Book of Abstracts

fit4nano

EUFN
EUROPEAN FIB NETWORK

Workshop 2024

September **16-20**, 2024
Durrës, Albania

UNIVERSITETI BARLETI

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Workshop Program 2024

Monday, 16 September			
9:00-10:00		FIT4NANO Core group meeting (on invitation only)	
10:00-12:00		FIT4NANO MC meeting (on invitation only)	
12:00-13:00		Registration	
13:00-13:20	Gregor Hlawacek, *FIT4NANO Action Chair* Prof. Aleksander Xhuvani, *Dean of Faculty of Applied Sciences and Creative Industries, Barleti University* Robert Dumi, *Director of International Programs, Albanian National Agency for Scientific Research and Innovation and National Representative of COST*	Welcome	
13:20-14:00	Nabil Bassim	3-D FIB-SEM tomography in metallurgical/biological systems – context matters	pg. 1
14:00-14:20	Subin Lee	Femtosecond Laser with FIB: A Tool for Advancing In Situ Micromechanical Testing	pg. 2
14:20-14:40	Elina Zhakina	Tuning the Superconducting Transition in Three-Dimensional Nanoarchitectures	pg. 3
14:40-15:00	Andreas Johansson	Ion beam sculpting of catalytic surface transferred to 2D material	pg. 4
15:00-15:40		Coffee Break	
15:40-16:20	Santhana Eswara	Operando Secondary Ion Mass Spectrometry Imaging of Lithium Redistribution in Solid-State Lithium-Ion Batteries: Correlation of Structural, Chemical and Electrochemical Characteristics	pg. 5
16:20-16:40	Elia Scattolo	FIB fabrication of shallow GeV and SiV color centers and solid immersion lenses in diamonds	pg. 6
16:40-17:00	Anne Delobbe	A new tool for high-temperature ion implantation to create dense NV assemblies in diamond	pg. 8
17:00-17:20	Tomás Fernández Bouvier	Molecular dynamics insights on the molecular P implantation for scalable spin-qubit arrays	pg. 9
17:20-17:40	Michael Paulgaard	Modular He Ion Camera	pg. 10
17:40-18:10	Smilja Djurdjevic, TOFWERK	TOFWERK: A Global Leader in TOF Mass Spectrometry	pg. 11
Tuesday, 17 September			
9:00 – 9:40	Roland Bruetsch	Preparation of “huge Microsamples” from Nuclear Cladding and Fuel Material using FIB/SEM	pg. 12
9:40-10:00	Armin Gölzhäuser	Imaging of SARS-CoV-2 infected Vero E6 Cells by Helium Ion Microscopy	pg. 14
10:00-10:20	Travis Casagrande	Enabling Correlative Microscopy Applications by the LaserFIB Fabrication of Customized FIB Grids	pg. 17
10:20-10:40	Jack Donoghue	Optimised workflows for 3D volume microscopy with fs laser-PFIB and EBSD	pg. 18
10:40-11:20		Coffee Break	
11:20-11:40	Fabian Henßler	Strain tuning in microstructured quantum materials	pg. 20
11:40-12:00	Wolfgang Lang	Optimization of the irradiation parameters for fabricating nanostructures in copper-oxide superconductors using He-FIB and assessing their long-term stability	pg. 22

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12:00-12:30	Miloš Hrabovský, TESCAN	Non-programmers guide to FIB-SEM automation	pg. 24
12:30-13:20		Break	
13:20-14:10	Achim Nadzeyka, Tutorial 1	Nano patterning using focused ion beams	pg. 25
14:10-15:00	Mahdi Ghorbani-Asl, Tutorial 2	Simulation of irradiation effects in solids	pg. 26
15:00-15:40		Coffee Break	
15:40-16:20	Michael Grange	Cryo-plasma FIB/SEM for in-situ structural biology and vEM	pg. 27
16:20-16:40	Lisa McElwee-White	Ion-Induced Chemistry of Pt Precursors	pg. 28
16:40-17:00	Iwona Szymańska	Fluorinated or non-fluorinated precursors for FEBID/FIBID process?	pg. 29
17:00-17:20	Alessandro Cian	Gold-assisted lithography for suspended nanostructures	pg. 31
17:20-17:40	Richard Curry	Nanoscale Advanced Materials Engineering using Focused Ion Beams	pg. 33
17:40-18:10	Letian Li, Thermo Fisher	The latest advancements in FIB technology for sample preparation for TEM, imaging and metrology	pg. 34
18:10-20:00		Poster Session	

