Miniature X-Ray

Mini-X2

Mini–X2 is a miniature X-ray tube system, which includes the X-ray tube, high voltage power supply and USB controller. It is designed for X-ray fluorescence analysis applications (XRF).

Features

- USB controlled
- Stable output
- Fast
- Low power
- Small

Options

Power: 4 W or 10 W

HV: 50 kV or 70 kV

Target: Ag, Au, Rh, or W

Applications

- X-Ray Fluorescence (XRF) analysis
- Portable systems
- OEM
- Process Control
- Research
- Teaching

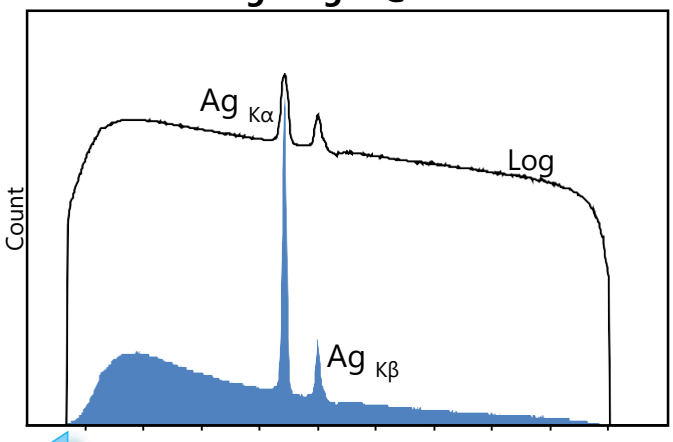
The Mini-X2 is a miniature X-ray tube system which includes the X-ray tube, the power supply, the control electronics, and the USB communications to the computer. It is optimized for compact X-ray fluorescence (XRF) applications.

The Mini-X2 consists of two components: the Mini-X2 X-ray tube module and the Mini-X2 Controller. The X-ray tube module includes the tube and HVPS. Several different options are available: 1) maximum power can be 4W or 10W; 2) maxium HV can be 50 kV or 70 kV; and 3) the anode can be Ag, Au, Rh, or W and several custom variations can be provided (www.amptek.com). The Controller includes the USB communications and software control. It can be configured, via software, to support any of the X-ray tube modules. A 10 pin flex cable connects the Controller and the X-ray tube module. Connections to the Controller are 12VDC power, USB for command and control, and an AUX connector with a safety inter- lock and a driver for a warning light.

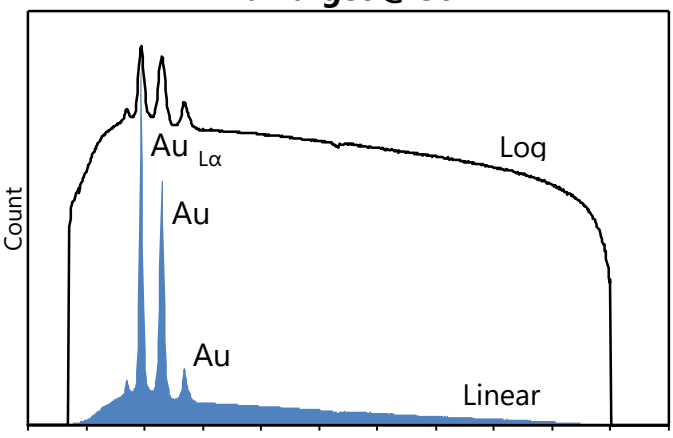
The Mini-X2 is a replacement for Amptek's previous Mini-X product family. The X-ray Tube Module is similar to the previous Mini-X-OEM. The Controller has significantly improved control features, including software configurability and faster control and readback. It utilizes a completely different software interface, based upon the FW6 protocol used with Amptek's digital pulse processors.

Mini–X Output X-Ray Spectra

Ag Target @ 50 kV



Au Target @ 50 kV



OEM's #1 Choice

The Mini–X2 is based on the Newton Scientific Inc. miniature X-ray sources.

