PHI 5600: X-Ray Source

PHI 5600: Model 10-610 X-Ray Source

The manual of the 10-610 X-Ray Source can be found here, these notes are a summary of the manual.

INTRODUCTION

The PHI Model 10-610 is a compactly packaged, high in-tensity, static anode x-ray source designed to optimize the performance of the PHI Model 10-420 X-ray Monochro-mator. The Model 10-610 has a single, water cooled, static aluminum anode designed for operation in two modes, focussed or diffuse.

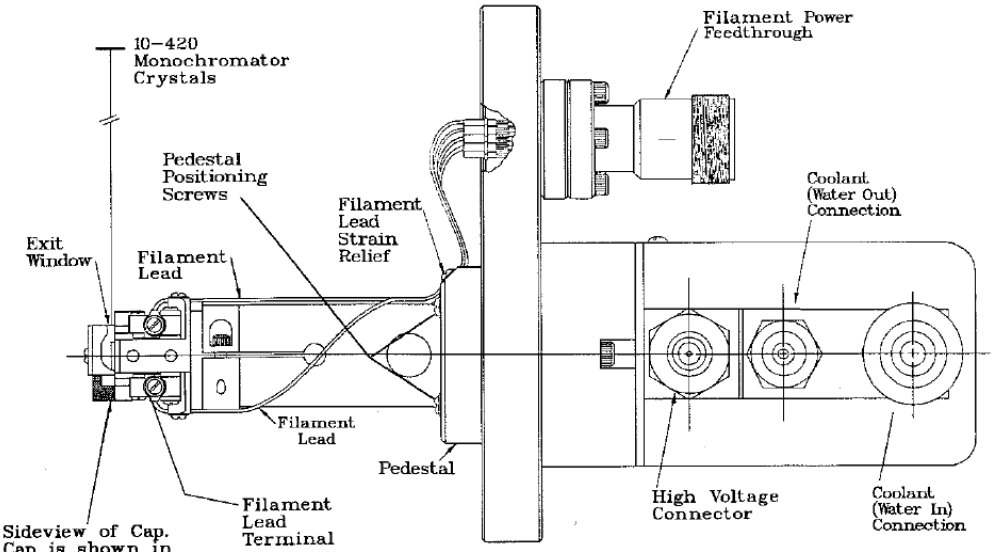

Figure 2-3. Side view of Model 10-610 X-ray Source.

In the focussed mode, the source operates at high power density. This is significant, because the monochromator selectively focusses photons emitted from the anode onto the surface of a sample to be analyzed by XPS. The resulting photoelectron emission from the sample and the subsequent count rate in the en-ergy analyzer are directly proportional to the brightness of the anode.

In the diffuse mode of operation, the power density is de-creased by enlarging the photon emitting area of the an-ode. In essence, the source is de-focussed. This mode of operation is useful for analysis of charge- or damage-sen-sitive samples.

The Model 10-610 is constructed with a single anode that is excited by electron bombardment from either of two, emission-enhanced tungsten filaments. Filament selection corresponds to either the focussed or diffuse mode of op-eration. The source may be run at up to 350 W at 15 kV in the focussed mode (short filament) or 600 W at 15 kV in the diffuse mode (long filament). (Filaments are shown in Figure 5-3.)

The source is mounted to the monochromator via a three axis mechanical aligner. This aligner provides the precision motions necessary to optically position the anode with respect to the monochromator crystal set.

THEORY OF OPERATION

This x-ray source is the "Secondary" source. it is mounted on the 10-420 X-ray monochromator (see figure), and it generates Al K_alpha x-rays, which are diffracted and focused by the mono-chromator.

The production of X-rays starts at one of the two grounded tungsten filaments which are heated to emit electrons. Two grounded fences shape the trajectory of the electrons from the filaments to the tip of an Al anode. The Al anode (Figure 4-2) is +14,000 V. All of this is enclosed in a grounded cover.

X-ray radiation is produced when the electrons impact the anode surface. The x-rays exit the source through a narrow window in the cover. Heat generated by the high energy electrons is removed by circulating de-ionized water through the interior of the anode.

