Annex no. 1 Contract for Work

**Specifications for** **Spin- and Angle- resolved Photoemission Spectrometer (SARPES)**

The University of West Bohemia in Pilsen wishes to acquire an advanced photoemission system suitable for energy, wave vector, spin and time resolved studies of advanced materials. The system will be a state-of-the-art photoelectron emission spectrometer with spin and angular resolution (SARPES).

The system must be capable of working with laboratory photon sources and allow for future extension to laser sources.

It must be equipped with a SARPES analysis chamber, a preparation chamber with surface analysis tools, a smaller “dirty” (for organic molecules) preparation chamber and a load lock. The system must be modular in order to facilitate reliable installation.

Complete sample transfer and handling between load lock, two preparation chambers and analysis chamber must be included.

**Specifications for analysis chamber for PES and XPS:**

The analysis chamber must be made of μ-metal (residual magnetic field < 0.5µT at sample position) with a diameter of no less than 23 cm and fitted with all necessary flanges for energy analyzer, X-ray source, UV source, flood gun, electron source, sample manipulator, sample introduction system, vacuum pumping system, pressure measurement, viewports and reserve flanges. A flange (35CF-63CF) for future laser UV source must be included too.

The base pressure must be equal or better than 2.0 x10-10 mbar. The fully interlocked vacuum system must be supplied together with an appropriate rigid system frame and bake-out facilities including an electronic temperature and bake-out time control unit. In addition to the turbomolecular pump and oil free rough system, one additional ion getter pump must be included.

This chamber must include at least the following surface characterization tools:

Suitable computer-controlled and motorized sample UHV manipulator must be provided. Sample manipulator must allow for at least 5 axis manipulation including 3 translations (*x/y* linear shift not smaller than +/-12mm, *z* linear shift adapted to system), polar rotation (not smaller than +/-180°)and azimuthal rotation (not smaller than +/-90°). Open-cycle cooling of manipulator with liquid N2 and liquid He must be included, as well as a system for heating to temperatures of approximately 800° C. With LHe cooling, temperature lower than 20K must be achieved on the sample surface. The system must include temperature measurement of the sample plate. Additional sample positions, suitable for standard sample analysis and with *x, y, z* and polar manipulation, must be included. A wobble stick for sample transfer to manipulator must be included. In addition to that at least 20 molybdenum standard single plate sample holders must be supplied. Software has to allow for automatic control of all 5 axis including possibility for creation of scripts for automatic acquisition and PID control of temperature.

State of the art hemispherical electron energy analyzer package for angular-resolved and spin-resolved XPS, UPS, and ARPES measurements must be provided. Analyzer mean radius must be equal or better than 150mm, working distance must be at least 34 mm. It must have at least 8 entrance and 3 exit slits and integrated double µ-metal shielding. The analyzer package must include scanned angle lens for 2D angular mapping. Full acceptance angle in tilt and polar direction must be equal or better than +/-15°. XPS and ARPES capabilities with corresponding lens modes as well as additional lens mode with lateral resolution must be included. Energy resolution must be equal or better than 2 meV. Angular resolution must be equal or better than 0.1 degree. Small spot capability must be equal or better than < 100 micrometers. Combined 2D-CCD detector and 3D-VLEED spin detector must be included. Complete spin analyzer package must be based on the single electron path. It must include one single 3D-VLEED detector for the measurement of all three spin components. It must include 90 degree deflector and spin rotator. Turbo molecular pump, pneumatic gate valve and pressure measurement must be included together with the detector. Hemispherical analyzer and spin detector must be fully computer controlled and must include all necessary hardware. Automatic data acquisition software and XPS data processing software must be included. Free upgrades of the analysis software must be guaranteed throughout the project's sustainability (ie. to 31. 10. 2027).

The performances in terms of energy and spin resolution, the available sample temperature range as well as the other figures corresponding to the standards of the supplier’s equipment, must be proven on-site by the acceptance tests.