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AMETEK MATERIALS ANALYSIS DIVISION

Specifications

Mini-X2 X-Ray Tube Module

X-Ray Tube Performance	
Target Material	Silver (Ag), Gold (Au), Rhodium (Rh), Tungsten (W)
Target Type	Transmission
Tube Voltage	10 to 50 kV or 35 to 70 kV
Tube Power	4 W or 10 W available
Tube Current	5 µA to 200 µA (Fold back for power limit)
Typical Dose Rate	Tested @ 30 cm on axis
Au & W	1 Sv/hr (100 rem/hr) at 50 kV and 80 µA (4 W)
Ag & Rh	2.2 Sv/hr (220 rem/hr) at 50 V and 80 µA (4 W)
Typical Flux Approximate flux values are tested @ 30cm on axis. Units are the following: counts/second/mm^2/uA	
Ag & Rh	6 x 10^4
Au & W	2 x 10^5
Leakage Radiation	< 5µSv/hr (0.5 mrem/hr) at 5 cm with safety plug installed
Target Thickness	
Ag & Rh Au & W	0.75 ±0.1 µm 1 ±0.1 µm
Window	125 µm Be (window grounded)
Focal Spot	Approx. 2 mm
Settling Time	0.5 s (typical)
Cathode Type	Tungsten filament
HV Polarity	Grounded anode
HV Stability	< 0.1%
Environmental & Physical	
Operating Temp	-10 to +50 °C
Storage Temp	-25 to +60 °C
Humidity	30 to 90% non-condensing
Cooling	Air cooled
Weight	< 400 g

Mini-X2 X-Ray Tube Module

Connectors	
Power	3 pos receptacle, 0.031" (Hirose)
USB	Standard Mini-USB
Interlock	4 pos terminal block, female sockets, 0.15" pitch
Mini-X2	10 pos latching ribbon, male, 0.10" pitch
Power	
Input Voltage	11.5 to 12.5 V
Input Current	1.5 A max
Power Consumption	4 W Tubes: 9 W @ full power 10 W Tubes: 18 W @ full power
Safety	
Controls	1) Safety interlock (with fail-safe lamp driver)
	2) USB enable command Tube shuts off if USB is lost
Indicators	1) Flashing LED
	2) Beeper
	3) External lamp driver
Physical	
Dimensions	2.270 x 2.770 x .770 in
Weight	85 g

Radiation Precautions

The Mini−X2 generates x-ray radiation during normal operation. The Mini−X2 has been designed to focus radiation in the designated output direction, however radiation in other directions is possible and should be addressed with shielding and/or monitoring in the final application.

Radiation Levels external to the X-ray tube housing with the brass safety plug ON do not exceed 25 µS/h (2.5 mrem/h) measured 5 cm from the surface of the housing in accordance with Requirements 5.2.2.2.2 of the American National Standard N43.2.

Examples of shielding the *4 W, 50 kV Ag anode tube* (that comply with the above standard)

1 mm (0.040 inch) of Pb will result in radiation levels of 0.5 mrem/h.
6.35 mm (0.250 inch) of Fe will result in radiation levels of 0.5 mrem/h.
3.18 mm (0.125 inch) of Brass will result in radiation levels of 2.5 mrem/h.

