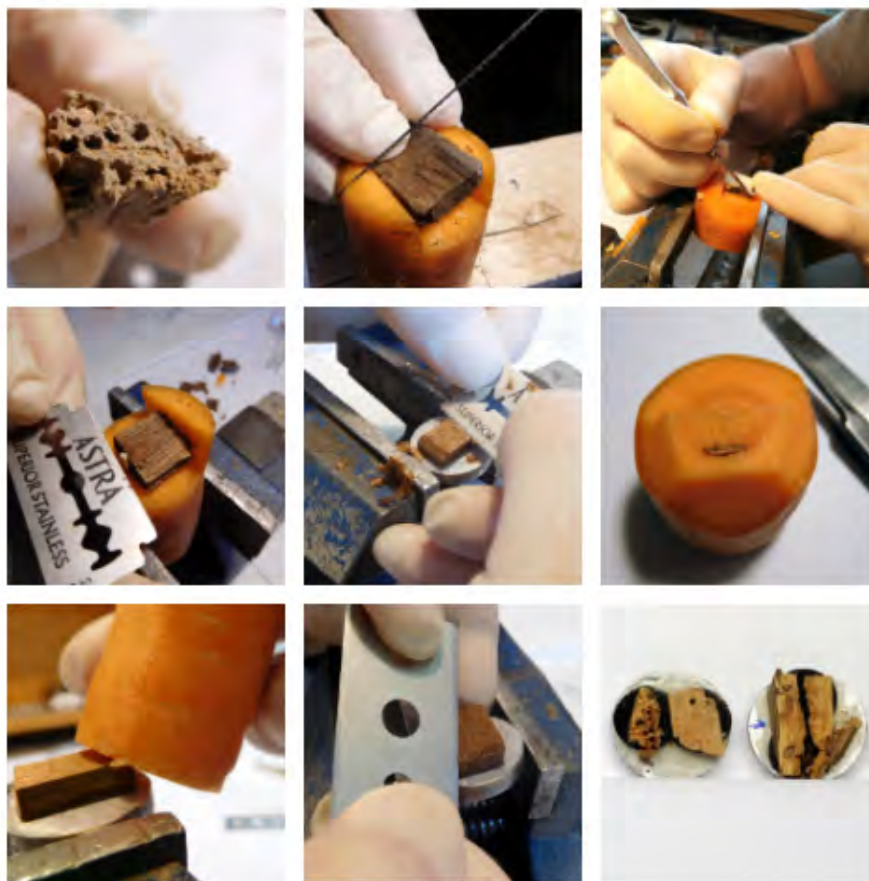
Príprava preparátov z historického dreva pre SEM

- **Označenie a fixácia** preparátov pomocou PVAC lepidla k alumíniovým terčikom
- **Osobitné požiadavky** sú kladené na lepidlo:
 - ❖ musí vytvoriť vodivý spojovací prvok medzi vzorkou a terčikom
 - ❖ nesmie vzniknúť absorpcia do lúmenov kapilár dreva (zamedziť kontaminácii a prekrytiu vnútornej štruktúry);
 - ❖ nesmie reagovať pri vysokom vákuu pri pozlacovaní

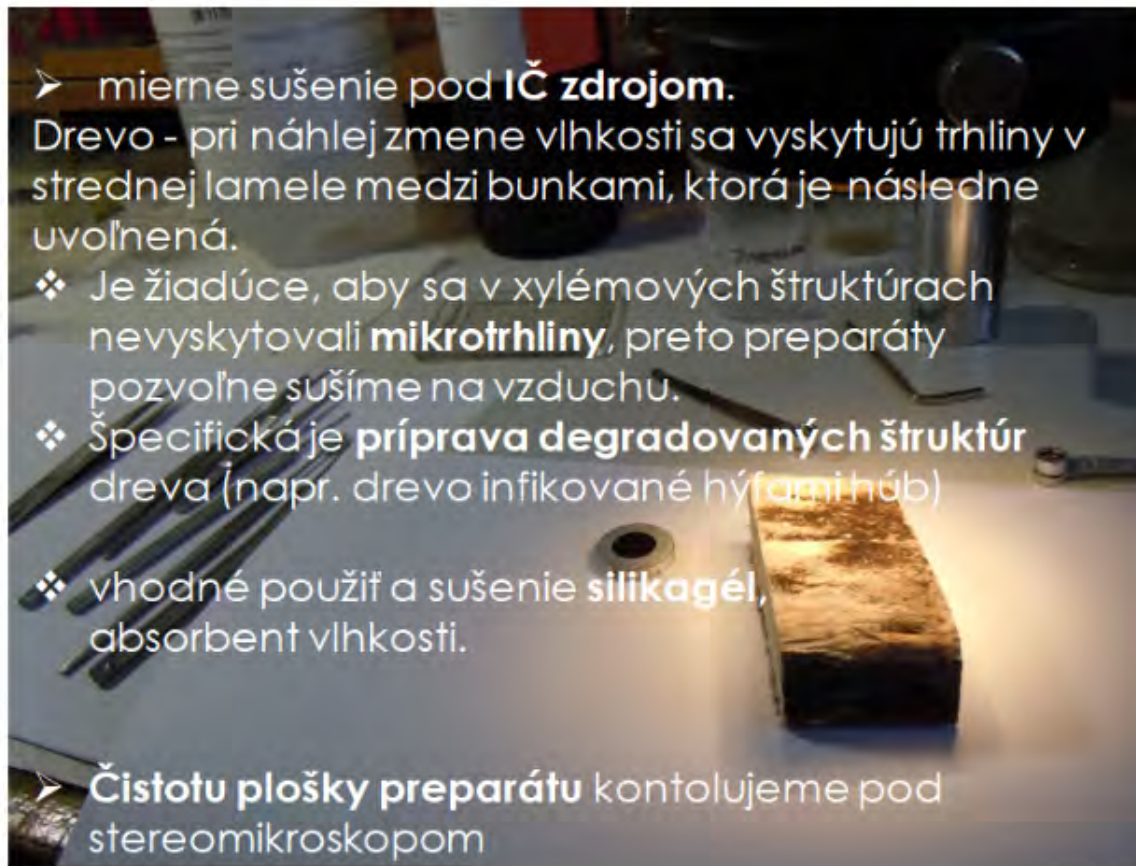
Ideálne riešenie - fixácia priečných rezov pomocou **uhlíkových samolepivých terčikov** – zamedzenie penetrácie adhezíva do kapilárnych štruktúr dreva

Pre orientáciu v hĺbke sondy je **vyznačený povrch** radiálnych preparátov šípkou odspodu terčíka.

Príprava preparátov z historického dreva pre SEM



Dehydratácia fixovaného preparátu



- mierne sušenie pod **IČ zdrojom**.

Drevo - pri náhlej zmene vlhkosti sa vyskytujú trhliny v strednej lamele medzi bunkami, ktorá je následne uvoľnená.

- ❖ Je žiadúce, aby sa v xylémových štruktúrach nevyskytovali **mikrotrhliny**, preto preparáty pozvoľne sušíme na vzduchu.
- ❖ Špecifická je **príprava degradovaných štruktúr** dreva (napr. drevo infikované hýľami húb)
- ❖ vhodné použiť a sušenie **silikagél**, absorbent vlhkosti.

- **Čistotu plošky preparátu** kontrolujeme pod stereomikroskopom

Príprava preparátov z historického dreva pre SEM



Pre zlepšenie
povrchovej vodivosti
sa vzorka **pozlacuje
24K zlatom.**

Cieľom pozlacovania
je kontinuálne
pokrytie vzorky veľmi
tenkou vrstvou ktorá
je hrubá len niekoľko
nm (10-20 nm)

- Materiál, ktorý je
dobré tepelne
a elektricky vodivý

Preparáty pre skenovaciu elektrónovú mikroskopiu pred a po pozlátení 24K zlatom

Fixácia preparátov pre SEM

- **Kryofikácia** – rýchle zmrazenie je v súčasnosti považované za najlepší spôsob, ako zachovať preparát čo najbližšie natívnemu stavu - **SEM s kryostolíkom**
- **Zmrazenie živých pletív v kvapalnom dusíku (na teplotu $-195.79\text{ }^{\circ}\text{C}$)**

Unikátne snímky
pre oblasť lesníckej fytológie
prične lomy RD



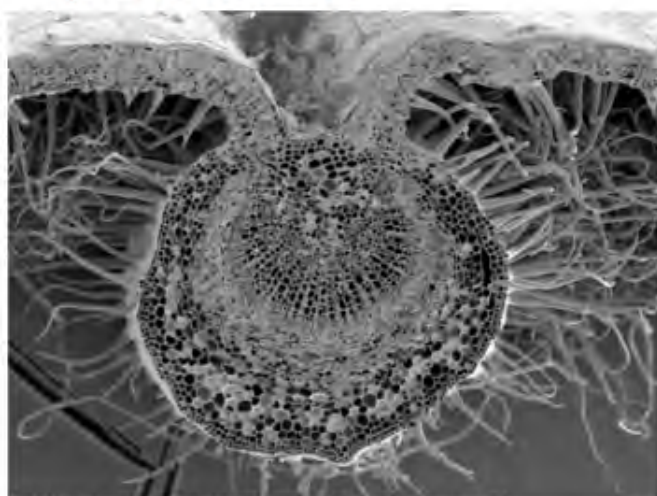
Sušenie preparátov pre SEM

Metódy sušenia preparátov pre SEM:

- **Metóda kritického bodu (CPD) - Critical Point Drying**
- pri kritickej teplote a tlaku zmiznú rozdiely medzi kvapalnou a plynnou fázou danej látky a čo je podstatné, zmizne aj fázové rozhranie medzi nimi.
- Špeciálna aparátúra - **kvapalný oxid uhličitý**. Hodnota kritického tlaku je **7 390 kPa**, **kritická teplota 31°C**.
- **Freeze drying** –pomalá sublimácia ľadu zo zmrazenej vzorky za zníženého tlaku a pri kontrolovanom zvyšovaní teploty

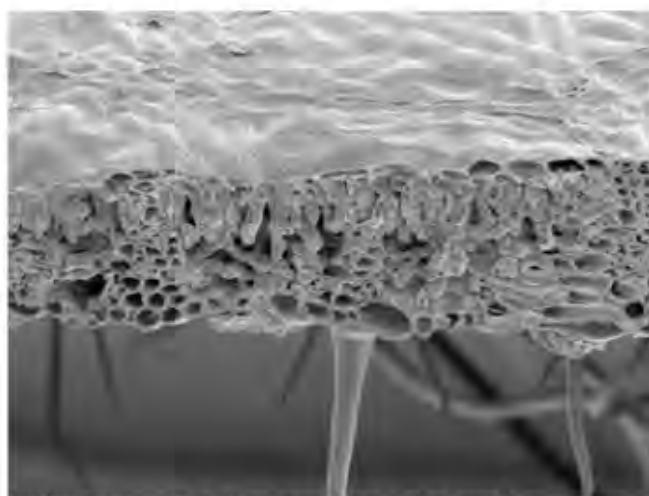
Sušenie preparátov pre SEM

- **Metóda kritického bodu (CPD) - Critical Point Drying**
- Metódu sme overili na biologických preparátoch (list *Ulmus x hollandica*) Riziko- tvarové zmeny mäkkých pletív z dôvodu vysokého tlaku.



SEM MAG: 150 x
HV: 16.7 kV
VAC: HiVac
DET: SE Detector
DATE: 07/24/12
Device: TS5130
500 µm
Vega ©Tescan
Katedra nauky o dreve - DF TU Zvolen

Priečny rez hlavnou žilou listu U. 'Dodoens'



SEM MAG: 750 x
HV: 16.7 kV
VAC: HiVac
DET: SE Detector
DATE: 07/24/12
Device: TS5130
100 µm
Vega ©Tescan
Katedra nauky o dreve - DF TU Zvolen

Priečny rez hlavnou žilou listu U. 'Dodoens'

Pokovenie vzoriek

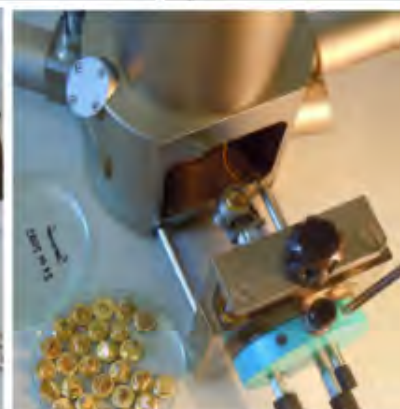
Obr. Lepenie vzoriek a ich pokovenie:

a) **Sputter Coater POLARON**

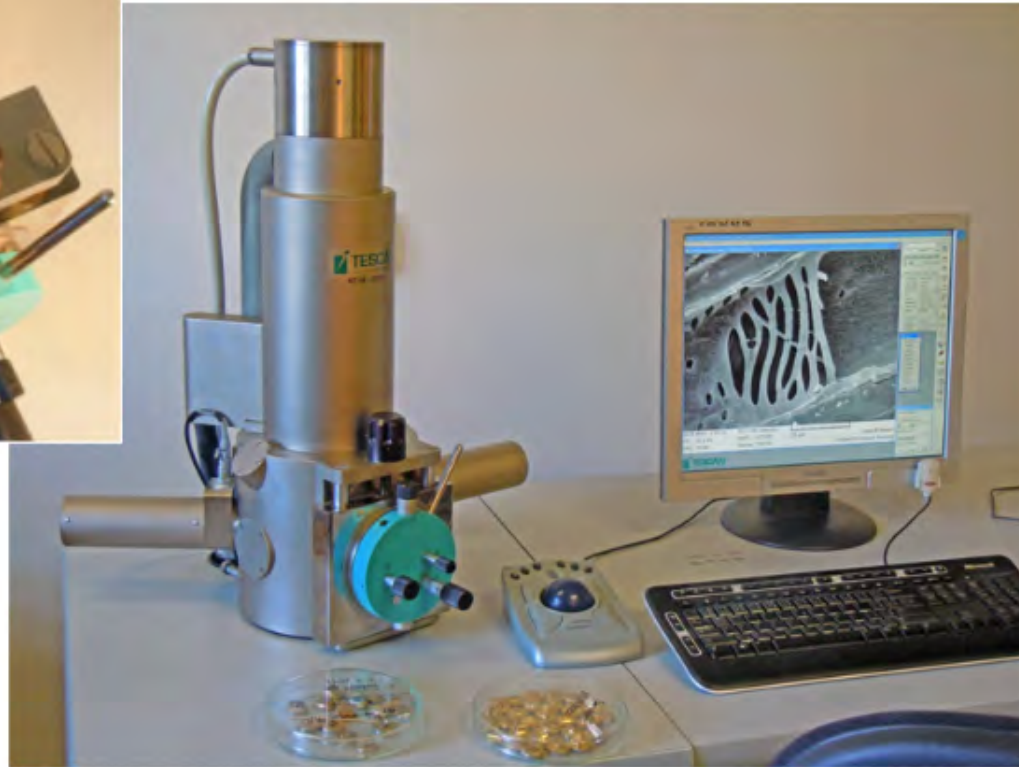
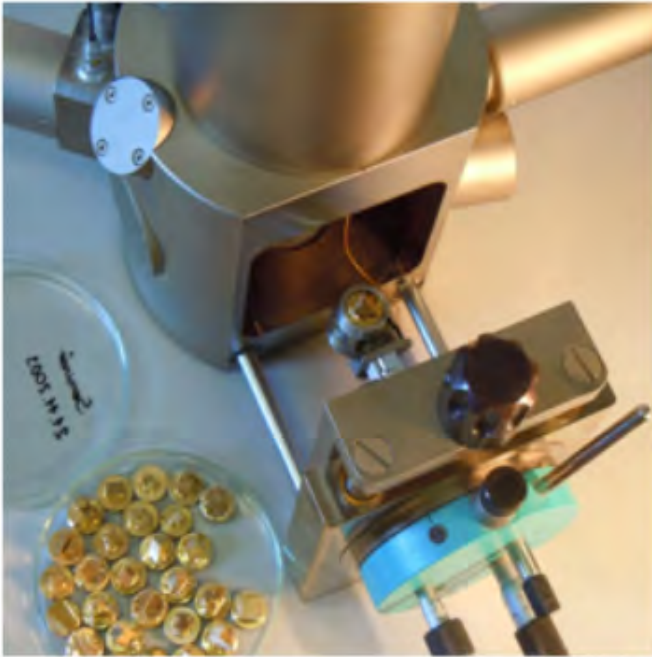
SC7680 - zariadenie na pozlacovanie preparátov iontovým naprašovaním v nízкотlakej argónovej atmosfére;

b) **Vákuové pokovovovacie zariadenie;**

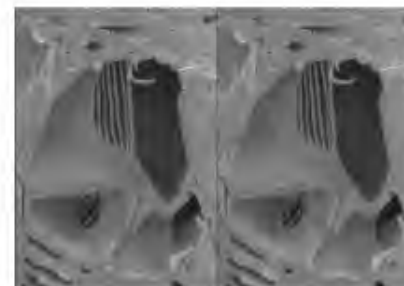
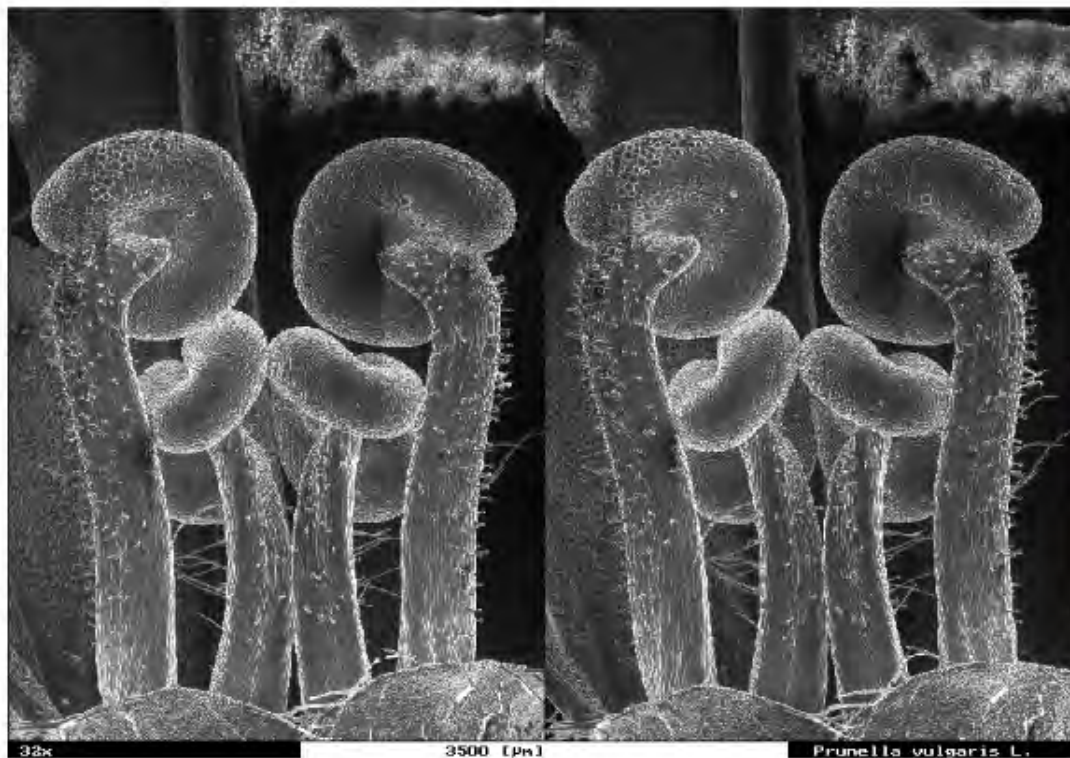
c) obojstranne lepivé uhlíkové vodivé terčičky; d) zlatom pokovené nosné alumíniové terčičky so vzorkami pripravené na pozorovanie



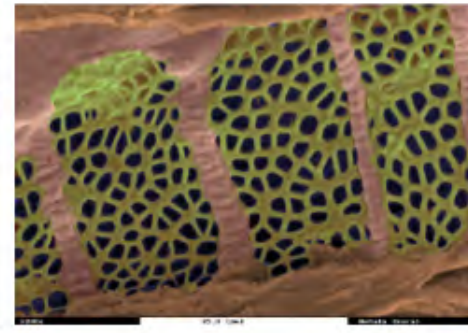
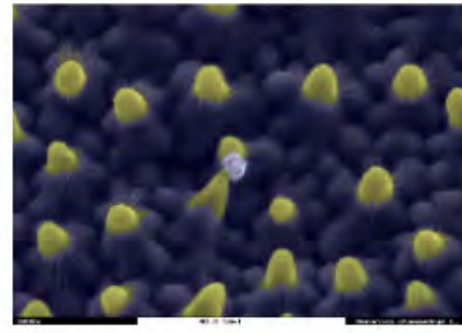
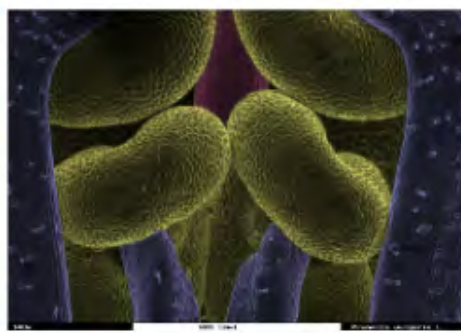
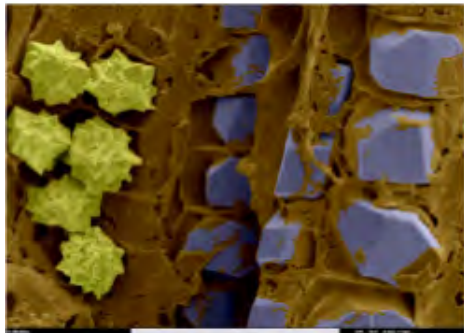
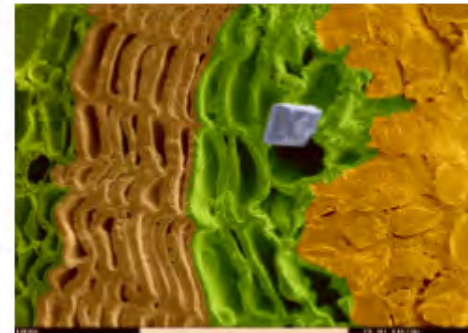
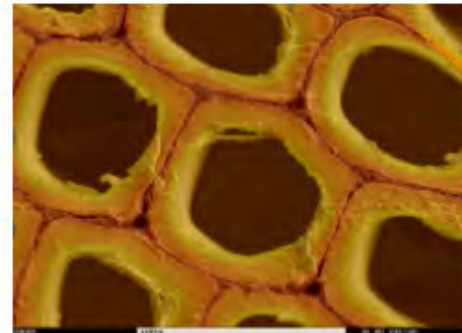
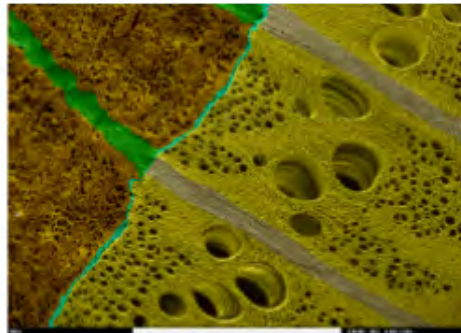
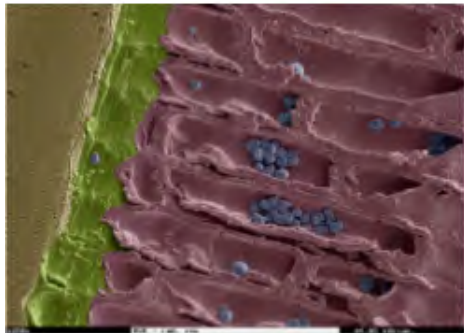
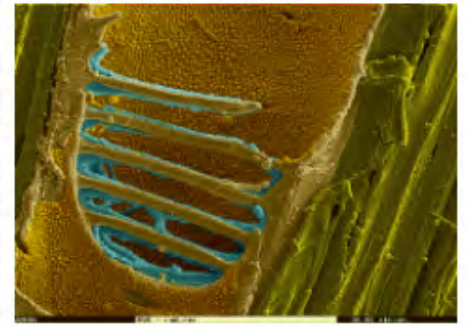
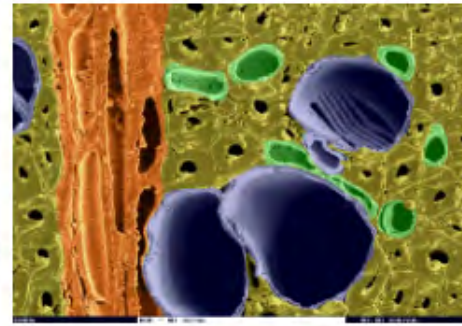
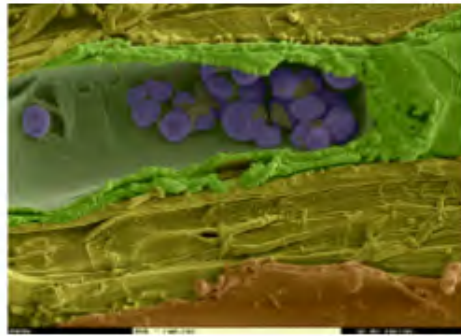
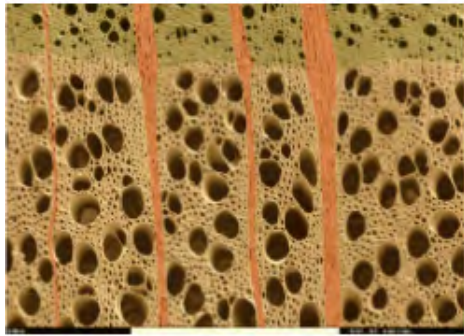
Tescan VEGA TS 5130