UHV compatible, filament less, UV microwave plasma source including elliptical focusing transfer capillary for ARPES studies must be provided. Source must be able to operate with different gases like He, Ar, Xe, H, Ne. Intensity of primary UV source must be > 1E15 photons/s\*sr. Small spot focusing capillary must have focal point of 500µm at 10mm working distance. Total intensity with He gas operation must be equal or better than 300 nA for photocurrent measured on grounded gold sample at 10 mm working distance. UV source should have self-igniting design. Microwave power must be equal or better than 400 W. Mounting flange should be DN35CF. UV source must have integrated gate valve with borosilicate glass window. Maximum output power must be equal or better than 600 W.

UV monochromator compatible with this lamp must be offered.

Monochromator must have two grids, switchable under UHV conditions. He I cassette, grating with 1200 grooves/mm must be provided. HeII cassette, grating with 1200 grooves/mm must be provided. Mounting flange must be DN35CF. UV line width must be <1meV after monochromator. Separate differential pumping stages for UV source and monochromator must be provided

UHV compatible x-ray source which allows XPS measurements in ultra-high vacuum with dual Al/Mg anode must be provided. The X-ray source must be ready for use with dual anodes with different material coatings. The mounting flange must be DN40CF. Maximum power of at least of 300W for Al and Mg is expected. Maximum sample temperature increase during long-term operation must be 5° C or less. Microprocessor driven power supply with maximum power of 1kW must be supplied. Maximum anode voltage must be at least 15kV. Power supply must have integrated safety electronics. The cooling unit must include integrated safety electronics for protection of persons and equipment. It must have sensors for water temperature, flow and pressure. In addition to that, a closed-cycle water cooling module with two closed-cycle water cooling circuits (one for the x-ray source and one for the turbo pumps) must be offered. Cooling performance must be equal or better than 1000W. Pumping power must be equal or better than 5l/min. Water sensors with alarm output and RS232 remote control functionality must be offered.

In addition to the light sources, flood electron gun package for sample charge neutralization must be included. The e-beam energy has to be controlled in the range of 0-100eV. Electron current should be in the range of 0-50µA. Insertion length should be 200 mm. Mounting flange should be DN40CF. Automatic adjustment of charge compensation must be included.

The system must include room for preservation of 8 samples.

**Specifications for preparation chamber used for sample preparations and characterization:**

UHV stainless steel chamber with a diameter of no less than 23 cm should include flanges for evaporators, RHEED, LEED/AES, ion source, microbalance, viewports, manipulator, sample handling, pumps and connections to neighboring chambers. The base pressure must be equal or better than 2.0 x10-10 mbar. The fully interlocked vacuum system must be supplied together with appropriate rigid system frame and bake-out facilities including an electronic temperature and bake-out time control unit.  
In addition to the turbo-molecular pump and oil free rough system one additional ion getter pump must be included.

Sample storage for 8 samples must be included.

This chamber must include the following surface characterization tools:

UHV sample manipulator for sample preparation and characterization must be provided. Sample manipulator must allow for at least 4 axis manipulation including 3 translations (*x/y* linear shift not smaller than +/-12mm, *z* linear shift adapted to system) and polar rotation (not smaller than +/-180°).Sample heating up to 800 degrees C and cooling with liquid nitrogen must be included.

Multi-pocket e-beam evaporator package, with at least four pockets allowing easy evaporation from rods and crucibles must be supplied. Evaporator must include at least 2 fixed length holders, 2 linear motion holders, set of flux electrodes, digital power supply for independent control of all four pockets, integral water cooling with fully enclosed filaments and motorized shutter driven with stepper motor. It should have in vacuum length of 231mm and diameter not larger than 34mm. Power supply must allow programmed deposition of up to four materials. It should deliver voltage in the range 0-2kV. Max emission current should be at least 200mA combined for all four pockets. Filament current should be in the range of at least 0-10A. Filament voltage should be in the range of at least 0-10V. Max power for all four pockets combined must be at least 400W. Max power for one pocket must be at least 300W. Filament replacement must be possible without the need to disassemble the evaporator.

