ICFO

SPECIFICATION SHEET

SUPPLY, INSTALLATION AND COMMISSIONING OF “TWO HIGH-PERFORMANCE OPTICAL MICROSCOPE SYSTEMS” FOR ICFO

FILE NUMBER: ICFO-2026-068

Contents

CLAUSE 1. Object of the contract

The purpose of this contract is the supply, installation, and commissioning of two high-performance optical microscope systems for ICFO's laboratory. The systems shall support the automated identification, inspection, laser patterning, alignment, and assembly of exfoliated two-dimensional (2D) materials and heterostructures for the fabrication of devices based on layered quantum materials.

CLAUSE 2. Needs to satisfy

The objective of this procurement is to support the development of a fully automated system capable of: (i) identifying exfoliated two-dimensional (2D) materials and patterning them using a laser beam; and (ii) assembling these materials into heterostructures with high lateral positioning accuracy. The resulting platform will enable the systematic fabrication of devices based on layered quantum materials, including metals, semiconductors, superconductors, topological insulators, Weyl semimetals, and magnetic materials.

The challenges associated with task (i) include the low optical contrast of atomically thin materials in reflectance microscopy, the identification of micron-scale features such as folds, wrinkles, and interfacial bubbles, the precise laser cutting of selected flakes while minimizing damage to neighbouring materials, and the efficient location of ultrathin flakes randomly distributed over substrate areas as large as 8-inch wafers.

The challenges associated with task (ii) include the accurate alignment and stacking of 2D materials while minimizing the introduction of defects, contamination, or other process-induced imperfections.

To address the challenges described above, this tender covers the procurement of two optical microscope systems: *Microscope A*, dedicated to the identification, inspection, and laser patterning of exfoliated two-dimensional materials; *Microscope B*, dedicated to the assembly and alignment of two-dimensional material heterostructures. Together, these systems shall provide the functionality required for automated device fabrication and shall satisfy the requirements specified below.

Microscope A: flake identification and laser patterning

To enable the rapid inspection and identification of exfoliated flakes on large substrates, Microscope A shall be equipped with a high-resolution motorized stage providing sufficient travel range to inspect substrates up to 8 inches in diameter. The stage shall support automated wafer-scale scanning and positioning with high repeatability and accuracy.

To enable precise laser patterning of selected flakes, Microscope A shall include an optical fiber input port suitable for coupling an external laser source into the optical path.

Microscope B: heterostructure assembly

To support the assembly of 2D-material heterostructures, Microscope B shall provide sufficient vertical clearance beneath the objective lenses to accommodate a separate stacking system (not included in this tender). The microscope geometry shall also provide sufficient lateral clearance to accommodate substrates up to 8 inches in diameter and any associated transfer hardware.

To enable the reliable identification of atomically thin materials and the characterization of assembled heterostructures, the microscope systems must provide advanced imaging capabilities beyond conventional brightfield microscopy. In particular, quantitative phase-contrast imaging is required to enhance the visibility of

low-contrast features, including folds, wrinkles, contamination particles, and interfacial bubbles, which may significantly affect device performance.

Furthermore, the microscope systems shall support the acquisition of complementary image data suitable for processing by user-developed image-analysis, machine-learning, and artificial-intelligence algorithms. This requires simultaneous image acquisition from multiple cameras and real-time access to image data and associated metadata through documented software interfaces.

The microscope systems shall be compatible with future integration into a fully automated fabrication platform, enabling automated inspection, laser patterning, material transfer, and heterostructure assembly workflows.

CLAUSE 3. Technical requirements

The proposed solution shall consist of two upright reflected-light microscope systems, designated Microscope A and Microscope B, together with all hardware, software, accessories, and documentation required for their operation.

The microscope systems are intended for installation inside a glovebox. While they shall be capable of accommodating substrates up to 8 inches in diameter, their overall footprint shall be minimized to ensure that both microscope systems and the ancillary equipment required for automated processing can be accommodated within the available glovebox volume.