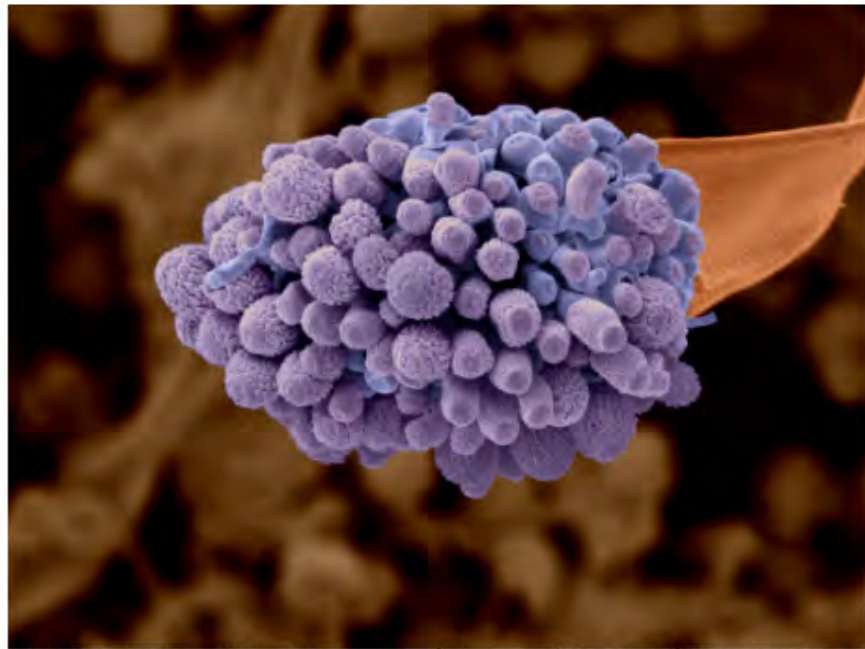


Stereo



Peľnica čiernohlávok obyčajný - *Prunella vulgaris*





SEM MAG: 4000 x DET: SE Detector 20 µm Vega ©Tescan



SEM MAG: 4.00 kx DET: SE Detector 20 µm Vega ©Tescan

● Anatomická diagnostika a determinácia druhu dreva

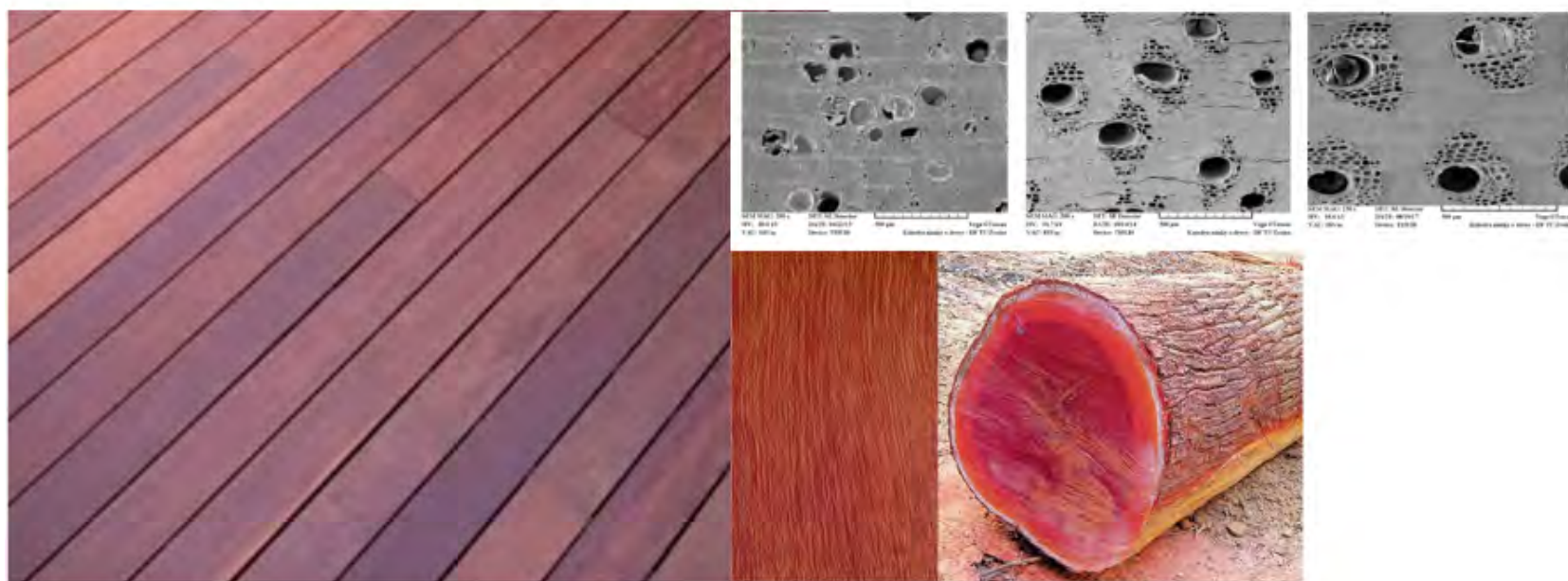
stenčeniny stien – dvojbodky tracheíd, dvojbodky ciev,
typy križových polí, kvalita pletív, anomálie rastu

● Prieskum poškodenia dreva v historických krovoch

- neskorogotický krov **Kostola sv. Kataríny v Banskej Štiavnici**,
 - krov neogotickej **kostolnej veže** v Spišskej Novej Vsi,
 - krov Rímskokatolíckeho kostola Všetkých Svätých v Brezovici nad Torysou
 - južná veža románsko-gotickej **Katedrály sv. Martina v Spišskej Kapitule**
 - Historický krov v **Kláštore premonstrátů v Želivě** (Česká republika)
-
- **Materiálové prieskumy historických objektov NKP Krásna Hôrka, NKP Slovenská Ľupča**

- **Štruktúra tropických drevín** vystavených expozičným testom – v prirodzených podmienkach a po umelom starnutí v Xenoteste

bangkirai (*Shorea obtusa* Wall.; Sh. spp.), **cumaru** (*Dipteryx odorata* (Aubl.) Wild.), **cumaru rosa** (*Dipteryx magnifica* (Ducke) Ducke), ipé (*Tabebuia serratifolia* Nichols.), jatobá (*Hymenaea courbaril* L.), kusia (*Nauclea diderichii* Merrill) a **massaranduba** (*Manilkara bidentata* A. Chev.)



- **Databáza anatomických dát** chránených druhov tropického dreva - *Diospyros spp. a Dalbergia spp.*
- Analýza štruktúry xylému **neivazívneho klonu**
Paulownia Cotevisa 2
- ▶ **V spolupráci s LF TUZVO - Katedrou fytológie**
 - Štruktúra dreva a listov vyšľachtených kultivarov *Ulmus x hollandica*, analýza anatomických parametrov dreva mikropropagovaných jedincov v podmienkach umelo vyvolanej infekcie hubovým patogénom *Ophiostoma novo-ulmi*
- ▶ **V spolupráci s LF TUZVO - Katedrou integrovanej ochrany lesa a krajiny**
 - Mikroskopická analýza odobratých vzoriek *Fraxinus excelsior* L. infikovaných patogénom *Chalara fraxinea*

►Spolupráca so Stredoslovenským múzeom v Banskej Bystrici:

- ◉ SEM analýza vzoriek odobratých zo sochy **sv. Františka s bradou**, ev. č. Vu-04391 – Analýza pred konzerváciou sochy.
- ◉ Mikroskopická analýza vzoriek drevnej hmoty z plastiky „**Hlava Jána Krstiteľa**“ s identifikáciou druhu dreva, ev.č.: Vu-03023

►V spolupráci s Fakultou stavební VŠB – TU Ostrava - Katedra Stavebních hmot a diagnostiky staveb

- ◉ Hodnotenie **modelovej mineralizácie** dreva pomocou SEM - roztoky organosilánov a kremičitanov, a ošetrenie pentahydrátom síranu meďnatého ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) pre simuláciu mineralizácie v kyslom prostredí
- ◉ Materiálové prieskumy historických krovov (Kateřinky, Želiv)

►V spolupráci s Department of Wood-Based Composites, National University of Forestry and Wood Technology of Ukraine, Lviv :

- Analýza **zhustenej štruktúry** dýhy jelše (*Alnus glutinosa* (L.) Gaertn.) - vplyv krátkodobého termo-mechanického zhustenia na šikmých priečnych a radiálnych rezoch.

►V spolupráci s Faculty of Wood Technology, Institute of Chemical Wood Technology, Poznań University of Life Science, Poznań, Poland+Italy

- SEM analýza celulózovej buničiny po dvoch a piatich rokoch prirodzeného starnutia - v jazernej vode a rašelinovej pôde - v **archeologickej lokalite Biskupin** - odhadnúť najlepšie podmienky pre obnovu zachovania archeologického dreva in situ

- Termicky modifikované drevo jaseňa, buka
- SEM analýza exponovaných povrchovo upravených šindľov

na vybraných historických objektoch (Rímskokatolícky kostol sv. Kataríny - Handlová, Augustovský dom - Banská Štiavnica, Vodný mlyn - Kolárovo, Hámor - Medzev)

- Degradovaný xylém:

drevo pagaštana konského - hubou **Fomes fomentarius**,

vnútorná bel duba zimného degradovaná hubou **Daedalea quercina (L.) Fr.**,

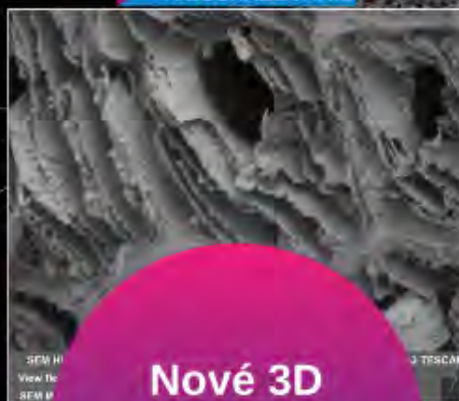
drevo buka – cielenou degradáciou eróznou hubou **Phanerochaete chrysosporium** a lignin-selectívnou hubou **Ceriporiopsis subvermispora**

drevo smreka pôsobením mikroskopickej huby **Trichoderma viride** a baktérie **Bacillus subtilis**

Elektrónová mikroskopia a štúdium drevných štruktúr

Ing. Miroslava Mamoňová, PhD.

22. 9. 2017



**Elektrónová
mikroskopia**

**Nové 3D
aplikácie
a zobrazenia**

**Materiálový
prieskum
historických
objektov**

2. ročník 3D meranie a zobrazovanie
Zobrazovanie a moderné diagnostické metódy v priemyselnej praxi

Nové 3D aplikácie a zobrazenia

Alicona
MEX

Stenčeniny

CRYO-SEM

FIB-SEM

SEM APLIKAČNÉ ANALÝZY

Zrubový dom v Nižnej Boci.

Stavba realizovaná v máji r. 2013.

Postavený z borovicového a smrekovcového dreva

Alicona MeX softvér

aplikovaný na kartáčovaný
povrch sondy

dreveného zrubu,

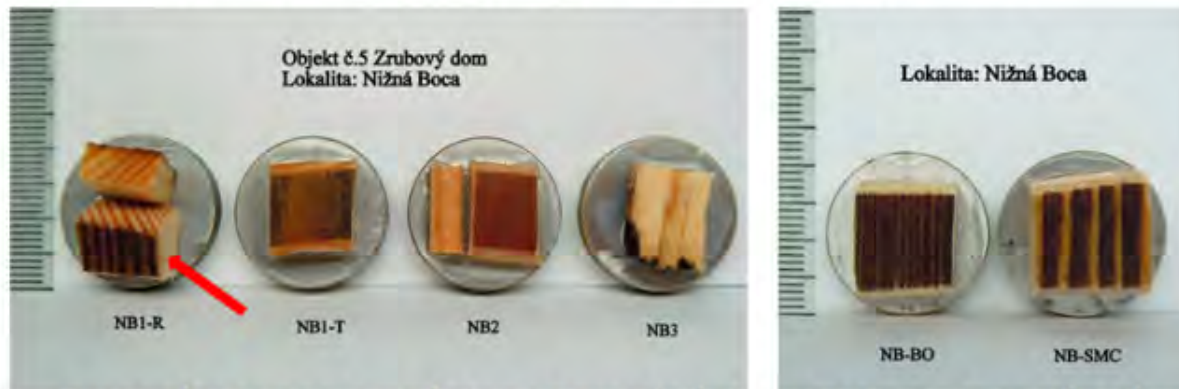
Nižná Boca – vytvorenie 3D
modelu povrchu



**Miesta odberu
exponovaných vzoriek**
z časti prizmy,
zo štítu a čelnej plochy

ALICONA MEX SOFTVÉR

- Následne boli vyhotovené **preparáty**
(NB 1-R, NB 1-T NB 2 a NB 3) fixované na duralumíniové terčičky



Preparáty exponovaných a referenčných vzoriek pred pozlátením

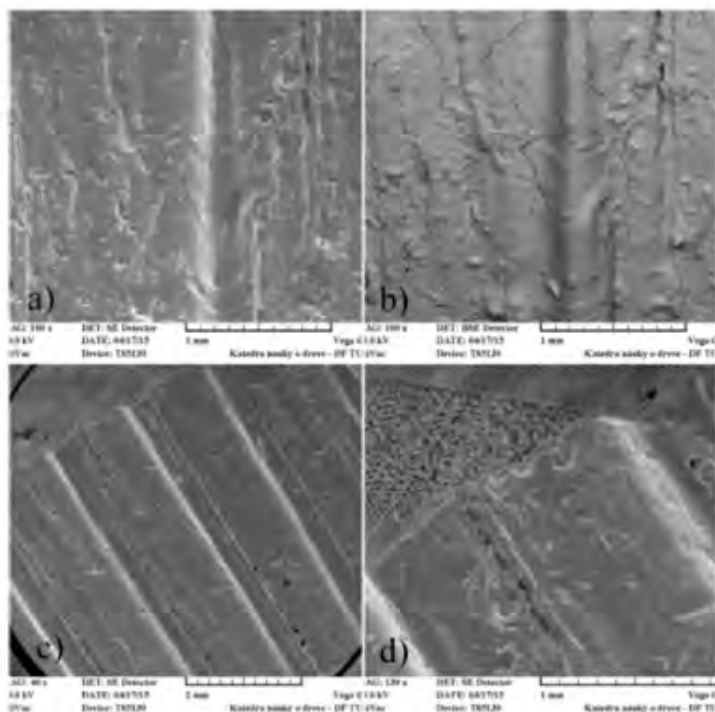
Tab. 1 Použitý náterový systém

Náterová látka	Počet nánosov
Boritá soľ	1x
Tungový olej	1x
OSMO ochranná olejová lazúra	1x
OSMO jednorazová olejová lazúra HS plus (odtieň Eben)	1x (miestami patina)
OSMO UV ochranný olej EXTRA (odtieň bezfarebný)	1x

- o Mikroskopická analýza exponovanej vzorky NB1-R – kartáčovaný povrch zrubového domu v Nižnej Boci

- plastická štruktúra spôsobená kartáčovaním
- trhliny v nátere

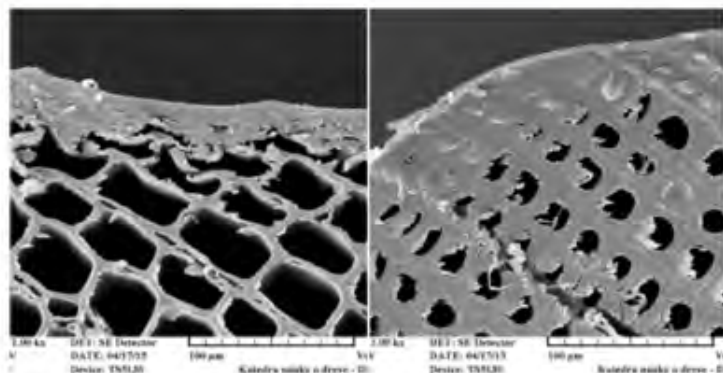
ALICONA MEX SOFTVÉR



c) zvlnený povrch,
d) trhliny na rozhraní
jarného a letného dreva,
prepady do štruktúry
dreva nad živicovým
kanálikom,

b) **detekcia trhlín v nátere**
pomocou BSE detektora,
pričom metodika
skenovania morfológie
trhlín (fraktografické
vyobrazenie) pomocou
BSE detektora bola takto
použitá unikátne v nátere
na povrchu dreva po prvý
raz

- o Mikroskopická analýza priečneho rezu exponovanej vzorky NB1-R (vľavo: jarné tracheidy, vpravo: letné tracheidy)



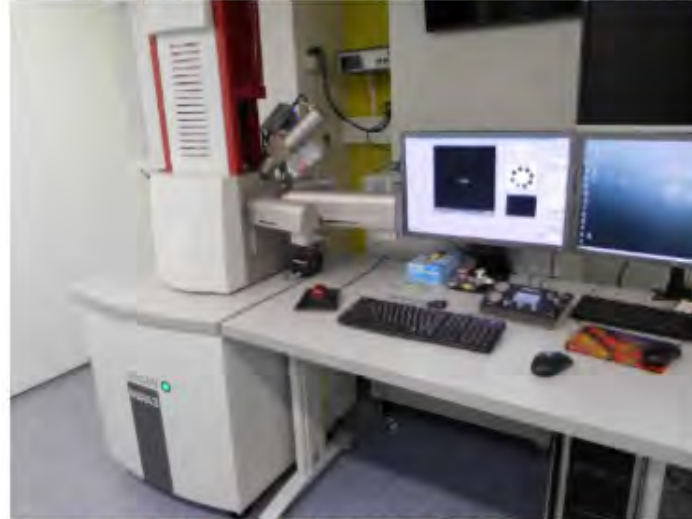
ALICONA MEX SOFTVÉR

Oblasť JD - náter nepenetruje do dreva, ale je príľnavý k povrchu, vrstva povrchových jarných tracheíd je zdeformovaná kartáčovaním

Oblasť LD - náter penetruje do hĺbky 2 – 3 lúmenov trachíd, je hladký a neodlupuje sa

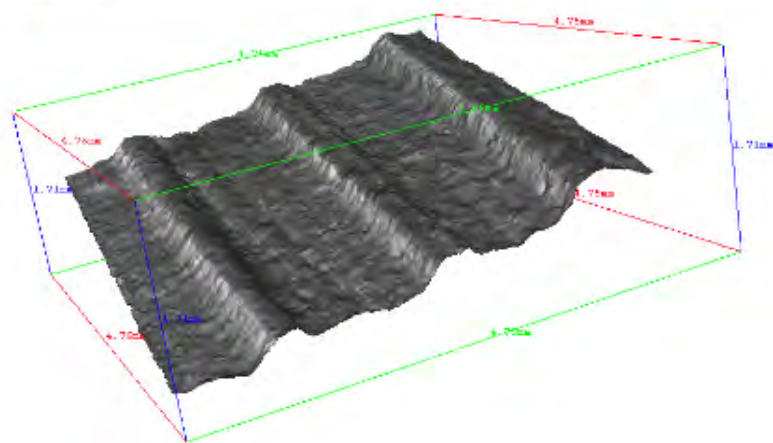
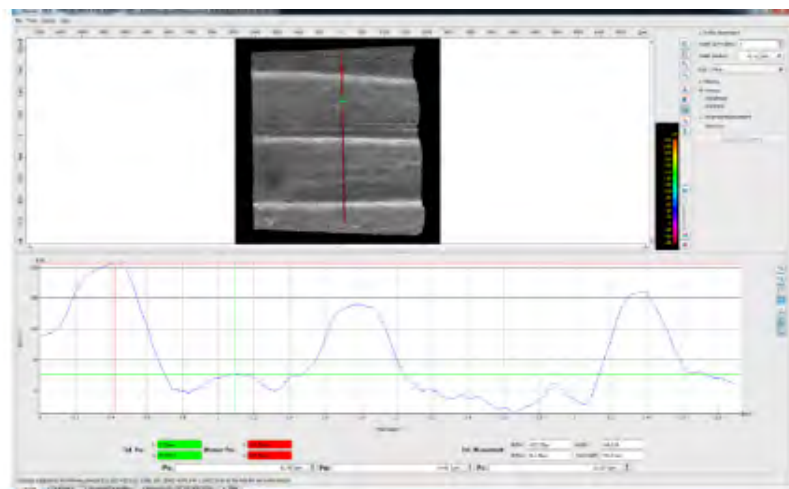
- 3D rekonštrukcia povrchu vzorky
- Pomocou softvérového modulu **Mex** sme získali DEM (Digital Elevation Model)
- MeX + analytické nástroje: 3D merania: nerovnosť, vlnitosť, profilová alebo objemová analýza
- + jednoduché a rýchle ovládanie, stereoskopický obraz SEM, Live 3D skenovanie, videosekvencie a generovanie obrazových sérií

ALICONA MEX SOFTVÉR



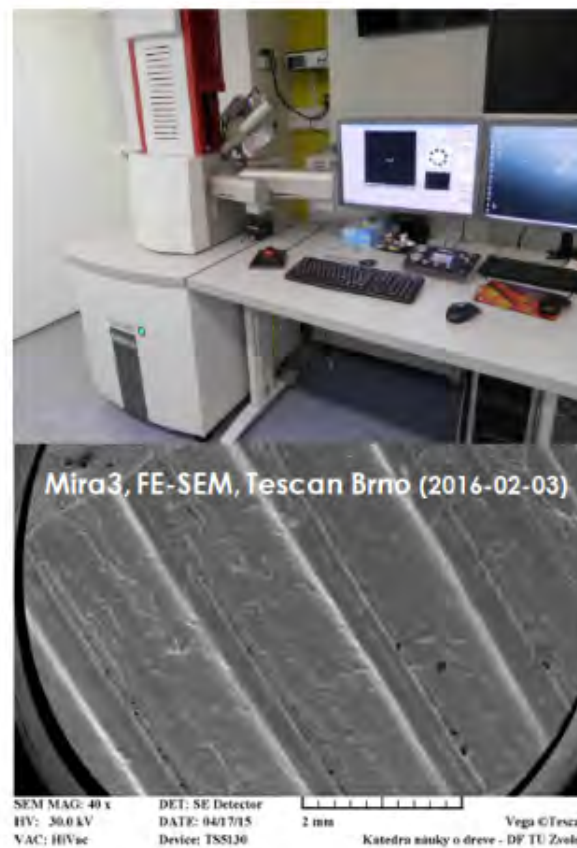
Mira3, FE-SEM, Tescan Brno (2016-02-03)





