Universität Marburg

Vergabeverfahren UMR-2026-0013

Leistungsbeschreibung

Call for Tender – Acquisition of a Focused Ion Beam/Scanning Electron Microscope (FIB-SEM) Research Platform

A factory-new focused ion beam/scanning electron microscope (FIB-SEM) system with a scanning electron column and an ion column is to be procured as the basis for a characterization and research platform. The system must offer excellent gallium ion optics as well as very good electron optics with electron beam lithography (EBL) functionality. Samples must be capable of being introduced into the experimental chamber via an inert gas and/or vacuum transfer system. In addition, the system must provide cryo-compatibility for ion beam thinning and transfer. Furthermore, ion beam preparation of samples for transmission electron microscopy (TEM) must provide automation for increased sample throughput. As a component of the platform, the system must provide, in addition to integrated diode detectors for backscattered and transmitted electrons in dark-field mode (BSE, ADF), a high-speed electron backscatter diffraction (EBSD) camera with state-of-the-art analysis software as well as transmission Kikuchi diffraction (TKD) capability. Energy-dispersive X-ray spectroscopy (EDX) with 3D capability must be available with a high degree of system compatibility.

Furthermore, the FIB-SEM must serve as a platform for a comprehensively integrated electrical characterization platform as well as an in-situ AFM. The system must integrate flexible micromanipulators with electrical probing tips, providing high-precision positioning and versatility, and must accommodate all necessary measurement amplifiers.

Due to the broad range of applications, the mechanical platform must be compatible with all components and implement robust collision detection for add-on modules.

The scope of services includes on-site installation, instruction/training, as well as commissioning and acceptance of the microscope (including all ancillary costs, such as travel expenses). In addition, the maintenance and repair of the research instrument must be compatible with the philosophy of our core facility, and our technicians must be trained to carry out maintenance and simple repairs independently.

The available funding limit is a maximum of EUR 2,900,000 including VAT. Bids exceeding this limit must therefore be excluded without exception. The limit for bids of foreign companies is a maximum of EUR 2,349,000 because of 19 % reverse charge.

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Z = Zuschlagskriterien (engl.: award criteria)

A = Aussschlusskriterien (engl.: exclusion criteria)

Example: “Criterion XYZ : Value = 100 [better than] “

Means: “100” is <u>mandatory</u> and “better values” increase the score

	Criterion	Fulfilled?	Score
1. System configuration			
a. Focused Ion beam (FIB) column with gallium liquid-metal ion source. Latest Release. − Specification better than: ○ Ion beam Energy from 0.5 keV to 30 keV ○ FIB resolution < 3 nm @ 30 kV ○ FIB resolution < 300 nm @ 500 eV ○ Ion beam current : from 1 pA to ≥ 60 nA [better than]	A A A/ Z = 1 pt	[ ] [ ] [ ]/ [ ]0, [ ]1	
b. Field-free high resolution (HR) electron optics − Specifications better than: ○ Energy range < 100 eV till 30 keV ○ Resolution of <1.0 nm @ 30 kV (STEM) ○ Resolution of < 1 nm @ 15 kV ○ Resolution of < 1.5 nm @ 1kV ○ Field of view (FoV) > 1.5 mm @ Coincident point in HR mode	A A Z = 1 pt	[ ] [ ] [ ]0, [ ]1	
c. No magnetic field at the sample in high-resolution mode	A	[ ]	
d. Retractable gas injection system Minimum: 3 (Tungsten, Platinum and Carbon Precursors)	A	[ ]	
e. Oil-free high vacuum system with vibration damping and noise reduction	A	[ ]	
f. High vacuum better than 1 x 10^{-2} Pa	A	[ ]	
g. Flexible modular 360° continuous rotation sample stage − Tilt range: -65° to +65° − Award Criterion: better than -65° − Award Criterion: better than +65°	A A Z = 1 pt Z = 1 pt	[ ] [ ] [ ]0, [ ]1 [ ]0, [ ]1	
h. Detectors Minimum: ○ Multiple parallel acquisition of minimum 4 Channels ○ E-T Detector	A	[ ]	