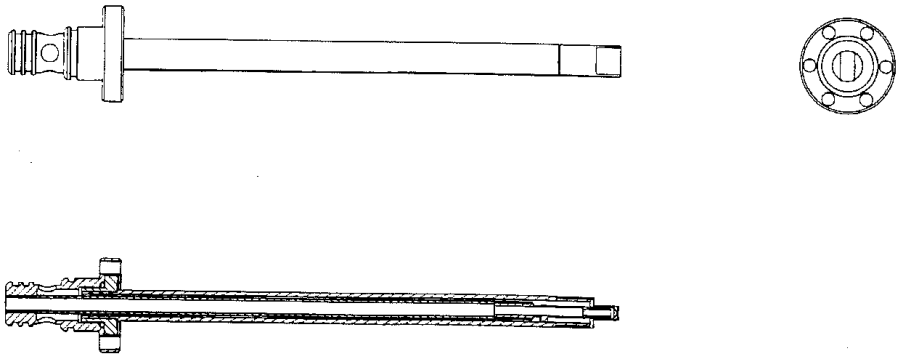

Figure 4-2. Side View of 10-610 Anode Assembly.

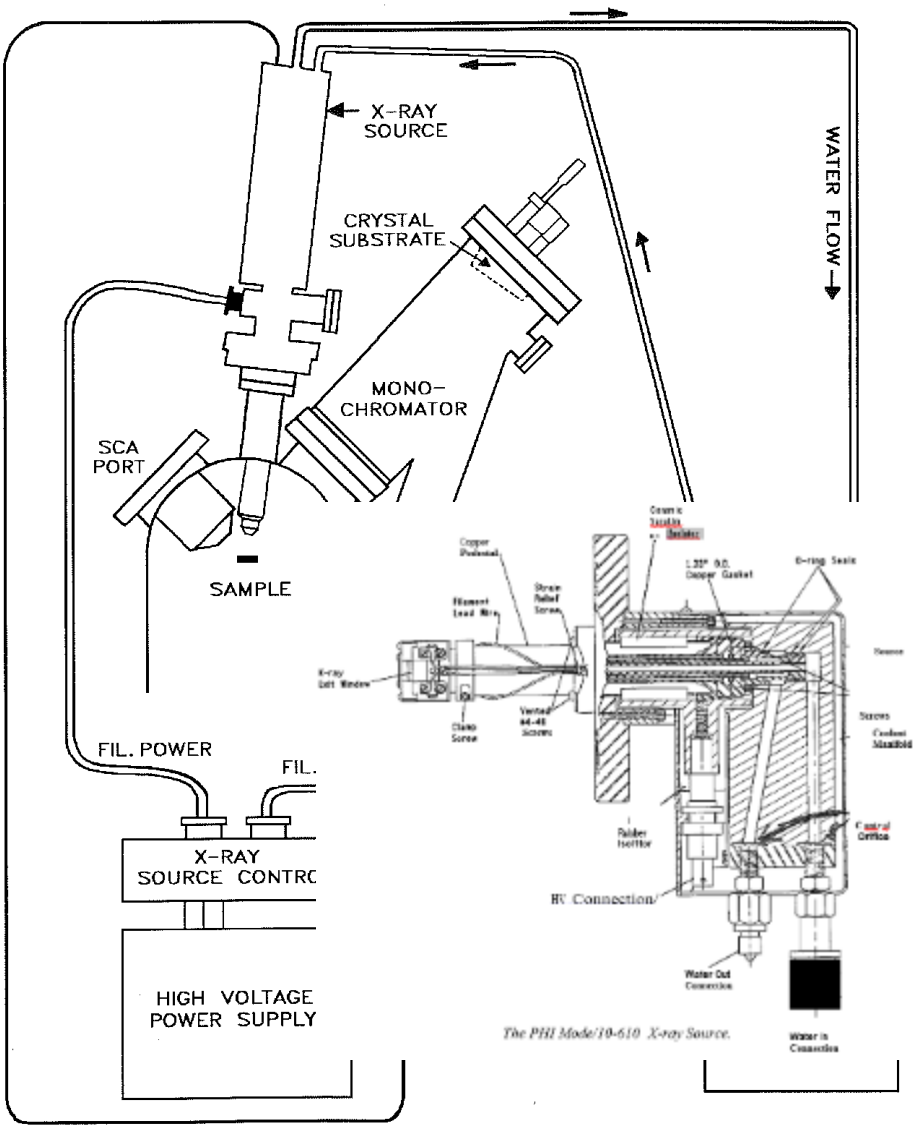

Figure 2-4. General System Configuration including the Model 10-610 X-ray Source.

