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## SPECIFICATION SHEET

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**Supply, installation and starting-up of a Nano Infrared Scanning Probe Microscope system for the Pilot Line PIXEurope at ICFO**

**FILE NUMBER: ICFO-2026-008**

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## CLAUSE 1. Object of the contract

The purpose of this contract is the supply, installation and starting-up of a Nano Infrared Scanning Probe Microscope system for the Pilot Line PIXEurope at ICFO for ICFO's laboratory.

The types of items supplied are linked to the CPV (Common Public Procurement Vocabulary), **38000000-5** Laboratory, optical and precision equipment (except glasses).

## CLAUSE 2. Needs to satisfy

The combination of Atomic Force Microscope (AFM) with nano scale Infrared (IR) spectroscopy allows to simultaneously look at morphological structures via AFM and chemical/compositional information, via nanoscale IR spectroscopy, with high lateral resolution. This is the technique of choice to map how material composition affects optical behaviour at the nanoscale, to study small photonic structures (such as metasurfaces, 2D materials) or to inspect large wafer samples to perform non-destructive analysis.

The system will be used as a Nano Infrared Scanning Probe Microscope system for the following applications:

- Inspection of thin films, coating and photonic layers (dielectric, semiconductor, organics) for material composition
- Identification of contamination or defects on large size samples (200 mm wafers)
- Studying 2D materials (graphene, hBN, metal dichalcogenides) and observing their properties at the nanoscale
- Evaluating micro and nanostructures of photonics integrated circuits for their morphological stability, material degradation, interface chemistry
- Enabling failure analysis and process control in photonics integrated circuits fabrication.

## CLAUSE 3. Technical requirements

### Technical proposal structure

The proposal has to follow as much as possible the structure of this technical requirements document to facilitate evaluation. Any optional accessories not included in the proposal will have to be put in a separate section, and not mixed with the included items.

#### Machine / Process overview

The system will be used as an atomic force microscopy in the Infrared (AFM-IR) measurement system for the following applications:

- Fast topography measurements
- Nano-Infrared measurements
- Mechanical measurements
- Electrical measurements
- Thermal properties measurements
- Scanning Tunnelling measurements
- Nanoindentation and nanolithography

It must allow to measure different sample forms and sizes, from small square samples (few millimetres large) up to 8" wafers, thus requiring an adaptive sample handling.

The measurement must be reproducible with time, and calibrated to be uniform within the sample area (XYZ calibrated, flatness and orthogonality, stable IR laser energy).

To comply these requirements the machine must allow a minimum noise and a reduced drift with time.

All the following technical specification must have already been proven by results obtained with the system. These data must be included into the technical presentation of the system.

1. Scanners, Resolution /noise
  - a. Flexure-guided, decoupled XY-Scanner and Z-Scanner mechanically driven by piezoelectric materials to improve dynamic performance as well as stationary positioning and guarantees a high linearity and orthogonality
  - b. The Z-scanner, which controls the vertical movement of the SPM tip, is completely separated from the XY-scanner which moves the sample in the XY horizontal directions and has a scan range of 15  $\mu\text{m}$  or better
  - c. The Z scanner must have high feedback speed with resonant frequency 9 kHz or better to allow for stable imaging conditions and for accurate, repeatable and reproducible results which do not suffer from tip wear
  - d. Supplier must proof this capability by using a noncontact or tapping mode to image a reference sample
  - e. Detection of the cantilever deflection by using SLD (Super Luminescent Diode) or a laser
  - f. The XY scan range must be at least 100  $\mu\text{m}$  and its out of plane motion must be less than 250  $\mu\text{m}$  for the scan range of 100  $\mu\text{m}$
  - g. An adaptive scan method that automatically adjusts the scan speed to the sample geometry
  - h. The Z detector noise must be less than 30  $\mu\text{m}$  over a large bandwidth
  - i. The lateral resolution for nano-IR must be 5 nm or better
  