Both microscope systems shall satisfy the following requirements:

Optical Configuration

- The microscopes shall be upright reflected-light microscopes.
- The microscopes shall support brightfield microscopy.
- The microscopes shall support darkfield microscopy.
- The microscopes shall support polarization microscopy.
- The microscopes shall support differential interference contrast (DIC) microscopy.
- The optical systems shall provide image quality sufficient to identify atomically thin materials and resolve micron-scale features including folds, wrinkles, cracks, contamination particles, and interfacial bubbles.
- The selection of microscopy modes, objectives, and filters shall be fully motorized.

Microscope head, objectives, and polarization kit

- Each microscope shall include a motorized objective turret with capacity for at least seven objectives.
- Each microscope shall be equipped with 5x, 10x, 20x, and 50x objectives optimized for high numerical aperture and long working distance applications. Each objective shall provide a working distance of at least 9 mm.
- The reflected-light optical path shall be apochromatically corrected and optimized for imaging in the spectral range from 340 nm to 1100 nm.
- Each microscope shall include a motorized filter turret with capacity for at least six filter positions.
- Each microscope shall support fully polarization microscopy. The system shall include an analyzer and a compensator/retarder with continuous 360° rotation.
- Each microscope shall include a motorized intermediate magnification changer providing at least three selectable magnification factors and an integrated Bertrand lens for conoscopic observation.

- Each microscope shall include independently adjustable and centerable field and aperture diaphragms for reflected-light illumination.
- Each microscope shall provide selectable beam-splitting configurations, including the ability to direct 100% of the optical signal to the camera.
- Each microscope shall provide motorized focus control with a minimum travel range of 5 mm and a minimum commanded step size of 10 nm or smaller.
- The system shall be suitable for high-precision Z-stack image acquisition.

Illumination sources and filters

- Each microscope shall be equipped with a high-stability LED illumination source for reflected-light microscopy. The illumination source shall provide broadband illumination covering the visible spectral range. The illumination source shall provide a correlated color temperature of approximately 5600 K and a color rendering index (CRI) of at least 90.
- Each microscope shall be equipped with an LED-based fluorescence excitation light source. The fluorescence illumination system shall provide excitation over a wavelength range of at least 380 nm to 770 nm. The excitation source shall include spectral emission peaks distributed across the ultraviolet, blue, green, red, and near-infrared regions of the spectrum.
- Each microscope shall be equipped with a fluorescence filter set consisting of an excitation bandpass filter (450-490 nm), a 510 nm long-pass dichroic beamsplitter, and an emission long-pass filter (515 nm).
- Each microscope shall be equipped with a fluorescence filter set consisting of a 546/12 nm excitation bandpass filter, a 580 nm long-pass dichroic beamsplitter, and a 590 nm long-pass emission filter.

Microscope stand

- The footprint of the microscope base plate shall not exceed 700 mm x 600 mm.
- The microscope stand shall provide motorized vertical positioning of the microscope body.
- The motorized vertical adjustment range shall be at least 250 mm.
- The microscope stand shall permit the accommodation of samples and auxiliary equipment with a maximum height of at least 250 mm when no sample stage is installed.
- When equipped with the supplied sample stage, the microscope shall permit the accommodation of samples and auxiliary equipment with a maximum height of at least 100 mm beneath the objective lenses.
- The mechanical design shall provide unobstructed access to the sample area and shall be suitable for the integration of transfer stages, micromanipulators, and other equipment required for the assembly of two-dimensional material heterostructures.
- For enhanced stability, the microscope stand and base structure shall consist of a monolithic assembly.

Mechanical stability and drift

Mechanical vibrations originating from the microscope stand, microscope head, motorized components, or associated subsystems shall not produce observable image degradation at the highest available magnification.