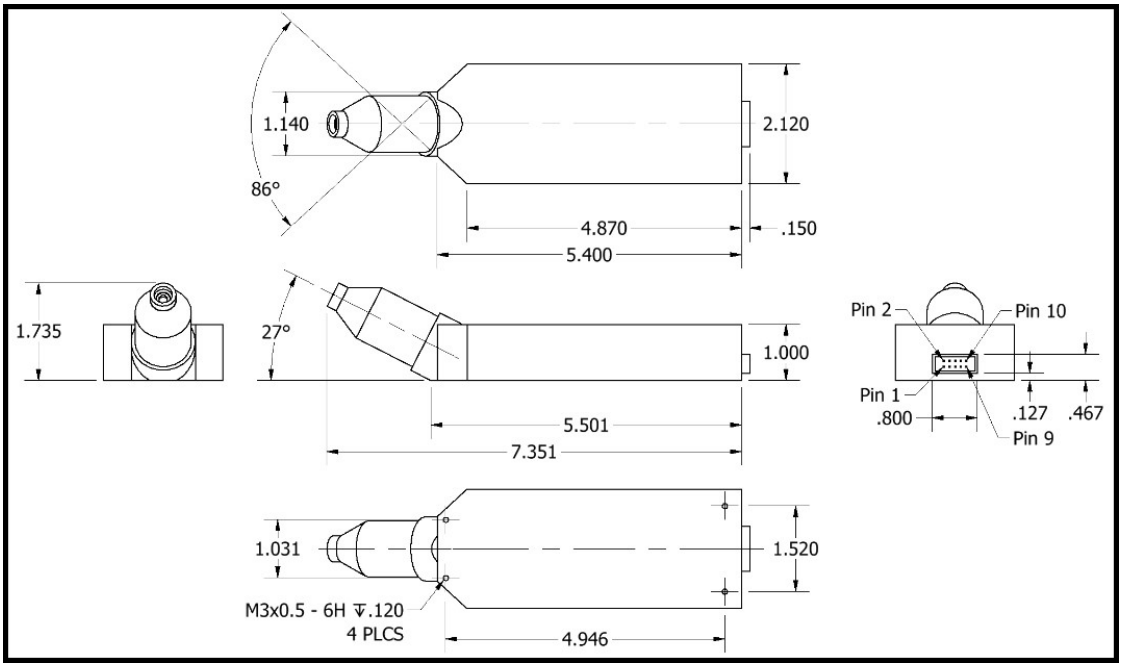
The inside of the housing can also be lined with 3.18 mm (0.125 inch) of aluminum (Al) in order to absorb the XRF from the shielding material.

Caution

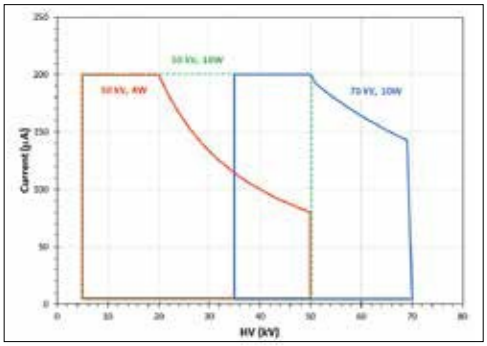
This device produces X-Rays when energized. To be operated only by qualified personnel.

Mini–X2 Mechanicals

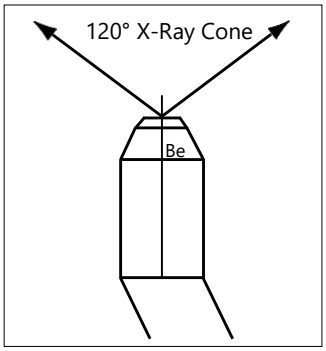
Mini-X2 Mechanical Dimensions



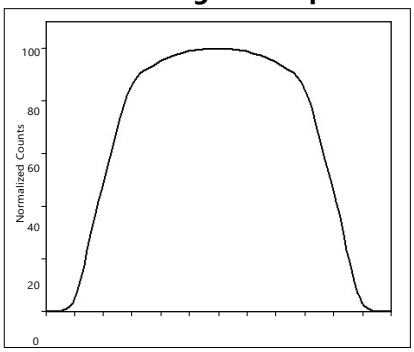
Mini-X2 50 kV Isopoer Curve (Max. 4 Watts)



Mini-X2 120° Cone



Mini-X2 Angular Response



How does the Mini-X2 differ from Amptek's existing Mini-X products?

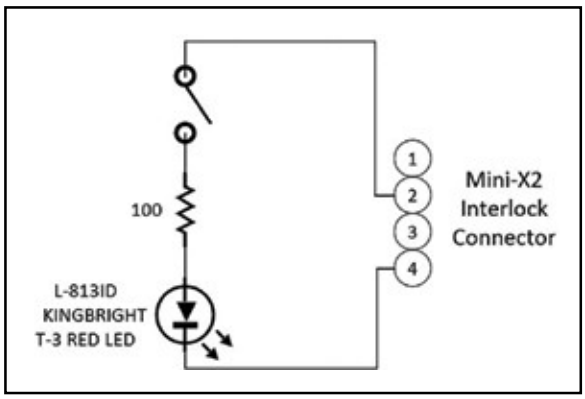
The Mini-X2 provides many additional control parameters and much better hard- ware monitoring than the first generation Mini-X. It provides a much faster readback and assessment that the tube is operating nominally. It allows one to easily reconfig- ure, via software rather than hardware, different tube parameters. The safety interlock includes a failsafe lamp driver and software configurability. It provides more complete fault monitoring and the ability to over-ride defaults.

