SPECIFICATION SHEET

Supply, installation and starting-up of a high precision cutting and polishing system for electron microscopy for the Pilot Line PIXEurope at ICFO

FILE NUMBER: ICFO-2026-015

Contents

CLAUSE 1. Object of the contract

The purpose of this contract is the supply, installation and commissioning of a “Supply, installation and starting-up of high precision cutting and polishing system for electron microscopy” 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

In the Pilot Line project, an important part is the study of interfaces and thin film layers. A method to investigate them is to look at their sections, allowing to have information about their thicknesses, morphology and uniformity. As we are working in the nanometre range the main technique to observe them is electron microscopy.

To observe samples sections in scanning electron microscopy over large areas one of the most common way is to cut the sample to make a cross section and then polish it to have a roughness optimum enough to be observed at the nanometre scale. Focused Ion beam can be used for this purpose too but it is difficult to apply on charging samples and on large areas. Diamond saw is usually a good solution for the cutting due to the large range of platforms materials that can be cut and that are considered in the Pilot Line: Ge-on-Si, SOI, SiN, Al2O3, and SiC. Chemical and mechanical polishing (CMP) can reduce the large roughness of these cross sections. Samples, after these steps of mechanical cutting and subsequent mechanical and chemical polishing, still shows some roughness and irregularities on its section. It can provoke artefacts on the SEM images. Ion beam polishing is thereafter used to obtain flat surfaces of samples in order to be observed with more precision in Scanning Electron Microscopy (SEM). The same system can also be used to smooth top sample surface to make it as flat as possible. For applications such as EBSD (electron Beam Backscattered Diffraction) the obtained roughness of the sample surface is very critical to obtain a good indexation of the crystallographic orientation. Cryogenic option of the ion beam polishing is important in order to reduce ion-beam-induced damage (ion-induced amorphization, implantation, and defect generation), suppression of beam-induced chemical changes or reduced charging and beam-induced heating.

The system will be used as to prepare surfaces with the following applications:
- Preparing accurately controllable cross-section of samples prior to SEM observation
- Flattening top surfaces, for EBSD analysis.

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.

Machines / Processes overview

The system must be composed of a diamond saw to section the samples and to get their rough cross section, of a mechanical and chemical polisher to polish these sections to the micrometer level and an ion beam polisher to polish these sections to the nanometer level. The technical specifications should have already been proven by results obtained with the system. These data should be included into the technical presentation of the system.

Diamond SAW:

The precision diamond saw must be a low speed saw for delicate and heterogeneous samples. The variable blade speed must reach the range between 10 and 500 RPM, at least, with a control increment of 10 RPM for fine control and minimal heat generation during cutting. The saw must have a precise sample positioning of 2 µm resolution, or less, over a 0–25 mm range, enabling reproducible cuts. The saw system must have a screen to control all the functions, including a list of editable recipes in order to provide reproducible results. The saw system must allow to apply or counterbalance downward force to the sample during sectioning with adjustable weights.

The saw must support a wide range of blade options, with a diameter range between 75 and 150 mm, at least. A blade much be provided, with diamond metal bond. A cutting fluid to cool down the sample while sawing must be provided too.

Handling of sample must be provided with general purpose holders, such as V-block fixture, with a capacity of 25mm, or more, and a single saddle clamp with v-grooves and flat side.

CMP Polisher

The Chemical and Mechanical Polishing system must be semi-automated, high-precision grinder/polisher designed to produce reproducible, quantifiable, and geometrically controlled cross sections suitable for electron microscopy and for materials including Ge, Si, SOI, SiN, Al2O3, and SiC. The system must have the capability of site-specific polishing.

A system of micrometers must allow to adjust precisely the sample tilt relative to the polishing pad plane.

The system must have 2 precision polishing platens of 8” diameter, or more.

A digital indicator must indicate quantitively the material removal in real time during the polishing process, with a 1um resolution, or less.

The variable polishing platen speed must reach the range between 5 and 350 RPM, at least, with a control increment of 5 RPM for fine control. The system must allow to perform unattended polishing operation with a controlled preset removal value and automatic fluid delivery.