3D model rekonštrukcie kartáčovaného povrchu sondy dreveného zrubu, Nižná Boca

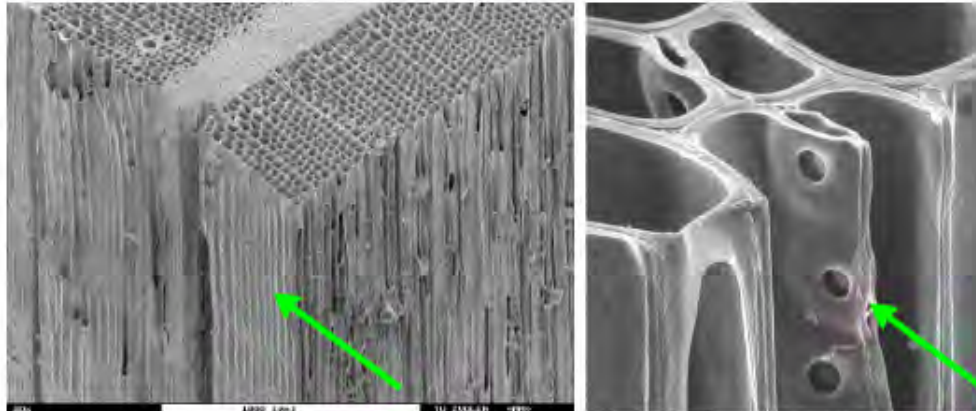
ALICONA MEX SOFTVÉR



STENČENINY

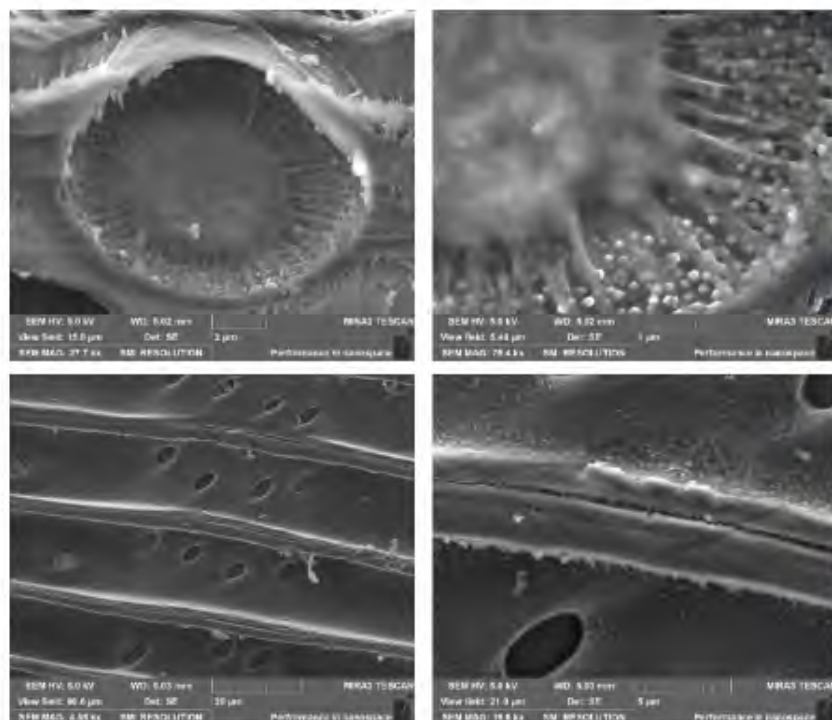
o Stenčenie bunkových stien tracheíd ihličnatého dreva

3D štruktúra ihličnatého dreva smrekovca (*Larix decidua* Mill.)
Usporiadanie dvojbodiek na radiálnych stenách tracheíd



- na radiálnych stenách tracheíd
 - pohyb tekutín v dreve v axiálnom a tg anatomickom smere
 - intertracheidálne dvojbodky
 - torus** - ukotvený na lúčovitej priepustnej blanke celulóзовých fibríl, nazývaných **margo**
- Pochopenie **transportných procesov v dreve**,
procesy **sušenia** dreva, **difúzia** vody v dreve,
impregnácia a penetrácia látok do dreva

- Stenčeniny bunkových stien tracheíd ihličnatého dreva



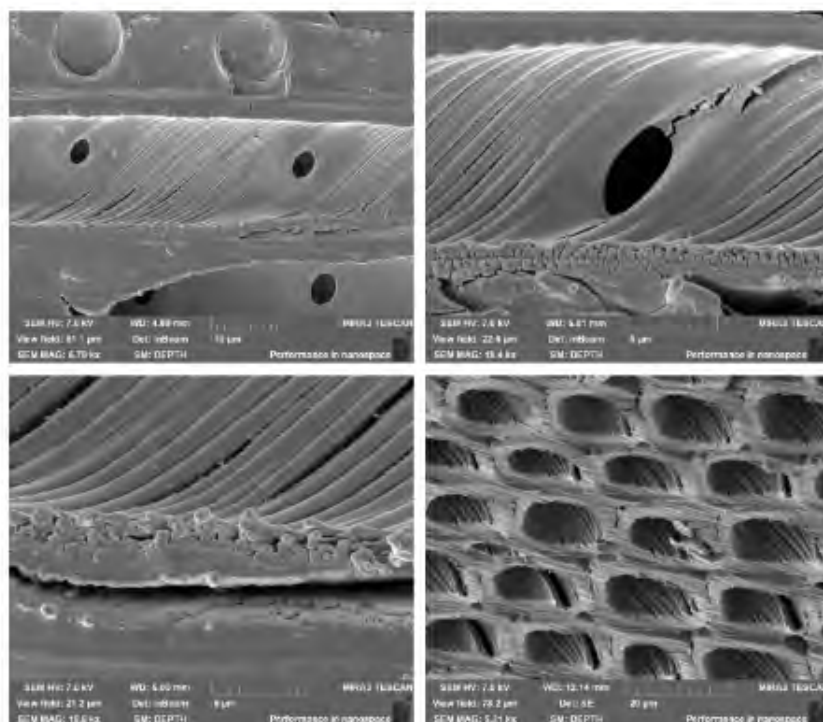
STENČENINY



Stenčeniny tracheidy jedle srienistej (*Abies concolor* (Gordon) Lindl. ex Hildebr.)
a, b) dvojbodka s bradavičnatým vnútorným povrchom (tzv. warty layer);
c, d) jednoduché stenčeniny v taxodioidnom krížovom poli

- o Stenčeniny bunkových stien tracheíd ihličnatého dreva

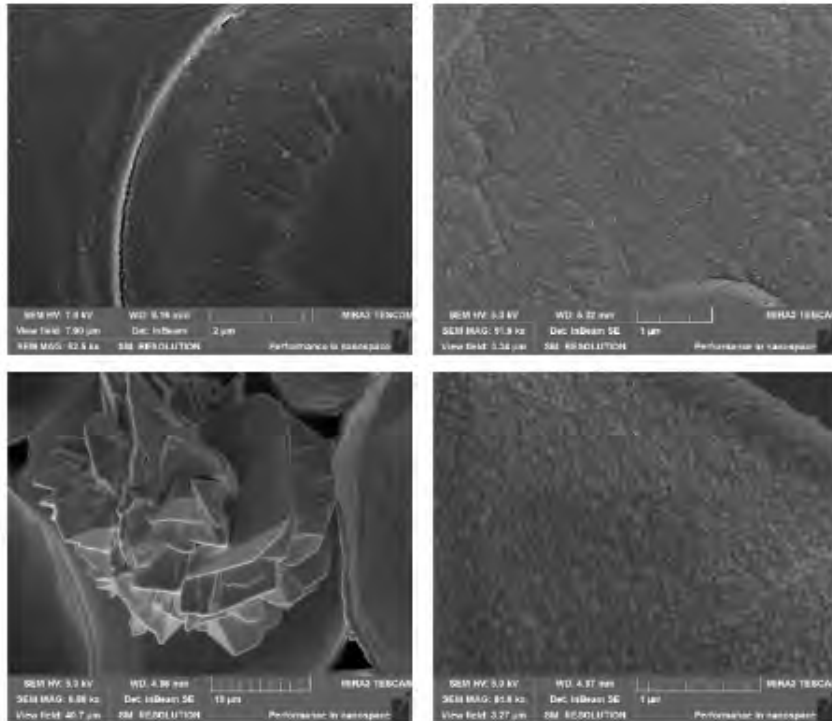
STENČENINY



Stenčeniny tracheidy borovice lesnej (*Pinus sylvestris* L.)

a, b) dvojbodka v tracheide reakčného (tlakového) dreva; c) šikmý priebeh fibríl v sekundárnej stene tracheidy reakčného dreva; d) priečny rez tlakovými tracheidami

STENČENINY

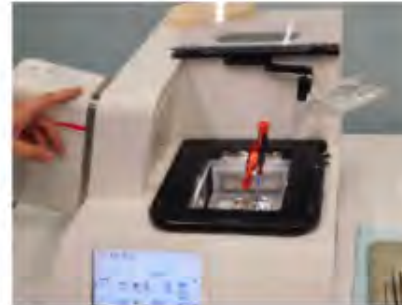


Formovanie granúl zlata pokovených preparátov xylému môže zasiahť jemné finesy ultraštruktúry

- a) bradavičnatá vrstva komory dvojbodky borovice zastretá granuláciou zlata pri pokovení preparátu, zv. 52 500x;
- b) povrch kryštálu šľavelanu vápenatého zastretý granuláciou zlata, zv. 51 900x;
- c) kryštalická drúza šľavelanu vápenatého v parenchýme;
- d) detail povrchu (c) pokovený zlatom, zv. 84 600x

CRYO SEM

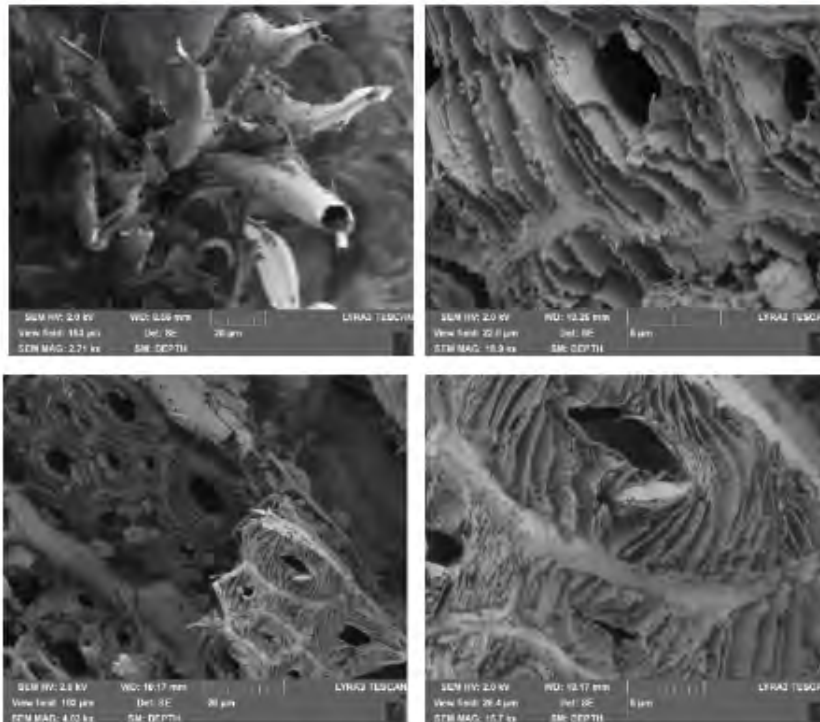
- o Cryo LOMY - Reakčné drevo buka



SEM Tescan Lyra3

Naprašovacie zariadenie Leica EM ACE600 (a, b) naprašuje veľmi tenké, jemne zrnité a vodivé kovové a uhlíkové povlaky pre analýzy s vysokým rozlíšením - **pre aplikácie FE-SEM**. **Systém vákuového prenosu Leica EM VCT500 (b, c)** implementovaný k naprašovaciemu zariadeniu Leica EM ACE600 pre prípravu vzoriek Cryo SEM bez kontaminácie;

● Cryo LOMY - Reakčné drevo buka, SEM Tescan Lyra3



**Cryo SEM zobrazenie priečných lomov zónou ťahových libriformných vlákien
buka (*Fagus sylvatica* L.)**

Zreteľná lamelárna štruktúra bola týmto spôsobom pozorovaná unikátne prvý raz.

CRYO SEM

o Mikroskopické Cryo-SEM analýzy na Tescan Vega na TU vo Zvolene

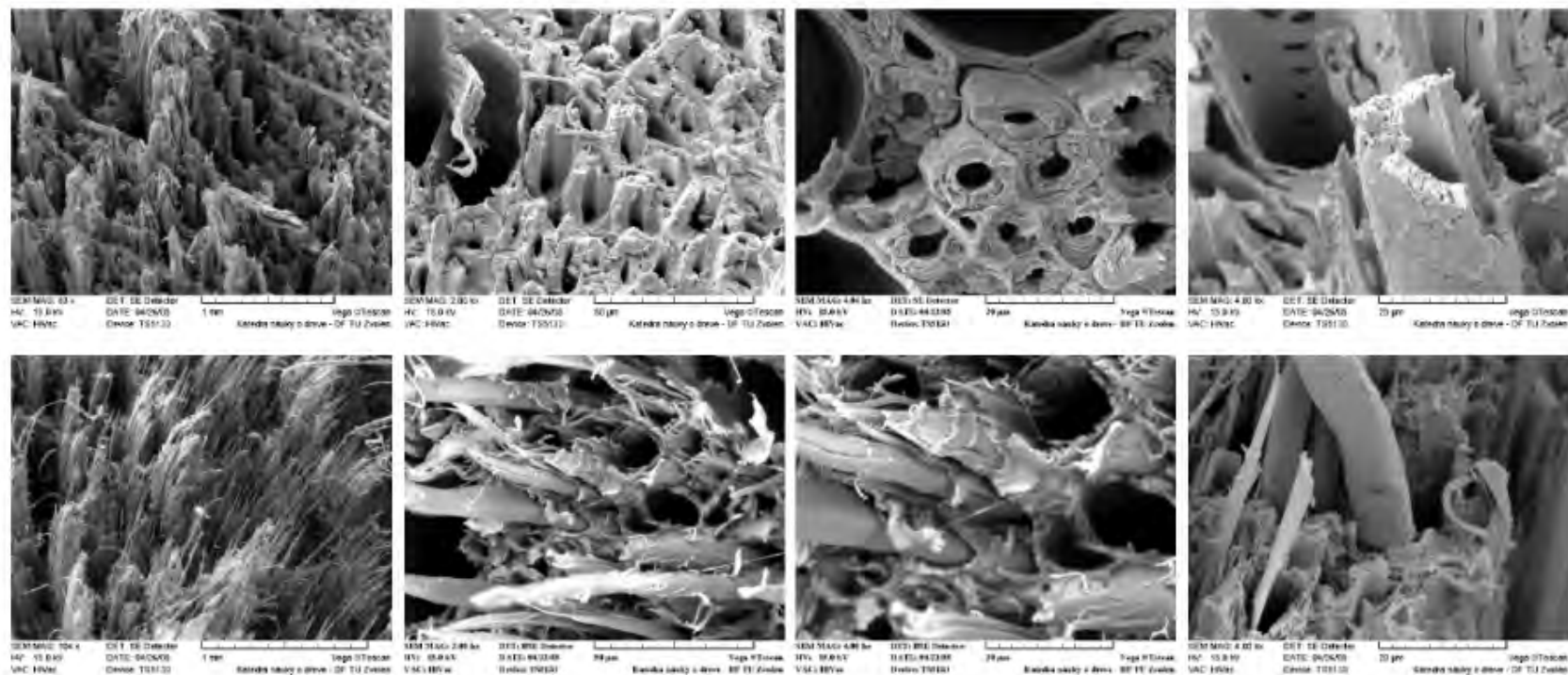
- na vzorkách bukového dreva, s anomáliou rastu – tvorbou reakčného dreva (**tension beech wood**) a neboli doposiaľ publikované
 - ❖ Vzorky malých rozmerov -
termonádobe s kvapalným dusíkom
zmrazené – do úplného nasýtenia
kapilárnych priestorov
 - ❖ (na teplotu -195.79 °C)
 - ❖ Prípravok, na ktorom bol uskutočnený
v strede telesa lom
 - ❖ Lomové plochy sa fixovali na terčík
a pozlátili



Kryogénne postupy boli pri príprave preparátov aplikované na xylém unikátne prvý raz.

o Cryo LOMY - Reakčné drevo buka, SEM Tescan Vega

CRYO SEM



Cryo-SEM analýzy v kvapalnom dusíku (-195,79 °C) na Tescan Vega, TU vo Zvolene

- lomové plochy bukového dreva, s anomáliou rastu – tvorbou G vrstvy reakčného dreva buka (tension beech wood)

o Dual beam FIB-SEM

(Focused ion beam scanning electron microscopy)

systém aplikovaný na **librifórné vlákno a parenchymatické bunky stržňového lúča buka** (*Fagus sylvatica* L.),

skenované pomocou Tescan LYRA3

TESCAN FIB-SEM vybavený ión-optikou s vysoko stabilným Ga⁺ LMIS zdrojom (Cobra column), pričom pri nano-obrábaní sa dosahuje

rozlíšenie 2,5 nm/5 nm.

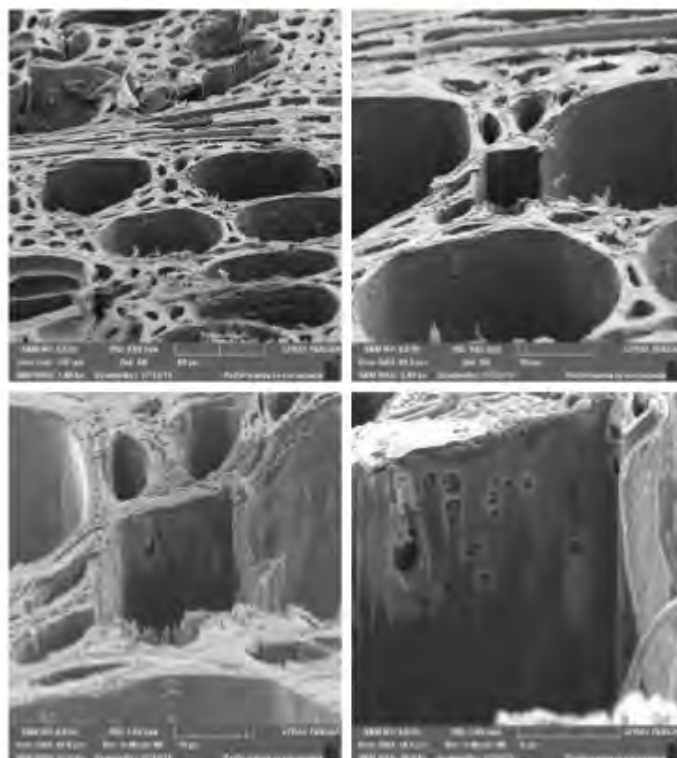
Parametre rezania: frézovanie /milling : 10 nA, leštenie /polishing : 200 pA

FIB-SEM



o Dual beam FIB-SEM Tescan LYRA3

FIB-SEM

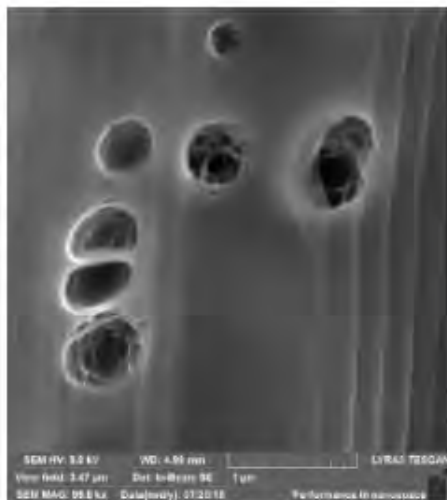
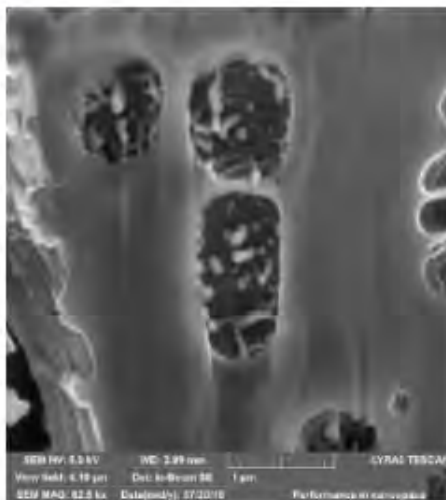


Prerezané stenčieniny v bunkovej stene libriformného vlákna buka (*Fagus sylvatica* L.) referenčná vzorka reakčného dreva (ref. I6 Ra) pred termickou úpravou

a) Pohľad na priečny rez preparátu buka pred FIB, b) Lokalizácia FIB-rezaného libriformného vlákna, c,d) detailné priestorové zobrazenie stenčienín v bunkovej stene vlákna, FIB-SEM

- Dual beam FIB-SEM Tescan LYRA3

FIB-SEM

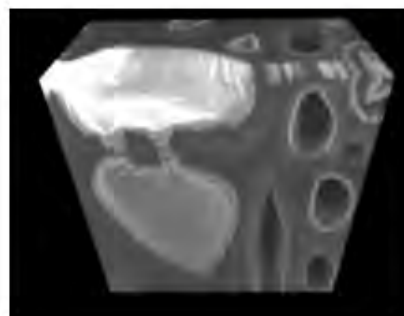
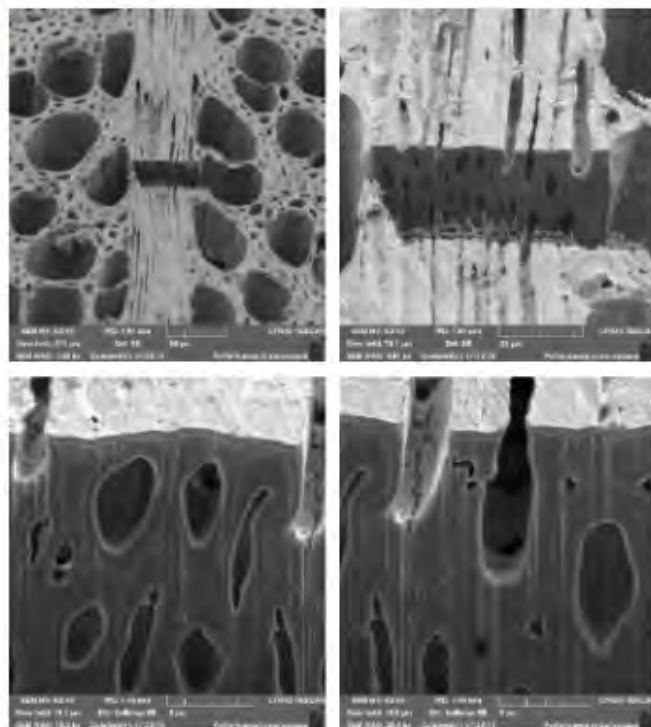


Prerezané stenčeniny v bunkovej stene libriformného vlákna buka (*Fagus sylvatica* L.) referenčná vzorka reakčného dreva (ref. I6 Ra) pred termickou úpravou

e,f) detailné priestorové zobrazenie mikrostenčení v štruktúre sekundárnej steny vlákna, FIB-SEM

o Dual beam FIB-SEM Tescan LYRA3

FIB-SEM



3D focused ion beam tomography of wood sample

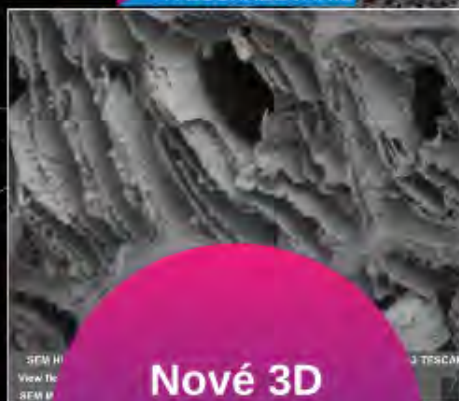
Dual beam FIB-SEM system aplikovaný na parenchymatické bunky stržňového lúča buka (*Fagus sylvatica* L.)

a) Lokalizácia rezaného stržňového lúča, b) Prierez parenchýmu viacradového stržňového lúča, c, d) detaily priečne rezaných parenchymatických buniek – pozoruhodné mikropriestory v kontakte parenchýmu v oblasti strednej lamely

Elektrónová mikroskopia a štúdium drevných štruktúr

Ing. Miroslava Mamoňová, PhD.

22. 9. 2017



**Elektrónová
mikroskopia**

**Nové 3D
aplikácie
a zobrazenia**

**Materiálový
prieskum
historických
objektov**

2. ročník 3D meranie a zobrazovanie
Zobrazovanie a moderné diagnostické metódy v priemyselnej praxi



Materiálový prieskum historických objektov

NKP
Krásna
Hôrka

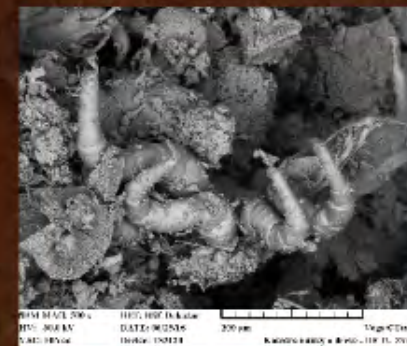
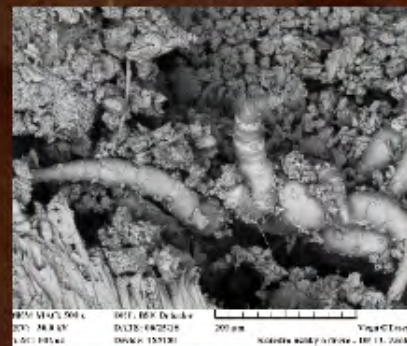
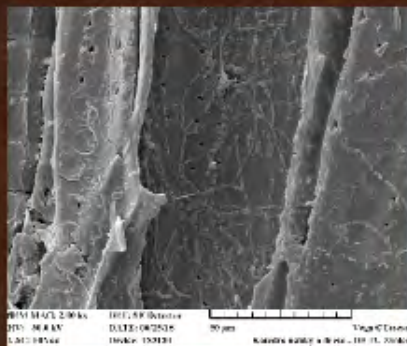
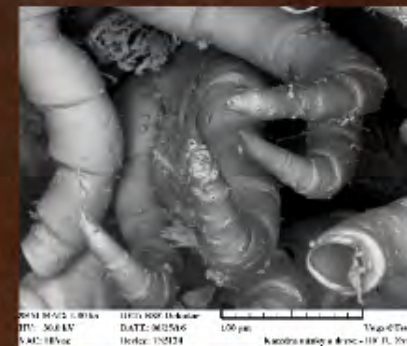
NKP
Slovenská
Ľupča

Klášter
v
Želivě

Poďakovanie

Materiálový prieskum drevených
prvkov konštrukcií
NKP Krásna Hôrka

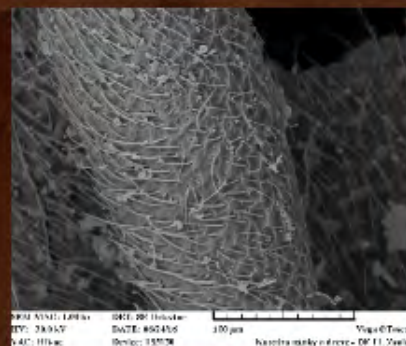
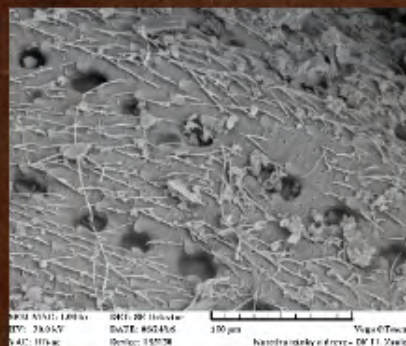
Odborné miesto č. 1 - Dolný Hrad – Schody do podkrovia Vzorka č. 1 (9. stupnica)



Diagnostikovaný
sklerotizovaný
rotoč prachový
(*Dermatophagoides
pteronyssinus* Tr.),
veľký 0,2-0,7 mm

Anobium punctatum

Črvotoč bodkovaný (*Anobium punctatum* De Geer) - nález dospelca (imágo) črvotoča. Femur imága črvotoča bodkovaného (*Anobium punctatum* De Geer) porastený ochlpením, krovky charakteristicky pokryté líniami okrúhlastých priehlbín, pokryté jemným ochlpením.





