ICFO

MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

Cofinanciado por la Unión Europea

AGENCIA ESTATAL DE INVESTIGACIÓN

SPECIFICATION SHEET

SUPPLY, INSTALLATION AND STARTING-UP OF AN ADVANCED ELECTRON SPECTROSCOPY FOR CHEMICAL ANALYSIS (ESCA) SYSTEM BASED ON X-RAY PHOTOEMISSION, HARD X-RAY PHOTOEMISSION AND AUGER ELECTRON (MICRO-) SPECTROSCOPIES FOR THE NCL LAB AT ICFO, THROUGH AN OPEN PROCEDURE SUBJECT TO HARMONIZED REGULATION

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CLAUSE 1. Object of the contract

The purpose of this contract is the Supply, installation and commissioning of an Advanced Electron Spectroscopy for Chemical Analysis (ESCA) system based on X-ray Photoemission, Hard X-ray Photoemission and Auger Electron (Micro-) Spectroscopies for the NCL laboratory at ICFO.

The system will be used as a spectroscopy system for the following applications:

- Survey and narrow x-ray photoemission spectroscopy (XPS)
- XPS imaging
- Hard x-ray photoemission spectroscopy (HAXPES)
- Ultraviolet photoemission spectroscopy (UPS)
- Auger electron spectroscopy (AES) and imaging
- Inverse photoemission spectroscopy (IPES)
- Reflection electron energy loss spectroscopy (REELS)
- Depth profiling

It must allow to measure with the different techniques indicated above the same area of the sample, implying that the system must be calibrated, the measurements must be reproducible with time and uniform within the sample area. To comply these requirements the machine must allow a minimum noise and a reduced drift with time.

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

CLAUSE 2. Needs to be satisfied

ICFO does not currently have advanced electron spectroscopy tool for chemical analysis to analyse the chemical composition of materials and structures at the microscale. This new system will offer advanced surface characterization techniques including XPS, HAXPES and AES all combined in a single tool offering a unique characterization platform for the chemical species analysis, oxidation state identification and mapping of such properties at the micro-scale. It will reveal composition and topographies of materials in such diverse fields of research from optoelectronics and semiconductors to quantum optics, nanophotonics, condensed matter physics and biophysics. In particular it should address challenges in the study of energy related materials, such as photovoltaics, catalysis etc., for which the understanding and knowledge of material composition and structure is indispensable.

CLAUSE 3. X-ray photoemission spectroscopy and imaging sources

3.1. The system must be equipped with a primary Al Kα x-ray anode for XPS, capable of delivering a monochromated 1486 eV x-ray beam for high resolution and high sensitivity XPS measurements. The maximum operation power for this source must be at least 100 W.

3.2. The Al Kα X-ray focus spot size may be adjusted to provide an illuminated area accordingly to the required analysis area.

3.3. The Al Kα x-rays must allow both XPS spectra and imaging measurements

3.4. Al Kα source must allow a maximum scanning area of at least 700 µm x 300 µm, or larger and a small spot scanning mode of 15 µm or smaller.

3.5. The system must include a secondary monochromated x-ray source for hard x-ray spectroscopy (HAXPES), of energy higher than 2900 eV, allowing core levels up to this binding energy to be excited. The specific emission energy level value of this source, of more than 2900 eV, will be evaluated as indicated in Annex 2.

3.6. The system must be allowing automatic switching between the 2 excitation sources (primary and hard) while maintaining focus of the X-rays areas on the analysis area and requiring the minimum intervention of the operator.

3.7. The two sources must be aligned to allow acquiring XPS and HAXPES spectra on the same location.

CLAUSE 4. Analyser and detector

4.1. The system must include a vertical mounted 180º hemispherical electron energy analyser

4.2. The high angular acceptance lens will provide small area XPS sensitivity

4.3. The analyser must provide an energy resolution smaller than 0.50 eV and a sensitivity of at least 2,000,000 cps at 0.6 eV for large area mode, defined as the maximum counts per second of the FWHM of Ag 3d 5/2 peak after subtraction of background with Al Kα x-ray excitation.

4.4. The system must include multichannel plane detector for spectroscopy and imaging with up to 128 data channels available.

4.5. The analyser must allow to define pass energy from 27 eV, or below, up to 224 eV or above.

CLAUSE 5. Ultraviolet photoemission spectroscopy source

5.1. The UPS option must provide information on the work function and ionization potential of the material.

5.2. The system must be equipped with an ultraviolet (UV) lamp to excite He I and/or He II sources.

5.3. The sensitivity, as the counts per second (cps) of the Ag 4d peak and where resolution is defined by the 80 - 20% measurement of the Ag Fermi edge excited by He I radiation must be higher than 1,000,000 cps with a 120 meV resolution or below.

