

Annex E - Program of requirements

In this program of requirements, ARC NL's requirements for the scanning probe microscope, pricing and services are listed. Subscribing parties need to sign Annex B - Declaration of conformity in a legally valid way and this annex needs to be included in the subscription on Tendered to declare that the subscribing party agrees with and complies with the program of requirements for the full duration of the assignment.

If a subscribing party cannot comply with one of the requirements listed, the contracting authority will exclude this subscribing party from the assessment procedure.

Requirements for the Scanning Probe Microscope (SPM)

General requirements	
Requirements for the tender procedure	
1.	The publication with accompanying tender documents is not a contract and cannot be construed as such.
2.	Your tender will not incur any costs for the Contracting Authority, regardless of whether any negotiations lead to the conclusion of an agreement. Until an agreement has been reached and a written contract signed by both parties has been concluded, the Contracting Authority will not be bound by any obligation and there will be no obligation to compensate any damages or costs whatsoever.
3.	The Contracting Authority reserves the right to stop the Tender in whole or in part, temporarily or permanently. Even in such a situation, Tenderer will not be entitled to reimbursement of any costs incurred in connection with this tendering procedure. Any damages are also at Tenderer's own risk.
4.	Tenderer agrees that the Contracting Authority reserves the right, in the event that Tenderer is eligible to be awarded the contract, to still request official supporting documents after the provisional award. If these supporting documents do not correspond to what is stated in the declarations, the company will be excluded from the award, without the right to compensation for any costs whatsoever.
5.	The person who makes your tender available via Tendered is authorized to represent your company.
6.	Registration and all further communication, including communication required during the term of the agreement, will be in the Dutch language or English language.
7.	The responsible management and the staff charged with carrying out the assignment shall have a sufficient command of the Dutch or English language, both spoken and written, to the extent relevant to the performance of the present work and any contractual obligations.
8.	Tenderer is familiar with and agree to the assessment methodology used by the Contracting Authority.
9.	No information that becomes available within the framework of this assignment will be made available to third parties from your company, with the exception of partners, subcontractors and/or auxiliary persons to be engaged by your company for the project at hand; in such a case, Tenderer will remain responsible for the confidentiality of those partners, subcontractors and/or auxiliary persons to be engaged.
10.	Your tender will have a standing period of at least 180 days from the deadline for submission of tenders. During this period, your tender has the character of an irrevocable offer.

11.	Tenderer agrees to extend the standstill period of your tender, in the event of summary proceedings being initiated, to at least two weeks from the date of the decision in the summary proceedings.
12.	All information submitted by your company has been completed truthfully and can be stood by Tenderer. The Contracting Authority reserves the right to compensation in case of incorrect and/or incomplete information and/or inability to fulfil what has been offered by a tenderer.
Communication, consultation and reporting requirements	
13.	If there are any changes in the name or address details of your company or the contact persons for the Contracting Authority, please notify the Contracting Authority's contract manager immediately.
14.	Your registration contains the names of the persons acting as central contact person and their deputy. These persons are employed by your organisation, they have sufficient knowledge of the Dutch or English language in word and writing and relevant work experience.
15.	Tenderer shall have a complaints procedure related to the service to be provided.
16.	Receipt of queries and complaints will be acknowledged in writing within three working days.
17.	Questions and complaints will be answered in writing within five working days.
18.	The initiative to schedule (evaluation) interviews lies with the Contractor. The Contractor must also take care of the reporting and submit it to the Principal for approval within five working days.
Legal requirements	
19.	Tenderer fully and unconditionally conforms to the attached General Conditions of Purchase ARIV-2018. This means that only the terms and conditions used by the Contracting Authority will apply. Your tender will not refer (in part) to other legal terms and conditions, even if these would not contradict the Contracting Authority's terms and conditions.
20.	Tenderer fully and unconditionally conforms to the attached (draft) agreement.
21.	If Tenderer claims to be the (main) contractor and Tenderer specifies (a) particular subcontractor(s) in your tender, Tenderer will be bound, when awarded, to actually use said subcontractor(s) in accordance with what is stated in the tender.
22.	Subcontracting work is allowed only if the Contracting Authority has given Tenderer written consent.
23.	As the main contractor, Tenderer bears full responsibility for the activities of your subcontractors. Tenderer handles communication on behalf of and to the subcontractor.
24.	Invoicing of subcontracted work will be handled by the main contractor.
Billing requirements	
25.	An invoice should contain at least the following information: • Invoice date • Level of compensation • Delivery dates • Order number • Description of all Products/Services provided, if necessary specified in a separate annex • Total invoice amount (excluding and including VAT) • Contract number • Work order number/Purchase number
26.	The Contracting Authority should be able to receive and process e-invoices. An electronic invoice (e-invoice) is a structured electronic file that allows automatic and electronic processing (not a pdf invoice). Sending e-invoices has become low-threshold in recent years. For example, most accounting software packages now have the option to send e-invoices built in. If the Tenderer does not use an accounting software package, there are portals via market parties, for example, that give the Tenderer access to a network that enables easy exchange of e-invoices to the Contracting Authority. If Contracting Authority eventually decides to make

