Technical specification for the Photoemission system for studying the surface electronic structure of quantum materials at the atomic level

University of West Bohemia in Pilsen wishes to acquire a photoemission spectroscopy system based on the momentum microscopy approach in order to perform surface science studies of quantum materials in UHV conditions: a base pressure equal or lower than 3.0 x10^{-10} mbar. In particular, the intended experiments will be designed to investigate the influence of experimental photoemission geometries and in particular dichroic-like studies: studying the impact of the light linear polarisation within an experiment. The system should have a spatial resolution equal or lower than 38 nm along with an energy resolution equal or lower than 30 meV. A suitable vibration study should be performed on the laboratory facilities prior to installation to insure adapted vibrational-decoupling such that the entire system should be equipped accordingly.

The system should be adapted for getting future upgrades, such as an extra X-ray source to the analysis chamber and spin-detector addition to the Momentum Microscope type detector including upgrade to the analyser if necessary.

The entire system should be designed such that buyers can, in the future, directly connect it to the SARPES laboratory system present at the NTC facilities. This should be compatible with a sample transfer system with flag style sample plates.

Additionally, bake-out tents adapted to the morphology of the designed Nano-ARPES with the sample transfer stage system should be provided in order to help reaching the UHV conditions with ease.

The Nano-ARPES system should undergo factory testing in order to prove the technical specifications. Consecutively, these tests should be repeated on delivery site and have to reproduce the same technical specifications.

A DN40CF port connection should be prepared for connecting a UHV suitcase (suitcase already present at NTC) at a suitable position including vacuum tubing to a suitable turbopump.

Specifications for analysis chamber for Nano-ARPES:
The analysis chamber must be made of μ-metal or stainless steel with μ-metal liner (residual magnetic field < 0.6 μT at sample position) with a diameter of no less than 20 cm and fitted with all necessary flanges for energy/momentum analyzer, UV sources, sample manipulator, sample introduction system, vacuum pumping system, pressure measurement, viewports and reserve flanges. In particular, a reserve flange DN63CF for future X-ray source must be included. As such, all view port should have a suitable lead coating for insuring radiation protection. The system must be given with at least 5 compatible sample plates.

The base pressure must be equal or lower than 3.0 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 2 turbomolecular pumps (of at least 200 l/s and 60 l/s) and oil-free rough system, one additional ion getter pump must be included. The oil-free rough system should consist of pumps making noise at most under 55 dB. Valves should be included in order to isolate and turn off the turbomolecular pumps in order to limit the vibrations during measurements.

Water cooling should be included for cooling the turbomolecular pumps and the UV lamps.

The analysis chamber should include a sample-storage device for 10 samples.

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

- High precision manipulator suitable for fine alignment of the sample in front of the analyser. The manipulator should be compatible with liquid He and liquid N_2 cooling techniques. In the case of liquid He, the lowest reachable temperature should be equal or better than 20K. The sample should be heatable up to 400 K. Translation along X, Y and Z axis should be motorised over a +/- 5 mm range. Rotation around the optical axis (azimuthal rotation) should be at least over a +/-50° range for flexible geometrical studies. All these axes should be controllable via the dedicated software of the Nano-ARPES machine. Polar rotations (around sample plan axis) is not necessary, however, the analyser deflectors should allow compensation of the slight sample domains tilts. Moreover, the sample stage should include electrical 4-contact for so-called "operando" experiment, this should include feed-throughs allowing connecting the 4-contact, in UHV condition, to external power supplies, at ambient pressure. The feed-throughs should allow voltages at least up to 40 V.