The supplier shall provide documentation demonstrating the mechanical stability of the microscope structure and microscope head during operation. The supplier shall perform and document an image-stability test using a high-contrast reference sample and a 100x objective, over a continuous period of 24 hours. The test shall demonstrate that image quality is not degraded by vibrations originating from the microscope structure, motorized components, or normal instrument operation. The supplier shall perform and document a long-term stability test at the factory prior to shipment. The supplier shall provide representative image data together with an analysis of lateral image

drift and focus drift measured during the test. The methodology used to quantify image drift and focus stability shall be documented and included in the acceptance documentation.

Following any motorized stage displacement, the microscope shall settle to a stable imaging condition suitable for high-resolution imaging. The supplier shall provide the corresponding settling-time specification and test methodology.

Imaging system

- Each microscope shall be equipped with two scientific-grade color CMOS cameras suitable for the characterization of atomically thin materials and for phase-contrast microscopy.
- Each camera shall provide a minimum sensor resolution of 20 megapixels.
- Each camera shall employ a global shutter architecture.
- Each camera shall provide a sensor size of at least 12 mm x 12 mm.
- Each camera shall provide a pixel size not exceeding 3 micrometers x 3 micrometers.
- Each camera shall operate over the visible spectral range.
- Each camera shall provide a full-well capacity of at least 10,000 electrons.
- Each camera shall provide selectable gain settings and programmable acquisition parameters.
- Each camera shall support pixel binning modes.
- Each camera shall provide a high-dynamic-range (HDR) acquisition mode with a dynamic range of at least 25,000:1.
- Each camera shall provide an acquisition rate of at least 25 frames per second at full sensor resolution.
- Each microscope shall support simultaneous image acquisition from both cameras for phase-contrast microscopy and other advanced imaging modalities.
- The cameras shall be fully integrated into the microscope control software.
- The cameras shall be accessible through documented third-party software interfaces, including APIs, SDKs, or equivalent mechanisms, enabling external software to control image acquisition, retrieve image data, and access camera settings.
- The system shall permit real-time access to acquired images and associated metadata for integration with user-developed image-processing, machine-learning, and artificial-intelligence software.

Computer workstation

- Each microscope shall be supplied with a workstation suitable for the control of all microscope functions and the acquisition, storage, and processing of image data.
- The workstation shall include at least 64 GB RAM, a solid-state drive (SSD) with a capacity of at least 2 TB, and a data storage system with a capacity of at least 10 TB.
- The workstation shall provide sufficient processing and graphics performance to support automated image acquisition, image analysis, and machine-learning-based workflows.
- The workstation shall be supplied with a monitor of at least 32 inches diagonal size.

Microscope control software

- The software shall provide control of all motorized microscope functions, including objectives, focus, illumination, filter turrets, cameras, and motorized stages.
- The software shall support multiposition, multichannel, multilayer (Z-stack), and time-series image acquisition.
- The software shall support automated image acquisition using user-defined acquisition protocols.

- The software shall support autofocus and automated region-of-interest detection.
- The software shall permit image acquisition using different imaging conditions, including varying channels, exposure times, and acquisition areas, within a single experiment.
- The software shall provide tools for image stitching, navigation, and correlation of multimodal and multiscale datasets.

Software interfaces and automation

- The system shall provide documented software interfaces enabling third-party software to access and control microscope functionality.
- The supplier shall provide documented APIs, SDKs, scripting interfaces, communication protocols, or equivalent mechanisms permitting programmatic access to the system.
- Third-party software shall be capable of controlling all motorized microscope functions, including cameras, motorized stages, Z-axis positioning, objective turrets, illumination systems, and filter turrets.
- Third-party software shall be capable of initiating image acquisition, retrieving image data and metadata, and monitoring microscope status in real time.
- The system shall permit the execution of user-developed automation routines and workflows.
- The system shall provide support for remote control through standard communication protocols, including TCP/IP or equivalent mechanisms.
- The system shall permit the development and execution of automation scripts using Python.
- The supplier shall provide all documentation necessary for the development of third-party software and automation workflows.
- No additional software licenses, software modules, hardware dongles, or proprietary development tools shall be required to permit third-party software access to the microscope functions specified in this tender.
- The supplier shall confirm that the software interfaces remain available during normal operation of the microscope and do not require manual intervention through the graphical user interface.