Wednesday, 18 September

9:00 – 9:40	Damjana Drobne	Successful application of Plasma Focused Ion Beam Scanning Electron Microscopy (PFIB/SEM) for morphological investigation of tissue	pg. 35
9:40 – 10:00	Umutcan Bektas	Spatially Resolved Phase Transition and Characterization in Gallium Oxide	pg. 36
10:00-10:20	Flyura Djurabekova	Atom-level Insights on local structural modifications using Focused Ion Beam irradiation	pg. 37
10:20 – 10:40	Mahdi Ghorbani-Asl	Ion-irradiation induced phenomena in two-dimensional materials: insights from atomistic simulations	pg. 38
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11:40 – 12:00	Klaus Leifer	Fluorinated graphene synthesised by particle beam assisted methods	pg. 40
12:00 – 12:30	Guillaume Brunetti, JEOL	New FIB-SEM JEOL	pg. 41
12:30 – 13:20		Break	
13:20 – 15:00	G. Hobler K. Höflich A. Delobbe G. Rius	WG1/2/3/4 meeting (open to all, parallel sessions)	
15:00 – 15:40		Coffee Break	
15:40 – 16:20	Brenton Knuffman	FIB-SIMS Applications with a Cs+ Low Temperature Ion Source	pg. 43
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16:40 – 17:00	Eteri Svanidze	Revealing intrinsic properties of solid-state compounds	pg. 46
17:00 – 17:20	Valentine Riedo-Grimaudo	TOF-based FIB-SIMS for Lithium Ion Battery Research	pg. 47
17:20 – 17:50	Olena Vertsanova, Zeiss	Zeiss Crossbeam FIB-SEM for nanofabrication and nanomaterials research	pg. 49

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9:40 – 10:00	Nico Klingner	Towards a quantitative secondary electron spectrometer for Single Ion Implantation in TIBUSSII	pg. 51
10:00 – 10:20	Alex Storey	Irradiation with filtered beams from ionic liquids	pg. 53
10:20 – 10:40	Thomas Löber	Rubidium and cesium ion-induced electron and ion signals for scanning ion microscopy applications	pg. 55

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14:00 – 15:00	Round Table Discussion	FIT4NANO summary and the future of the Eu-F-N	
15:00 – 15:40		Coffee Break	
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17:20 – 17:40	José María De Teresa	Application of ion- and electron-irradiated spin-coated PdAc films for electrical gating	pg. 70
17:40 – 18:10	Andrew Smith, Kleindiek Nanotechnik	Enhancing FIB Operations with Micromanipulators, Substages, and More!	pg. 72
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10:20-10:40	Abah Arielle Desiree Koffi	Comparison between Smart and Soft Nanoimprint Lithography using Focused Ion Beam master	pg. 77
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11:20 – 11:40	Petr Bábor	Real-time Monitoring of Chemical Waves by Focused Ion and Electron Beams	pg. 79
11:40 – 12:00	Tsuyoshi Onishi	Variable-Speed Serial Sectioning Using AI for Layer Determination	pg. 80
12:00-12:20	Bartlomiej Winiarski	Comprehensive 3D Characterization Workflow for Solid Oxide Cells	pg. 82
12:20 – 12:40	Gregor Hlawacek	Final words, closing of the workshop	

Legend

Invited Speaker

Industry talk

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Poster session:

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FIB-SEM Tomography for Porosity Characterization of Inkjet Printed Nanoparticle Gold Ink

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Inkjet printing is a versatile technology for the manufacturing of electronic devices to be used in various applications [1,2]. Common inks to create conductive layers are suspensions of a solvent with metal nanoparticles such as gold or silver [3]. After the deposition and solidification of an ink on a substrate, the metal nanoparticles are sintered to realize the conductivity of the printed layer. A porous, solid metal matrix remains, whereby the conductivity of the metal layer tends to be dependent on the porosity. To characterize the porosity of inkjet printed conductive layers, focused ion beam-scanning electron microscope (FIB-SEM) tomography is suggested as a potential characterization method in the presented study.