	e-invoicing mandatory for its suppliers, Tenderers should be able to send invoices electronically so that they can be received and processed electronically by Contracting Authority subject to the specifications provided by Contracting Authority. No costs may be charged to Contracting Authority for this.
Commercial requirements	
27.	All prices are submitted in Euro excluding VAT.
28.	The cost structure will take place in accordance with the schedule described in document 'Price entry form'. The total amount of your tender is fixed and includes all costs, such as and insofar as applicable, but not exhaustive: execution, aftercare, overhead, travel and other costs.
29.	The prices quoted by Tenderer cover all the requirements set out in the Tender Document. This means that no additional costs will be charged by Tenderer.
30.	Additional work can only be carried out upon request and written consent of Contracting Authority.
Technical requirements	
Requirements regarding measurement techniques in ultra high vacuum (UHV, see requirement 54-56): Scanning Tunneling Microscopy (STM)	
31.	The system must be capable of imaging graphite/graphene or a similar crystalline material with atomic resolution. This means that individual atoms in the crystal, as well as missing atoms, must be visible in the STM images. It must be possible to record the atomic resolution images without image processing, except for corrections of the slope of the sample with respect to the scanner. For an example, see https://doi.org/10.1103/PhysRevB.60.6007. The system must be capable of achieving the above described imaging performance in the ARCNL lab which achieves vibration level VC-G, when the SPM system is placed on our vibration isolated floor. Temperature and humidity stability in the lab are 22 +/-1.5 degrees Celsius and 50 +/-10 %, respectively. Acoustic noise is below 55 dB.
32.	The noise level of the electronics that drive the scanpiezos must be lower than the equivalent of 0.7 Å root mean squared (rms) in the scan directions (x,y) and 0.05 Å rms in the normal direction from the sample (z), all within a bandwidth of 1 Hz – 10 kHz.
33.	The noise level in the current signal of the pre-amplifier must be lower than 5 pA rms within a bandwidth of 1 Hz – 5 kHz. The bandwidth of the pre-amplifier (-3 dB) must be 10 kHz or more.
34.	The STM must be capable of measuring at least 10 ⁴ pixels per second, while the measured current and height (z) are stored.
35.	An extra channel must be available for measurements with a user-supplied lock-in amplifier.
Requirements regarding measurement techniques in UHV (see requirement 54-56): Scanning Tunneling Spectroscopy (STS)	
36.	The system must be capable of measuring the tunneling current while the bias between tip and sample is varied over a range of at least +/- 10 Volt. During this measurement, the tip is kept at a fixed height with respect to the sample. The STS measurement, as described above, must be possible -as defined by