2. Stage, samples size
  - a) A vacuum sample chuck including vacuum grooves for 50, 100, 150 mm and 200 mm wafers and at the same time vacuum handling of small samples (few millimetres large)
  - b) A motorized XY stage which is capable of addressing full 200 mm  $\times$  200 mm area and a motorized Z stage with a stage travel range of at least 25 mm
  - c) A motorized focus stage synchronized to Z stage
  - d) Z stage encoder resolution of 0.05  $\mu\text{m}$
  - e) X Y stage encoder resolution of 0.5  $\mu\text{m}$  and stage position repeatability of 2  $\mu\text{m}$  in unidirectional and 3  $\mu\text{m}$  in bidirectional movement
  - f) Sample size of 150 mm and 200 mm wafers, small sample holder supports samples of arbitrary shape up to 10  $\times$  10 mm
  - g) Vacuum pump and accessories
  
3. Infrared Laser sources

The IR laser beam must be easily aligned on the cantilever and whose wavenumber can be chosen within the following options:

1. Extended Quantum Cascade Laser (QCL)
  - a) QCL for extended range with 4 modules
  - b) Tuning wavenumber should range at least 800  $\text{cm}^{-1}$  to 2,300  $\text{cm}^{-1}$
  - c) Wavenumber accuracy lower than 1  $\text{cm}^{-1}$
  - d) Wavenumber repeatability lower than 0.1  $\text{cm}^{-1}$
  - e) Spectral linewidth lower than 1  $\text{cm}^{-1}$
  
2. Optical Parametric Oscillator / Difference Frequency generation (OPO/DFG)
  - a) Tuning wavenumber should range at least: 7,000  $\text{cm}^{-1}$  to 5,000  $\text{cm}^{-1}$  for a first interval, and 4,300  $\text{cm}^{-1}$  to 2,300  $\text{cm}^{-1}$  for a second interval and 800  $\text{cm}^{-1}$  to 600  $\text{cm}^{-1}$  for a third interval
  - b) Spectral linewidth: < 5  $\text{cm}^{-1}$  (FWHM)

#### 4. Electronics / PC & software

- a) Control electronics
- b) AFM data size of at least 4096 x 4096 pixels
- c) 24 DACs for signal generation, 4 high-speed 16-bit DACs, 20-bit DACs for X, Y and Z scanner positioning, 20-bit DACs for Aux output and Tip/Sample bias
- d) 18 ADCs for signal acquisition, 4 high-speed 20-bit ADCs, 24-bit ADCs for X, Y and Z scanner position sensor, 20-bit for PSPD, Option and Aux signal
- e) At least 8 channels of integrated digital lock-in amplifier
- f) Integrated signal access ports for AFM signals (7 inputs and 3 outputs)
- g) External signal access ports
- h) 1 Gbps communication with the PC
- i) The operating software and analysis software run on Windows 10 or 11 and can be installed on any number of PCs for data analysis. No license or dongle required

#### 5. AFM/SPM modes

- a. Non-contact mode, Tapping mode and Phase imaging
- b. Contact mode and LFM (Lateral Force Microscopy)
- c. Force/distance (F/d) spectroscopy and Force volume imaging
- d. Spring constant calibration by thermal vibration method
- e. Nanolithography
- f. Force Modulation Microscopy
- g. Nanoindentation
- h. Electrostatic Force Microscopy (EFM) including Kelvin Probe Microscopy (KPFM) and Piezo-response Force Microscopy (PFM), including Heterodyne KPFM and Dual Frequency Resonance Tracking PFM
- i. Scanning Thermal Microscopy

#### 6. Nanomechanical Property mapping

- a) Fast mechanical properties imaging
- b) Acquired data type: Deformation, Adhesion force, Adhesion energy, Energy dissipation and Approach and Retract stiffness
- c) F/d curve control: Maximum force, Tip travelling range, Speed
- d) Young's modulus model: Hertzian, JKR and DMT model
- e) Modulus range: up to 100 GPa, selecting cantilever depending on the sample modulus
- f) Nano Dynamical Mechanical analysis
- g) The Fast-mechanical properties mode must reach a speed of 2500 curves per second, or more

