Application Note: 31057

XR3: Twin Anode X-ray Source

Key Words

- Surface Analysis
- Large Area XPS

Introduction

The Thermo Scientific XR3, Figure 1, is a twin anode X-ray source. The standard source is supplied with aluminum and magnesium anodes.

Figure 1: XR3 twin anode X-ray source

Its key features include:

- Standard anodes Al Kα (1486.6 eV) and Mg Kα (1253.6 eV)
- High power (400W for Al and 300W for Mg)
- Optional linear drive minimizes working distance and allows retraction for multi-technique flexibility
- Profiled nose piece helps avoid mechanical clashes
- Guaranteed < 0.35% cross contamination of radiation

Figure 2 shows the components of the X-ray source.

Cathodes

The XR3 has two thoria-coated iridium cathodes, providing high emission and a long lifetime. Only one of these cathodes is used at any one time, depending upon the anode material required for the analysis.

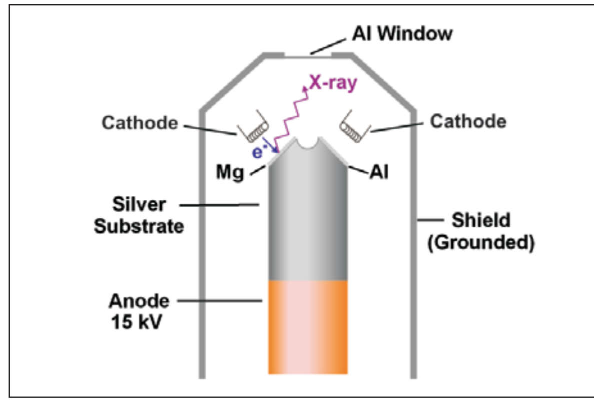

Figure 2: The main components of the XR3 twin anode source

The Anode

The anode has two active faces, each face has a different material coating it. The usual materials are magnesium and aluminum. The energy of the X-rays emitted from the source depends upon the anode material from which they are formed. If Mg Kα radiation is required, the cathode nearest the magnesium face is used. If Al Kα is required the other cathode is used.

The anode is designed to minimize cross contamination of the X-ray radiation. For example, when Mg Kα radiation is selected < 0.35% of the radiation is from Al Kα.

The aluminum and magnesium are deposited on a silver substrate. This eliminates Cu Lα breakthrough, which could interfere with XPS spectra as the anode coating degrades naturally through usage.

The internal design of the anode ensures efficient water cooling by creating turbulent flow conditions.

Table 1 shows the X-ray energies and line widths of the standard and alternative anode materials.

ANODE	RADIATION	ENERGY (EV)	LINE WIDTH (EV)
Mg	Kα	1253.6	0.7
Al	Kα	1486.8	0.85
Zr	Lα	2042.4	1.6
Ag	Lα	2984.3	2.6

Table 1: X-ray energies and line widths

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The Window

The X-ray flux from the source is filtered by use of a very thin aluminum window. An X-ray window is essential:

- To shield samples from the high potential of the anode
- To reduce bremsstrahlung irradiation of samples
- To minimize contamination of samples due to thermal desorption from the internal structures of the source
- To allow differential pumping, if required

Electronics

A digital power supply controls all of the source parameters via the *Avantage* data system. This power supply can control both the XR3 twin anode source and the XR5 monochromated X-ray source.

This unit operates from a single-phase mains supply. It controls all of the functions of the source and monitor the state of all of the interlocks.

Interlocks

In the interests of safety, of both the source and the operator, interlocks are provided:

- Vacuum interlock (if ionization gauge is fitted)
- Water flow interlock
- Source cover interlock
- Power supply interlock

Installation

The X-ray source is mounted on a 2$^3/_4$", UHV flange. The electrical and water connections are quickly and easily made for both the initial installation and following instrument bake-out.