**Materiálový prieskum drevených
prvkov konštrukcií
NKP Slovenská Ľupča**

NKP Slovenská Ľupča

Je to jeden z mála hradov na Slovensku, ktorý je nepretržite obývaný od stredoveku až po súčasnosť.

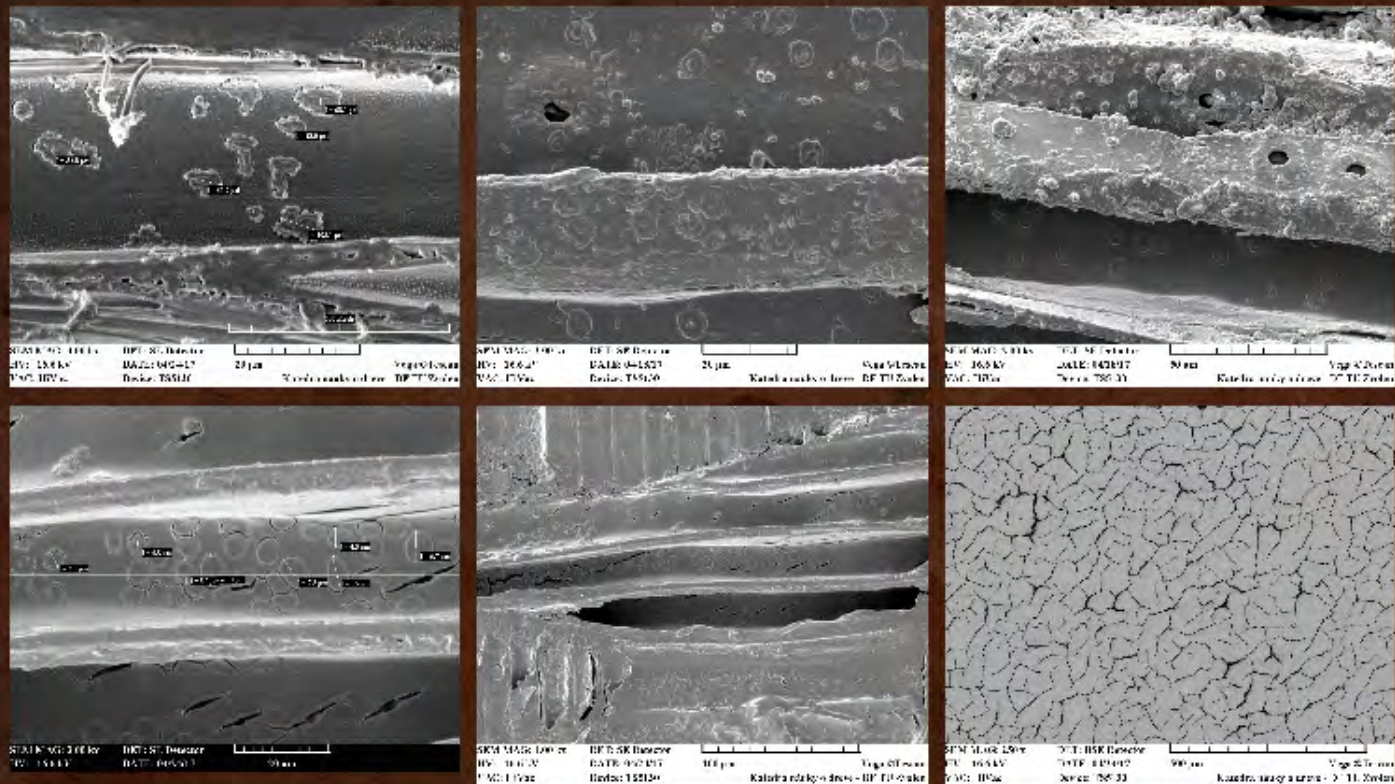
Najstaršia písomná zmienka o hrade pochádza z roku 1250. Hrad postavili krátko po tatárskom vpáde.

Vďaka dobrej polohe v minulosti spoľahlivo strážil starú cestu údolím Hrona vedúcu zo Zvolena do Brezna a ďalej na Spiš.

Dnes hrad spravuje nový majiteľ (Železiarne Podbrezová Group), ktorý vedie rozsiahlu rekonštrukciu na záchranu tejto NKP.



Odberné miesto č. 8 – XIII. trám
Vzorka č. 6 Nerenovovaný trám porovnaný s referenciou





Materiálový průzkum krovových konstrukcí v Klášteře premonstrátů v Želivě

Prof. Ing. Ladislav Reinprecht, CSc., KMTD TU Zvolen

Ing. Jana Daňková, PhD., Fakulta stavební VŠB TU Ostrava

Katedra Stavebních hmot a hornického stavitelství



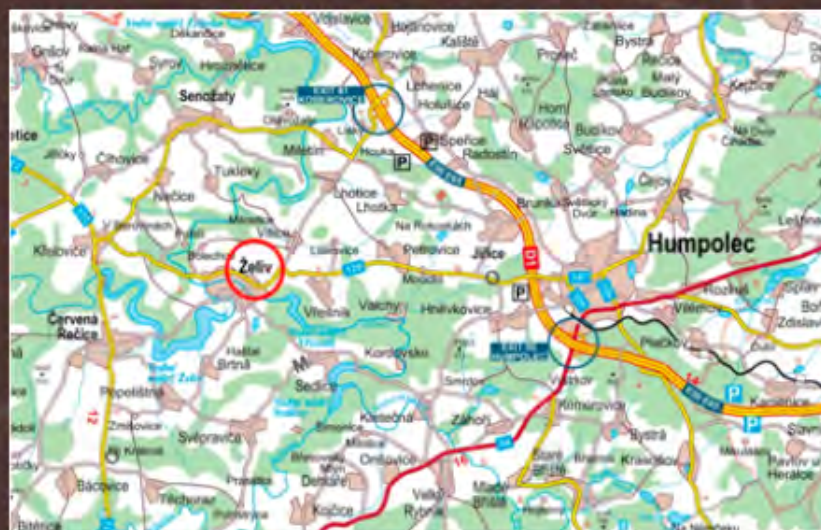
Výzkumný výjezd č.2 - klášterní komplex Želiv



Súčasnosť premonstrátskeho kláštora v Želivě

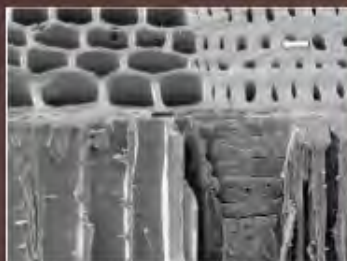


Areál kláštora v Želivě bol
prehlásený za národnú
kultúrnu pamiatku v roku 2010.



V r. 1991 bol areál kláštora navrátený premonštrátom.
V súčasnosti prebieha postupná obnova kláštorného
areálu, ktorej základnou koncepciou je rehabilitácia
funkcií všetkých objektov.

Náročná krokva SZ traktu Prelatury



Obr. 6.1 Vysoký podiel letného dreva, šesťuholníkový prierez letných tracheid - *Larix decidua* Mill.

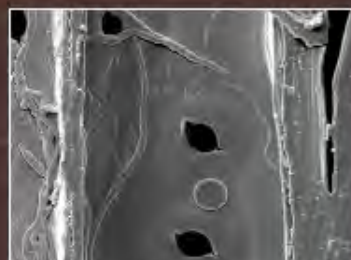


Obr. 6.2 Biseriové usporiadanie dvojbodiek v jamách tracheidách. *Larix decidua* Mill.

Krov konventu



Obr. 8.9 Ruplúra v bunkovej stene jarnej tracheidy (P3)

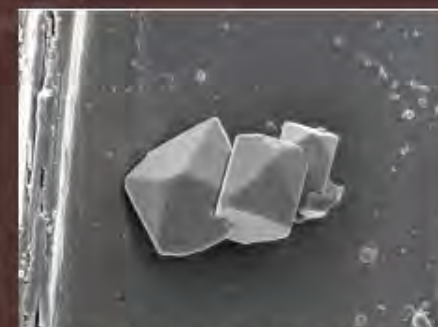


Obr. 8.10 Detail – erózia S3 bunkovej steny, vypadnutý torus, vplyvom enzymatickej činnosti (P6)

Krov konventu



SEM MAG: 2.00 kx
HV: 15.0 kV
VAC: HVVac
DET: SE Detector
DATE: 05/10/12
DETC: TSM10
Výpočtový
Kvalita snímky v dreve - DP TU Zvolen



SEM MAG: 7.00 kx
HV: 15.0 kV
VAC: HVVac
DET: SE Detector
DATE: 09/10/12
DETC: TSM10
Výpočtový
Kvalita snímky v dreve - DP TU Zvolen

Pod'akovanie

Táto práca vznikla predovšetkým
vd'aka zariadeniu
pani **Ing. Jany Havránkovej**
a **Ing. Kristíny Rosíkovej**,
ktoré mi boli nesmierne nápomocné
pri aplikačných prácach a metódach,
spoločnosti **Tescan Orsay Holding,**
a.s. Brno

Moje pod'akovanie patrí
Oddeleniu špeciálnej meracej
techniky,
spoločnosti **Kvant, s.r.o. Bratislava,**
za všestrannú podporu a pomoc.

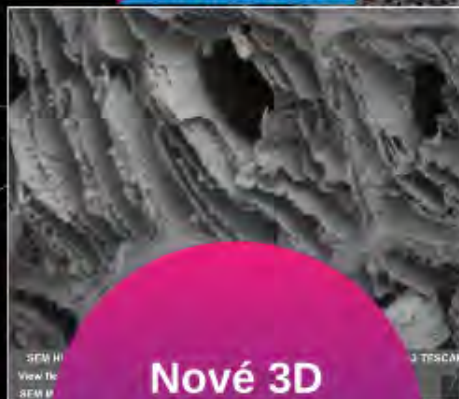


This work was funded by the following subjects: the Scientific Grant Agency of the Ministry of Education SR and the Slovak Academy of Sciences (Grant No. 1/0822/17 "Surface modification of wood and coating materials in order to improve stability of the wood – coating material system."). This paper has been included into the project APVVP-18-0177 "Progressive modifications of the wood surface, film-forming materials and their interactions at the phase interface."

Elektrónová mikroskopia a štúdium drevných štruktúr

Ing. Miroslava Mamoňová, PhD.

22. 9. 2017



**Elektrónová
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**Nové 3D
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APPLICATIONS OF CONTACTLESS MEASUREMENT SYSTEMS IN THE AUTONOMOUS MOBILITY

Prof. Branislav Sitár, DrSc ¹

¹ FMFI UK, Bratislava

Abstract

Universal Autonomous Transport Systems (ATS) with highly organized transport including hundreds of electric Autonomos Guided Vehicles (AGV) working round the clock could be built in large areas. The world development of AGVs can be divided in two basic categories: a) global: individual AGVs moving alongside with the existing traffic. The basic feature of category a) is the effort to replace the human eye by technology, attaching LiDARs, optical cameras and radars to standard vehicles and operating AGVs on ordinary carriageways.

Category b) - local: Autonomous traffic systems. Their characteristic feature is the use of driverless cars only, involving total exclusion of human drivers from a delimited space, which will lead towards increased order in traffic and towards a substantial reduction in the number of accidents. European patent by B. Sitar introduced a “computer friendly” technology “i-cars on i-road” with a very low imput data flow. The tests show, that our AGV navigation system could provide 10 times higer precision, be 10 times faster and 10 times cheaper, than AGV navigation systems based on other technologies.

The implementation of Autonomous Transport Systems brings a number of social, ecologic and economic benefits. The consortium of the top Slovak universities and innovative companies has prepared an industrial-technology platform, with the aim to produce ATS systems for industrial zones, airports, recreation resorts, exhibition grounds, as well as in the new eco-cities worldwide.

Autonómny Transportný Systém

Prof. Branislav Sitár, DrSc. FMFI, Univerzita Komenského, Bratislava

Kvant
22.9.2017, Bratislava



možno rozdeliť do dvoch kategórií:

Globálne riešenie

**Individuálne autonómne vozidlá (AGV)
pohybujúce sa na existujúcich cestách spolu
s vozidlami riadenými ľuďmi**

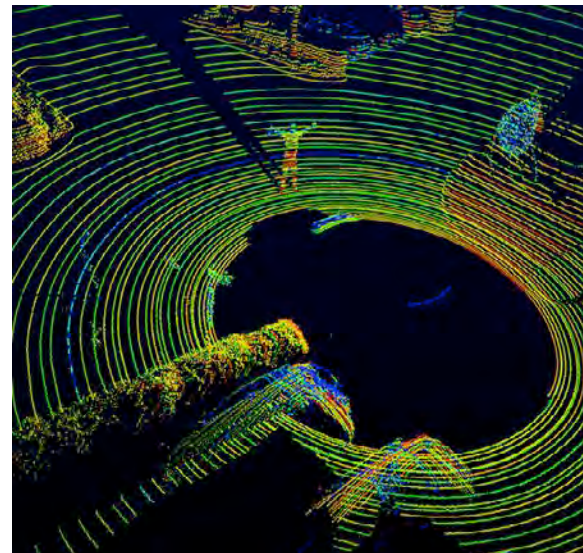
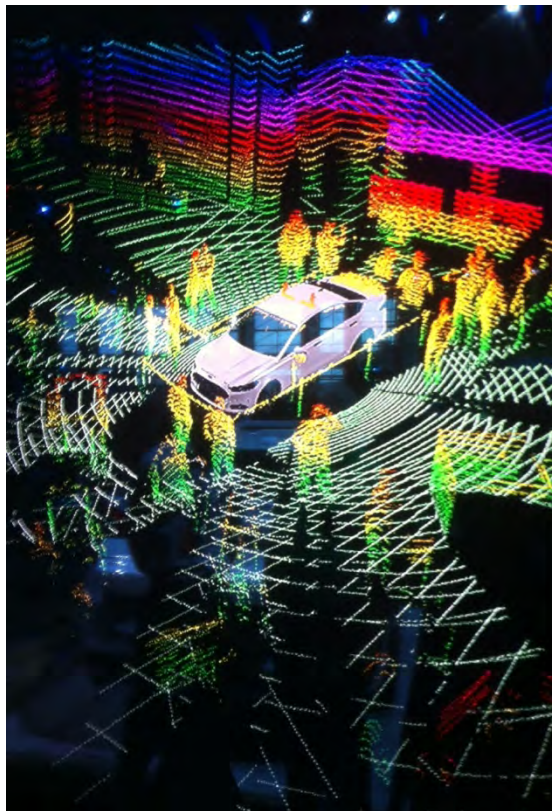
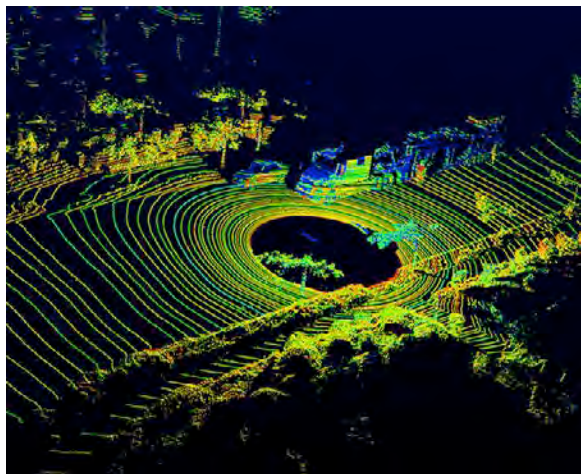
Lokálne riešenie:

Autonómne transportné systémy v ohraničenom území



A. Individuálne autonómne vozidlá
pohybujúce sa na cestách
spolu s vozidlami riadenými ľuďmi

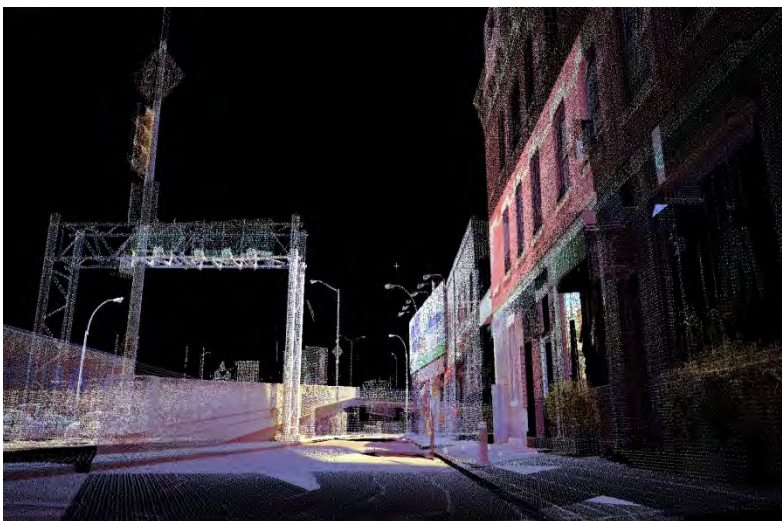
Technológia LiDAR scanning





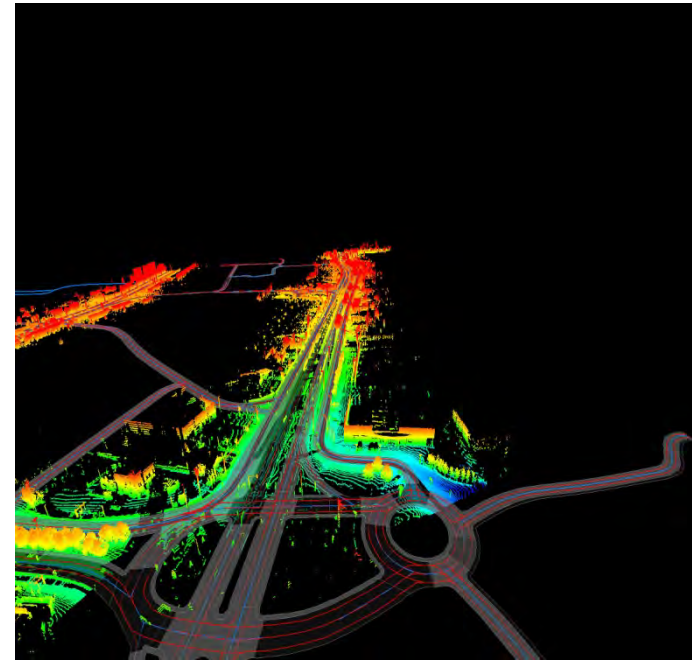
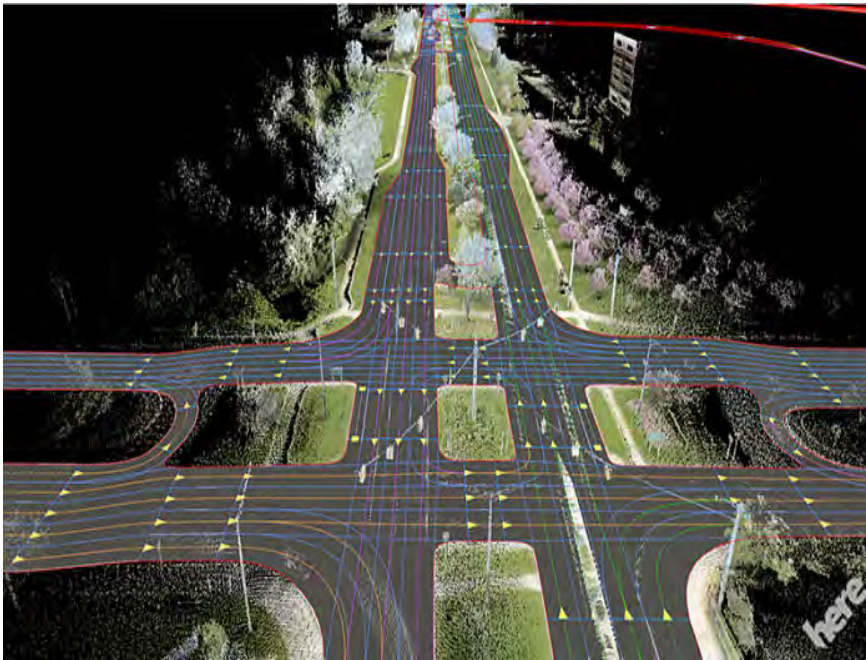
Individuálne autonómne vozidlá
pohybujúce sa na cestách
spolu s vozidlami riadenými ľuďmi

HD mapping: 3D model





Trajectory planning: lines

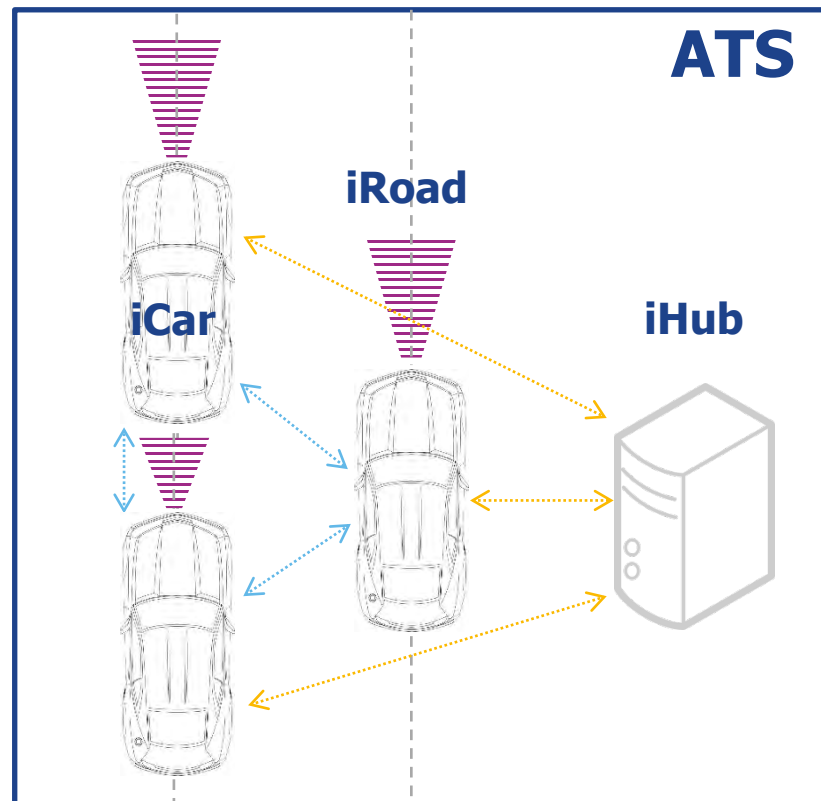


Lokálne riešenie: Autonómny Transportný Systém



ATS funguje na originálnej patentovanej technológii interakcie inteligentného vozidla s inteligentnou vozovkou

- Patentovaná technológia ATS je prispôsobená schopnostiam počítačov, ktoré riadia AGV, je „computer friendly“
- ATS je 10x presnejšie, 10x rýchlejšie, 10x lacnejšie
- Reakčný čas navigačného systému ATS je menej ako 0,1 s
- Schopnosť vyriešiť akúkoľvek dopravnú situáciu, križovatky, parkovanie
- Nízka cena navigačného systému ATS
- Nízka cena infraštruktúry ATS



