SPECIFICATION SHEET

Supply, installation, and commissioning of a Nanoxerography Scanning Probe System for the PIXEurope Pilot Line at ICFO

FILE NUMBER: ICFO-2026-044

CLAUSE 1. Object of the contract

The purpose of this contract is the supply, installation and starting-up of a **Nanoxerography Scanning probe 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 Nanoxerography technique is a combination of Scanning Probe Microscope (SPM) and voltage biasing for electrostatic charge patterning. The system will use the tip of SPM to locally write electrical charge patterns on an insulating or semiconducting substrate, which then act as templates to deposit nanomaterials. The local modified charge distributions will subsequently guide the selective adsorption of charged or polarizable nanomaterials from solution.

In the frame of the PIXEurope project the Nanoxerography Scanning Probe Microscope system is planned to be used for the deterministic placement and patterning of nanoscale materials such as colloidal quantum dots (CQDs) and two-dimensional (2D) materials. As it can act as a conventional AFM too, it will also be used for topography check of micro and nanostructures patterned in the ICFO cleanroom for PIXEurope project, such as waveguides.

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.

1. Machine / Process overview

The system will be used as an easy-to-use scanning probe microscope for the following applications:

- Xerography
- Fast topography measurement
- Electrical measurement
- Nanolithography

The system must allow to measure different sample forms and size, from small square samples (few millimetres large) up to 200mm diameter wafers, thus requiring an adaptive sample handling.

The measurement should be reproducible with time, and calibrated to be uniform within the sample area (XYZ calibrated, flatness and orthogonality).

To comply these requirements the machine should 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.

2. Scanners, Resolution / noise

2.1. The system must have flexure-based and fully decoupled XY-Scanner and Z-Scanner in close loop, mechanically driven by piezoelectric materials to improve dynamic performance as well as stationary positioning. It must therefore guarantee a high linearity and orthogonality.

2.2. The system must have a complete decoupling between the Z-scanner, which controls the vertical movement of the SPM tip, and the XY-scanner which moves sample in XY horizontal directions. The Z scanner must a scan range of at least 15µm, and a noise detection level < 0,03 nm, or less, at 1 kHz.

2.3. The Z scanner must have a high feedback speed with a resonance frequency of 9 kHz or larger to allow for accurate, repeatable and reproduceable results which do not suffer from tip wear and at the same time for stable imaging conditions.

The system must use a focused SLD (Super Luminescence diode) that guarantees a minimized inter noise on cantilever deflection detection. The illumination spot diameter must be of 10 µm or smaller t flexible use of any cantilevers.

The XY scan range of the system must be at least 100 µm or larger and its out of plane motion should than 1 nm for the scan range of 80 µm.

The system must have an adaptive scan method that automatically adjusts the scan speed to the topography.

2.4. The system must be able to perform fast measurement up to 50Hz scan speed without artefact.

2.5. The motorized XY stage range must be at least 200 x 200 mm with 0.6µm stage travel step or better. The Z stage must be at least of 20 mm traveling range with 0.10µm stage travel step or better.

3. Ease of use, sample handling, tip exchange

3.1. The system must handle samples of size ranging from few mm up to 200 mm with thickness up to 20 and mm or higher.

3.2. The system must be able to accommodate several coupon size samples (< 20mm * 20mm and thickness < 20mm) with a precise repositioning (<5µm) via easy magnetic mounting, and up to 16 coupons via vacuum handling.

It must be able to accommodate also wafers with diameters ranging from 50mm to 200mm via vacuum handling.

3.3. The system must have a dedicated sample camera allowing to take a picture of sample mounted on the stage, with dimension up to 200mm diameter wafer, and address the scan locations precisely with a point and click feature.

3.4. The main system camera should be a CCD of at least 5Mp and coupled to a 10x objective in top view position.

The system must have an integrated automatic tip exchange module (loading at least 16 probes cassette, or several, of pre-mounted cantilevers, or more) for fully automated probe loading and exchar

The system can perform tip exchange without user physical interaction on the system.

3.6. Premounted cantilever should have a procedure enabling identification of each cantilever mounted in the cassette.

3.7. The system should be user friendly and allow to perform the following tasks:

- Select a tip in the cassette according to the selected mode
- Pick up the correct tip.
- Identify the tip.
- Automatically detect the cantilever and align the SLD on it using pattern recognition.
- Automatically centre the laser on the PSPD detector.
- Perform a frequency sweep to determine resonance frequency.
- Detect the best position for the measurement and adjust setpoint accordingly.

