Technical Specification

Valid from Dec. 12, 2011

**Axis Ultra DLD imaging X-ray photoelectron spectrometer**

1.0 Overview.

The Axis Ultra provides highest resolution spectroscopy, small spot analysis and parallel chemical state imaging capabilities on a single instrument.

**Analysis area (spot size)**

- **Hybrid mode**
  - 700×300µm
- **Small spot modes**
  - 110, 55, 27 and 15µm

Small spot modes are determined by inserting and combination of a precise aperture and variable iris mechanism into the electrostatic transfer lens and these spot sizes are available with both of Al Kα monochromator or Mg Kα/Al Kα achromatic sources.

**Imaging XPS**

The spherical mirror analyzer provides a range of predetermined analysis areas of 2 mm, 800, 400 and 200µm fields of view.

- **Guaranteed spatial resolution in imaging mode < 3µm**

2.0 XPS Specification

Standard system specifications indicate minimum guaranteed performance of an instrument. Installed systems will meet or exceed performance defined by a graph of the tabulated values. Specifications will be demonstrated at the customer site by Kratos engineers during installation of an appropriate configuration instrument.

All specifications given here relate to instruments manufactured after the date of issue of this document and are subject to future revision without notice.

2.1 X-ray excitation - flood source

All intensities refer to the maximum count rate in the Ag 3d₅/₂ photoelectron peak of a cleaned silver sample scales as appropriate to the indicated power. Source: Mg Kα radiation, 15 kV, 30mA (450W)

<table>
<thead>
<tr>
<th>Resolution (eV)</th>
<th>2000×800</th>
<th>700×300</th>
<th>110</th>
<th>55</th>
<th>27</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>1,100,000</td>
<td>900,000</td>
<td>200,000</td>
<td>50,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1.0</td>
<td>9,200,000</td>
<td>4,750,000</td>
<td>1,200,000</td>
<td>300,000</td>
<td>100,000</td>
<td>25,000</td>
</tr>
<tr>
<td>1.3</td>
<td>11,800,000</td>
<td>7,500,000</td>
<td>1,800,000</td>
<td>450,000</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
2.2 X-ray excitation – monochromator

<table>
<thead>
<tr>
<th>Resolution (eV)</th>
<th>700×300</th>
<th>110</th>
<th>55</th>
<th>27</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.48</td>
<td>400,000</td>
<td>75,000</td>
<td>18,000</td>
<td>4,000</td>
<td>650</td>
</tr>
<tr>
<td>0.55</td>
<td>1,100,000</td>
<td>175,000</td>
<td>48,000</td>
<td>12,000</td>
<td>2,000</td>
</tr>
</tbody>
</table>

All intensities refer to the maximum count rate in the Ag 3d\(_{5/2}\) photoelectron peak of a cleaned silver sample scales as appropriate to the indicated power. Source: Al k\(\alpha\) radiation 15kV, 30mA (600W)

The minimum spot size available for spectroscopy is < 15\(\mu\)m.

"Slot" area is approximately 700\(\mu\)m x 300\(\mu\)m: in all selected area modes, spot diameters are defined as the 20% to 80% signal rise across a sharp edge. The selected area specification is verified at 80eV and applies to all analyzer pass energies below 80eV. Survey is large area, greater than 2mm x 0.8mm. Energy resolution measurements are guaranteed to ± 1%.

2.3 Imaging performance.

**Image resolution**

Guaranteed spatial resolution in imaging mode is < 3\(\mu\)m

Defined as the 20% to 80% signal rise across a sharp edge

2.4 Performance on insulators.

<table>
<thead>
<tr>
<th>Resolution (eV)</th>
<th>700×300 ((\mu)m)</th>
<th>110 ((\mu)m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.68</td>
<td>16,000</td>
<td>2,600</td>
</tr>
<tr>
<td>1.0</td>
<td>130,000</td>
<td>13,000</td>
</tr>
<tr>
<td>1.3</td>
<td>195,000</td>
<td>19,500</td>
</tr>
</tbody>
</table>

**Performance on insulators**

This performance is guaranteed on a clean polyethylene terephthalate (PET) sample. The signal intensity is specified as the number of counts per second in the hydrocarbon (C-C, C-H) peak and the resolution as the FWHM of the ester (O-C=O) component. The specification will be obtained following curve fitting of the acquired data with a standard 4 peak model for the main components.