Retraction Mechanism

A retraction mechanism can be added between source and analysis chamber to allow:

- Optimum positioning of the source with respect to the specimen
- The source to be retracted when not in use allowing other analytical facilities easier access to the sample

Differential Pumping (Optional)

Although differential pumping of a modern twin anode X-ray source is not usually necessary, it is possible to fit a vacuum 'T'-piece to the analysis chamber. An internal support tube ensures that a good differential pumping seal can be achieved between the 'T'-piece and the source.

The 'T'-piece should be located between the analysis chamber and the retraction mechanism so the source can be advanced and retracted without moving the differential pumping line.

Options

- Linear retraction mechanism for optimal positioning
- 480 watt water chiller
- Optical microscope, camera and monitor

Spectroscopy

In these examples, the XR3 was used with an Alpha110 analyzer.

Figure 3 shows the XPS spectrum from clean copper acquired using both Al Kα and Mg Kα radiation. The kinetic energy of the Auger peaks is independent of the anode material used and so their position on the binding energy scale depends upon the energy of the X-rays used. Having more than one anode material available means that interferences between XPS and Auger peaks can be resolved.

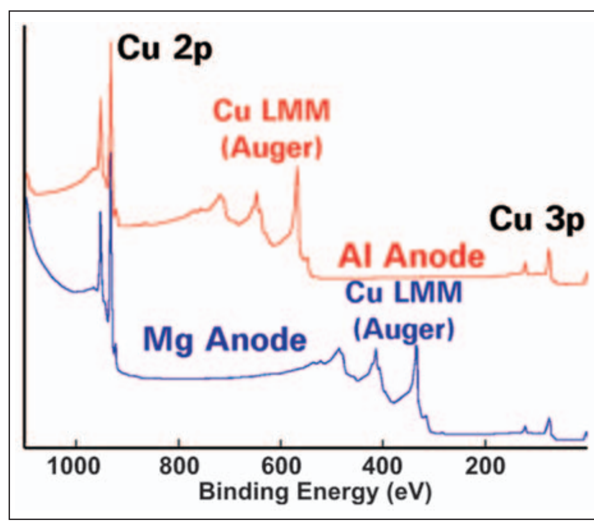

Figure 3: Spectra from a clean copper surface showing that the position of the Auger peaks on a binding energy scale depend upon the energy of the X-rays being used

Figure 4 and Figure 5 show the way in which the peak width and peak intensity change with the pass energy of the analyzer.