For the experiment, a wafer diced silicon substrate with size of 10 x 10 mm² was used, onto which a 1.2 µm thin layer of commercially available nanoparticle gold ink was inkjet printed and then sintered. Subsequently, a four-step procedure for the FIB-SEM tomography-based porosity characterization was performed: 1) FIB preparation of the volume of interest (VOI), 2) serial sectioning including image acquisition, 3) image processing and 4) 3D-reconstruction and porosity analysis.

The steps 1) and 2) were conducted using a FIB-SEM dual beam system ZEISS AURIGA 40 (Carl Zeiss Microscopy Deutschland GmbH, Germany). Prior to serial sectioning, a thin platinum layer was FIB induced deposited on top of the inkjet printed gold layer. A cube-shaped VOI with the size 5000 x 6000 x 5000 nm³ was then prepared by FIB milling. The surface to be sectioned was end face polished and a line trench serving as a reference marker for the image processing was milled along the VOI. The prepared VOI prior to FIB sectioning is shown in Figure 1. a). Next, the serial sectioning was conducted. The ion acceleration voltage was set to 30 kV. The aperture current was set to 50 pA, resulting in an ion beam spot size of 12.5 nm, which corresponds to the section slice thickness. No melting and re-sintering of the solid metal structure could be observed during sectioning. SEM images of the revealing surface areas were acquired with 1024 x 768 pixels image resolution and a pixel size of 5.82 nm. Both a secondary electron (SE) detector as well as a backscattered electron (BSE) detector were used for imaging. In total, a 2D stack of 368 SEM images was recorded. For comparison of individual sections, Figure 1. b) and c) show BSE detector images of the cross-sectioned VOI after slice 70 and slice 140. One can clearly see that the size and distribution of sintered metal particles varies along the VOI, forming a porosity network within the solid gold.

Since the images acquired with the BSE detector presented a higher contrast and thus, a better distinction between the pores and the metal structure, these images were used for the image processing and final porosity analysis, for which the software AVIZO (Thermo Fisher Scientific Inc., USA) was used. First, the 2D images were aligned to correct for the shifts which occurred during the serial sectioning. Then, a sub-VOI was cropped out to exclude the reference line. The new 3D VOI was of a size of 3026 x 1164 x 2750 nm³, representing a stack of BSE detector images ranging from slice 30 to 250. Noise interference was minimized by applying a Gaussian filter. Afterwards, thresholding was applied as a segmentation technique to differentiate between pores and the solid gold as well as erosion as morphological operation. As a result, a reconstructed 3D model of the pores located in the solid gold was obtained, as shown in Figure 2. a). Using this 3D pore model, the number of pores and their diameters within the VOI could be determined. For the calculation of the pore diameters, each pore was

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considered to be of a spherical shape. A total of 1509 pores was counted. The pore diameter distribution is shown in the box plot in Figure 2. b). As it can be obtained from Figure 2. b), a pore size of 23 nm represents the lower quartile, while a pore size of 112 nm represents the upper quartile. The median pore size is 44 nm, while the mean is 63 nm, which indicates a trend towards smaller pores surrounded by larger pores.

Based on the obtained results, FIB-SEM tomography with subsequent image processing is assessed by the authors to be a proper method to characterize the porosity of inkjet printed conductive layers, which was tested by means of a nanoparticle gold ink.