The Mini-X2 controller has the same physical form factor as the MX-50, operates on the same voltages, draws the same current, and still communicates via USB. The INTERLOCK connector has a different pinout. The software interface is completely dif- ferent: new USB drivers, new command set, new parameter set, etc. A new version of the application software is required; all of the existing operations will still exist, with little change, but a menu of advanced settings will be added. For customers writing their own software, their code will need to be replaced using a new set of subroutines.

APPLICATION NOTES

Safety Interlock

The AUX connector on the Mini-X2 Controller contains a safety interlock, designed for use with a failsafe warning lamp. A typical application circuit is sketched below. The controller applies a configurable voltage across the external interlock circuit and monitors the current; the tube is only enabled if the current is within a programmable range. It turns off if the switch is open or if the lamp fails.

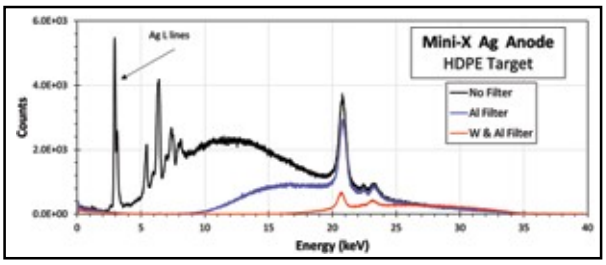


Warning lamp and beeper

The Mini-X2 controller includes an LED and a beeper which indicate that the tube's HV and current are enabled. They flash/beep at about 1 Hz. The safety interlock drives a lamp with a failsafe circuit. See the Mini-X2 User Manual for warning lamp technical specifications.

Filters and Collimators

In XRF, the characteristic X-rays of a given element (the analyte) are only stimulated by incident X-rays with energy above the analyte's absorption edge (and most efficiently by those between 1.5 and 2 times the absorption edge). An X-ray tube produces X-rays across a broad continuum (brehmstrahlung spectrum) extending below the absorption edge; these contribute to spectral background and degrade the precision, accuracy, and detection limits of an analyte. Filters (and HV settings) are used to reduce the background for a particular analyte and are key to high quality XRF measurements. See the Mini-X2 User Manual for more information.



Software

The Mini-X2 is provided with software which allows the user to set the HV and current, enable or disable the tube, to set various configuration parameters, and to read back the unit's status. Amptek also provide a software developer's kit (SDK) for customers who need to write their own control software. The Mini-X2 software interface is based on Amptek's FW6 communication protocol, via USB. It is completely different from the software interface on the original Mini-X.

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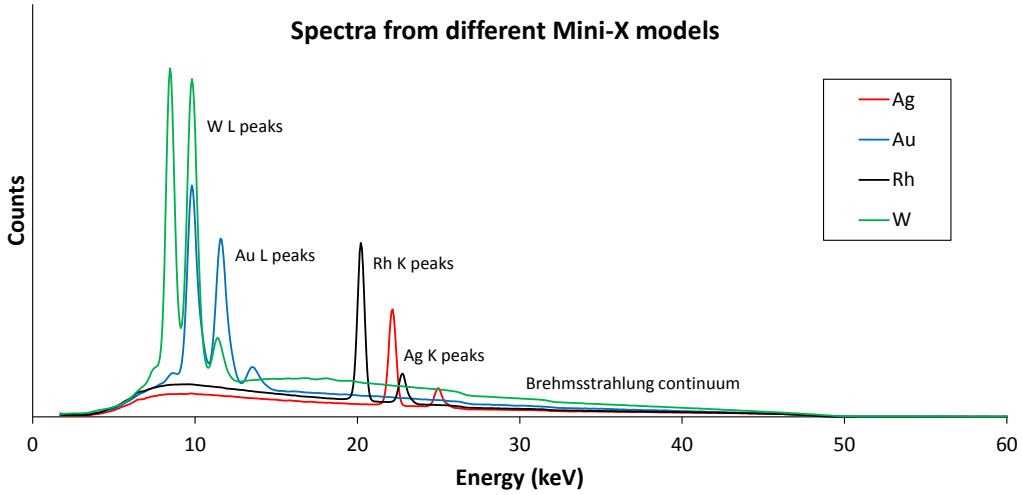
AMETEK MATERIALS ANALYSIS DIVISION