3.8. The approach step of the scanning should be automatic and not require user pre-approach.

3.9. The system should be able to focus automatically on the surface of the sample using a laser auto focus option.

3.10. The system should be able to perform recipe measurement using different methods on several samples automatically, even when changing tip is necessary between each method.

3.11. The system must be able to execute automatic sequential imaging of a sample at the user selected coordinates, to exchange tips and modes between steps, to realize the following typical sequence of 1) image scanning 2) tip retract 3) move to the next selected coordinate 4) tip approach 5) image scanning 6) repeat

3.12. The AFM system will have a total of 3 cameras, one for the sample view, one for the tip identification and one for the precise positioning.

4. Electronics / PC & Software

4.1. The system must have control electronics including at least 23 DACs for signal generation including 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, plus 18 DACs for signal acquisition including 4 high-speed 16-bit DACs, 24-bit DACs for X, Y, and Z scanner position sensor and 20-bit DACs for Photodiode detector and Aux signal

4.2. AFM maximum data size must be of at least 4096 x 4096 pixels

4.3. The system must have at least 8 channels of integrated digital lock-in amplifier (with bandwidth up to 5 MHz)

4.4. The system must have integrated signal access ports for AFM signals (7 inputs and 3 outputs)

4.5. The system must have at least 6 digital I/Os in LV-TTL

4.6. The system must have external signal access ports

4.7. The operating software and analysis software run on Windows 11 and can be installed on any number of PCs for data analysis. No license or dongle required.

4.8. The computer must have the following configuration, or better:

- Intel® CoreTM i7 CPU or compatible
- 16 GB DRAM
- 1x 500 GB Solid State Disc Drive (SSD)
- 2 TBs Hard Disc Drives
- Single 49-inch wide monitor (5120 x 1440 pixels)

5. AFM/SPM modes

5.1. The system must allow the following AFM scanning modes:

- Tapping mode, and Phase imaging with the choice of working on repulsive or attractive force regions.

- Contact mode and Lateral force mode.

- Force Distance spectroscopy and Force volume imaging

- Mechanical properties imaging (Deformation, Adhesion force, Adhesion energy, Energy dissipation) and nanoidentation. The mechanical measurements, including adhesion and Young modulus must be acquirable simultaneously with topography-

- Magnetic Force Microscopy

- Force Modulation Mode

- Piezo Force Microscopy in off resonance, contact resonance and dual frequency tracking-PFM (coupled to a non-contact technique to avoid friction forces).

- Single pass and dual pass KPFM technique using amplitude modulation, frequency modulation (sideband) and heterodyne.

- Conductive AFM, internal amplifier requiring no specific mounting (internal switch) and allowing user to switch from PFM to C-AFM.

- Side wall roughness of optical waveguides, on a full 200mm wafer.

5.2. The system must allow the spring constant calibration of each cantilever by thermal vibration method.

5.3. The system must allow to perform nanolithography.

6. Data acquisition and analysis software / Handling

6.1. The system must have an auto mode to produce high quality AFM imaging with few clicks. The software will automatically select the oscillation frequency slightly larger or lower than the resonant frequency of the cantilever probe.

6.2. The system must at the same time have a manual mode to control all the functions and settings for AFM scans.

6.3. The system must have a program mode to execute multiple measurements, including approach, measurement, withdraw, move at a determined position and approach.

6.4. The system must include a software for image processing, data analysis and data presentation support.

6.5. 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.

6.6. the software should be compatible with Python scripting for a complete control of the system via external python programming.

6.7. Using automatic sequential imaging, the AFM system must be able to do sequenced scanning of sample at the user-selected coordinates, comprising of image scan, cantilever retract, move to the next selected coordinate, tip approach, and repeat.

7. Acoustic enclosure, antivibration isolation and cleanroom compatibility

7.1. The system must include an environmentally sealed acoustic enclosure to protect from external acoustic and light noise.

7.2. The enclosure must have an ergonomic design for user convenience.

7.3. The system must have an active vibration isolation to reduce the floor vibration with a damping frequency range of 1 Hz to 200 Hz.