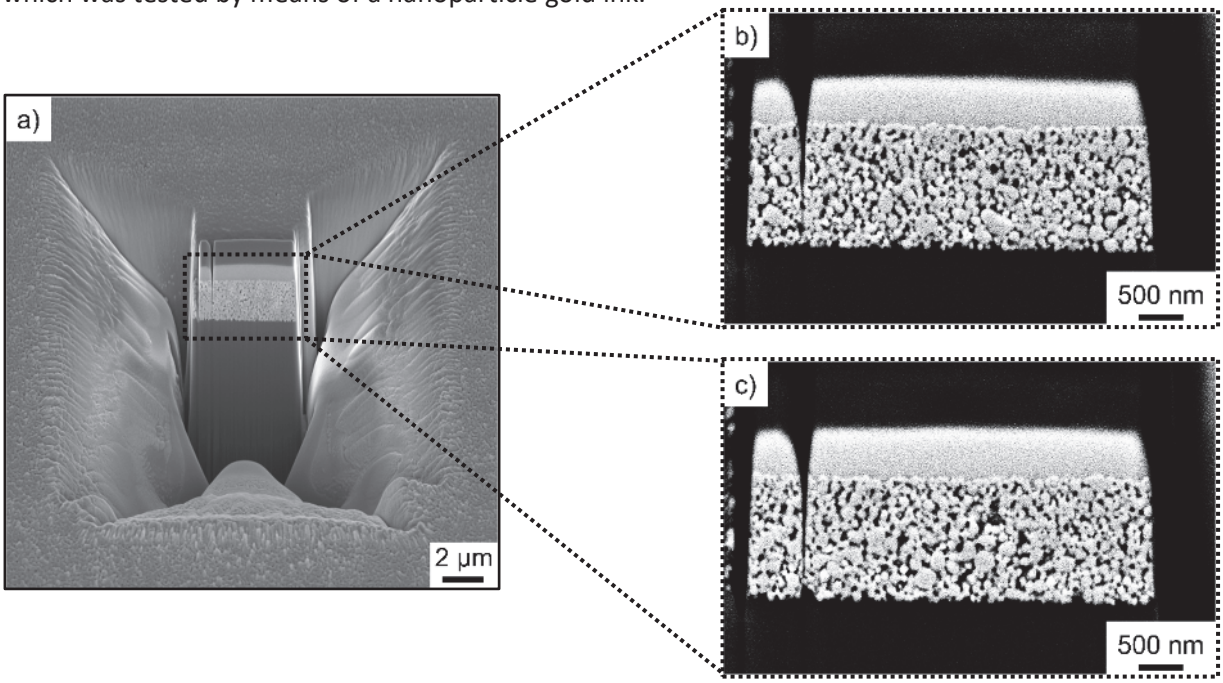

Figure 1. a) Secondary electron detector image of volume of interest (5000 x 6000 x 5000 nm³) of inkjet printed nanoparticle gold ink prepared for subsequent FIB-SEM tomography. SEM image of b) slice 70 c) slice 140 acquired with the backscattered electron detector

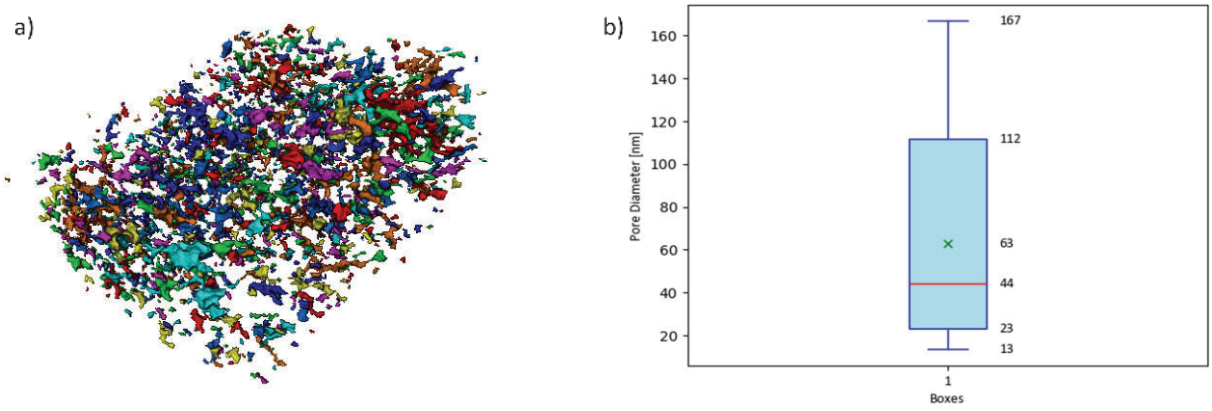

Figure 2. a) 3D reconstruction of pore structure and b) box plot of pore diameter of inkjet printed nanoparticle gold ink for a volume of interest of 3026 x 1164 x 2750 nm³

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References:

[1] Trotter, M., *et al. Sensors*. 20, 1333 (2020)
[2] Bastola, A., *et al. Materials Today Electronics*. 6, 100058 (2023)
[3] Cummins, G., *et al. Circuit World*. (38/4), 293-213 (2012).

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