Ion source with power supply and gas inlet must be provided. Ion source should be extractor type source suitable for inert or reactive gases. It should enable in vacuum surface cleaning via sputter etching. Beam currents up to 20μA must be possible. Analog power supply for ion energy range up to 3 keV must be included.

RHEED with power supply must be included. Electron gun must have beam current in the range of <0.01-50µA. Focal length must be in the range of 200-1000mm. Spot size must be at least <100µm. *X,y* deflection must be equal or better than +/-15°. Primary energy range must be equal or better than 25keV. In addition to that Phosphor imaging screen DN160CF with shutter must be included.

LEED optics with shutter and power supply must be included. LEED optics must be mounted on DN150CF flange. Working distance must be 20mm. It must have 100mm *z*-retraction mechanism and 4 grids made of gold coated molybdenum. Electron gun must have a filament made of thorium-coated iridium hairpin. It must work in the energy range of 0-3000eV. Beam diameter must be equal or better than 1mm. Screen material should be glass coated with ITO conducting layer and P43 cadmium free phosphorus. A fully digitally operated LEED/AES control unit with integrated lock in amplifier and software for standard LEED applications and Auger electron spectroscopy (AES) must be included. Power supply must be fully floating and it must allow true beam current measurement. It must deliver primary energy in the range of 0-1000eV for LEED and 0-3000eV for AES. The screen voltage must be equal or better than 0-10kV. Power supply must have RS232 interface for external operation via PC.

Software package for image acquisition and processing for LEED and RHEED must be offered.

Quartz crystal microbalance package must be offered. It should include crystal microbalance, thin film deposition monitor, 100mm *z*-retract mechanism.

For residual gas analysis in UHV, the quadrupole mass spectrometer is expected. Mass range must be equal or better than 1- 200 amu, mounting port DN40CF (2.75"). It must have Faraday cup and secondary electron multiplier-detector.

**Specifications for smaller “dirty” preparation chamber:**

UHV stainless steel chamber with a diameter of no less than 16 cm should include flanges for evaporator, ion source, viewports, manipulator, sample handling, pumps and connections to neighboring chambers. The base pressure must be equal or better than 2.0 x10-10 mbar. The full interlocked vacuum system must be supplied together with appropriate system frame and bake-out facilities including an electronic temperature and bake-out time control unit.

This chamber should include the following surface characterization tools:

UHV sample manipulator for sample preparation and characterization must be included. Sample manipulator must allow for at least 4 axis manipulation including 3 translations (*x/y* linear shift not smaller than +/-12mm, *z* linear shift adapted to system) and polar rotation (not smaller than +/-180°). In this chamber,sample heating by the button heater up to 800 degrees C and cooling with liquid nitrogen must be included.

E-beam evaporator package with one pocket for easy evaporation from rods and crucibles must be included. Evaporator must allow evaporation from the rod with a diameter of at least 2mm. Rod feed must be equal or better than 50 mm. It must allow evaporation from the crucible with the size of at least 0.25cc. It must have integral water cooling with fully enclosed filaments, motorized shutter and flux electrode. Power supply must allow programmed deposition. It must deliver voltage in the range 0-2kV. Max emission current must be equal or better than 200mA. Filament current must be equal or better than 0-10A. Filament voltage must be equal or better than 0-10V. Max power must be equal or better than 300W. Filament replacement must be possible without the need to disassemble the evaporator.

Ion source with power supply and gas inlet must be offered. Ion source should be extractor type source suitable for inert or reactive gases. It should enable in vacuum surface cleaning via sputter etching. Beam currents up to 20μA should be possible. Analog power supply for ion energy range up to 3keV must be included.

Gas inlet system for organic molecules must be supplied. It must include at least one leak valve, three separate gas lines and differential pumping via bypass.

**LoadLock chamber system with pumping and transfer system.**

Load lock system module for sample introduction must be offered. Load lock chamber should have DN40CF quick access door. The base pressure must be equal or better than 5.0 x10-8 mbar. It must include pressure monitoring and sample handling.