Porovnanie LiDAR a ATS



ATS „i-cars on i-roads“ technológia

- cena ~ 10 000 EUR



LIDAR technológia so superpočítačom

- cena ~ 100 000 – 200 000 EUR



Porovnanie metód LiDAR scanning a ATS:

Technológia "LiDAR scanning"	Technológia ATS „i-cars on i-roads"
Zložitá: s veľkým tokom informácií, ktorú vie spracovať len supercomputer	Jednoduchá: s malým tokom informácií „computer friendly", stačí obyčajný počítač
Drahá: navigačný systém AGV ~ 100-200 tisíc €	Lacná: navigačný systém AGV ~ 12-15 tisíc €
Pomalá: (10-20 frames/s)	Rýchla: (100 frames/s) – umožňuje rýchlosti nad 100 km
Relatívna: poloha sa určuje len vzhľadom na okolie s presnosťou desiatok cm	Absolútna: poloha sa určuje absolútne s presnosťou ~ 1 cm
Nespolahlivá: znížená kvalita orientácie v daždi alebo snehu	Spolahlivá: funguje bez ohľadu na poveternostné podmienky
Globálna: plánuje sa na globálne použitie	Lokálna: plánujú sa komplexné lokálne systémy



- Univerzálny ATS komplexne vyrieši dopravu v danej lokalite, nákladnú aj osobnú
- Masové nasadenie elektromobilov s vyriešením ich dojazdu
- Výrazné zníženie energetickej náročnosti dopravy
- Vysoko organizovaná doprava permanentne riadená centrálnym počítačom
- Flexibilita – v prípade potreby sa zmeny alebo rozšírenia ATS dajú urobiť v krátkom čase
- Modularita – lokálne ATS systémy je možné ľahko spájať do veľkých celkov
- ATS zachová výhody individuálnej mobility a zároveň prinesie výhody verejnej dopravy

- Investícia do ATS sa podľa štúdie uskutočniteľnosti od Ernst&Young vráti zákazníkovi veľmi rýchlo
- Vozidlá budú plne využité 24 hodín denne, 7 dní v týždni
- Podstatné zrýchlenie dopravy pri znížení nákladov na dopravu
- Automatický prevoz tovarov a materiálov v noci s využitím lacného nočného prúdu
- Náklady na ATS sú neporovnateľne menšie ako náklady na iné autonómne systémy
- Plné využitie súčasnej cestnej siete a priemyselne vyrábaných elektromobilov všetkých typov a veľkostí

Sociálne a ekologické benefity



- Veľmi výrazné zníženie počtu dopravných nehôd na cestách, počtu zabitých aj zranených – veľké úspory liečebných nákladov a straty pracovnej sily
- ATS odvezie individuálne každého: deti, starých aj imobilných
- Masové nasadenie elektromobilov podstatne zníži produkciu emisií a hluku
- Nahradenie fosílnych palív v doprave zelenou elektrickou energiou (hlavne solárnou a z atómových elektrární)

Vytvorilo sa konzorcium silných Slovenských univerzít a inovatívnych firiem

Konzorcium združuje viac ako sto vedcov, vysoko kvalifikovaných špecialistov v odbore IKT a inžinierov rôznych špecializácií

Centrálne riadenie ATS

- Virtual Reality Media, a.s. Trenčín
- Trenčianska Univerzita, Trenčín

Navigačný systém pre bezpilotné vozidlá

- Kvant s.r.o., Bratislava
- VRM a.s., Trenčín
- Fakulta Matematiky, Fyziky a Informatiky, Univerzita Komenského Bratislava

Bezpečnostný systém pre bezpilotné vozidlá

- Kvant s.r.o., Bratislava
- Fakulta Matematiky, Fyziky a Informatiky, UK Bratislava

Riadiaci systém bezpilotných vozidiel

- Ústav Automobilovej Mechatroniky, STU, Bratislava

Telekomunikačný systém ATS

- Ústav Telekomunikácií, STU, Bratislava

Systém počítačovej bezpečnosti v ATS

- Beset s.r.o., Bratislava

Za predpokladu, že štát podporí výskum a vývoj v smere Autonómna mobilita:

- Je tu príležitosť **dostať Slovensko do svetovej technologickej ligy** a zvýrazniť imidž Slovenska ako modernej priemyselnej krajiny
- Slovensko môže vybudovať a prevádzkovať **prvý „Smart Industrial Park“** aj **jedno z prvých Smart City na svete**
- Slovenský priemysel môže **vyrábať a exportovať autonómne dopravné systémy** na mnohé miesta vo svete, na letiskách, v priemyselných areáloch, v rezortoch oddychu, výstavných priestoroch a tiež nových **Smart Cities**
- Zo štrukturálnych fondov EU sa na podporu významných a strategických projektov sa práve v týchto týždňoch rozdeľuje 1,044 miliardy EUR.
Bude v tom zahrnutá aj Autonómna mobilita?

SMART CUSTOMIZATION OF 3D SENSORS WITH APPLICATION SPECIFIC ALGORITHMS

Andreas Hoffmann¹

¹ Application Engineering Team lead EMEA, LMI Technologies

Abstract

Solving specific application needs is one of the challenges in today's 3D sensor market. A modern factory cannot only care about speed, but also has to reach a high precision in quality control through accurate and reliable measurement data. In order to achieve this, LMI will demonstrate different options that allow the user to adapt 3D smart sensors to solve their unique inspection problems. With the help of real life examples, LMI will explain how software developers can test their own applications in a safe offline environment without the need for a physical sensor. Also how working with large 3D point clouds can be simplified by adding the data-processing power of one or more PCs to an inspection solution. Additionally, the presentation will highlight how users can develop custom measurement algorithms that run directly on 3D smart sensors. This extends the functionality of the sensors and allows for the flexibility needed in a fast changing environment.



SMART CUSTOMIZATION OF 3D SENSORS WITH APPLICATION SPECIFIC ALGORITHMS

2nd International Conference 3D Measurement and Imaging

22 September 2017

Andreas Hoffmann
Application Engineering Team lead EMEAR

CONFIDENTIAL



LMI TECHNOLOGIES

ABOUT LMI TECHNOLOGIES



QUICK FACTS



Owned by TKH Group

39+ years experience
1978 – Present



*One of our
Selcom
displacement
sensors
developed in the
1970s*

**100+ patents
and 220+
employees**



**110,000+ sensors
in the field**



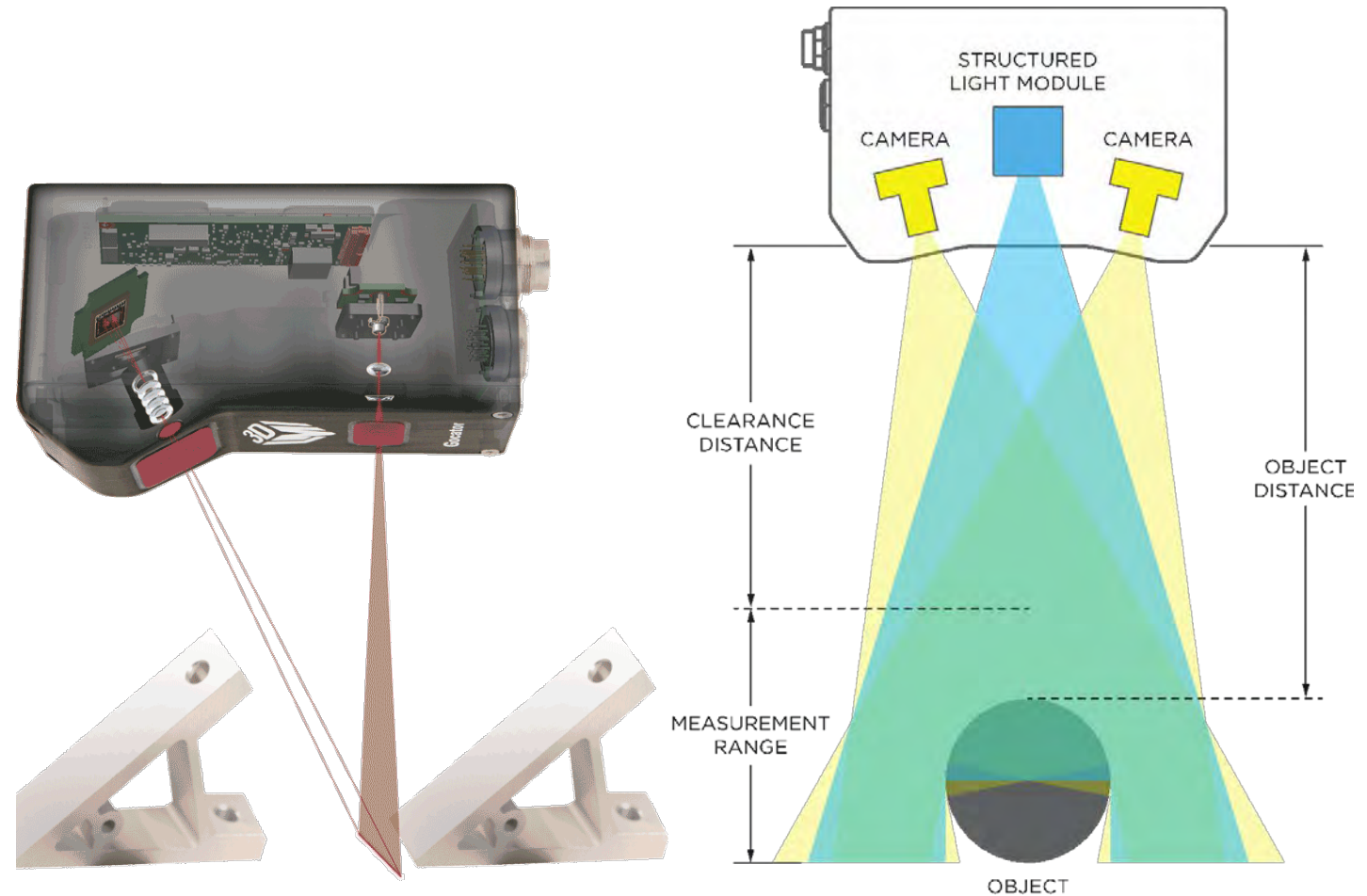
ABOUT LMI TECHNOLOGIES

Gocator



TYPICAL INLINE MEASUREMENT DEVICES

- » 3D Sensor Technologies:
 - Laser triangulation
 - Structured light
- » Industrial housing
- » Calibrated once in the factory, holds accuracy in industrial environments
- » Embedded processing makes hardware “smart”



SMART 3D-SENSORS



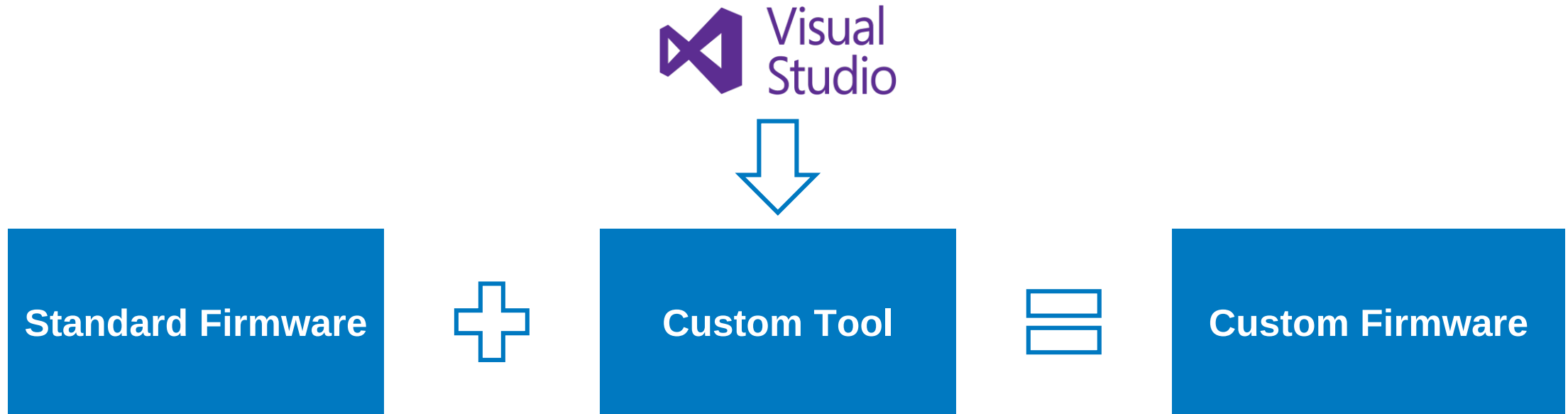
EXTENDABLE 3D SENSOR OVERVIEW



- » Core Hardware/Software platform
 - ◉ Acquisition Modules
 - ◉ Measurement Tools
 - ◉ Interface Modules
- » Open Programming Interface
- » Open Tool Interface
 - ◉ Native Sensor C API
 - ◉ Visualisation Functions
 - ◉ 3rd Party Library Support

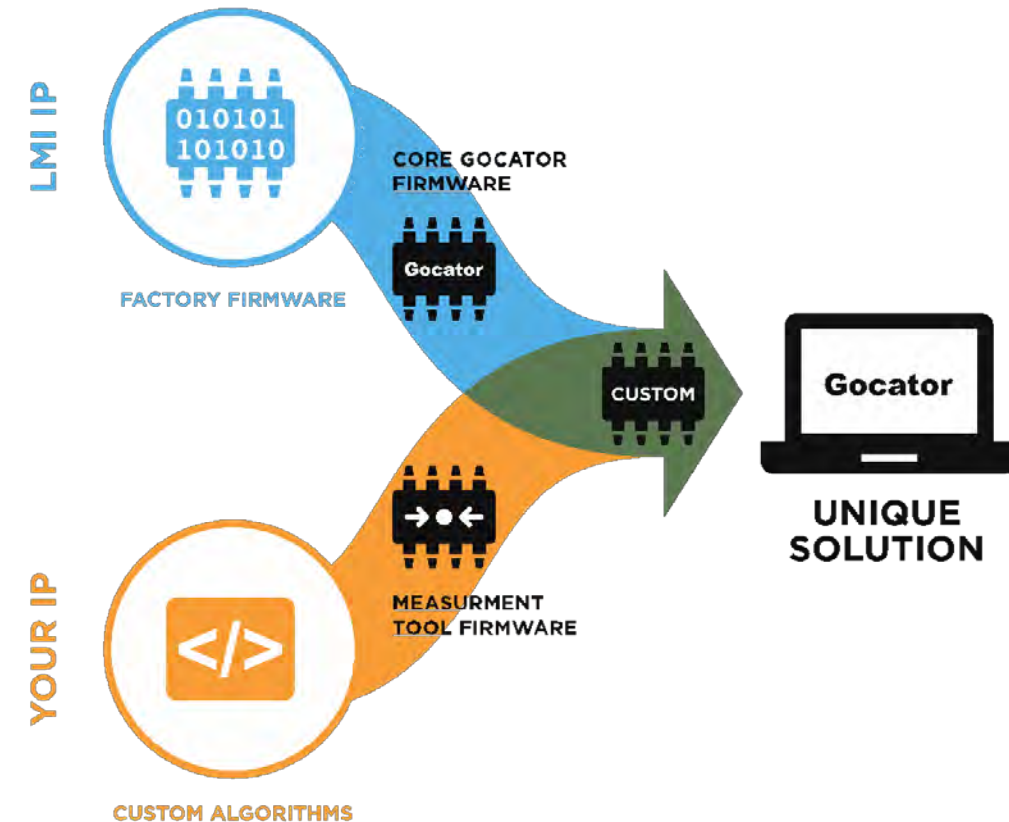


GOCATOR DEVELOPMENT KIT (GDK)

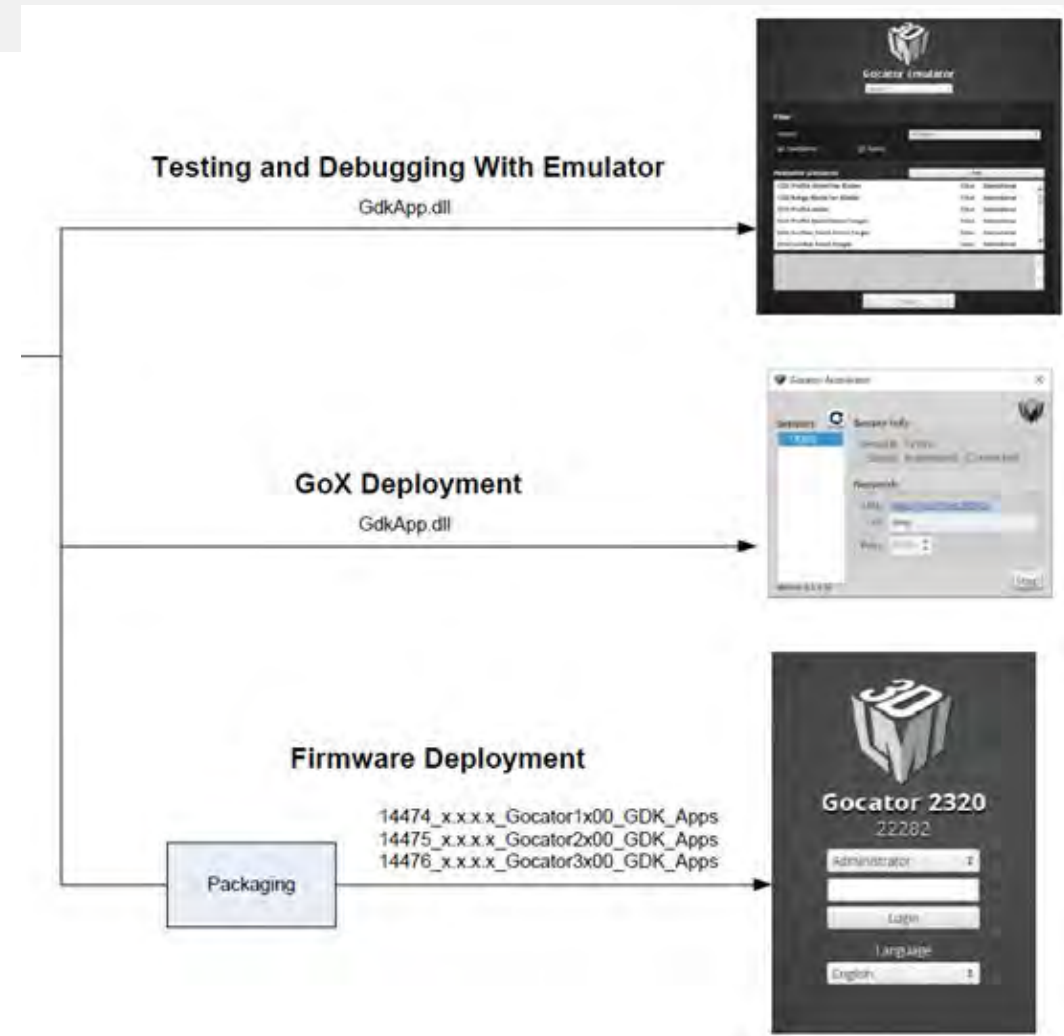


GOCATOR DEVELOPMENT KIT (GDK)

- » Users customize their Gocator for even more control over the inspection process
- » Extend the Gocator firmware
- » IP and pricing protection
- » Integrators can modify their algorithm on-site
- » Reduces development and integration time



GOCATOR DEVELOPMENT KIT (GDK)



GOCATOR DEVELOPMENT KIT (GDK)

```
min = profileData[regionStartIndex];

numHighPeaks = 0;
numLowPeaks = 0;

// loop through region
for (i = regionStartIndex; i <= regionEndIndex; i++)
{
    if (profileData[i] != k16S_MIN && ((profileData[i] > regionZStart) && (profileData[i] < regionZEnd)) && deltaInt > 0)
    {
        // find max
        if (profileData[i] > max)
        {
            maxPos = i;
            max = profileData[i];
        }
        // find min
        if (profileData[i] < min)
        {
            minPos = i;
            min = profileData[i];
        }

        if (detectHighPeak && profileData[i] < max - deltaInt)
        {
            if (numHighPeaks >= maxHighPeaks) /* not enough spaces */
                kThrow(KERROR_ABORT);

            highPoints[numHighPeaks].x = maxPos * GdkDataInfo_Scale(itemInfo)->x + GdkInputItem_Offset(item)->x;
            highPoints[numHighPeaks].y =
            highPoints[numHighPeaks].z = profileData[maxPos] * GdkDataInfo_Scale(itemInfo)->z + GdkInputItem_Offset(item)->z;
        }
    }
}
```

algorithm example

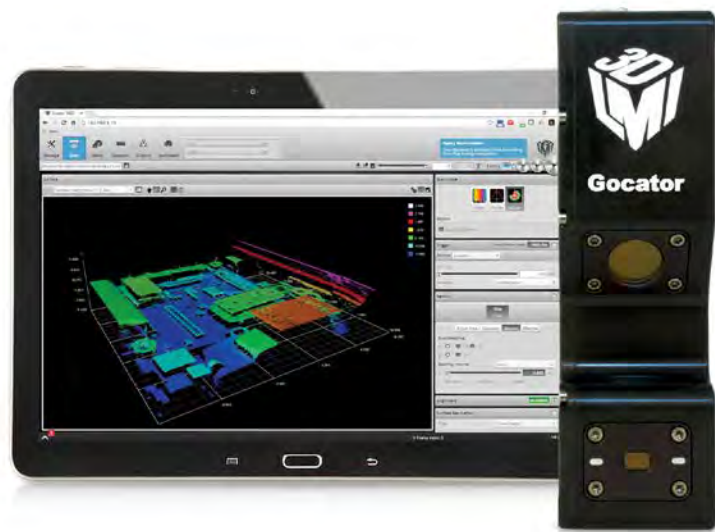


CAPABILITY

- » Allows FAE/AE and users to develop measurement tools for customers
 - ⦿ With same capability as internal tools.
- » Covers all Gocator series running on FW 4.x
- » Supports Range, Profile, Surface and Intensity data
- » Works with Gocator Emulator, Gocator accelerator, and actual sensor
 - ⦿ Accessible from web interface, SDK and PLC protocols etc



WHY AND WHEN NEED A GDK TOOL



SENSOR



CONTROLLER



3D CONTROLLER



SENSOR



CONTROLLER



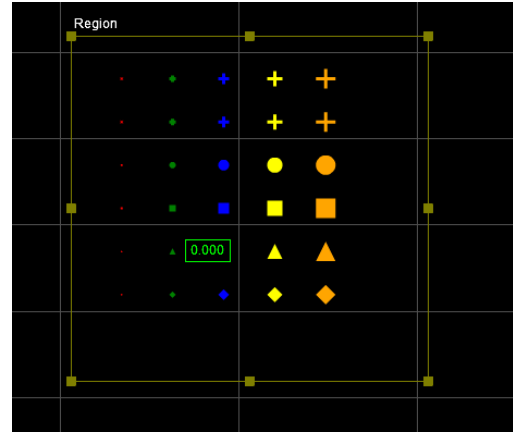
3D SOFTWARE

Sensor head only, no PC or controller required
3D point cloud and surface tools without extra
controller/processor.