5.4. The system can be equipped with a filter to reduce the UV lamp intensity to less than 5% in transmission. This feature would be evaluated as indicated in Annex 2

CLAUSE 6. Auger electron spectroscopy, secondary electron microscopy and scanning Auger microscopy

6.1. The system must allow performing Auger electron spectroscopy and imaging, line scans, depth profiling and maps.

6.2. It must include a shielded source, a secondary electron detection and imaging system.

6.3. The minimum electron beam size and spatial resolution must be 100 nm or lower at 10kV.

6.4. The sensitivity, defined as the Cu LMM Auger peak height at a maximum near 917 eV above the background at 950 eV and as the FWHM of the elastic peak after background subtraction must be 500 000 cps or larger.

6.5. A Fixed retard ratio (FRR) sweep mode must be included.

CLAUSE 7. Inverse photoemission spectroscopy (IPES) and reflection electron energy loss spectroscopy (REELS) systems

7.1. The IPES option must allow the acquisition of the light emitted by electrons making direct transitions into the unoccupied states, allowing to study the density of unoccupied electronic states between the Fermi and the vacuum levels. The system must include a low energy electron source for this IPES application.

7.2. It must also include a photon detector, an amplifier to obtain the IPES spectrum. Optical bandpass filters can be included and would be scored as established in Annex 2

7.3. The REELS option must enable the collection of reflected electron energy loss spectra from the surface of the sample by focusing the beam of electrons on the sample and by collecting the scattered electrons through a lens and an analyser. The spectroscopy detector must allow an energy resolution lower than 0.5 eV.

7.4. The electron source will have an acceleration voltage of at least 2 kV for REELS measurements.

7.5. The REELS sensitivity defined as the counts per second of the elastically scattered peak on sliver sample must be at least 1,000,000 cps at 0.65 eV resolution or lower.

CLAUSE 8. Charge compensation

8.1. The system must include an in-built charge compensation system, either using independent electrons and Ar ion beams or a source of low energy electrons, which will efficiently neutralise sample charging caused by the photoemission process and for a wide range of insulating samples.

CLAUSE 9. Sample holders

9.1. The system must be equipped with at least two sample holders hosting samples 40x30 mm lateral size, or larger, and up to 7.5 mm thick, or thicker. One sample holder may allow sample rotation for depth profiling experiment.

9.2. The sample holders must allow clip/screw options to aid sample mounting.

9.3. The system must have a sample holder which allows to make angle resolved XPS.

CLAUSE 10. Stage and temperature control

10.1. The system must be equipped with a five-axis stage

10.2. The stage must be capable of moving up to +/- 37.5 mm in X and Y directions, or more, and 18 mm at least in Z direction

10.3. The in-plane rotation allowed from the stage must be up to +/- 180º, while it must allow a tilt -55º to 85º, at least, with the dedicated sample holder

10.4. The stage must allow compucentric rotation, adjusting the X and Y positions when rotating the stage to stay on the same sample area

10.5. The stage must fit a heat and cool facility with a dynamic control of the temperature through a PID in the range of -100ºC to 500ºC

10.6. A liquid nitrogen (LN_2) dewar and reservoir allowing for sample cooling must be provided

CLAUSE 11. Sputtering and depth profiling

11.1. The system must be equipped with a dual-source Ar ion gun, allowing sputtering both with monoatomic and cluster Ar ions

11.2. The monoatomic Ar+ ion source must produce a stable, high current with energies from 0.5 to 4keV, at least.

11.3. The beam energy of the Ar cluster ions must be at least 20 keV.

11.4. The system must include an Ar cluster size measurement tool (time-of-flight spectrometry) to measure the size of the Ar clusters.

CLAUSE 12. Navigation system

The system must be equipped with the necessary navigation system to locate the analysis position on the sample easily and quickly. In particular:

12.1. A high-resolution digital colour camera to capture a photo of the sample in the introduction chamber so that a global view of each sample holder such that analysis positions can be viewed.

12.2. It must be possible to select the analysis area on the picture taken when the sample was in the introduction chamber

12.3. An in-situ camera and light source to provide a live view of the sample at the analysis position. It must allow sample viewing and analysis position selection

CLAUSE 13. Vacuum system

13.1. The intro chamber must be equipped with a main pump (turbomolecular pump) and a rotary pump, allowing a pressure down to 10^{-7} mbar range

13.2. The analysis chamber must be equipped with a main pump (turbomolecular pump), a rotary pump and a Titanium sublimation pump, allowing a pressure down to 10^{-9} mbar range, or below

13.3. One additional rough pump for the Ar gun

13.4. Fully automatized bake-out system to clean the analysis chamber from contaminants, including a safety mechanism activating if the temperature or the pressure overpass a critical value.

13.5. The system must be equipped with a safety interlock not allowing to open the analysis chamber if the vacuum in the intro chamber is above a safety level.

CLAUSE 14. PC and software

14.1. PC with LCD monitors and windows 10 installed

14.2. The computer must control all the necessary hardware, software, data processing and data analysis needed for the measurements

14.3. It must allow remote operations and diagnostic.

14.4. The software must include an extensive library of post-analysis data processing algorithms including background subtraction, smoothing, peak identification, linear least squares fitting, target factor analysis, curve and peak analysis and separation of multiple chemical states in maps, line scans and profiles

CLAUSE 15. Power distribution and safety

15.1. Power system compatible with standard Spanish voltages, frequencies and configurations and with all Spanish laws and regulations.