#### 7. Infrared (IR) Module for Nano-IR Spectroscopy and Imaging

- a) The module must set, deliver and focus IR beam to the tip, in an easy way, preferably automated, for nano Infrared spectroscopy and imaging
- b) Must include Multiplexer to support IR beam range sweep with integrated guide laser for IR beam alignment, beam path box for IR beam delivery, steering mirror and focusing optics actuator for IR beam focus
- c) Includes board for connecting, enabling driving and controlling actuators in the IR module set
- d) Includes electronic controller for controlling Nano-IR module set
- e) Chiller for laser cooling
- f) Dry air generator to reduce humidity in IR beam path for stable measurement

## 8. Data acquisition and analysis software

- a) Auto mode to produce high quality AFM imaging with few clicks: the software automatically selects the oscillation frequency
- b) Manual mode to control all the functions and settings for AFM scans
- c) Program mode to execute multiple measurements, including approach, measurement, withdraw and move at a determined position
- d) Automatic sequential imaging to allow sequenced scanning of the sample at the user-selected coordinates, comprising of image scan, cantilever retract, move to the next selected coordinate, tip approach, and repeat.
- e) Adaptive scan option included in the software
- f) Possibility of scripting for advanced automation: the data acquisition software must have built-in macros, which can be easily loaded and applied for repeating operations, such as moving the XY or the Z stage to a specific location or resetting the operation. Users can edit existing macros or create new ones as needed
- g) Independent software for image processing, data analysis and data presentation support
- h) Full Python control of the system must be possible.

## 9. Automation

- a. The system must be equipped with automatic tip detection and laser or SLD alignment on the tip, including the automatic alignment on the PSPD detector
- b. Automatic probe exchanger for fully automated probe loading and exchange, allowing multiple experiments with the same setup
- c. Automatic detection of probe loading position on probe slots
- d. Automatic recognition of the probe information and of the status of the probe slot
- e. Automated alignment of the IR laser beam on the tip position for nano-IR measurements. This must include:
  - i. Acquiring the IR beam position
  - ii. Repositioning of the tip position to the middle of the beam
  - iii. After performing an alignment scan, positioning the tip to the maximum intensity point

## 10. Acoustic enclosure

- a) Environmentally sealed acoustic enclosure to block external acoustic and light noise.
- b) Ergonomic design for user convenience.
- c) Active vibration isolation to cancel out the floor vibration
- d) Active isolation frequency: 1 Hz to 200 Hz
- e) A thermal regulation and stabilization of the enclosure should be integrated.
- f) Humidity must be removed from the measurement area and within the enclosure
- g) Safety of the operator while using IR laser should be guaranteed via an interlock to make the opening of the enclosure impossible while the laser is illuminating the cantilever and the sample

## 11. Accessories

- a) 20 non-contact probes
- b) 20 non-contact probes for nanoIR
- c) Calibration grating for lateral/vertical calibration
- d) Manuals: Operational, Maintenance and Software manual
- e) Table and cabinet

#### CLAUSE 4. Power distributions and safety

- The system should be configured for EU (Spain) power grid (voltage, sockets, etc.) and be CE marked.
- The system will be fully protected against unexpected power cuts and, in that case, will be fully safe for the operators. A quick and easy turning on of the system has to be possible after a power cut.
- Component wiring routed to a centralized power distribution panel.
- EMO protection.
- Appropriate hardware and software safety interlocks. Extended error diagnostics.
  - The system will be fully protected against unexpected power cuts and, in that case, will be fully safe for the operators. A quick and easy turning on of the system has to be possible after a power cut.