○ In-column SE detector ○ In-column axial BSE/SE detector ○ Continuous energy filtering on in-column detector ○ Retractable backscatter electron detector (rBSE) with system for fast detector protection ○ Retractable segmented transmission scanning electron microscopy (STEM) with dark-field detector and bright-field capabilities			
i. Chamber and sample plasma cleaner	A	[ ]	
j. Current meter for all optics	A	[ ]	
k. Infrared chamber camera	A	[ ]	
l. Manual control panel	A	[ ]	
m. Collision prevention system with: ○ electrical “touch alarm” ○ Full 3D modeled collision system with integration of 3rd party components and user specified sample holders	A Z = 1 pt	[ ] [ ]0, [ ]1	
n. Multilevel programmable interface including ○ Visual programming interface ○ Python-based programming interface ○ Low-level interfacing API / SDK (i.e. C,C++,C#) ○ Offline tools and licenses for safe sandbox development	A	[ ]	
o. Windows 11 compatibility of all software and hardware components	A	[ ]	
p. Large chamber with large number of ports Minimum: 16 [better than]	A/ Z = 1 pt	[ ]/ [ ]0, [ ]1	
q. Sample holders capable of performing all modes of measurement (EBSD, EDX, STEM, BSE) as well as TEM-sample preparation	A	[ ]	
r. Uninterruptible power supply (UPS) with at least 2 kW	A	[ ]	
Subtotal of points or exclusion			/ 6 Pts
2. Cryo-Operation, transfer and preparation			
a. 360°-rotation cryo-preparation stage with shuttle system gas-cooled by liquid nitrogen ○ Temperature of -190 °C or lower and stability +/- 0.5°C ○ Anti-contamination device for reduction of ice-formation on cryo-stage and samples	A	[ ]	

○ Cryo-dewar with run time > 18h of continuous operation			
b. Cryo-nanomanipulator integrated in microscope controls with dewar	A	[ ]	
c. Inertgas-sample transfer with full cryo transfer capabilites	A	[ ]	
d. Argon atmosphere capabilities for inertgastransfer	A	[ ]	
e. In-line preparation chamber for cryogenic samples including fracturing tools, sputtering coating and thickness control.	A	[ ]	
f. Nitrogen freezing station for TEM specimen including suitable transfer systems for full cryo workflow	A	[ ]	
g. Integration in 3D collision system	A	[ ]	
h. Assortment of suitable shuttles for SEM, FIB and TEM applications	A	[ ]	
i. Controls with remote-support capability	A	[ ]	
Subtotal of points or exclusion			
3. Electron beam lithography (EBL)			
a. Integrated fast electron blanker	A	[ ]	
b. Software for planning, creating and running of EBL patterning Minimum: Standalone Maximum: Fully-Integrated [10 pts]	A	[ ]	
Hardware for: ○ EBL speeds per pixel < 50 ns ○ Pattern procession speed ≥ 50 MHz	A	[ ]	
Subtotal of points or exclusion			
4. Automation and sample preparation for transmission electron microscopy samples (TEM)			
a. Vibration-free, high-precision, 360°-rotation motorized nano-manipulator integrated into microscope control software	A	[ ]	
b. Multi-site / Batch processing of SEM and FIB tasks	A	[ ]	
c. Fully automated autonomous TEM sample preparation from trenching to final low-keV polishing at the grid	A	[ ]	
Subtotal of points or exclusion			

5. Energy dispersive X-ray spectroscopy (EDX) and Electron back scattering detection camera (EBSD)			
a. Motorized silicon drift detector for EDX with at least: ○ Detector area ≥ 100mm² ○ Energy resolution ≤ 127 eV @ MnKa @ 200kcps or more ○ Energy resolution ≤ 46 eV @C @ 50kcps or more ○ Qualitative and quantitative element analysis from Be to Cf	A	[ ]	
b. Electron back scatter detection camera (EBSD) with ○ Minimum: 1024x1024 pixel ○ Minimum Acq. Speed: 5000 Patterns per second with simultanous EDX acquisition and data processing ○ Minimum: Acq. and analysis down to 5 keV or lower ○ Angular resolution ≤ 0.05°	A	[ ]	
c. Motorized detector tilt for pattern alignment	A	[ ]	
d. Forescatter and backscatter diodes for additional image contrast	A	[ ]	
e. Transmission Kikuchi diffraction capabilities and necessary mounting hardware with distortion correction if required by SEM optics design	A	[ ]	
f. Live, in-acquisition combined EDS+EBSD phase mapping	Z = 1 pt	[ ]0, [ ]1	
g. Software processing and analysis with all analytical function of EDS and EBSD with: **h.** Modern standard-less and standards-based quantification methods including libraries **i.** Quantitative EDX mapping and Phase determination **j.** Crystallographic phase identification and orientation mapping (Euler, IPF) and advanced grain analysis tools like grain orientation distribution analysis and grain boundary and orientations analysis methods **k.** Defect analysis like dislocation density and burgers vector determination **l.** Drift-Compensation during acquisition **m.** Automated batch processing and data merging **n.** EBSD indexing with dynamical pattern simulation matching	A A A A A A A	[ ] [ ] [ ] [ ] [ ] [ ] [ ]	