	the user- on a point, along a line or in a square plane. It must be possible to couple the measured I(V) curves to a user supplied lock-in amplifier.
Requirements regarding measurement techniques in UHV (see requirement 54-56): Atomic Force Microscopy (AFM)	
37.	It must be possible to perform cantilever based AFM measurements in contact and tapping mode (see for example https://doi.org/10.1016/j.wear.2023.204975).
38.	It must be possible to perform tuning-fork based AFM measurements, as opposed to cantilever-based measurements (see for example https://doi.org/10.1126/science.ado1544).
39.	It must be possible to conduct frequency modulated tapping mode measurements (see for example https://escholarship.mcgill.ca/concern/articles/tb09j909v).
40.	It must be possible to measure both normal and tangential (friction) forces in contact mode (see for example https://doi.org/10.1007/s40544-023-0764-4).
41.	It must be possible to calibrate the normal stiffness of the cantilever through the thermal noise spectrum.
42.	It must be possible to obtain atomic lattice resolution in one or more of the AFM measurement modes, under the conditions in the ARCNL lab (see Requirement 31). For example, an atomic lattice image of a graphene crystal must be obtainable without image processing other than corrections for the slope of the sample with respect to the scanner (see for example https://pubs.acs.org/doi/pdf/10.1021/j100056a016?casa_token=To9p-gd0XkwAAAAA:a4Bq6_xPKVAdsnnV9KLci1ie2b5t7Sm4AaNHgbmcCPq1F0q2k71B_IYBvZ5eYAJYdBzbnO1j_oZlrXC6X).
43.	User friendly alignment and calibration of the cantilever is a requirement: an experienced user must routinely be able to record AFM images within 10 minutes after loading sample and tip into the microscope without prior alignment.
44.	The system must be capable of measuring and recording the normal force while the tip moves to and from the sample in the normal direction, to enable indentation and adhesion measurements with user-defined amplitude and speed. The accuracy and speed with which the z-position and deflection of the cantilever in the normal direction are measured should be comparable to the accuracy and speed that can be obtained in the atomic resolution measurements (Requirement 42).
45.	It must be possible to apply a desired bias to the tip and or sample within a range of at least +-10 Volt, before or during the AFM measurements (Requirements 37-49).
46.	The system must be capable of performing adhesion measurements within a user-defined (square) array of points on the sample such that images with adhesion values are generated.
47.	The system must be capable of measuring normal and tangential forces during 'Lift mode'; this means that the system must be able to measure the normal and tangential deflection of the cantilever while the tip hovers over the sample at a controlled distance (see for example https://doi.org/10.1063/5.0150276).

48.	The system must be capable of conducting Kelvin Probe Microscopy measurements; measurements of the bias between tip and sample required to minimize electrostatic interaction between tip and sample (see for example https://doi.org/10.1063/1.121577 and https://doi.org/10.1063/1.121577).
49.	The AFM must be capable of conducting tapping and contact mode measurements within an area on the sample of at least 9 µm by 9 µm. It must be possible to observe sub nanometer height changes on the sample in such scans, see for example https://doi.org/10.1016/j.triboint.2019.105983 .
Requirements regarding measurement techniques in UHV: STM and AFM	
50.	If the proposed solution makes use of different scanners for STM and cantilever-/tuning-fork-based AFM measurements, it must be possible to exchange these scanners/run these different measurements subsequent to one another without breaking UHV.
51.	It must be possible to move tip and sample relative to one another such that the described STM and AFM measurements can be conducted within a volume of at least 0.9 cm by 0.9 cm by 0.9 cm on the sample.
52.	The system should be capable of automatically approaching to an appropriate distance for imaging after coarse approach by the user (without making contact with the surface for non-contact imaging modes).
Requirements regarding the optical microscope	
53.	The system must be equipped with a camera and optical lens through which the sample and the position of the cantilever relative to the sample can be viewed. This optical microscope must be capable of distinguishing features with clear optical contrast at a scale of 4 µm or smaller.
Requirements regarding the UHV system	
54.	The system must be capable of achieving a pressure lower than $5 \cdot 10^{-10}$ mBar through bakeout and pumping over a period of maximally three days. Adequate pressure gauges to measure these pressures must be included.
55.	Equipment for performing bakeout of the UHV system must be included.
56.	The system must be capable of performing the described STM and AFM measurements in the presence of small amounts of background gas, for example O ₂ , H ₂ , H ₂ O, N ₂ , CO ₂ or CO at pressures of up to $1 \cdot 10^{-5}$ mBar. Demonstration (see Req. 64 and 72) of this capability with one of the gases is sufficient.
Requirements regarding tips, samples and connections of the system	
57.	The system must be capable of performing the described AFM and STM measurements on samples which are placed on <i>flagpole</i> sample plates. It must be possible to measure samples with a sample height of up to 4 mm.
58.	The system must be capable of storing at least 5 samples and 4 tips under UHV conditions but not in the load lock chamber. The tip and sample storage must be designed in such a way that the exposure of tips and samples in the storage to the gases that may be introduced into the measurement environment (Req. 56) is reduced by at least two orders of magnitude in pressure. This means that a valve must be present between the measurement chamber and the sample storage. A possible solution can be a by-pass line connecting measurement and preparation chamber that can be gradually closed using an all-metal angle valve and is used for pumping the measurement chamber during gas