#### CLAUSE 5. System layout and services

- The proposal will include a complete set of pictures, drawings and layouts of the system, including dimensions, location and details of the different components.
- The proposal **will include full installation and start-up requirements (Unpack all system components; Assembly; Pump; Run system to helium liquid production ratio; During the installation process, instruction should be provided on proper procedures for operation and maintenance of the system)**, clearly specifying connection type, tubing materials, pressures, flows, etc, for the specific configuration of the offered system.
- A set of documentation should be delivered in English or Català/Spanish including the following topics:
  - Complete set of manuals, drawings, schematics and layouts about system assembly and configuration (mechanical assembly, vacuum system layouts, electrical schematics, system modules interconnection, etc)
  - Complete system user manual, including routine servicing, troubleshooting and basic repairs
  - System components spare list, specifying quantity, manufacturer, part number, etc
  - All the above documentation will be supplied in English or Català/Spanish, in electronic format (CD/DVD) and in paper copy.
  - In case the system hosts refurbished optional items, they should be explicitly specified in the proposal. When possible, it should be detailed which refurbishment process they have been through.

#### CLAUSE 6. Transportation, installation, start-up and training

- The proposal will include transportation to ICFO's facilities including insurance and all export/import and customs duties. **DAP incoterm will apply.**
- The machine will be placed in the designated location by ICFO. The contract winner shall cover all costs, organization, and coordination related to the placement, including the provision of any required specialized equipment or vehicles, as well as any necessary component disassembly and reassembly for unloading and transportation inside the building, strictly following the route specified by ICFO. The machine will be equipped with its own wheels to facilitate transportation and with levelling pads to ensure a stable and properly levelled position once installed.
- Depending on the size, machine crate may need to be disassembled outside ICFO building. The contract winner will be responsible for taking accurate measurements of the transportation route outside and inside ICFO and plan in advance any required component dis-assembly and re-assembly. The contract winner will be responsible for checking the selected location and for taking any required measurements to guarantee the suitability of it for the offered system. The

compatibility with the operation of the systems already installed in the lab and the mobility of users will have to be guaranteed as well. The system will be installed in a provisory location and should be moved within a duration of 4 years in a definitive laboratory. The contract winner will take care of the move to the final destination.

- Installation and start-up of the system, including system checking, functional tests and process qualification
- The contract winner will be responsible for the removal and proper disposal of the packaging when the machine is delivered and unpacked, or its storage during the warranty period in case the original packaging needs to be kept.

### **Process qualification**

The flowing specifications will be demonstrated at the factory before shipment and at the side at the installation:

1. XY flatness of 2 nm over 100  $\mu\text{m}$
2. XY/Z orthogonality of less than 2 degrees
3. XY linearity error of less than 0.5% over 100  $\mu\text{m}$
4. Feedback speed Z resonant frequency major than 9 kHz
5. 2D flake (MoS2 or graphene) height detection, measured less than 5 nm in topography at 5 Hz
6. CrN film (so called TipCheck) sample, run the scan for at least 50 times using 1 single cantilever tip, and show no degradation in image quality and profile line generated
7. For the IR imaging part, a lateral resolution of 5nm must be proven on a Ps-b-PMMA Block Copolymer on a 300 nm x 300 nm image overlaid with 1493 nm-1 and 1731 nm-1 wavenumbers images

### **CLAUSE 7. Warranty and Follow-on Support**

- **3-year Full Warranty** on all parts and components of the system irrespective of the manufacturer. The warranty will include the replacement of any faulty or damaged part(s) during normal use of the system, no matter the manufacturer of the component(s). It will cover any cost related with the disassembly, transportation, reparation and re-assembly of the damaged component(s), including all travelling and living costs of the required service engineer(s). An on-site repair, or a justified alternative to reduce the system down time to the minimum, will always be the first service option. A team of properly qualified and skilled service engineers will have to be available.
- System lifetime support:
- By phone and e-mail with a response within 3 hours
- Emergency visit after a system breakdown within 10 working days
- Spare parts will be available during, at least, 10 years after system supply and, in case of failure, will be delivered within 10 working days
- An estimation of the cost of a warranty extension or available support contract options after warranty period will be included

### **CLAUSE 8. Training**

- System training for ICFO personnel shall be included. The proposal must specify the number of training days and the approximate schedule with a minimum of 5 days. Training will cover both system operation and process use for ICFO users at ICFO facilities, as well as specific maintenance and advanced service training for ICFO lab technicians.