3.0 System specification.

3.1 Automated sample manipulator

High precision manipulator with automated X, Y, Z, tilt (\(\theta\)) and rotation (\(\Phi\))

**Stage travel**

130mm in X, ± 15mm in Y, ± 7.5mm in Z
Tilt  
-90 ~ +90° as X axis

Rotation  
360° continuously around normal of sample

Resolution  
1μm

The automated stage may be controlled directly from Vision data system or from a remote control unit at the instrument console.

3.2 Vacuum system.

3.2.1 Analysis chamber

**Primary pumping**  Noble diode Ion pump  480 l/min

**Secondary pumping**  Ti sublimation pump  1000 l/min

Cryoshield  1000 l/min

**Guaranteed minimum pressure**  \(< 5 \times 10^{-8} \text{ Pa}\)

This pressure is guaranteed in a clean fully degassed system after baking for 48 hours at ~150°C as indicated by the instrument vacuum gauges.

3.2.2 Sample treatment chamber

**Primary pumping**  Turbo molecular pump  240 l/min

**Secondary pumping**  Rotary pump

**Guaranteed minimum pressure**  \(< 7 \times 10^{-7} \text{ Pa}\)

This pressure is guaranteed in a clean fully degassed system after baking for 48 hours at ~150°C as indicated by the instrument vacuum gauges.

3.3 Analysis chamber specification

The analysis chamber is a spherical stainless steel chamber with an inner and outer Mu metal screen.

**Chamber diameter**  267mm (10.5”)

**Number of ports**  23

**Line of sight ports**  15
### Table 1: Port Specifications

<table>
<thead>
<tr>
<th>Port</th>
<th>Flange OD mm</th>
<th>Elevation angle</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>200</td>
<td></td>
<td>Transfer lens</td>
</tr>
<tr>
<td>B</td>
<td>200</td>
<td></td>
<td>Manipulator</td>
</tr>
<tr>
<td>C</td>
<td>150</td>
<td></td>
<td>Magnetic lens</td>
</tr>
<tr>
<td>D</td>
<td>200</td>
<td></td>
<td>Entry gate valve</td>
</tr>
<tr>
<td>E</td>
<td>115</td>
<td>30°</td>
<td>CCTV camera</td>
</tr>
<tr>
<td>F</td>
<td>115</td>
<td>25°</td>
<td>Mg/Al X-ray gun</td>
</tr>
<tr>
<td>G</td>
<td>70</td>
<td>35°</td>
<td>Spare/UPS lamp</td>
</tr>
<tr>
<td>H</td>
<td>150</td>
<td>30°</td>
<td>Al monochromator</td>
</tr>
<tr>
<td>I</td>
<td>115</td>
<td>35°</td>
<td>Electron gun</td>
</tr>
<tr>
<td>J</td>
<td>70</td>
<td>40°</td>
<td>Iris drive</td>
</tr>
<tr>
<td>K</td>
<td>70</td>
<td>35°</td>
<td>Spare</td>
</tr>
<tr>
<td>L</td>
<td>70</td>
<td>0°</td>
<td>SED/Spare</td>
</tr>
<tr>
<td>M</td>
<td>70</td>
<td>0°</td>
<td>Ion gauge</td>
</tr>
<tr>
<td>N</td>
<td>70</td>
<td>45°</td>
<td>Ion gun</td>
</tr>
<tr>
<td>O</td>
<td>70</td>
<td>0°</td>
<td>Viewport</td>
</tr>
<tr>
<td>P</td>
<td>70</td>
<td>0°</td>
<td>Viewport</td>
</tr>
</tbody>
</table>

### 3.4 Electron energy analyzer.

The spectroscopic 180° hemispherical analyzer has a mean radius of 165mm in combination with an imaging concentric spherical mirror analyzer. The analyzer has a multi-element electrostatic transfer lens in combination with a magnetic immersion lens.