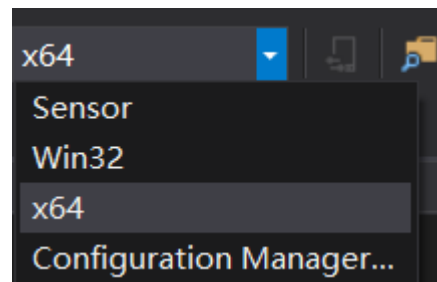


WHAT IS GOCATOR DEVELOPMENT KIT

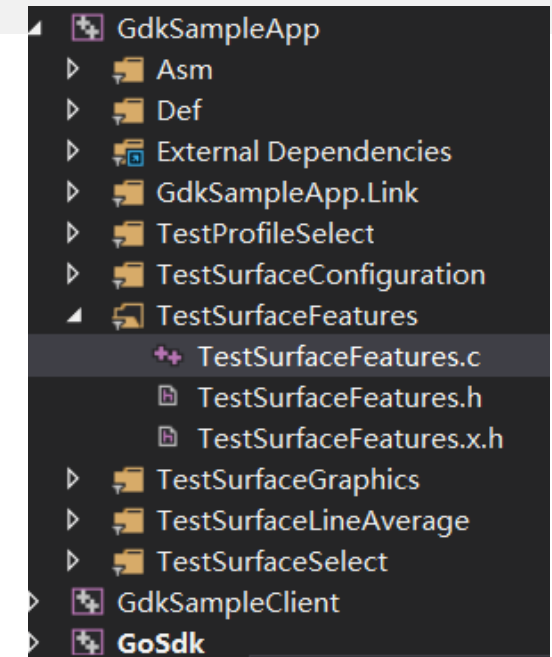
Graphic Rendering capabilities



Cross-platform
integrated
environment



Reduced
development and
integration Time



Easy Hands-on
sample code for
both profile and
surface tools



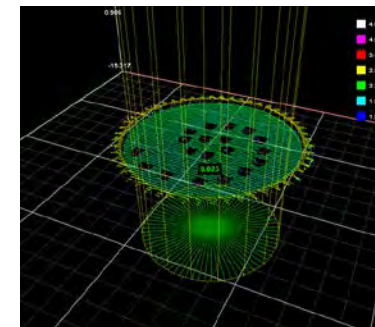
HOW DOES IT WORK

- » Register Tool
Framework can thus
identify your tool



```
kBeginAssembly(Tool, ToolAsm, TOOL_VERSION, GOCATOR_VERSION)
kAddDependency(GdkLib)
kAddType(TestProfileSelect)
kAddType(TestSurfaceSelect)
kAddType(TestSurfaceConfiguration)
kAddType(TestSurfaceGraphics)
kAddType(TestSurfaceLineAverage)
kAddType(TestSurfaceFeatures)
kEndAssembly()
```

- » Implement tool runtime functions
 - VDescribe: Define parameters, feature and measurement outputs
 - Vstart: Called when sensor start, resource allocation and initialization
 - Vprocess: Main place to implement your algorithm
 - Vstop: Called when sensor stops, resource release and cleanup

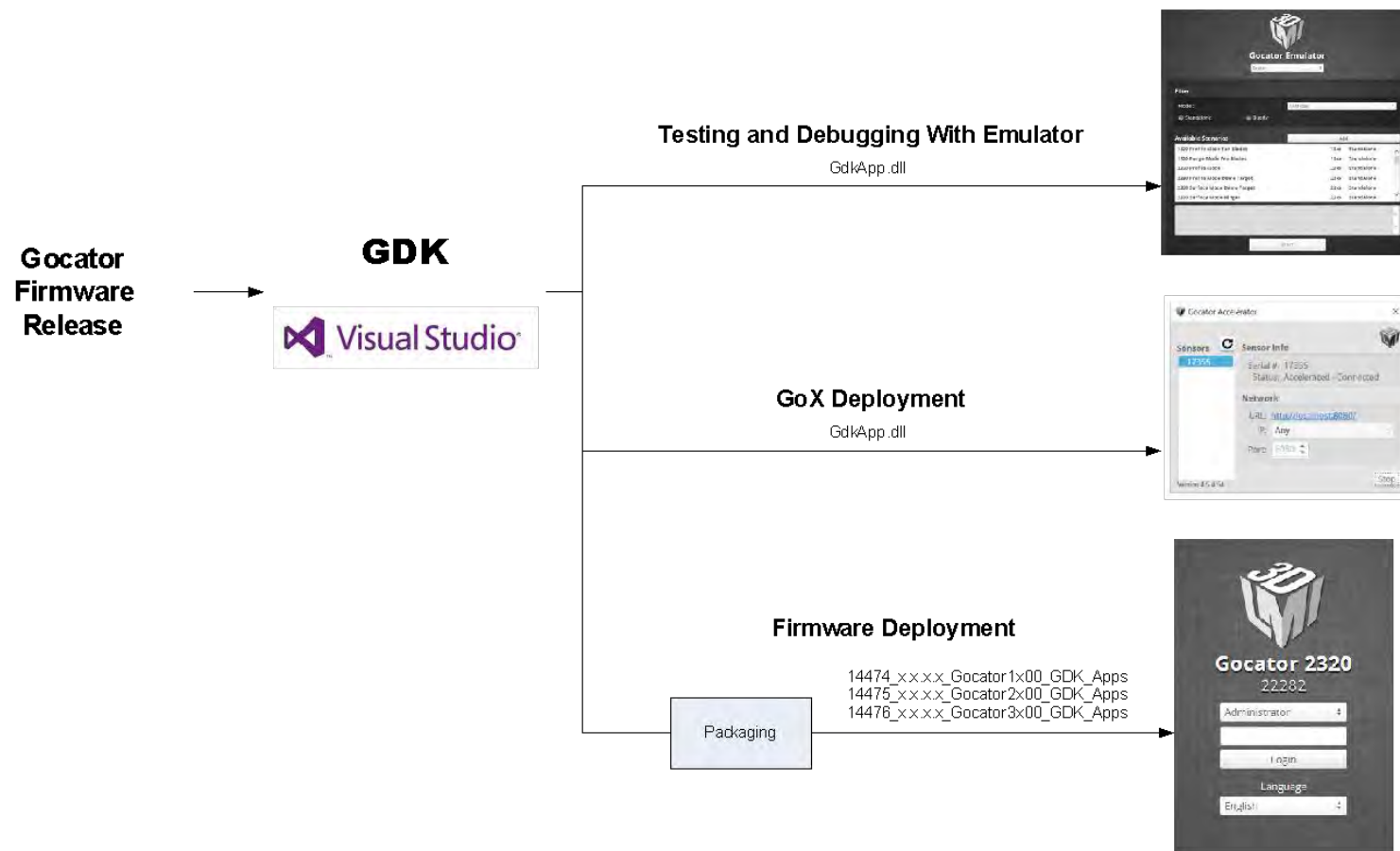


WORKFLOW

When using GoX, Sensor does NOT require firmware with the GDK tool

Why is this important?

Allows integration with 3rd party software



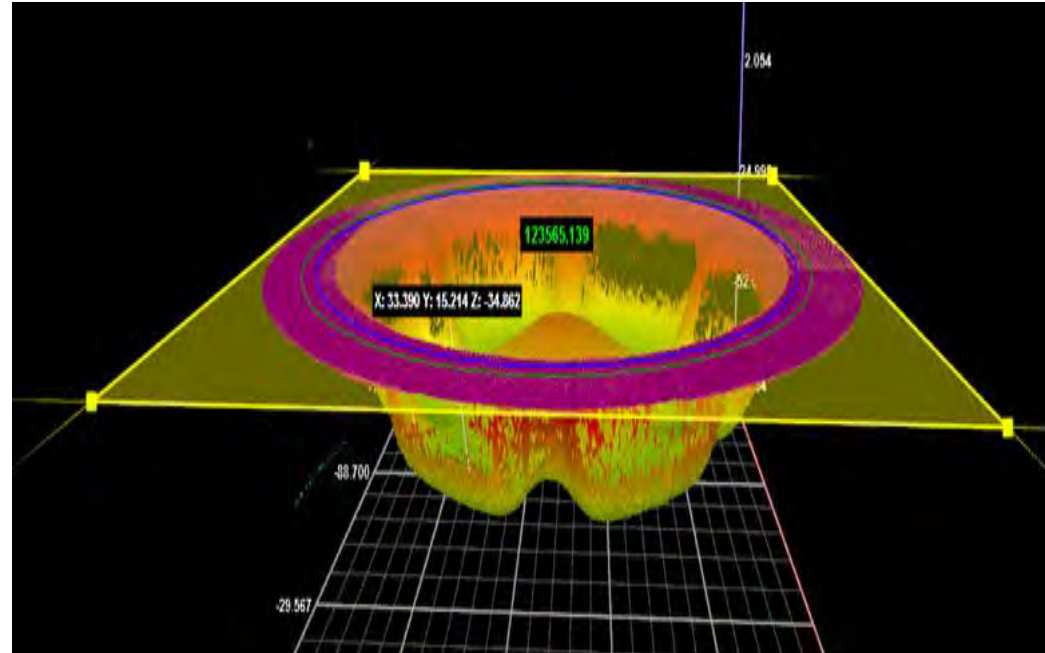


WORKFLOW



VISUALIZATION

- » Create regions, lines and points on the visualizer.
- » Graphics on 2D and 3D visualizer



APPLICATION EXAMPLES

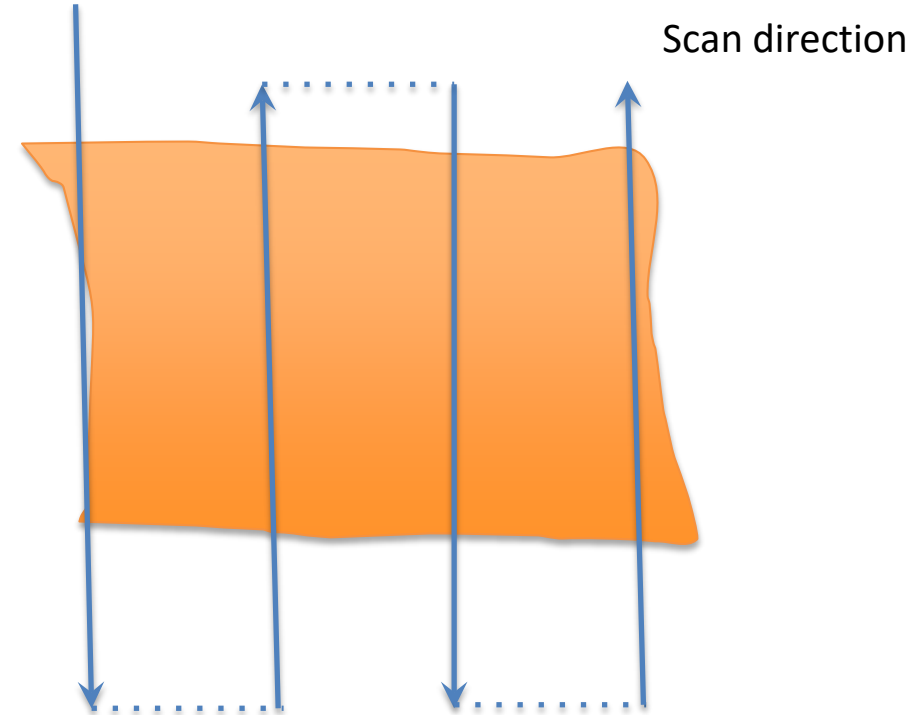
APPLICATION EXAMPLES

- » State machine based processing
- » Application specific measurements
- » Combine intensity and 3D height map processing
- » 3rd party library and camera integration
- » IP and pricing protection



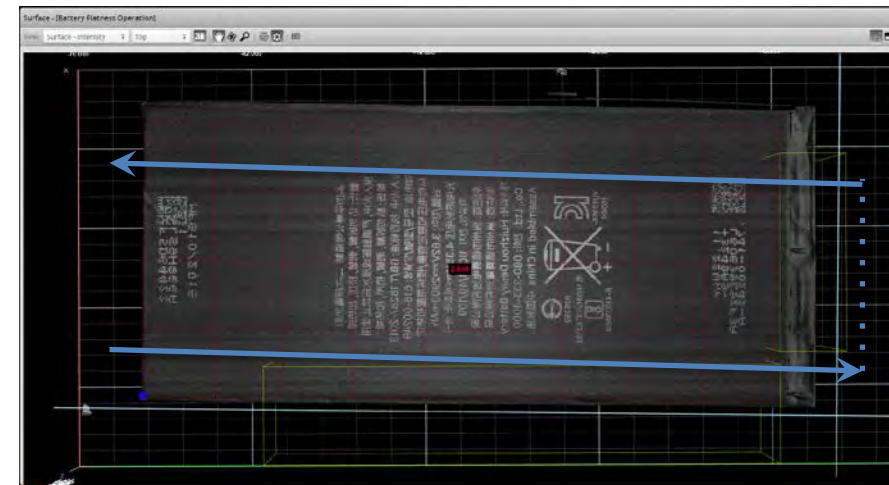
STATE-MACHINE BASED PROCESSING

- » Scans are processed differently based on the position in the sequence
- » Sensor mounted on a robot / transport to scan over a large part
- » Example: Battery flatness



BATTERY FLATNESS APPLICATION

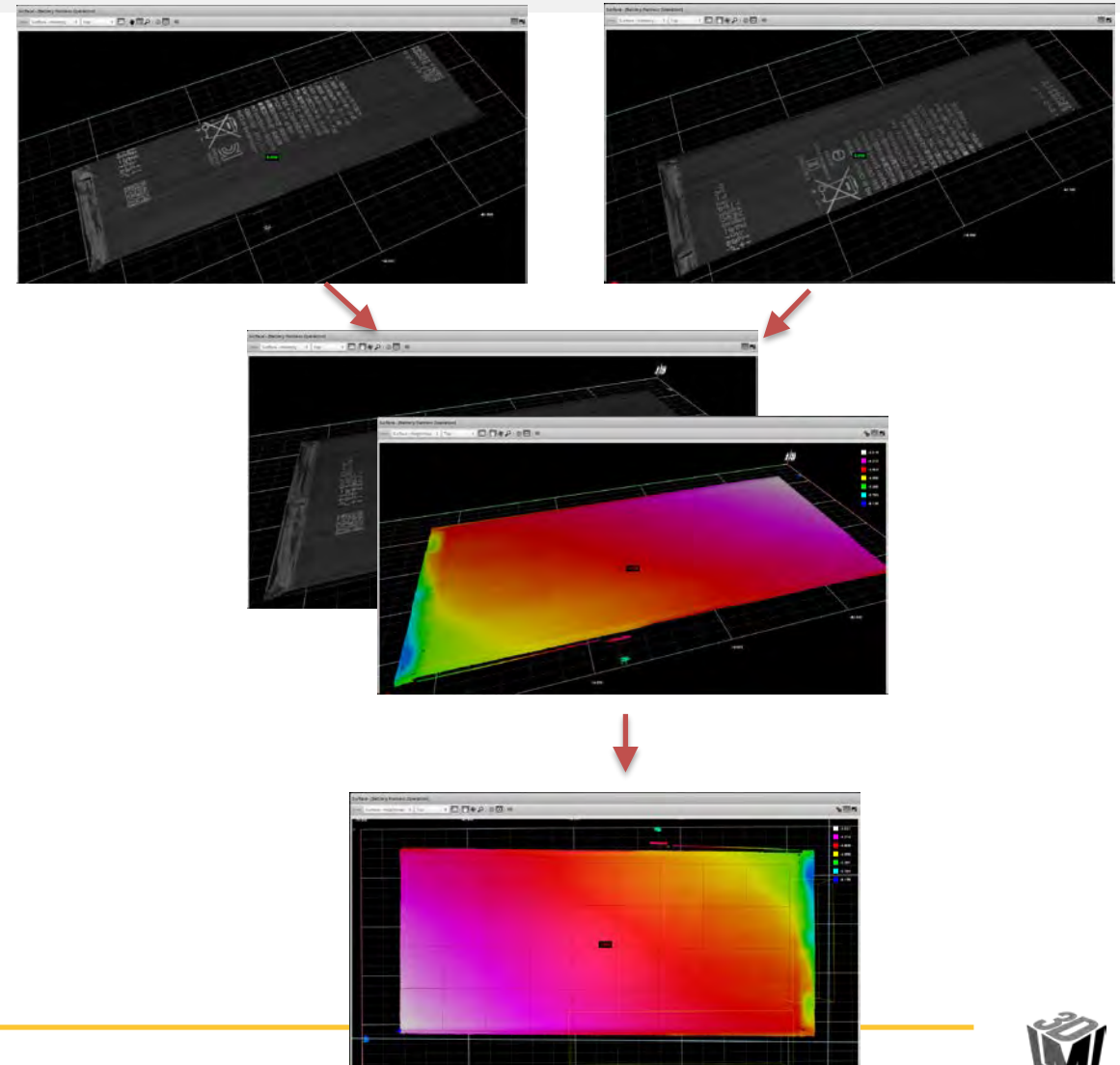
- » Customer wants to measure flatness in different regions of a battery
 - ◉ Dimension ~ 50mm*120mm;
 - ◉ Repeatability within 10um;
 - ◉ CT within 2 seconds;
 - ◉ Whole region is divided into 36 sub-regions (4*9 grid);
 - For each sub-region, the flatness is calculated;
 - A flatness number is also calculated for the whole grid region;
 - ◉ Cost effective;
 - ◉ Real time visualization;



BATTERY FLATNESS APPLICATION

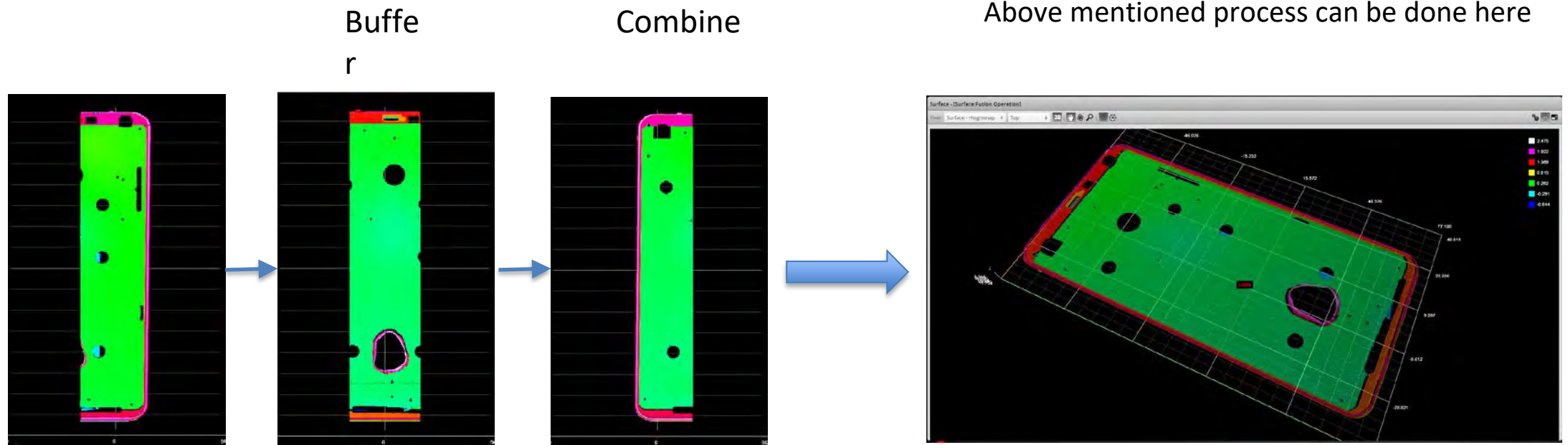
» Applications

1. G2420 scanning twice;
 - 3kHz frame rate;
 - 0.1mm Y resolution;
2. Stitch the data together
 - Based on motion slide movement;
3. Locate the part based on edge detection;
4. Measure flatness in required regions;



COMPLETE ENCLOSURE INSPECTION

» Data combine



SPECIALIZED SHAPE / DEFECT MEASUREMENTS

- Anchoring/Alignment,
- Filtering,
- Measurement
- Inspection
-

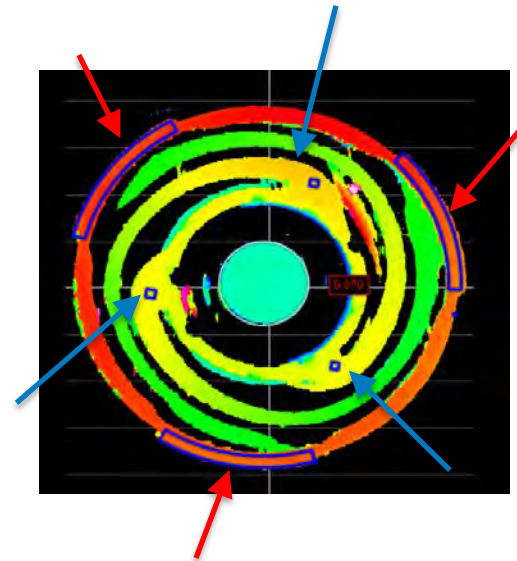


**Customization
Needed!**

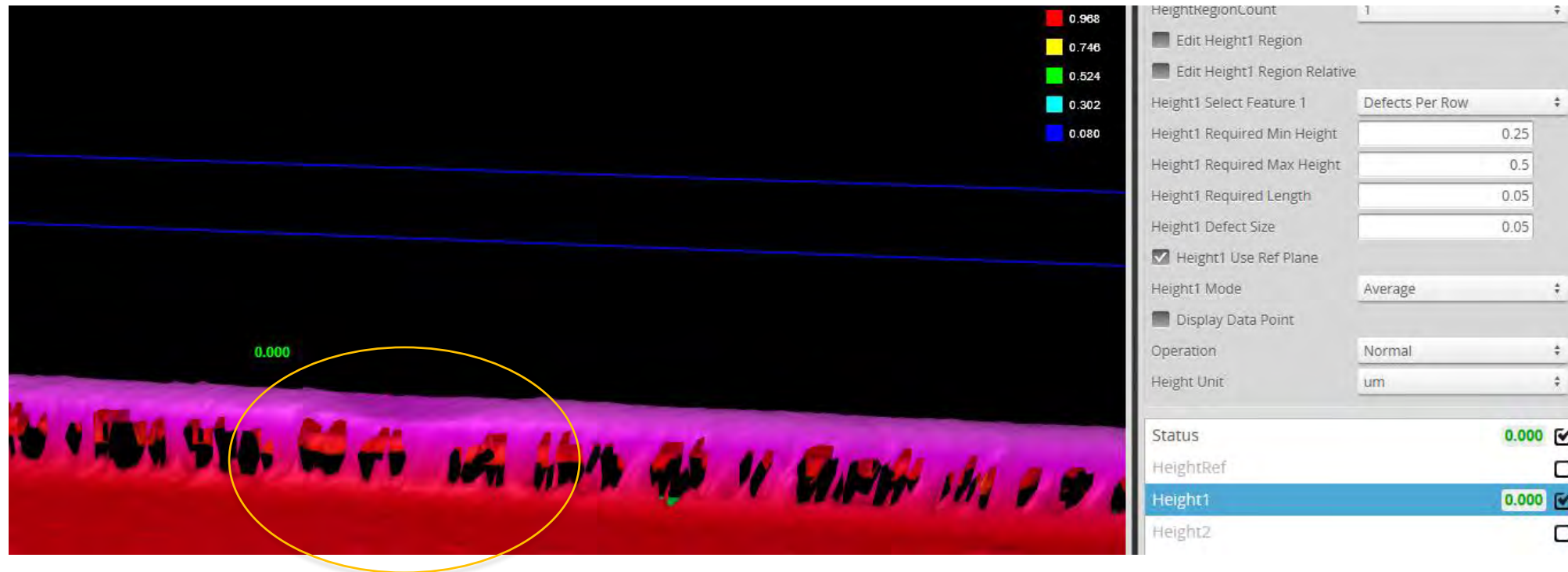


APPLICATION-SPECIFIC DETECTION REGIONS

- » Customer wants to measure the maximum height from the RED region to BLUE region;
 - Sample Size 9mm;
 - CT 1 second;
 - Repeatability 10um;
- » Algorithm
 1. Locate the center and rotation;
 2. Get points in 3 blue region and fit a plane;
 3. Calculate the distance from each point in red region to ref plane;
 4. Find maximum distance;
 5. Output measurement value and OK/NG;

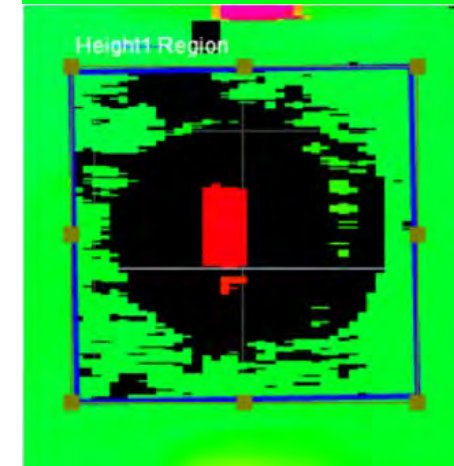
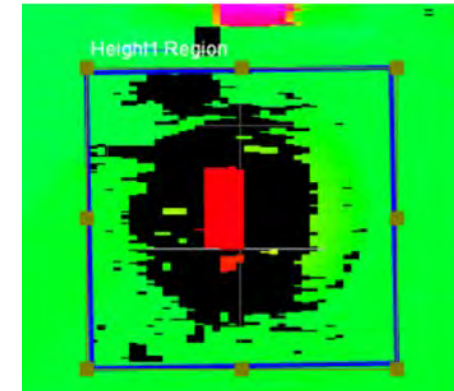
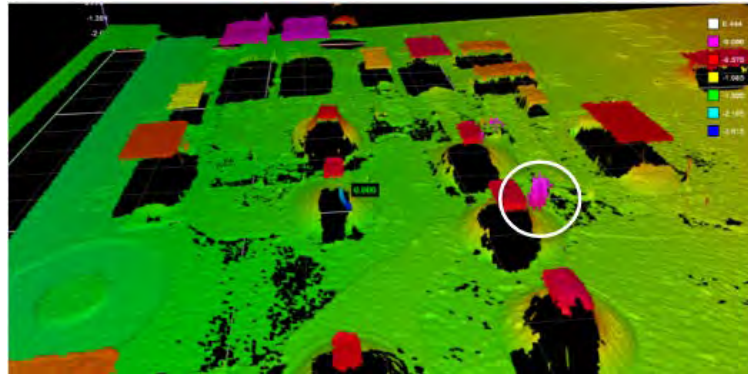
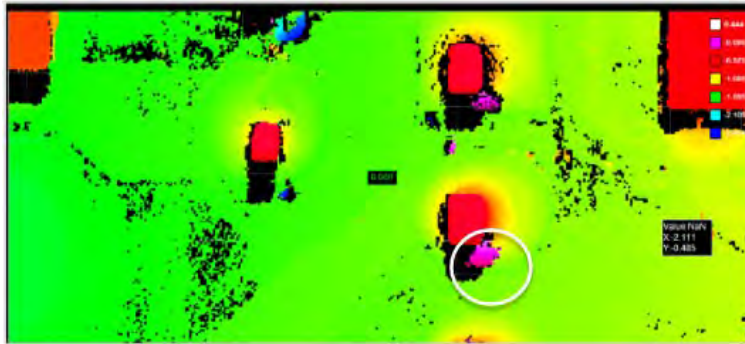


