VG Scienta PES solutions

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Scientific Instruments

• 1981: Nobel Prize to Prof Siegbahn
• 1983: Prof Siegbahn co-founder of Scienta
• 1994: Parallel ARPES
• Today:
  • Global leader ARPES, HAXPES and APPES
  • Very active R&D
    • Latest release: R4000 HiPP-3
Energy levels in the atom

Valence levels

Core levels

Nucleus

Core level

Valence level
Phototelectron spectroscopy

$BE = h\nu - E_k$

1921 Nobel Prize in Physics
Photoelectron spectroscopy

HAXPES

APPES

XPS

\[ BE = h\nu - E_k \]

SARPES

ARPES

UPS

Core levels

Valence levels

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Photoelectron spectroscopy

\[ \text{Core levels} \rightarrow \text{Valence levels} \]

\[ \text{BE} = h\nu - E_k \]
Photoelectron spectroscopy

Inner Sphere +

Outer Sphere -
Vacuum tank

Electron Lens

Detector
Sample

11/6/2014 www.vgscienta.com
2-D detection

- 2-D detector: 2 properties may be probed
- Energy perpendicular to slit
- Angle/Position along slit
Angular mode

• Angular mode enables parallel measurement of different emission angles
• This enables a number of powerful techniques without sample rotation:
  – Band structure measurements (bandmapping)
  – Depth profiling
  – X-ray photoelectron diffraction (XPD)
• Technique pioneered by VG Scienta in 1994
• VG Scienta still world leading in energy and angular resolution

VG Scienta’s Dr. Björn Wannberg was the recipient of the American Physical Society Keithley award 2008: "For advances in the development of angle-resolved electron analyzers for photoelectron spectroscopy."
Application areas

BE = hν - Ek

HAXPES → SARPES

APPES ← HAXPES

XPS ← APPES

APTES ← SARPES

ARPES → UPS

UPS → ARPES
Application areas

HAXPES

APPES

XPS

BE = \hbar \nu - E_k

SARPES

ARPES

UPS
XPS – X-ray Photoelectron Spectroscopy

Element and chemical state specific information

Data courtesy: F. Mangolini

Siegahn: “The ESCA molecule”
Application areas

HAXPES  <->  APPES

XPS  <->  SARPES

APPES  <->  ARPES

UPS

\[ \text{BE} = \hbar \nu - E_k \]
Ambient Pressure

- Traditional PES require UHV
- Some systems/processes cannot be studied under UHV
  - Volatile samples prohibits UHV (gaseous samples, liquids)
  - Some processes are fundamentally different in higher pressures

Problems:
- Some components sensitive to high pressures (e.g. MCP)
- Electrons are scattered before reaching the detector
  - Differential pumping
Ambient Pressure - Range

- $10^{-13}$ mbar
- $10^{-11} - 10^{-1}$ mbar
- 1 - 5 mbar
- $\sim 25$ mbar
- 1 bar

Catalysis
Water chemistry
Atmospheric chemistry
Liquid jet
Ionic liquids

$P_{\text{Water vapor}}$
$P_{\text{Atmosphere}}$
Ambient Pressure Analysers

R3000 HP

Aperture

Diff. pumping

R4000 HiPP-3

Aperture

Pre-lens

Extra pumping

Diff. pumping
Differential pumping stages
Differential pumping design

• The Scienta design provides very rapid pressure decrease
• Nodeless design
  • High transmission
  • Angular mode in full kinetic energy range
Install Base

- Pressure
  - 1 bar $P_{\text{Atmosphere}}$
  - $\sim 25$ mbar $P_{\text{Water vapor}}$
  - $10^{-13}$ mbar
  - $10^{-11} - 10^{-1}$ mbar
  - 1 - 5 mbar

- Suzuki SES-100
- de Brito R4000 Spec.
- U Penn R3000 HP
- Pune R3000 HP

- ALs HiPP
- PSI HiPP-2
- ALS HiPP-2
- Tokyo HiPP-2
- Spring-8 HiPP-2

- Nilsson SES-100
- Imp. Collage
- HiPPlab
- FZ Jülich
- HiPPlab
Install Base - examples
Customer proven performance

http://www.vgscienta.com/publicationlist.aspx
HiPP-3 System Solution
Scienta R4000 HiPP-3
New analyser for APPES+Imaging

• Based on Scienta R4000 HiPP-2
• Optimized for XPS energies (E_k<1500 eV) but available up to 6 keV
• Improved Swift Acceleration Mode
• Imaging XPS <20 µm
Scienta R4000 HiPP-3

Swift Acceleration Mode

4500 V

Ten times faster!
Imaging XPS

• Spatial Resolution 20 µm
• Field of view 0.8 mm
• Step size 2.5 µm
• Parallel imaging in one direction
Sample:
Si substrate with Au lines

Au 4d
Spatial Resolution

<20 µm Resolution
HiPP-3 System Solution

- **Double side**
  - Used to open the HiP cell after non-uniform measurement to transport the sample holder to the another chamber (if it is required)
  - Used to load the flag style sample from the adapter to helium manipulator

- **View ports**
  - Quantity and size match to chamber

- **Manipulator K2021-2**
  - Details shown on a separate drawing

- **Load lock**
  - Pumping system is located under the frame

- **Analyser chamber**
  - Pumping system (HiP, 10x, ion pumps) is located under the frame

- **Heater**
  - Used to heat the sample

- **Heater control**
  - Controls the heater temperature

- **Analyser pumping set**
  - Ensures vacuum inside the analyser

- **X-ray monochromator**
  - Works with positive in the HiP conditions

- **HiP manipulator**
  - Controls the movement of the sample holder

- **Synchronisation beam**
  - Provides energy for the analyser

- **Maximum expansion options**
  - Additional components for future expansion
HiPP-3 HPGC