	exposures. It must be possible to prepare a tip or sample from the storage for AFM or STM measurement within 15 minutes.
59.	The system must include a preparation chamber within which tips and samples can be prepared for measurements. This preparation chamber must have at least three free CF38 connections, at least two free CF63 connections, and at least one CF150 connection. These connections must be facing the center of the preparation chamber. It must be possible to fix individual samples or tips at the center of the preparation chamber. Later addition of a heater stage (user provided) up to 700 degrees C must be possible.
60.	A method must be available for transferring at least 3 tips or samples into the system from atmosphere without breaking UHV in the measurement chamber or the preparation chamber. The pressure within the measurement chamber and preparation chamber must be restored to a value below 10^{-9} mBar within 15 minutes of loading tips or samples.
61.	The system must be compatible with standard AFM probes, for example those sold by Nanoandmore (https://www.nanoandmore.com/eu/).
62.	The proposed mechanism with which new samples can be loaded into the system must be capable of moving samples in and out of our vacuum suitcase with transfer arm (design attached). A connection to which our vacuum suitcase can be mounted on the system must be present. If necessary, the vacuum suitcase can be removed during measurements.
63.	At least 1 CF63 and at least 2 CF38 connections must be freely available on the measurement chamber. In addition, there should be at least two windows (CF 63 or larger) on the measurement chamber in addition to the window for the microscope (Requirement 53).
Other requirements	
64.	Each of the requirements described must be demonstrated in the ARCNL lab (see requirement 31) when the system is delivered.
65.	Compatible versions of components of the system, with which the described measurements can be conducted, must be available for purchase during the 10 years after delivery of the system.
66.	Support in trouble shooting problems with the system, at ARCNL or from a distance, must be available after the guarantee period against a market-conform price. Tenderer needs to indicate the hourly rate for support in the Price Sheet (Annex C).
67.	The system must include a computer with software and documentation, that can perform the described STM and AFM measurements. General updates in this software must be available at no extra costs in the first 10 years of usage of the system.
68.	A built in method must be available for transferring the measurement data, including all measurement channels at the resolution and precision that is available in the native software, to other software such as Gwyddion and Matlab. This can for example be realized through comma separated value files (CSV files).
69.	The software with which the system is controlled must remain available without limitations or extra cost.
70.	The instrument and software must be user friendly, such that a person with UHV and SPM experience can perform each of the described STM/AFM measurements independently (with a user manual) after

	1-2 days of training for that specific measurement. Detailed documentation must be available for all steps of the measurement and sample/tip transfer process.
71.	The instrument must fit onto the vibration isolated concrete block in the ARCNL lab with size 3 m by 3 m.
72.	The subscribing party must demonstrate, through peer-reviewed scientific articles based on similar systems made by the subscribing party, that the proposed system is capable of satisfying the requirements regarding the operation modes of the device. The subscribing party must therefore have experience in delivering at least 10 comparable instruments to academic research institutes in the EU and USA.
73.	Before the system is shipped to ARCNL, the supplier must demonstrate, at their location, that the system meets all requirements.
74.	Temperature control over sample and tip during STM/AFM measurements as described in the requirements above must be available. Temperatures between room temperature and 650 K must be achievable.
75.	The system must have a CE-mark and a risk inventory and evaluation (RI&E).
76.	User training at ARCNL within a month after the on-site demonstration and acceptance must be included in the price. This training must include the operation of the full setup and all SPM modes.
77.	The system must be delivered at ARCNL within 12 months after signing the purchasing agreement, capable of performing each of the described measurements in the ARCNL lab.
78.	Tenderer warrants that the Scanning Tunnelling Microscope to be supplied by Tenderer shall be and remain of unchanged, good quality and that the equipment shall in all respects conform to the usual requirements of soundness, efficiency, task suitability, workmanship, standards, specifications, government regulations and environmental provisions.
79.	At least one year of replacement warranty on all major components of the UHV SPM after the last acceptance test is included in the offer.
80.	Tenderer shall be responsible for supplying, placing, installing and delivering the Scanning Tunnelling Microscope in working order.
81.	The Scanning Tunnelling Microscope to be supplied by Tenderer shall be new, most recent and unused (it shall not be refurbished, remarketed or renewed).