15.2. CE marking.

15.3. Component wiring routed to a centralized power distribution panel.

15.4. EMO protection

15.5. Appropriate hardware and software safety interlocks. Extended error diagnostics.

15.6. 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 16. System layout and services

16.1. The proposal will include a complete set of pictures, drawings and layouts of the system, including dimensions, location and details of the different components (vacuum chambers,

including intro and analysis chamber, ion columns, sample chuck, electronics rack, controllers, etc.)

16.2. The proposal will include full installation and start-up requirements of power and other conditions for the specific configuration of the offered system.

CLAUSE 17. Documentation

17.1. Complete set of manuals, drawings, schematics and layouts about system assembly and configuration (mechanical assembly, vacuum system layouts, electrical schematics, system modules interconnection, etc).
17.2. Complete system user manual, including routine servicing, troubleshooting and basic repairs.
17.3. System components spare list, specifying quantity, manufacturer, part number, etc.
17.4. All the above documentation will be supplied in English, in electronic format (CD/DVD) and in paper copy.

CLAUSE 18. Tools and system spares

18.1. Spare fuse kit (where applicable).

CLAUSE 19. Transport, installation and start-up

19.1. The proposal will include transportation to ICFO's facilities and all export/import and customs duties.
19.2. The machine will be placed in the selected location by ICFO. Contract winner will cover all costs, organization and coordination of machine placement, including any required specialized equipment or vehicle, and any required component dis-assembly and re-assembly for system unloading and transportation inside the building, following the route specified by ICFO. The machine will have its own wheels to facilitate these operations and levelling pads to hold it in a stable and levelled position once in place.
19.3. 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.
19.4. Installation and start-up of the system, including system checking, functional tests and process qualification will be included.

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.

CLAUSE 20. Acceptance criteria for installation

20.1. XPS energy resolution and sensitivity at 0.6 eV for large area mode with Al Kα x-ray excitation, defined as the maximum counts per second of the FWHM of Ag 3d 5/2 peak after subtraction of background

20.2. UPS sensitivity, as the counts per second (cps) of the Ag 4d peak and where resolution is defined by the 80 - 20% measurement of the Ag Fermi edge excited by He I radiation at 120 meV resolution or below

20.3. Auger sensitivity, defined as the Cu LMM Auger peak height at a maximum near 917 eV above the background at 950 eV and as the FWHM of the elastic peak after background subtraction.

20.4. REELS sensitivity defined as the counts per second of the elastically scattered peak on sliver sample at 0.65 eV resolution of lower

20.5. Guaranteed minimum pressure in the analysis chamber and in the intro chamber.

CLAUSE 21. Training

21.1. System use and process training to ICFO users at ICFO's facilities and specific maintenance and advanced service training to ICFO lab technicians will be included. The training days will be a minimum of 6 days but additional days will be evaluated as stated in Annex 2.

CLAUSE 22. Warranty and support

22.1. **1-year full warranty**, starting at system acceptance. The warranty will include the replacement of any faulty or damaged part(s) during the normal use of the system, no matter the manufacturer of the component(s) but does not have to include third party parts such as vacuum pump, and consumables. 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

22.2. System lifetime support:

- By phone and e-mail with a response within 3 hours
- Emergency visit after a system breakdown within 10 working days

22.3. 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

22.4. An estimation of the cost of a warranty extension or available support contract options after warranty period will be included.

CLAUSE 23. Additional optional improvements

The following points will be evaluated positively as it is stated in Annex 2.

23.1. The possibility to get an X-ray image that is acquired using the same X-rays and analyser used for XPS measurement, ensuring precise measurement area location that is critical for micro-area analysis

23.2. The offer can include the third-party software casa XPS to analyse XPS measurements. It would be evaluated positively as stated in Annex 2.

CLAUSE 24. Delivery time

The machine must be delivered **no later than 22 June 2026**.

CLAUSE 25. Technical proposal structure

Bidders must submit in Envelope 2 documentation proving compliance with the technical requirements indicated above. Any optional accessories not requested for the proposal will have to be put in a separate section, and not mixed with the included items, although they are not going to be scored.

In addition to the requirements indicated above, bidders must submit a report containing the following sections that will be evaluated as it is explained in Annex 2:

o Technical proposal for equipment actions:
• Minimum spot size
• Greater resolution in energy and sensitivity of XPS table
• Greater resolution in energy and sensitivity of the UPS table
• Greater sensitivity of the Auger table

o Technical proposal for equipment options:
• Sample load neutralization system
• Maximum sample holder size
• Degree of measurement automation

o Technical proposal for analysis of equipment measurements:
• XPS measurement analysis software license
• Casa XPS measurement analysis software license
• Thin layer structure analysis software

o Supply, supplier and services:
• Maximum repair time, sending of damaged parts and planned response protocol in case of breakdowns and/or problems
• Activities proposed for training on the operation of the equipment, and actions for the continuous monitoring of training for technicians and users of the equipment (complementary and advanced training)

Castelldefels, on the date of its digital signature

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