In addition, Microscope A shall satisfy the following requirements:

Motorized stage

- Microscope A shall be equipped with a motorized XY scanning stage suitable for automated inspection and mapping of substrates up to 300 mm (12 inches) in diameter.
- The stage shall provide a minimum travel range of 300 mm x 300 mm.
- The stage shall provide a positioning resolution of 0.2 micrometer or better.
- The stage shall provide a positioning repeatability of ±1 micrometer or better.
- The stage shall provide an absolute positioning accuracy of ±5 micrometer or better over the full travel range.
- The stage shall support continuous automated scanning and coordinate-based navigation over the entire travel range.
- The stage shall provide a maximum translation speed of at least 40 mm/s.
- The stage shall support automated wafer-scale mapping and image acquisition workflows.
- The stage shall permit relocation of previously identified features using stored stage coordinates.
- The stage shall accommodate substrates and sample holders up to 300 mm (12 inches) in diameter.
- The stage shall include vacuum-compatible mounting fixtures suitable for substrates up to 200 mm (8 inches) in diameter and shall support the future accommodation of substrates up to 300 mm (12 inches) in diameter.

- The stage shall be fully integrated into the microscope control software and accessible through documented third-party software interfaces, including APIs, SDKs, or equivalent mechanisms.

Optical fiber input port

- Microscope A shall include an optical fiber input port suitable for coupling an external laser source into the microscope optical path.
- The optical design shall permit delivery of the laser beam through the microscope objective and focusing onto the sample plane.
- The laser coupling system shall maintain coaxial alignment between the imaging and laser beam paths.

CLAUSE 4. Power distributions and safety

- The system shall be configured for EU (Spain) power grid (voltage, sockets, etc.) and be CE marked.
- The system shall be protected against unexpected power cuts and, in that case, should 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 start-up requirements (Unpack all system components; Assembly; Run system; Demonstrate scan range; Demonstrate resolution; During the installation process, instruction should be provided on proper procedures for operation and maintenance of the system)**, clearly specifying temperature, pressure, humidity, vibration level, etc, for the specific configuration of the offered system.
- 1 copy of the Operating and maintenance manuals must be delivered in English.

CLAUSE 6. Transportation, installation, start-up and testing

- The proposal will include transportation to ICFO's facilities including insurance and all export/import and customs duties. **DAP incoterm will apply.**
- The system will be placed in the selected location by ICFO. Contract winner will cover all costs, organization and coordination of system placement, including any required specialized equipment or vehicle, and any required component disassembly and reassembly for system unloading and transportation inside the building to the target lab location.
- A test demonstrating the stability and absence of drift of the microscope head will have to be performed at the factory before shipment and on site after installation.

CLAUSE 7. Warranty and Follow-on Support

- **1-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.

- The supplier shall provide technical support by telephone and e-mail throughout the operational lifetime of the system. Initial response to support requests shall be provided within one business day.
- In the event of a system failure that cannot be resolved remotely, the supplier shall provide on-site technical support within 10 working days.
- Spare parts shall remain available for a minimum period of 10 years following system installation. In the event of a component failure, replacement parts shall be delivered within 10 working days.

CLAUSE 8. Delivery and Installation Time

The system must be delivered at ICFO before 18th of December 2026.

Delivery time is defined as the time elapsed since the signature of the contract until the system delivery at ICFO facilities. It includes the manufacture of the system, the transportation and the installation at ICFO's premises.

CLAUSE 9. Target price

- The target price for the system is 285.000,00 € (VAT excluded).
- Payment terms: after installation and acceptance - 100% total price

Castelldefels, on the date of its digital signature

Prof. Dr. Frank Koppens
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