- State-of-the-art momentum spectrometer, capable of both Real- and Reciprocal-space imaging. In Real Space mode, the lateral resolution should be equal or better than 38 nm. In k-space, the optimal resolution should be equal of better than 0.006 $Ang.^{-1}$ while the maximum k-space field-of-view should be equal or larger than +/- 2.3 $Ang.^{-1}$ range. Zooming into this field of view should be possible anywhere in this k-space range: it should not be only possible at the aligned center. The energy resolution should be equal or lower than 30 meV for electron with a kinetic energy ranging from 0 to at least up to 190 eV. In PEEM mode, the field-of-view should range down to at least 4 micrometers. The extractor lens system of the microscope should at least be able to function within the 80 V to 18 kV range.

The analyser should be combined with a state-of-the-art camera to insure optimal signal-to-noise ratio during measurements. The camera should be based on the CCD technology and be fully controlled by the provided software.

The analyser should consist of a double-hemisphere momentum microscope, it is requested that it includes the possibility of the two hemispheres running concurrently in the energy dispersive mode, both hemisphere contributing to the energy filtering. As well, it should be possible that the second hemisphere can run in a mode such that it compensates the aberrations introduced by the first hemisphere in the energy dispersive mode.
The performances in terms of energy, momentum and real-space resolutions, the available sample temperature range as well as the other figures corresponding to the standards of the supplier's equipment,

must be proven within the factory and on-site by acceptance tests. The on-site acceptance tests can be performed without the transfer connection (see description further below).

A suitable software should be provided on a dedicated computer to insure control of the analyser and easy utilisation on a daily-basis with programmable sequences of measurements. The software should as well provide full control of all power supplies of the corresponding analyser. It should enable automated adaptation of the lens settings while using lower extraction field, in a few V range, as well as the "regular" working conditions, using kV extraction fields. The software should also allow on-the-fly basic analysis and feature suitable data format exportation options. The same software should also be compatible with the measurement camera. Updates for this software must be insured until 2028 for no extra cost. The software should be installed on a provided computer with all necessary hardware included. Finally, the software should have a flexible structure in the sense that it should be possible to interface it with outside instruments and it should also allow interfacing the new spectrometer with external control systems.

The momentum spectrometer should be prepared such that an upgrade with an imaging spin-filter is possible.

- UHV compatible noble gas based UV light source. The source must be able to operate with different gases like He, Ar, Kr, Xe. Intensity of primary UV source must be better than 6.0 $x10^{12}$ photons/(s*mm^2) with a spot size equal or smaller than 250 micrometer in diameter. The involved differential pumping should insure preservation of the base pressure within the analysis chamber with a pressure equal or better than 2 $x10^{-9}$ mbar range during measurements. The obtained light beam should be linearly polarised. The system should include valves for isolating the lamp when not in use.

- Additional UHV compatible Mercury UV light source. Its photon energy should correspond to 4.9 eV. The obtained light beam should deliver a power density equal or bigger than 0.8 W/cm^2.

- The system should be prepared for installation of a normal incidence mirror within the analyser. The normal incidence mirror would insure light beam incidence via the microscope column axis.

All the above mentioned parameters should be clearly proved on already produced system.

LoadLock chamber system with pumping and transfer system :
Load lock system module for sample introduction must be offered. Load lock chamber should have DN63CF 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. It must have a dedicated turbomolecular pump with its dedicated oil free rough pump.

Transfer coupling with the SARPES equipment already present at NTC facilities :

Assistance should be provided for the design of a transfer system between the new Nano-ARPES and the SARPES systems, including drawings of the combined systems and clear references of all different parts required to be added. Drawings of the SARPES system and the dimensions of the corresponding lab will be provided. The SARPES system should remain at its current position. The transfer system should insure sample transfers between the new Nano-ARPES machine and the already present SARPES machine within an aimed base pressure equal or better than 5.0 $x10^{-10}$ mbar. Moreover, a vibration decoupling instrument should be present to insure the required vibration insulation required for the Nano-ARPES set-up to preserve its spatial resolutions (vibration requirements not met on the already present SARPES machine side). The designed combination of the systems should allow enough space for future upgrades, namely the spin-filter and X-ray source for the Nano-ARPES machine.

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