Choosing the anode material

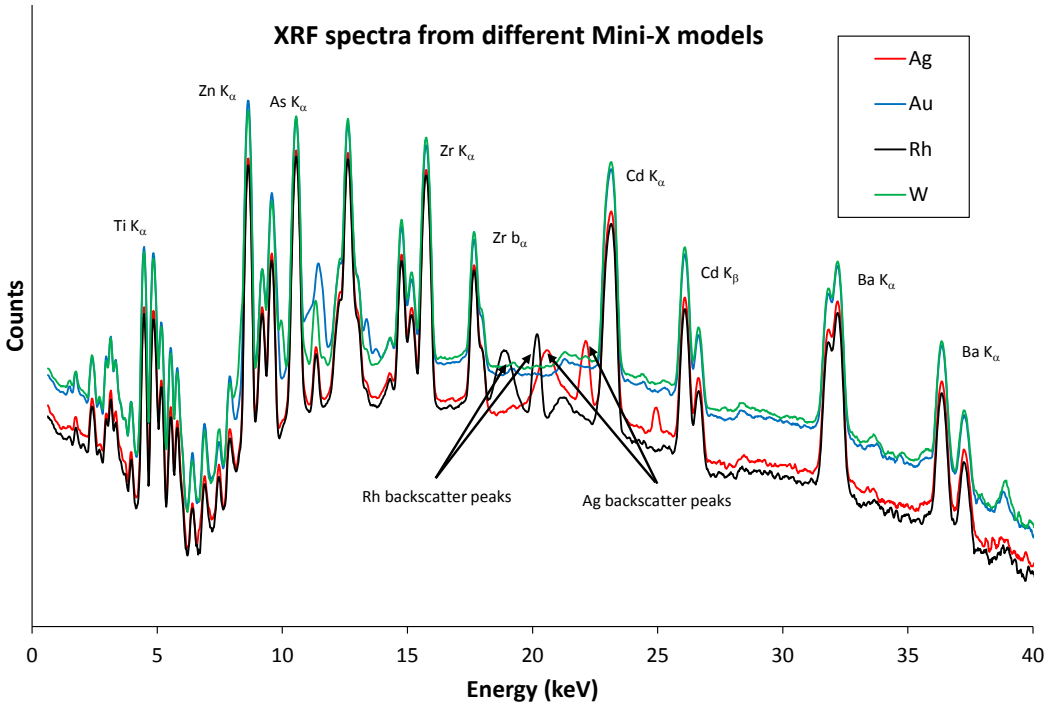
Amptek's Mini-X is available with silver (Ag), gold (Au), rhodium (Rh) or tungsten (W) as the anode material. A common question is: Why would I pick one material versus another one? In general, the excitation spectrum depends on the tube material. The plots below shows the spectra from the tubes, at 50 kV and 80 μA.