APPLICATION-SPECIFIC SHAPE / DEFECT DETECTION



APPLICATION-SPECIFIC FILTERING

» Filtering algorithm tailored using the knowledge of the whole surface and part positions



COMBINED INTENSITY AND 3D HEIGHT MAP PROCESSING

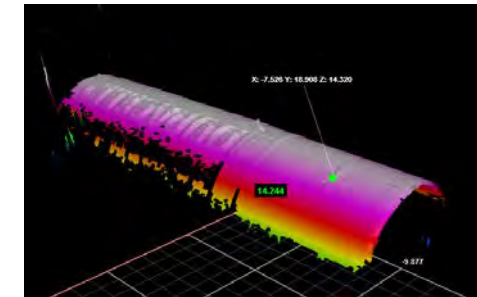
Measure
position at
the cross
point



Locate cross
position using 2D
image
processing

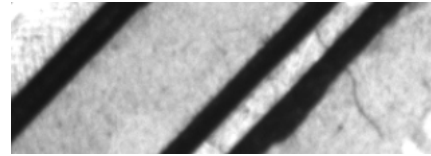


Locate cross
position using
2D image
processing

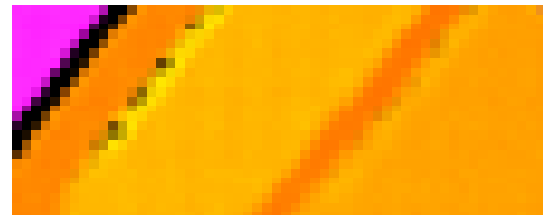


INTEGRATE WITH 3RD PARTY LIBRARY OR CAMERA

5MP
photos



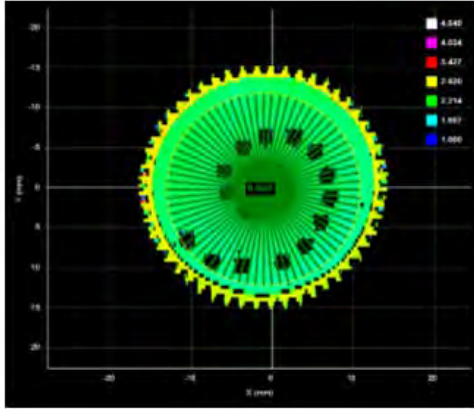
Gocator
height
map



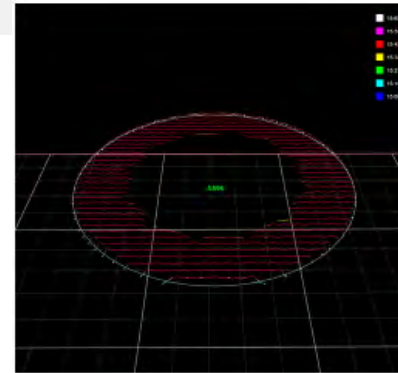
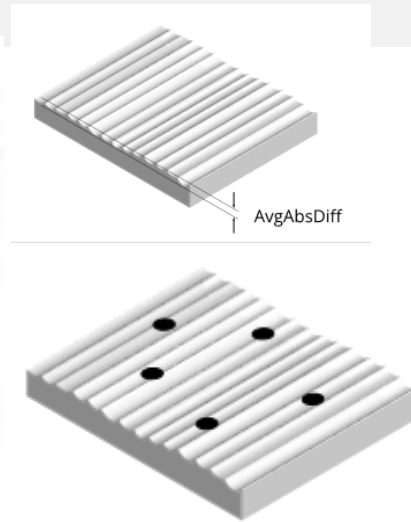
IP AND PRICING PROTECTION



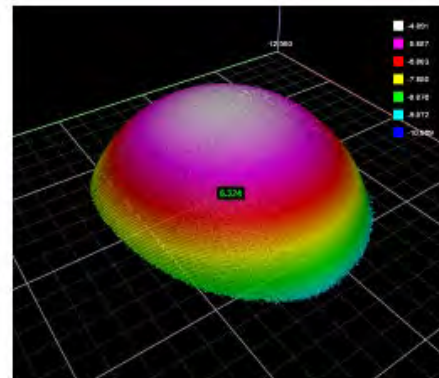
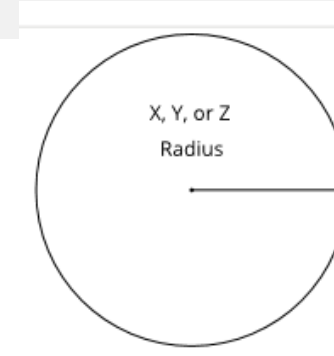
GDK – PRE-BUILT CUSTOM TOOLS



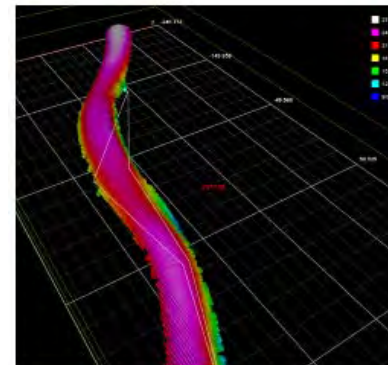
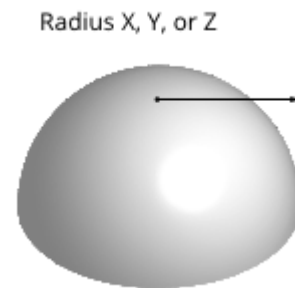
Radial surface texture



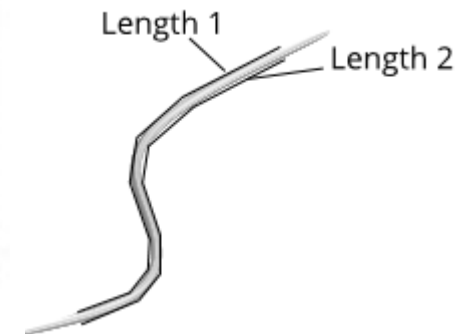
Surface circle fit



Sphere fit

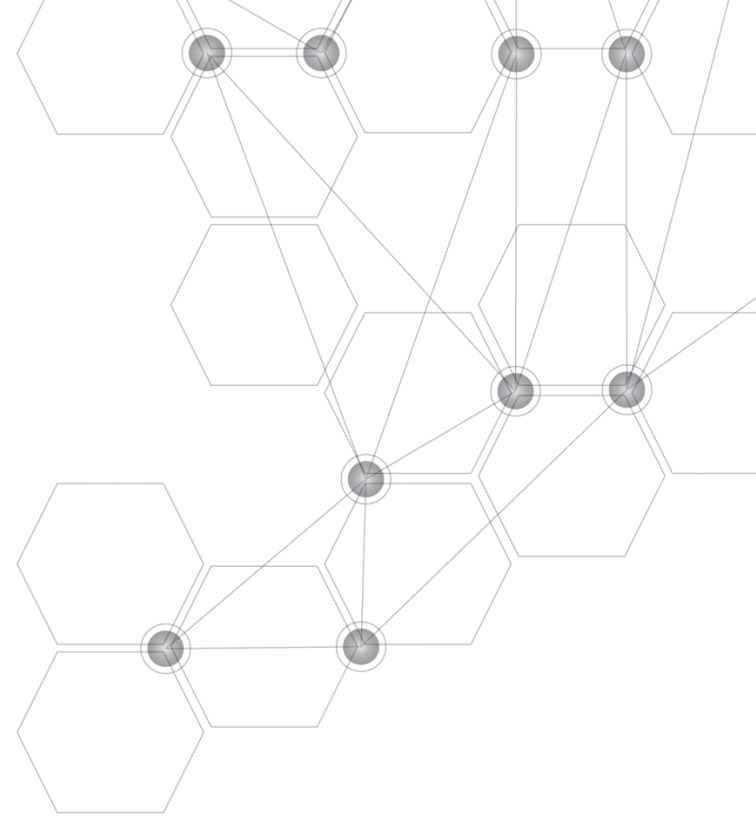


Irregular length





LMI TECHNOLOGIES



INSPECTION AND DETECTION OF MATERIALS USING LINE SCAN CAMERAS

Pavol Polóni¹

¹ Camea

Abstract

UniscanDETECTOR is a visual inspection system designed for defect detection on metal plates, nonwoven textiles, foils, paper, etc. System was developed as highly modular. It is therefore fully configurable according to customer's requirements. It can be used in various phases of production process, including slitting quality inspection.

For surface scanning the system uses fastest line-scan cameras actually in production with bandwidth over 20 Gb/s. This also brings the need for high quality illumination of material, which was developed specially for this purpose in the form of an advanced LED unit. Thanks to the use of state-of-the-art components UniscanDETECTOR is able to detect defects as small as 0,1 mm² at speeds up to 2000 m/min and strip width up to 5 m.

Inspection results are visualized in real-time on several distributed consoles to provide a feedback for output quality of material. Operator can therefore instantly respond and eliminate rising problem in the shortest possible time. Significant impact for production efficiency is given by the fact that detected defective product doesn't have to be uselessly processed further. All inspection reports are also archived and statistically processed to provide an overview of long-term production quality development.

APLIKÁCIE V PRIEMYSLE

APLIKÁCIE V DOPRAVE



Kontinuální
sledování pásů



Kontrola lahví



Kontrola součástek



3D rekonstrukce



Kontrola potisků



Vážení vozidel za
jízdy



Dopravní přestupky



Monitorování
dopravy



Identifikace vozidel



Technologie

CAMEA vo svete

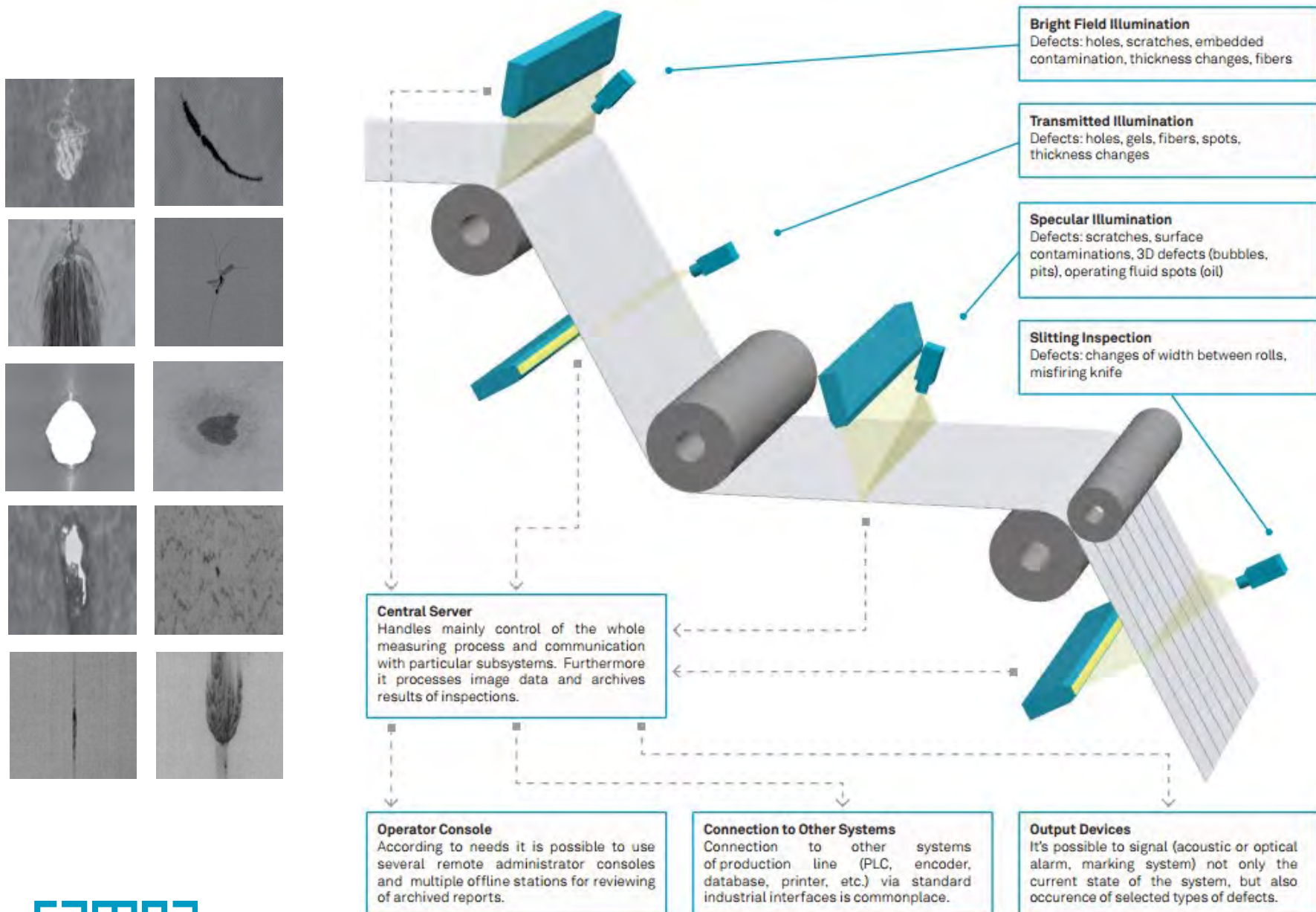


Aktuální prehľad inštalácií v doprave

Servis	Stát	Město	MUR/SDDÚ	SPEED	DJČ	WIM	DD	KTDS	Kamera	Rozvaděč
Ano	ČR	Zlín	5						12	11
Ano	ČR	Šternberk		2					2	2
Ano	ČR	Praha	79	37	20	8	74	160	654	239
Ano	ČR	Bílina	1						4	4
Částečně	ČR	Ústí n/L, D8	6	2	11	2	2		58	33
Částečně	ČR	Ostrava, Klimkovice	2	3	1				15	8
Částečně	ČR	Brno	1		1	1			8	5
Podpora	ČR	Kladno	1		2				9	9
Částečně	Polsko	-	33			15			170	66
Podpora	Rakousko	-				11			20	
Podpora	Mexiko	-				6			18	6
Podpora	Itálie	Tierst	1						8	2
Podpora	Rusko					44			128	44
Podpora	Kazachstán					4			12	4
-	Keňa					4			17	13
CELKEM			129	44	35	87	76	160	1135	446

UniscanDETECTOR

SEA 2017



camea

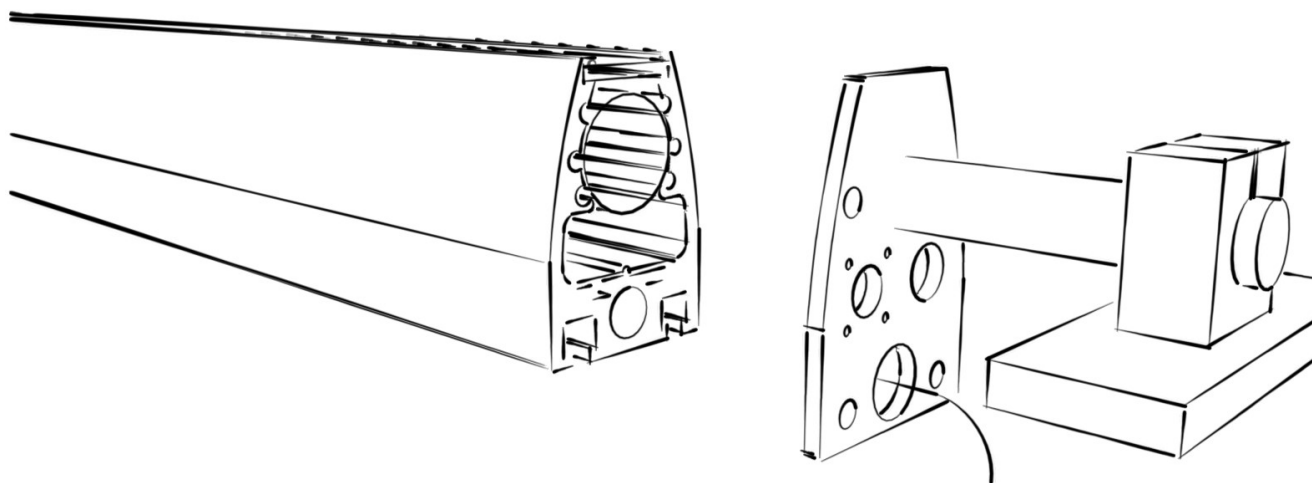
Novinky

- » Tipický systém 300 x 300 μm pri 4,5 m šírke a 1200 m/min
 - » Kamery 70 kHz 4096 pix.... 280 MB/s
- » Upgrade na 100 x 100 μm pri 4,5 m šírke a 1200 m/min
 - » Kamery 200 kHz 11000 pix.... **2200 MB/s na 1 kameru**

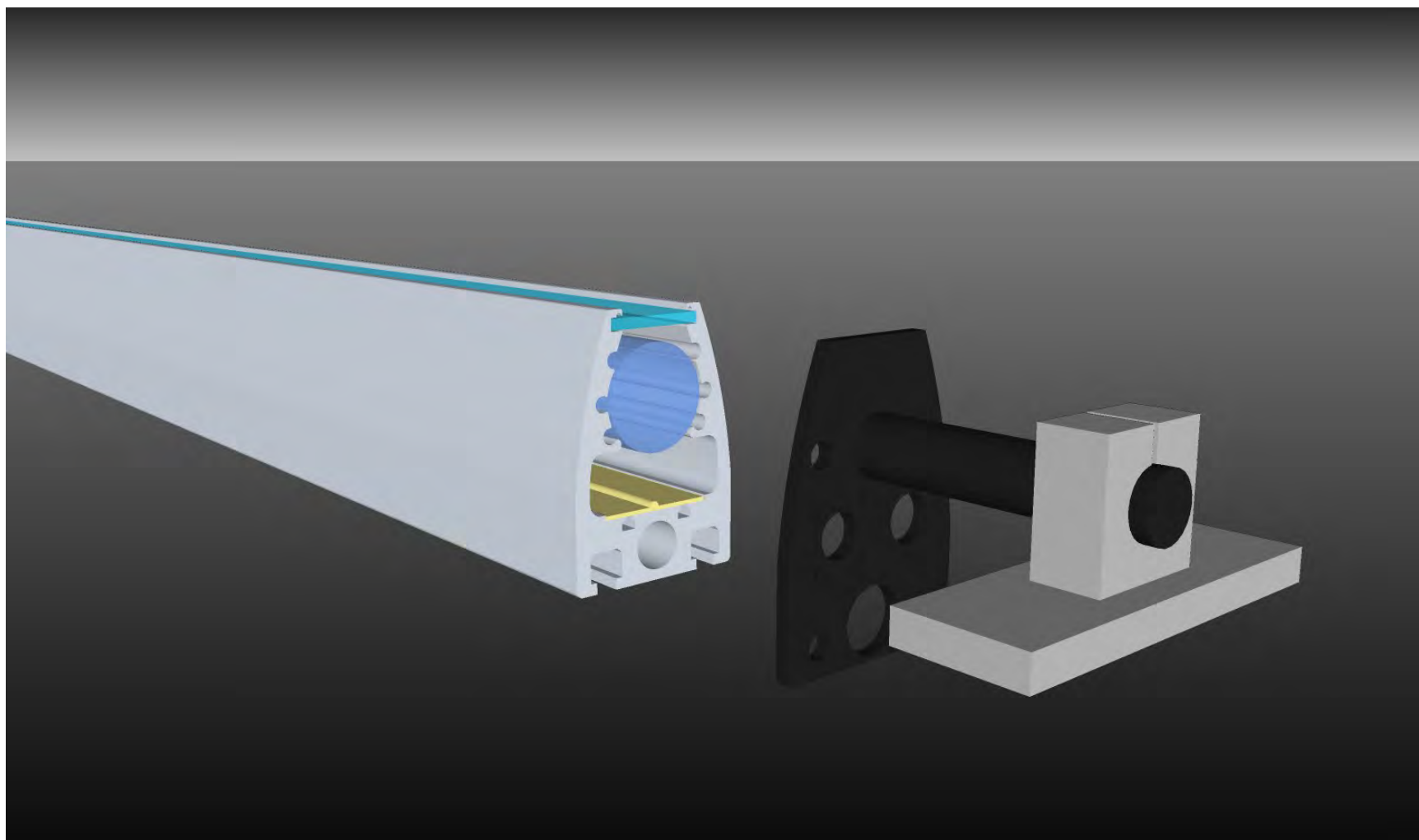


Líniové LED svetlo

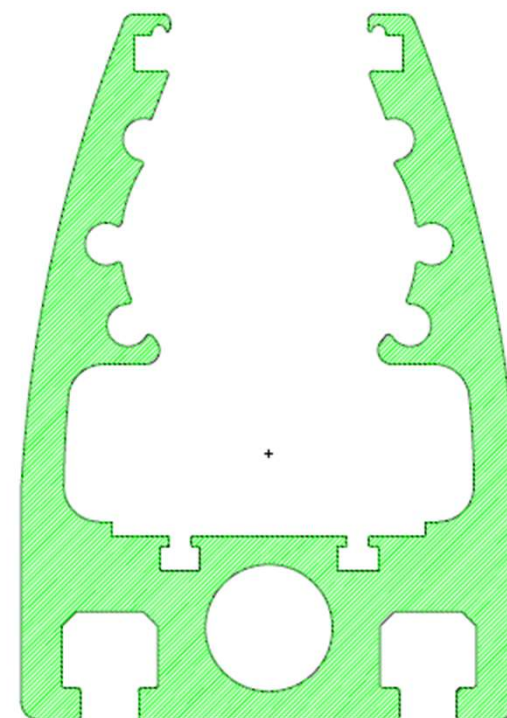
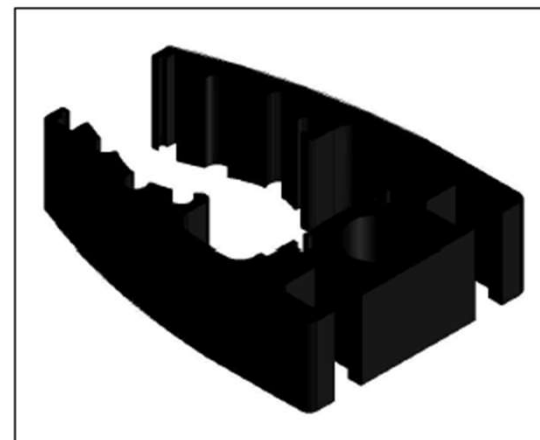
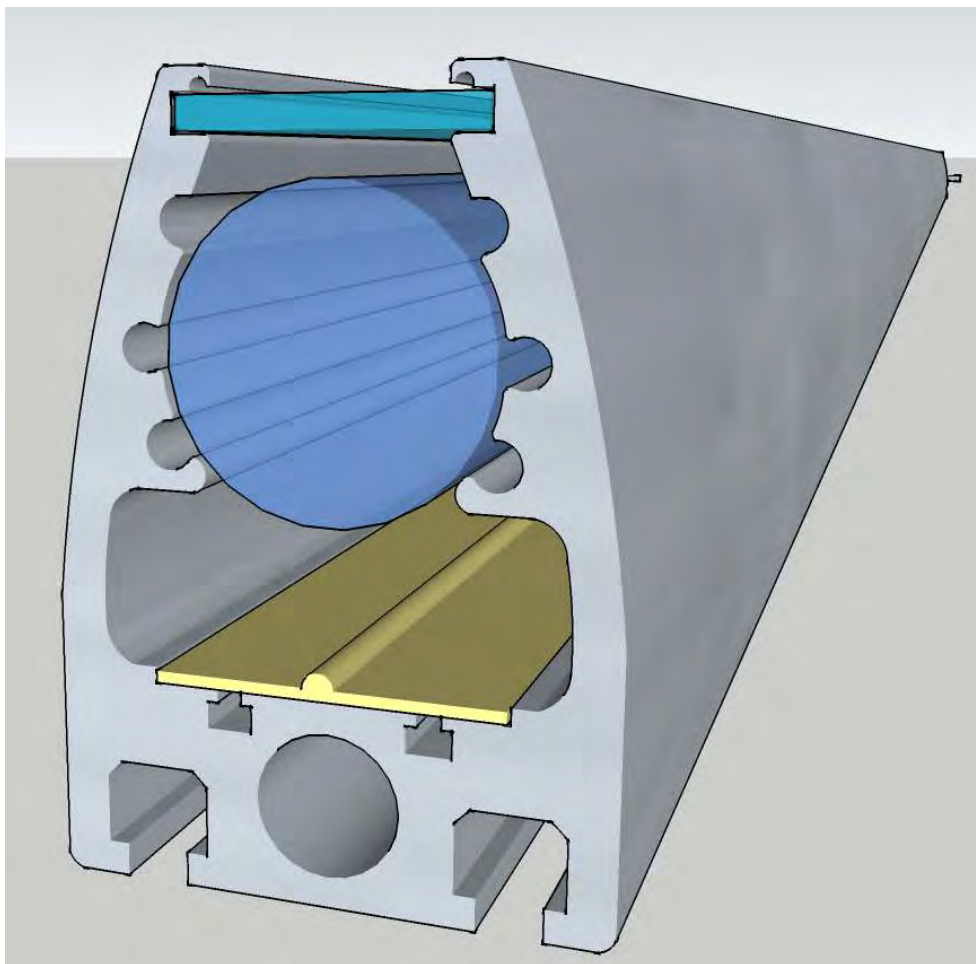
- » Dimenzované pre 200 kHz Ips (expozícia 4 μ s/r)
- » Návrh vlastný extrudovaný AL profil 6000 mm
- » 2500 W/m (LED čipy 10W, rozteč 4 mm)
- » Chladenie kvapalinou s turbulentným prúdením
- » Intenzita cca 12.000.000 lux