An adjust loading with a variable force application must be available and adaptable to different sample sizes and hardnesses. The system must have user friendly control with a screen.

The system must have different solutions to handle samples: accessory and fixture sets, and special adapter for the ion beam polisher system.

ION Beam Polisher

The ion polisher system must be prepared to prepare clean, smooth and possibly wide cross sections for high resolution SEM, at the nanometer scale, and EBSD compatible surfaces with minimal roughness. This system must show the following:

1. Chamber

   a. The system will be equipped with a chamber that can be vacuum pumped, with a material such as metal or glass ant that must be implosion proofed.
   b. The system chamber must be of sufficient size to accommodate large sample and the corresponding holders, and moreover must be freely accessible from the outside.
   c. The system chamber must allow observation of the inside by an integrated window with the means of a light microscope or of a camera.
   d. If the sample holders have to be mounted on the chamber door by a support, in order to be introduced in the chamber for process, then the construction must allow an easy changing of the sample holders by being able to remove the support.
   e. The chamber must accommodate samples with size up to 50 mm in diameter for flat polishing or 20mm in width for cross section polishing and their corresponding holders.

2. Sample handling

   a. The system must include a stage that will be used to mount holders for cross section polishing and for flat milling.
   b. The stage must be able to swing to get a more uniform polishing and avoid curtaining effects, compared to static stage, for cross section polishing. The operator must be able to choose between at least 3 different values of swing angles and at least 2 different speeds in the cross section polishing mode. In flat milling mode the operator must be able to choose at least 2 different swing conditions.
   c. The system must include a dedicated sample holder for cross section and a holder for flattening
   d. The cross-section holder must allow to mount sample sizes of at least 20mm wide, 12mm deep and 7mm high. On a single holder the operator must be able to place at least 3 different samples to process them simultaneously.
   e. The cross-section holder must be removable from the system to allow an easy mounting of the sample prior to introduction in the chamber and process.
   f. The samples for cross section must be mounted on holders with a flexible positioning and not glued to shielding masks.
   g. The system or an optical microscope external to the system must allow to adjust the sample and the shielding mask positions optically, with a magnification of at least 100x.
   h. Adjustment options of the cross-section specimen holder must be available in X-direction (along the cutting edge), in Y-direction (perpendicular to the cutting edge), in rotation (aligning the cutting edge parallel to the edge of the shielding mask) and in mask position (definition of the cross-section position).
   i. The cross-section holder must be equipped with a motorized adjustment axis in the X direction. This must allow to move the cross-section stage continuously and periodically along the specimen cutting edge perpendicular to the ion beam by a distance accurately programmed by the user according to the current sample polishing needs, up to 10mm at maximum.
   j. The support of the holder must always remain in the focus of the beam in order to ensure consistently high removal rates. There should also be no restrictions on the maximum sample size compared to stationary cross-sections.
   k. The surface polishing holder needs to be easily removable from the system.
   l. The surface polishing specimen holder must allow the mounting of cylindrical specimens up to 50mm in diameter, at least, and 25mm in height, or larger.

3. Cross section polishing process

   a. The system must be able to polish Si for the creation of wide cross-sections in acceptable times.
   b. The system must be able to polish a process width of at least 8mm.

4. Surface milling process

   a. The samples during surface polishing process must be able to continuously rotate to have a homogeneous surface finish (0 to 360º).
   b. The samples during surface polishing process must be continuously tiltable from 0° to 90° relative to the ion beam in order to flexibly allow different polishing effects such as smoothing or large removal with subsequent shallower smoothing.
   c. The milling area must reach 30mm diameter, or more.
   d. The beam incidence angle during the flat milling process must be adjustable from 0 to 90º.