o. Report generation with compatibility to standard office formats (word, spreadsheets) **p.** At least 2 additional full offline licenses	A A A	[ ] [ ] [ ]	
q. Appropriate control computer	A	[ ]	
r. Integration in 3D serial-FIB sectioning data acquisition of EDX and EBSD	A	[ ]	
s. Collision detection and prevention	Z = 1 pt	[ ]0, [ ]1	
Subtotal of points or exclusion			/ 2 Pts
7. 3D Tomography			
a. Integrated EDX, EBSD and SEM measurements during automated FIB-sectioning tomography including. Software and Hardware for Acquisition, Evaluation and 3D Rendering ○ Movement-free 3D EBSD and EDX acquisition	A Z = 1 pt	[ ] [ ]0, [ ]1	
b. Protection mechanisms to prevent damage to detection devices	Z = 1 pt	[ ]0, [ ]1	
Subtotal of points or exclusion			/ 2 Pts
8. Electric Failure Analysis (EFA)			
a. Nano-probing platform kit with advanced EFA capabilities and complete measurement periphery incl. hardware and software	A	[ ]	
b. 4 Nano-probing robots including control software with easy manual positioning **a.** Travel range > 1cm **b.** Sub-nanometer positioning **c.** Four-degrees of freedom (X,Y,Z, rotation around Z) **d.** Lightweight and stable at 55° tilt **e.** User-friendly soft-landing from > 10 µm **f.** Sub-nanometer precision in x, y and z movements	A Z = 1 pt Z = 1 pt	[ ] [ ]0, [ ]1 [ ]0, [ ]1	
c. Integration with the AFM system (section 9)	A	[ ]	
d. Integration in 3D anti-collision system	Z = 1 pt	[ ]0, [ ]1	
Subtotal of points or exclusion			/ 3 Pts
9. In-Situ atomic force microscopy (AFM)			

− Addition of a user-mountable AFM on the SEM stage without any permanent modifications of the SEM chamber with the following operation modes: • Correlative AFM and SEM in a single scan • Topography (dynamic and contact mode) • Phase imaging and energy dissipation • C-AFM • SSRM • Current-voltage Spectroscopy • Force-distance spectroscopy • KPFM • EFM • MFM • PFM	A A A A A A A A A A A A A	[ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]	
a. Measurement tips and auxiliary hardware (e.g. lock-in amplifier) for all measurement modes included	A	[ ]	
b. Operable in SEM vacuum ($p < 10^{-4}$ Pa) and under atmospheric conditions	A	[ ]	
c. Scan range at least 50 x 50 x 10 µm [better than]	A/ Z = 1 pt	[ ] [ ]0, [ ]1	
d. Compatibility with standard SEM Stubs	A		
e. Compatibility with inert transfer mechanism	Z = 1 pt	[ ]0, [ ]1	
f. Integration of permanent contacts and feedthroughs	Z = 1 pt	[ ]0, [ ]1	
g. Integration of at least 2 electrical probing robots on the platform	Z = 1 pt	[ ]0, [ ]1	
h. Integration in 3D anti-collision system	Z = 1 pt	[ ]0, [ ]1	
Subtotal of points or exclusion		¨	/ 5 Pts
10. Software and Periphery			
• A wide range of measurement tools for lengths, areas, sizes from images • Flexible navigation including external overlays images • Time-resolved recordings for in-situ and FIB/SEM process tracking	A Z = 1 pt Z = 1 pt	[ ] [ ]0, [ ]1 [ ]0, [ ]1	
Subtotal of points or exclusion			/ 2 Pts

11. Service Contract			
FIB/SEM service contract for 4 years after expiration of warranty included	A	[..]	
Total of points or exclusion			/ 20 Pts