7.4. The system will be installed in a cleanroom class ISO7 and must be compatible with this environment.

8. High voltage kit for xerography

8.1. Tool kit to apply high voltage for Nanolithography and EFM

8.2. The Hardware module must withstand up to DC bias ±300 V and AC bias ±10 V

8.3. The module must allow to apply high voltage bias to a tip or sample by mixing DC and AC signals: DC bias up to ±175 V or 150 V, AC bias up to ±10 V

8.4. The kit must include external bias module for tip and sample bias.

8.5. The kit must include an insulated sample holder to apply high voltage above ±10 V to the tip and sample

8.6. The kit must provide electrical contacts to the tip and/or the sample.

8.7. High voltage amplifier with minimal electric noise for Nanolithography or other electrical measurements requiring higher bias voltage: voltage bias up to ±150V (20x amplification ratio), high voltage amplifier, bandwidth: DC to 100 kHz at full-power and low output noise: < 300 µV rms, or better.

9. Sample holder for sidewall measurements

9.1. The system must have a sample plate to tilt wafer sample using vacuum for sidewall measurements with a tilting angle of at least 15°

9.2. The sample size accommodated are 100, 150, 200 mm wafers. The system must have vacuum grooves for 100 mm, 150 mm, 200 mm wafers.

9.3. The XY stage range will be at least 100 mm in Y direction from the bottom of the tilting sample chuck

9.4. The allowable XY scan size will be 25 µm or more in Y-direction

9.5. The system must also have a sample plate to tilt sample for sidewall measurements of smaller samples (< 20 mm × 20 mm, < 2 mm thickness) with tilting angle of 10° and 15°.

10. Accessories

10.1. 4 cassettes for automatic standard operation mode must be provided with a capacity of 8 cantilevers each, with at least 2 cassettes loaded with a total of 12 mounted non-contact cantilevers and 4 mounted contact cantilevers.

10.2. Calibration grating for lateral and vertical calibration.

10.3. Sample disks.

10.4. 1 clip type probehand for un-mounted cantilever, using a non-magnetic tip holding mechanism and allowing tip bias from -10 V to +10 V.

11. Tools and system spares

12.1. Spare fuse kit (where applicable).

12. Additional optional improvements

12.1. A sample holder to place samples on a repeatable position with a repeatability of 5um in X and Y direction

12.2. Extra optional cassettes for automatic standard operation mode

12.3. Spare boxes of conductive cantilevers made of Pt

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 of 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.

- 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. Flatness, orthogonality, drift, speed
    2. XY mechanical orthogonality deviation of less than 0.5 degree
    3. Z mechanical linearity error of less than 1%
    4. Tapping or non-contact mode stable over more than 15 000 measuresments with a roughness variation 1σ < 2% on polished Si sample, scan rate of 10 Hz.

CLAUSE 7. Warranty and Follow-on Support

- **3-year Full Warranty** on all parts and components, regardless of their individual manufacturer. The warranty period shall commence on the date of the formal acceptance act (Acta de Recepción) signed between ICFO and the contractor, in accordance with Article 210.3 of the LCSP. 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 during, at least, 10 years:

    i. By phone and e-mail with a response within 3 hours
    ii. Emergency on-site engineer dispatch after a system breakdown: within 10 working days hours or less after initial response and after possible remote diagnose

- 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 in the proposal.

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 2 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 **SEVEN** (**7) months,** counted from the day following the date of its formalisation.

- Within this period, the supplier must complete the manufacturing, transportation, delivery, installation, integration, commissioning of the system, and the execution of the Site Acceptance Tests (SAT). The delivery time shall therefore be understood as the full period required to complete all contractual obligations up to the successful acceptance of the equipment at ICFO facilities.

- At the same time as the delivery of the equipment, the contractor must deliver the technical documentation and

manuals indicated in clause 5.

CLAUSE 10. Tender budget

- Tender budget (maximum bid price) for the supply is **200.000,00 €** (VAT excluded).

- Payment terms:

  - Advance payment on order — up to 30% of the total contract price: this advance payment is at the contractor's discretion. Should the proposed successful tenderer wish to receive an advance of up to 30% of the contract price, they shall be required to constitute a complementary guarantee for an amount equivalent to the advance requested, in accordance with the forms of security set out in Clause 18.2 of the Special Administrative Clauses (PCAP). Receipt of this advance payment shall not constitute acceptance of the equipment. The complementary guarantee shall be released upon payment of the corresponding contract price instalment. In the event of non-performance or deficient performance, the contractor shall reimburse the full advance amount in accordance with the terms set out in Clause 18.7 of the PCAP.

  - 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

Prof. Dr. Valerio Pruneri
Group Leader Optoelectronics – ICFO