- **Analysis area**: 2mm to 15μm
- **Exact spot sizes**: 110, 55, 27, 15μm
Spectroscopy detector  double layers 128 channel delay line detection system
Imaging detector  2-D multichannel plate and with 2-D delay line detection system
Sweep modes  Fixed analyzer transmission (FAT) for imaging and spectroscopy
Fixed retard ratio (FRR) optional with Auger.
Energy range  50-3200 eV  50meV
10-1500 eV  25meV
10-1500 eV  2.5meV optional UPS
Pass energy  Programmable  5, 10, 20, 40, 80, 160, 320eV
Retard ratios  Programmable  3, 6, 14
Resolution  Better than  0.05%
Polarity  Negative
Positive (optional ISS)

3.5  X-ray source.

3.5.1  Achromatic source.

Mg/Al dual anode source mounted on linear retractor with tilt mechanism for optimal positioning of each source face.

Nominal operating voltage  15kV
Maximum current  30mA  (450W)
Cooling  Closed circuit water system
Interlocks  Pressure, vacuum flow rate
Automatic control  Full Vision control of operating condition, degassing routine, read back of kV, filament and emission current from digital power supply.

3.5.2  Al Kα monochromator

Large 500mm Rowland circle monochromator with fixed X-ray spot size.
Anode  
**Al**

**Crystals**  
Single toroidal backplane with three degrees freedom for adjustment

**Interlocks**  
Pressure, vacuum flow rate

**Automatic control**  
Full Vision control of operating condition, degassing routine, read back of kV, filament and emission current from digital power supply.

**Water cooling**  
High pressure water circuit for anode, low pressure water cooling for backplane

### 4.0 Optional analytical techniques

#### 4.1 Ultra violet photoemission spectroscopy (UPS)

**Sensitivity**  
1,000,000 cps at 100 meV resolution  
2,000,000 cps at 140 meV resolution

Performance is guaranteed on clean, polycrystalline silver using He I radiation. Sensitivity is defined as the counts per second (cps) of the Ag 4d peak. Resolution is defined by the 80-20% measurement of the Ag Fermi edge excited by He I radiation.

The He I : He II ratio is guaranteed 4 : 1

#### 4.2 Ion scattering spectroscopy (ISS)

**Sensitivity**  
12,000 cps/nA at 12eV FWHM
Performance is guaranteed on pure Au scattering 1 kV He\(^+\) ions using ion source. Sensitivity is defined as counts per second per nA of ion current at the Au peak energy. Energy resolution is defined as the FWHM.

### 4.3 Auger electron spectroscopy – SEM/SAM

**Schottky field emission source**

The following performance is guaranteed when measured on a standard gold test sample. Spatial resolution is defined a distance measured by a retrospective line scan corresponding to 80-20% fall of intensity over a sharp edge.

**SEM resolution:**

- <95 nm at 10 kV and 5 nA sample current
- 300 nm at 3 kV and 5 nA sample current

**Auger Spectral performance**

- Sensitivity > 500, 000 cps
- Signal to Noise 500 : 1

Using Schottky Field emission source, detected peak Cu LMM peak at 918eV Kinetic Energy, background measurement at 955eV. Measurements are at 0.4% ± 0.05% relative energy resolution 5nA beam current, 10kV beam energy. Signal to Noise ratio defined by S, the signal in the 918eV Cu peak and N the square root of the background signal at 955eV.