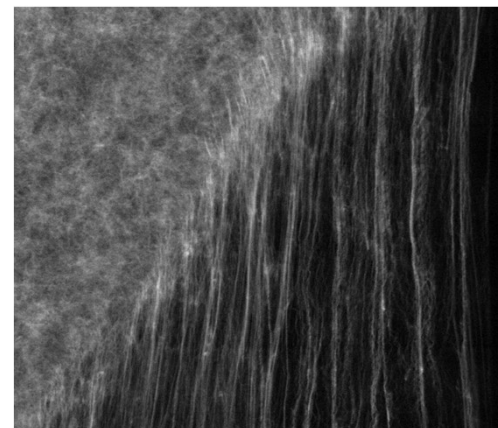
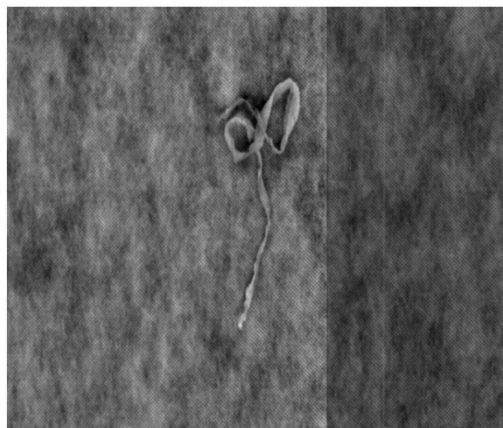
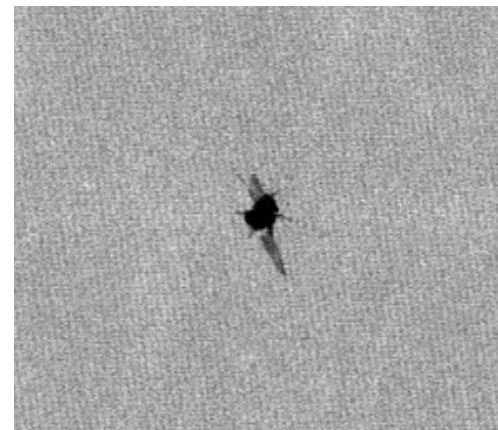
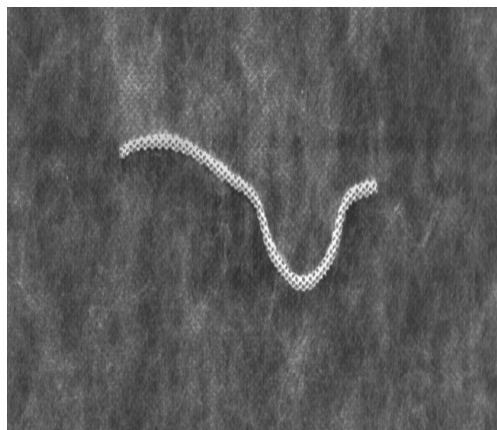
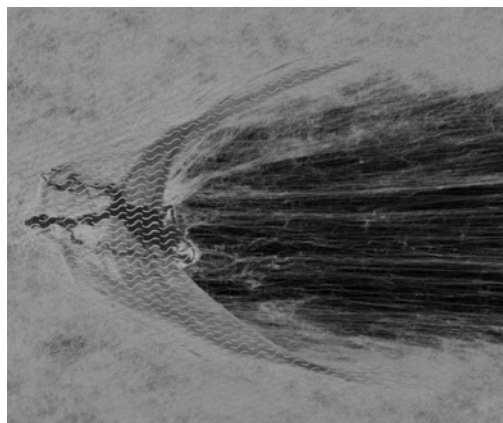
Líniové LED svetlo – 3D model



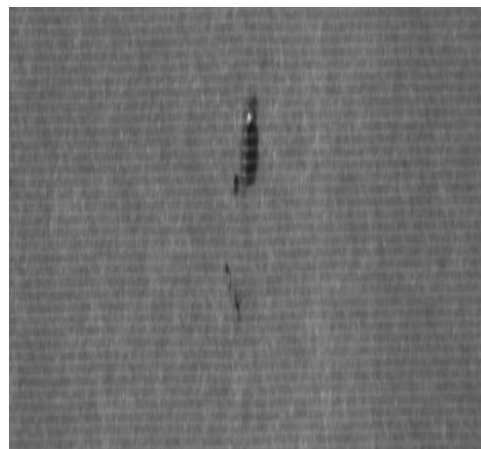
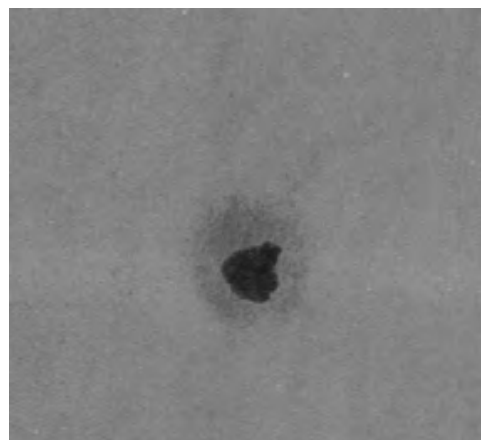
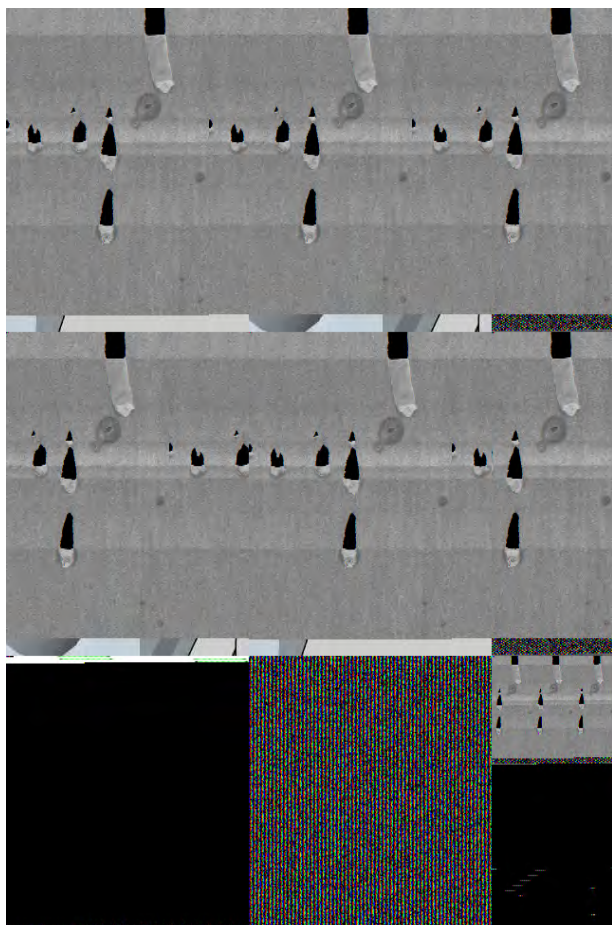
Extrudovaný profil



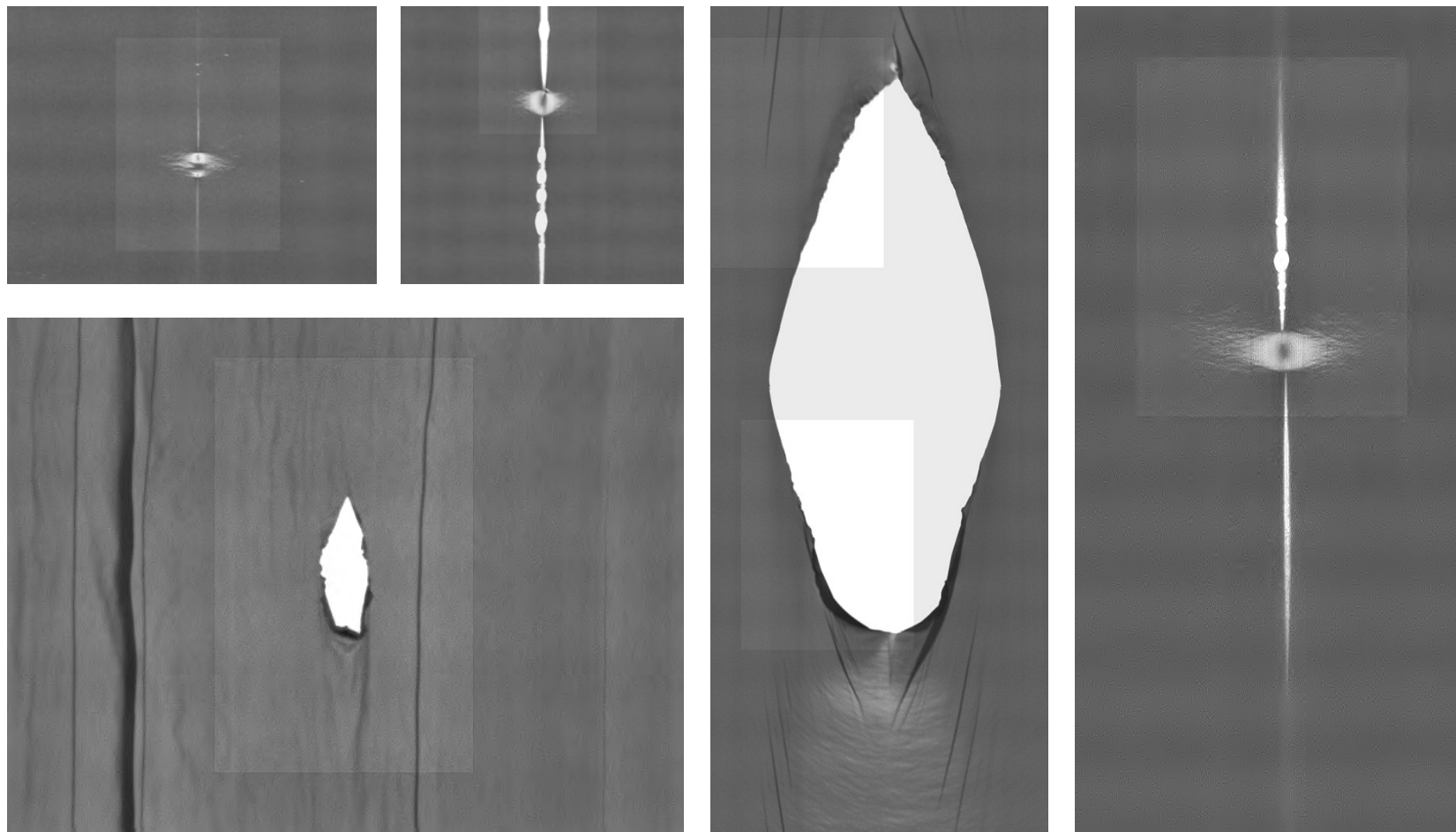
Galéria - netkaná textília



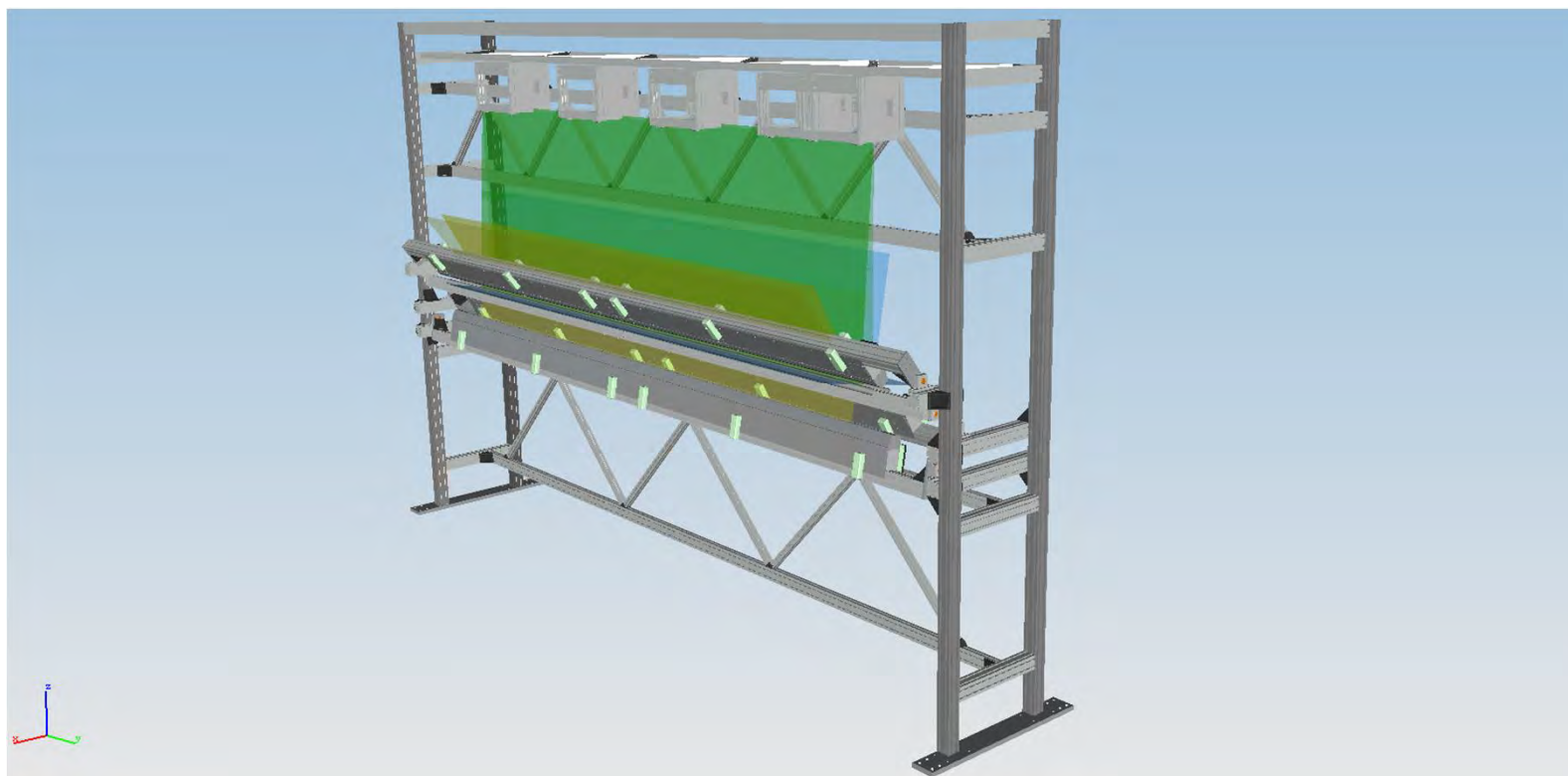
Galéria - papier



Galéria -fólia



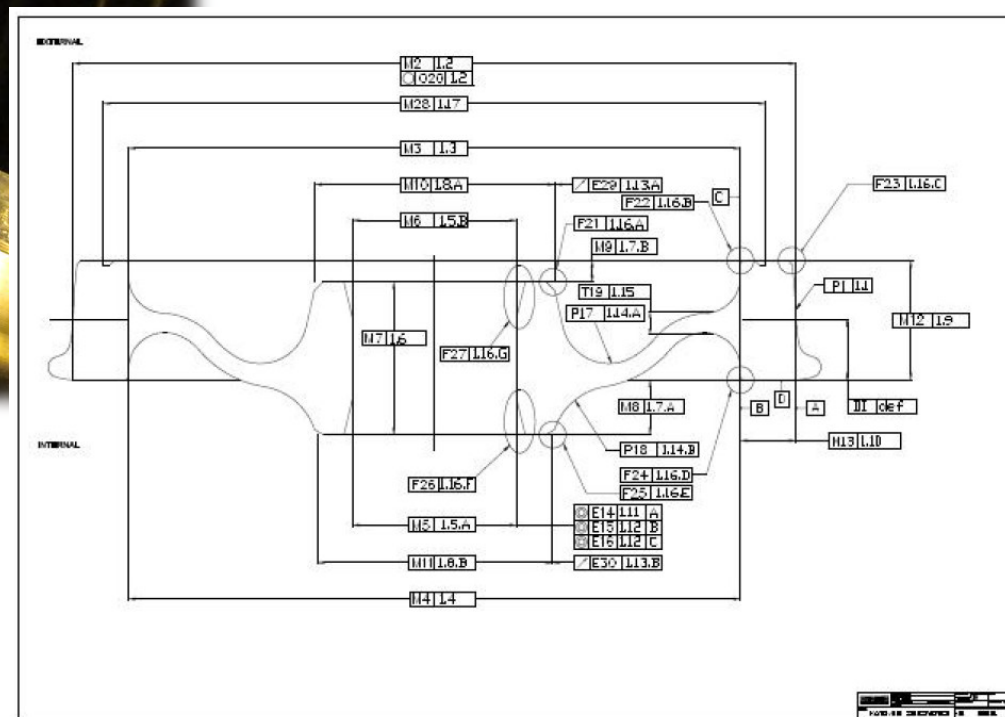
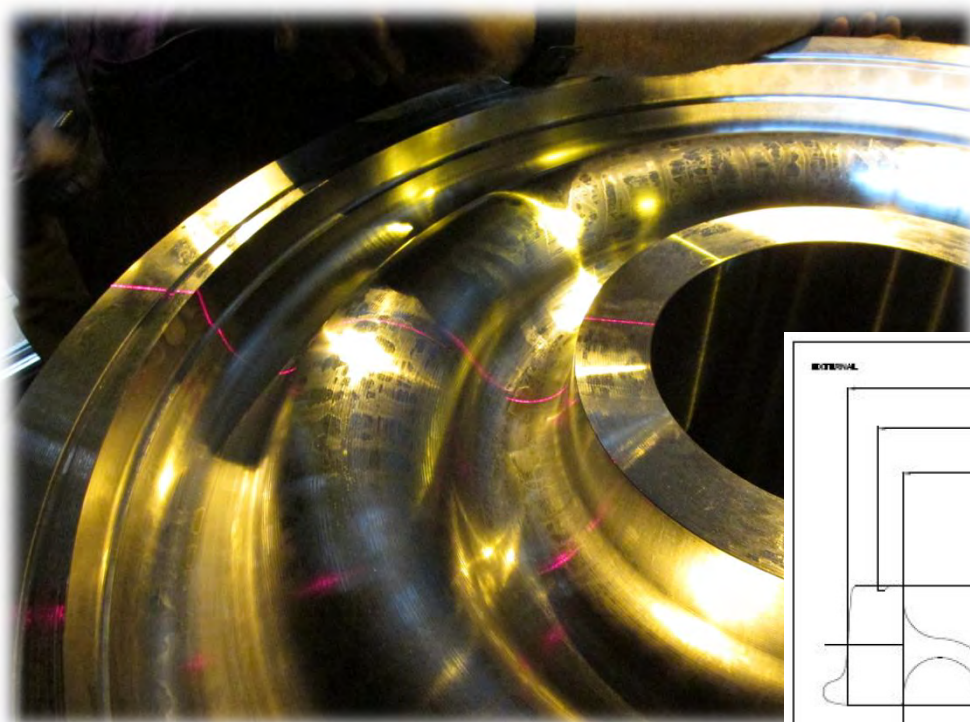
Model kamerového portálu



Inštalácie

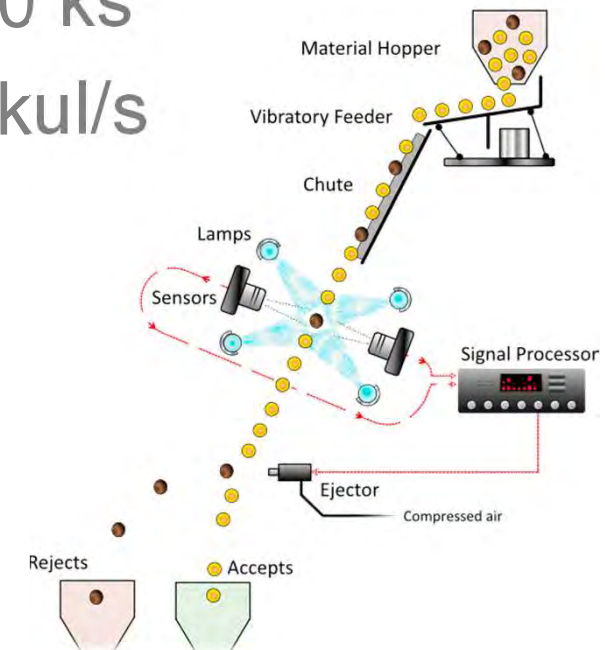
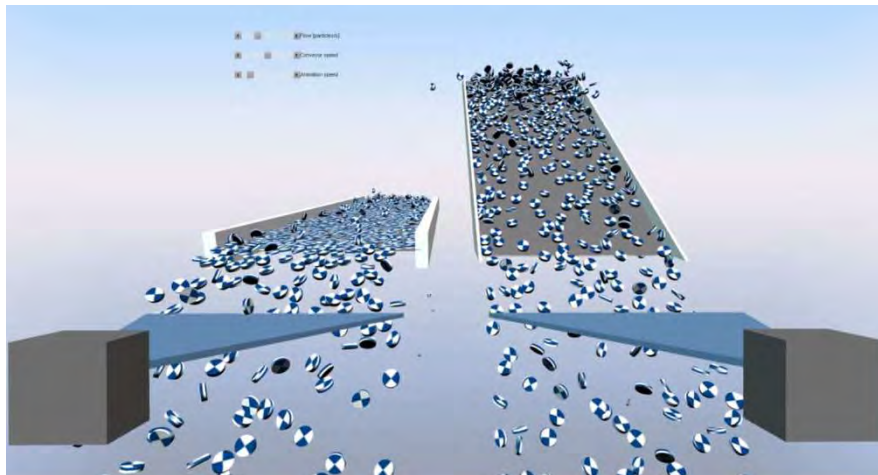


Meranie profilu železničného kolesa

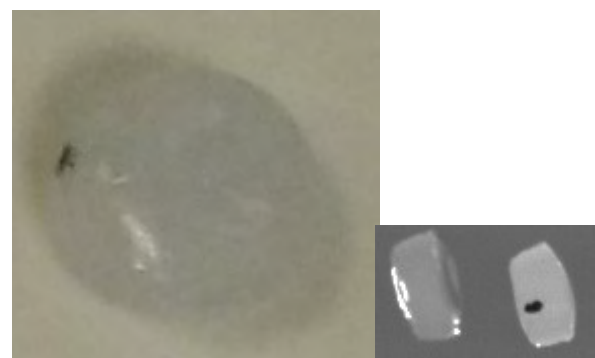
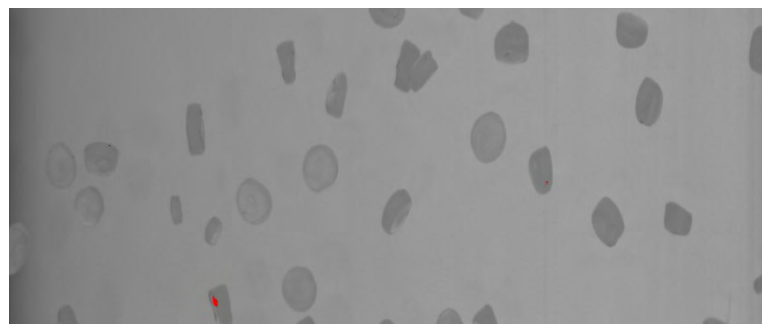


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- » Rozmery guľôčky: valec $r = 2\text{mm}$, $h = 2$
- » Hmotnosť guľôčky: $\rho = 0,977\text{g/cm}^3$, $m = 0,024\text{g}$
- » Počet guľôčok v 1t = 40.000.000 ks
- » Pri rýchlosti 1,5 t/hod. = 16600 kul/s
- » Rozlíšenie kamery 50um/px



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Unirail



Optické čítanie UIC kódov



Ďakujem za pozornosť.

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