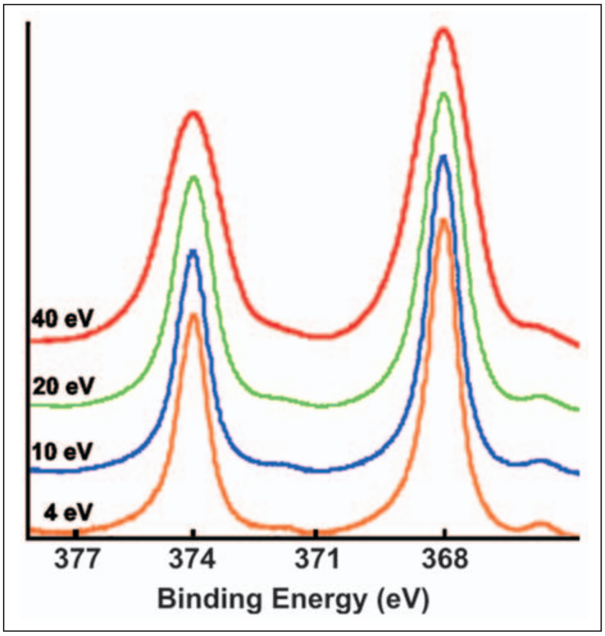

Figure 4: Ag 3d spectra taken at a series of pass energies using Mg Kα radiation

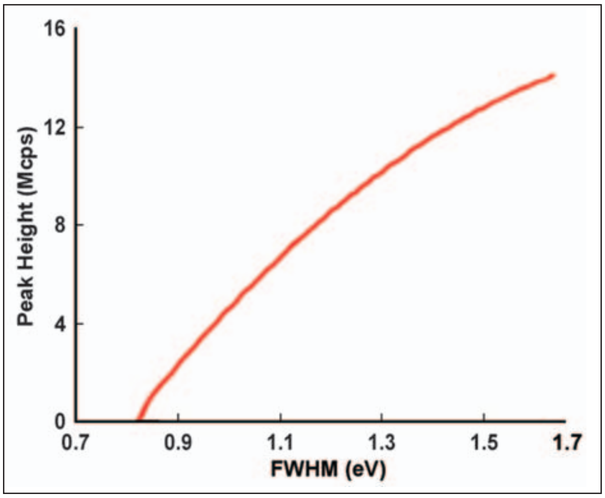

Figure 5: Peak height as a function of full width at half maximum for Ag 3d using Mg Kα radiation

Specifications

- Anode voltage: 0 to 15 kV
- Anode power: > 300 watts
- Filament emission: 0 to 26 mA current
- Crosstalk: When operating the Mg anode, Al Kα radiation is guaranteed to be < 0.35% of the X-ray flux

Spatial Dimensions

Figure 6 shows the outline dimensions for the XR3 twin anode X-ray source.

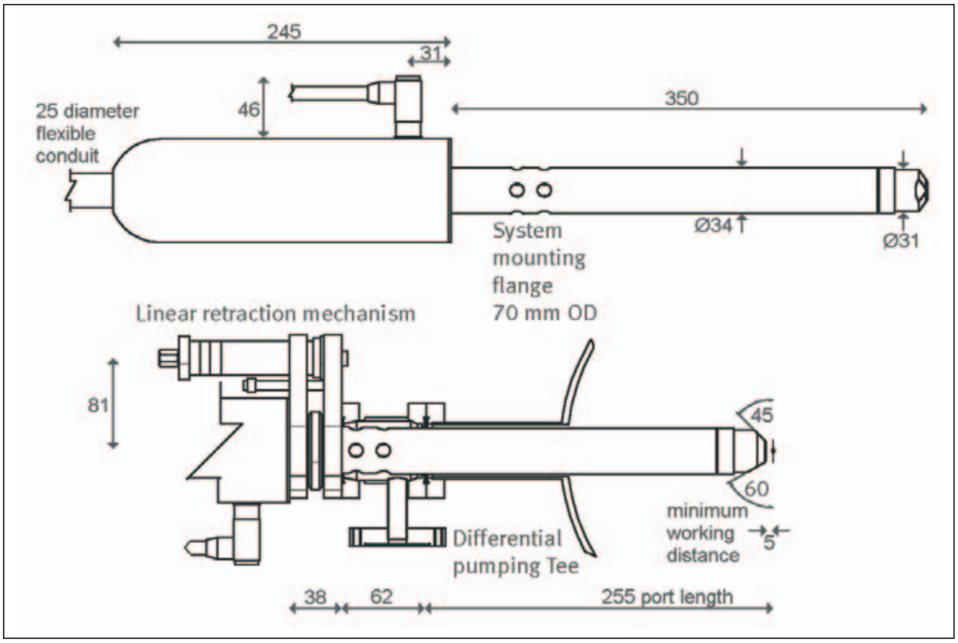

Figure 6: Dimensions of the XR3 twin anode X-ray source. The lower diagram includes both the differential pumping 'T' and the retraction mechanism.

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Africa
+43 1 333 5034 127
Australia
+61 2 8844 9500
Austria
+43 1 333 50340
Belgium
+32 2 482 30 30
Canada
+1 800 530 8447
China
+86 10 8419 3588
Denmark
+45 70 23 62 60
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Sweden/Norway/Finland
+46 8 556 468 00
Switzerland
+41 61 48784 00
UK
+44 1442 233555
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+1 800 532 4752

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