Both filaments (Fig. 5-3) illuminate areas of equal width on the anode surface. The length of the target area is controlled by the emitting length of the filament in conjunction with the internal geometry of the cover. The desired spot size is chosen by energizing the appropriate filament. The X-ray beam is then filtered by the monochromator and focused onto the surface of the sample to be analyzed.

The optics are supported by a copper pedestal which also conducts the radiated heat from the filaments to the mounting flange. Adjustments are provided on the pedestal to align the electron optics to the anode (Fig. 5-3 or 4-1).

The anode is cooled by de-ionized water provided by a manifold coupled to the anode via an o-ring sealed gland.

The high voltage connection to the anode is located under the coolant manifold assembly for safety reasons. To access the high voltage components the manifold must be removed first, which in turn faults the coolant flow interlock and turns off the high voltage. The high voltage is connected through an coaxial feedthrough which is connected to the anode mounting flange that is isolated from ground via a brazed ceramic vacuum isolator. The high voltage components are insulated from arcs by a molded silicone rubber insulator.

The optics assembly is supported by a three- axis manipulator, which positions the target spot with respect to the Rowland Circle geometry of the toroi-dal monochromator crystal set. The X and Y axes of the manipulator are simple lever mechanisms that swing the anode tip on long radius arcs. (Figures 2-1 and 2-2) The vertical Z-axis is a linear slide. All three axes are controlled by simple micrometer heads. A welded bellows allows the motion to be transmitted through the vacuum wall. Finally, two torsion springs balance the differential pressure force exerted on the metal bellows.

CALIBRATION AND MAINTENANCE

The following operations are described in the manual:

- **Anode replacement** (requires to open the system).
- **Anode alignment** (needed after installing a new anode).
- **Filament performance check**. Filaments used on the 10-610 are coated with a low work-function ther-mionic emitter which slowly depletes with use. Before replacing it is convenient to to test the performance of the filament coating using these two tests:
  - Focused spot filament test
  - Diffused spot filament test
- **Filament replacement** (requires to open the system).
- **Filament Burn-in**. New filaments should be brought up to operating temperature in a slow, controlled manner to avoid thermal shock and possible distortion.

- **Coolant manifold cleaning**. The internal wetted surfaces of the coolant manifold will darken during operation due to copper oxide deposition. This normally does not cause a problem. If, however, the water is de-ionized to 500,000 ohm-em or better and the leakage current still exceeds 3.0 mA, the wetted surfaces of the manifold should be cleaned.
- **Filament and Source outgassing**. Procedure used to heats the filaments and surrounding source surfaces to remove adsorbed gases. If not performed, during use the filament gets hotter than during a bakeout and outgassing can occur, and since filaments and surrounding structure are in the high voltage field, the outgassing can cause arcing problems and, therefore, must be eliminated before the source is operated.
- **High voltage insulator conditioning**. The surfaces of the high voltage insulators must be cleaned or conditions by applying voltage in a controlled manner.
- **Anode outgassing.** This procedure applies power to the anode in a controlled manner to remove adsorbed gasses and minimize chemical changes in any contaminant film built up on the anode surface.
- **Source Outgassing After Limited Idle Periods.** This procedure is used to outgas the x-ray source after limited periods of disuse (5 - 10 days) or after limited exposure to reactive gases.

OPERATING PROCEDURES

- **Filament selection**. When the FILAMENT ENERGIZE push button on the 32-096 X-ray Source Control is pushed, the source functions in the **foc used** mode. Likewise, when the second button is selected, the source functions in the **diffuse** mode. CAUTION: NEVER SELECT BOTH FILAMENTS SIMULTA-NEOUSLY!
- **Source Aligner Operation.** The source aligner provides three orthogonal axes of alignment. The procedure for aligning the 10-610 X-ray Source to the monochromator crystal set is found in the *Model 10-420 Monochromator manual*.
- **Bakeout.** Bakeout may be required whenever the 10-610 or the sys-tem to which it is attached has been exposed to air.See instructions here.