5. Ion gun

   a. The system must produce an ion beam through Argon with one ion gun, or more.
   b. The acceleration voltage of the ion beam must be adjustable in the range of 0 kV to 8 kV, or more, by steps of 100V and its current within 0 to 500 uA, or more. The emission of the ion gun(s) must be stable within the entire voltage range.
   c. The Ar flow will be controlled by a Mass flow controller

6. Operation control

   a. The system must have a touchscreen that allows to edit and run recipes to perform the polishing. It will be possible to store predefined recipes for standard protocols, and customizable recipes for tailored applications.
   b. The system software must allow to execute two-step processes with independent choice of accelerating voltage, ion beam current, process time, to start time-delayed execution for all polishing processes and to select and choose freely and independently times for ion beam bombardment and ion beam pause or blanking.
   c. The graphic interface must allow to view the last runs and should provide reminders for periodical maintenance.
   d. It will be possible to observe the chamber inside during all operation with the means of a light microscope or of a camera, including during cross section and surface flat milling processes. The optical view system must include a 5x objective.

7. Vacuum system

   a. A fully safety interlocked high vacuum (HV) system to pump the milling chamber, consisting of a dry rotary pump and a turbomolecular pump.
   b. The turbomolecular pump (TMP) to efficiently keep the HV internally integrated in the system must have a pumping capability of 65 l/s or higher.
   c. The dry rotary pump to back up the TMP, externally integrated in the system, must have a pumping capability of 120 L/min or higher. This fore pump will be external to allow easy maintenance and to avoid vibrations.

8. Sample cooling

a. The system must allow to cool down the sample while ion cross section polishing with a temperature maintained between -100 ºC to 0 ºC.
b. The selected temperature, down to -100ºC, must be maintained by cooling and counter heating with a stability of +/- 2ºC, or better.
c. The cooling will be done with liquid nitrogen which will be stored in a dewar connected to the system.
d. The cooling operation must not have restrictions on sample size compared to non-cooled operation. The cooling operation in cross-section polishing must be allowed for process width of 8mm, or more (wide area cross section).
e. The cooling operation must be managed entirely by the system and executed by recipe, including steps of cooling down to target temperature, waiting time for thermal equilibration of stage components, cross-section polishing, warm-up after end of cross-section polishing process)

9. Accessories

a. Parts requiring cleaning must be provided minimum twice to allow hot-swap for minimum downtime.
b. An external optical microscope to conveniently adjust sample and the mask position before process in the system.
c. A digital hotplate
d. At least 5 Masks made of Titanium to produce the cross sections.

CLAUSE 4. Power distributions and safety

- The system should be configured for EU (Spain) power grid (voltage, sockets, etc.) <u>and be CE marked.</u>
- 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 **<u>will include full installation and start-up requirements</u> (Unpack all system components; Assembly; Pump; 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 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, 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:

DIAMOND SAW

- Test Sample: PMMA, 5 mm thickness.
- Cutting conditions: diamond disk, Spinning speed 100–200 RPM, Cooling with water if necessary, low applied load

- Expected result: clean cut, with no thermal deformation, neither excessive side cracks nor leftovers, so that further surface preparation should be minimal.

CMP

- Test Sample: Recently cut PMMA layer of 5 mm thickness.
- Polishing conditions: succession of thin sanding, ultrafine sanding with SiC paper and fine sanding with colloidal diamond 3um, finishing with alumina 0.05um.
- Expected result: The prepared surface after polishing should appear flat and homogeneous, and present minimum plastic deformation, with no sample dragging or smearing.

ION POLISHER

- Test Sample: Si chip. Previously to the ion polishing, the Si surface must be mechanically cut and may be polished at least to a 3 μm diamond phase.
- Polishing conditions: Beam voltage < 10 kV, one-hour process for Si protruding 100 μm from the mask edge.
- Expected result: removal of 1000 μm of polished Si.

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.
- 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 1 training day and the approximate schedule. 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 should be delivered within **5 months from the start 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 5 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 200.000,00 € (VAT excluded).
- Payment terms:
  - Payment on order - 30% total price. This payment is optional for the contratist, but in case the contractor requests a payment of 20% of the contract, he will have to constitute a guarantee for an amount equivalent to the amount that was advanced. 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

Castelldefels, on the date of its digital signature

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Optolectronics