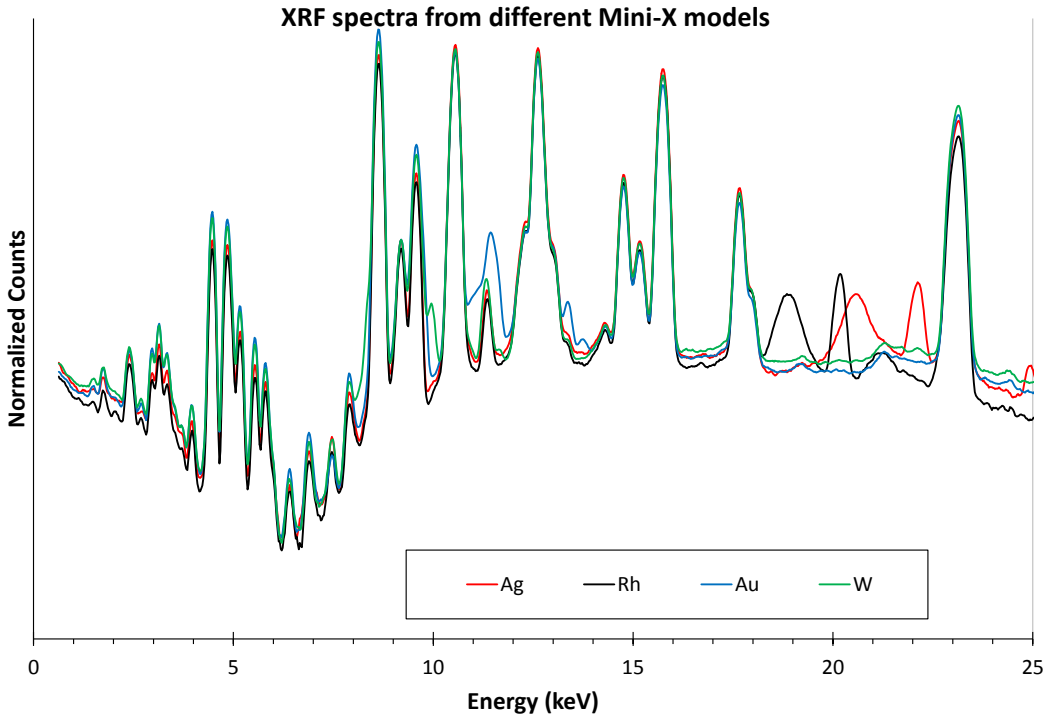


How does this impact XRF analysis?

- To best measure the characteristic X-rays of any single element, the analyte, one should excite with X-rays with an energy about 1.5 to 2 times the element's K edge, and with the background continuum low at energies near the characteristic lines.
- The spectrum of X-rays emitted by a tube has two components: a continuum (from bremsstrahlung) and lines (from the characteristic X-rays of the anode materials).
- At high energies, the spectrum arises entirely from the continuum; to measure analytes at these high energies, one wants a source with an intense continuum. The intensity of bremsstrahlung increases with atomic number, so the intensity of the continuum and total intensity are higher for the Au and W anodes than Ag and Rh.
- The characteristic X-ray lines are clearly seen in the spectrum above; Ag and Rh have higher energy characteristic X-rays.
  - Using excitation from these lines can improve signal to background relative to using the continuum as the primary excitation. These energies will be well suited to excite some elements but not for others. The Ag K lines, for example, are well suited to excite a range of metals from Cr through Mo.
  - These energies may interfere with elements in the sample. The Au and W L lines interfere with several metals of common interest. The Ag lines make it difficult to measure Ag in a sample.
  - The strong K_α line from Ag and Rh produces clear backscatter peaks from Rayleigh and Compton scattering. Some algorithms use this ratio to estimate sample atomic number; this is much harder with the Au and W, due to the many L lines.

The plots below show spectra taken from a calibration standard (multiple elements in a glass matrix) using the four different anode materials, with a light filter (10 mil Al) and 50 kVp. The bottom plot is normalized. Each tube produces different ratios for the intensity of the analytes and produces different scattered characteristic X-rays from the anode.





General advice for anode selection

- Silver (Ag) is probably the most commonly used material. This is in part legacy (much software was built around ^{109}Cd as an excitation source). The clear 22.1 keV peak provides good excitation for many elements of most common interest and provides a clear backscatter ratio, for those using the scattered intensity method to characterize the matrix.
- Rhodium (Rh) is very similar to Ag but it permits one to measure Ag in samples. Rh is relatively rare so is less likely to be an interference concern.
- Gold (Au) produces about twice the continuum intensity. One can use filters to shape the spectrum and retain and higher total count rate. It is particularly useful for analytes with a K edge above the silver lines, where the continuum alone produces the excitation. Moreover, the L lines of gold are low enough energy to easily filtered out, producing an almost pure-continuum spectrum.
- Tungsten (W) is similar to Au but it permits one to measure Au in samples. W is relatively rate so is less likely to be an interference concern.