## CLAUSE 9. Delivery and Installation Time

The machine must be delivered within **3 months from the formalization of the contract.**

For the purpose of this tender, delivery time is defined as the period from the purchase order (PO) issuance until system delivery at ICFO facilities, including manufacturing, transportation, installation, and acceptance tests.

### Installations record

- Such a system must have been fabricated at least 3 times by the same provider with a proven record of installation. The record list should be provided upon request.
- For these systems, compliance with the specifications set out in paragraph “Process qualification” (clause 6) must be demonstrated.

## CLAUSE 10. Target price

- The target price for the system is 1.000.000,00 € (VAT excluded).
- Payment terms:
  - Advance - 30% total price. The payment of this amount does not imply conformity in the equipment, is an advance payment that the contractor must return in the event of non-compliance or deficient compliance.
  - Payment on delivery, commissioning and training - 70% total price

## CLAUSE 11. Environmental clause

It is hereby stated that, in compliance with the provisions of the Recovery Plan, Regulation (EU) 2021/241 of 12 February 2021 establishing the Recovery and Resilience Facility, and its implementing regulations, in particular Commission Communication (2021/C58/01) Technical guidance on the application of the principle of “do no significant harm”, as well as the requirements of the Council Implementing Decision concerning the approval of the assessment of Spain’s Recovery and Resilience Facility (RDF), all financed actions carried out under this contract must respect the principle of not causing significant harm to the environment (the “Do No Significant Harm” principle). This includes compliance with the specific conditions set out in component 17, measure I1, under which this contract falls. During the execution of the actions covered by the contract, no significant damage will be caused to the environment, in accordance with Article 17 of Regulation (EU) 2020/852.

The activities carried out will not cause direct environmental impacts, nor will they have primary indirect impacts throughout their life cycle, understood as those that may materialize once the activity has been completed.

The activities carried out by the successful bidder under this contract will not generate waste that, in its long-term disposal, could cause environmental damage, as this is one of the situations excluded from funding by the Recovery, Transformation and Resilience Plan, in accordance with the Technical Guidance on the application of the principle of “not causing significant harm” under the Regulation on the Recovery and Resilience Facility (2021/C 58/01), the Council’s Proposal for an Implementing Decision on the approval of the assessment of Spain’s recovery and resilience plan, and its annex. The activities carried out by the successful bidder will be adapted, where appropriate, to the characteristics set for the measurement and sub-measure of the assigned component, and reflected in the Recovery, Transformation and Resilience Plan.

The activities carried out will comply with all applicable environmental regulations in force.

For the transport, installation, and commissioning of the equipment covered by this contract, the contractor will implement waste minimization measures and, should any waste be generated, will be responsible for its collection, preparation for reuse, recovery, or recycling, or appropriate treatment.

#### Methods for monitoring and controlling compliance with the conditions

With regard to compliance with environmental and social requirements, the contractor remains obligated to:

- The contractor must sign, before the contract is formalized, the declaration of commitment regarding the implementation of actions under the Recovery, Transformation, and Resilience Plan (RTRP) and compliance with the principle of not causing significant harm to the environment, included as Annex of the Special Administrative Clauses.
- Issue a manual detailing the dismantling instructions for the equipment, including the reuse, recovery, or recycling operations, or appropriate treatment, including the disposal of fluids and selective treatment, applicable to each of the materials or parts that comprise it. The manual must include a table summarizing, expressed as a percentage by weight, the expected fate of the materials that make up the equipment at the end of its useful life, according to the following options: reuse (including recovery and recycling), energy recovery, and rejection/disposal.
- For the transport, installation, and commissioning of the equipment covered by the contract, the contractor will implement waste minimization measures and, should any waste be generated, will be responsible for its removal and management.

Castelldefels, on the date of its digital signature

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