X-RAY SOURCE SELECTION

The PHI 5600 has a dual anode, non-monochromatic x-ray source and a monochromatic Al K x-ray source.

The monochromatic x-ray source should be used for the following reasons:

- The 10-610 x-ray source generates x-rays very efficiently and provides good sensitivity.
- A monochromator filters out undesired high energy x-rays, x-ray satellites, and narrows the Al K lines, greatly reducing x-ray-induced sample damage.
- The filtered Al K beam eliminates x-ray satellites, eliminating some peak overlaps and, in general, simplifies the spectra and peak identification.
- The filtered Al K beam provides a narrower x-ray energy distribution, increasing the energy resolution and chemical sensitivity of the instrument.

There may be situations where a peak overlap exists between a photoelectron peak and an Auger peak, changing the x-ray energy can eliminate this overlap; this would be the most common reason to use the non-monochromatic x-ray source.

Alignment of the system and sample is critical for optimum performance when using the monochromatic x-ray source. **The x-ray source type is chosen in the Setup X-ray menu or in the Acquisition Setup menus**.

The monochromatic x-ray source has two filaments: a 2 mm filament and a 7 mm filament. Physical Electronics recommends using the 2 mm filament, because this will provide the highest sensitivity. Note: the charge neutralization system will effectively neutralize insulating samples under these conditions.

SELECTING THE SIZE OF THE ANALYSIS AREA

The x-ray sources flood a relatively large area of the sample with x-rays, and the size of the analysis area is determined by the energy analyzer input lens. The user has control of two variables that effect the size of the analysis area. The first is the size of the aperture in the analyzer input lens. A rotary motion located on the side of the analyzer input lens is turned to select one of five apertures. Aperture 1 is the smallest and 5 is the largest. The aperture also must be selected in the Analyzer/Detector menu to apply the correct lens voltage for the selected analysis area. The second variable is the relative magnification of the input lens. Three magnifications are available: large (1 X), small (1/3 X) and minimum (1/5 X)

SELECTING THE X-RAY ENERGY

When first turned on, the Model 50-096 X-ray source power supply needs to be programmed to operate at 15 keV. To do this, perform the following steps:

1. Press the Local button under Control Select.
2. Press the Start button for the Water Pump.
3. Press the High Voltage button above the keypad.
4. Press the Display/Enter Setpoints button above the keypad. (LED should light.)
5. Press 1 - 5 - 0 - # on the keypad.
6. Press the remote button under Control Select.

The 50-096 will retain the 15 keV setting until it is manually turned off or there is a power interruption.

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The control of lens settings (voltages) is performed in the Analyzer/Detector menu, which is under the System Control pulldown. In this menu, you can select the lens magnification and the correct lens constants for a specific aperture. You must also manually select the correct physical aperture.

The size of the analysis area for a given combination of aperture and analyzer input lens magnification is shown in the following table.

Analysis area for a given combination of aperture and analyzer input lens magnifications.

		Analysis Area Size	
Aperture #	Minimum	Small	Large
1	30 m diameter	-----	-----
2	120 m diameter	180 m diameter	0.4 mm diameter
3	400 m diameter	600 m diameter	2 mm diameter
4	800 m diameter	1100 m diameter	4 mm diameter
5	0.6 x 2.0 mm	1 x 3.5 mm	3 x 10 mm

Physical Electronics recommends using the minimum mode for most analysis and selecting as large an aperture as possible for the sample that you have, in order to maximize sensitivity and minimize data collection time. For Auger analysis, Physical Electronics recommends using either Aperture 4 or 5 along with the small or minimum lens area magnification.

SELECTING A PASS ENERGY

The pass energy determines the energy that detected photoelectrons will have as they pass through the hemispherical analyzer. The lower this energy is, the better the energy-resolving capability of the analyzer is. However, as pass energy is lowered to improve energy resolution, the intensity of the detected photoelectron peaks is reduced. This relationship is nearly linear (when the pass energy is reduced by a factor of two, so is the detected count rate). When elemental information is of primary interest, such as in survey spectra, a high pass energy and a large data step size should be used. When detailed chemical information is being sought, a lower pass energy and smaller data step sizes should be used. By selecting a pass energy that is no lower that necessary to resolve the ESCA peaks of interest, you will maintain as high a count rate as possible and improve the efficiency of your experiments.

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