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HAXPES reference spectra of bulk Mo and MoSe₂ with Cr K_α excitation

Pierre-Marie Deleuze¹, Nicolas Gauthier¹, Kateryna Artyushkova², Eugénie Martinez¹ and Olivier Renault^{1, a)}

¹ Univ. Grenoble Alpes, CEA, Leti, F-38000 Grenoble, France

²Physical Electronics, 18725 Lake Drive East, Chanhassen, Minnesota 55317

(Received day Month year; accepted day Month year; published day Month year)

Monochromatic Cr K_α radiation (5414.8 eV) was used to acquire high-energy photoelectron spectroscopy (HAXPES) data on pure Mo and bulk MoSe₂ compound with special attention paid to binding energy scale correction and quantification. The reported spectra include a survey scan and high-resolution Mo 2s, Mo 2p_{1/2}, Mo 2p_{3/2}, Mo 3d, Mo 3p_{1/2}, Mo 3p_{3/2}, Mo 3s, Mo 4s, Mo 4p, Se 2s, Se 2p_{1/2}, Se 2p_{3/2}, Se 3s, Se 3p_{1/2}, Se 3p_{3/2}, and Se 3d core-levels. The data will be useful as reference core-level spectra for HAXPES studies on molybdenum and its compounds.

Keywords: Mo, MoSe₂, HAXPES, Cr K_α

INTRODUCTION

Mo and its compounds are widely used in mechanics, electronics and phototonics, as well as in chemistry and catalysis. Recently developed laboratory based hard x-ray photoelectron spectrometers (HAXPES) allow to excite deeper core-levels, enabling different probing depths as a function of the studied core-level. In the case of Mo and MoSe₂, Cr K_α radiation (5414.8 eV) allows to ionize all Mo and Se core-levels of principal quantum numbers N=2, 3 and 4. In this work, we report HAXPES spectra recorded on pure bulk Mo and MoSe₂ compound. The data include a survey scan and high-resolution spectra of Mo 2s, Mo 2p_{1/2}, Mo 2p_{3/2}, Mo 3d, Mo 3p_{1/2}, Mo 3p_{3/2}, Mo 3s, Mo 4s, Mo 4p, Se 2s, Se 2p_{1/2}, Se 2p_{3/2}, Se 3s, Se 3p_{1/2}, Se 3p_{3/2}, and Se 3d.

SPECIMEN DESCRIPTION (ACCESSION # 01900)

Specimen: Mo

CAS Registry #: (Mo) 1317-33-5

Specimen Characteristics: Homogeneous; solid; polycrystalline; conductor; metal; Other

Chemical Name: Molybdenum

Composition: Mo

Form: Polycrystalline solid

Structure: Body-centered cubic

History & Significance: Air exposed thick Mo and bulk MoSe₂ samples

As Received Condition: Bulk Mo metal

Analyzed Region: Same as specimen

Ex Situ Preparation/Mounting: The sample was mounted on the sample holder using double sided conductive tape.

Accession#: 01900, 01901

Technique: XPS

Specimen: Mo, MoSe₂

Instrument: ULVAC-PHI Quantes

Major Elements in Spectra: Mo, Se

Minor Elements in Spectra: O, C

Published Spectra: 22

Spectral Category: Reference

In Situ Preparation: The Mo sample was sputter cleaned by Ar⁺ ions (2 keV) for 5 minutes prior to measurements to remove carbon and oxygen contamination.

Charge Control: Low-energy electrons (1 eV, filament 1.1 A) and low-energy Ar⁺ ions (100 eV)

Temp. During Analysis: 300 K

Pressure During Analysis: < 2×10⁻⁷ Pa

Pre-analysis Beam Exposure: 0 s

SPECIMEN DESCRIPTION (ACCESSION # 01901)

Specimen: MoSe₂

CAS Registry #: (MoSe₂) 12058-18-3

Specimen Characteristics: Homogeneous; solid; polycrystalline; semiconductor -

Chemical Name: Molybdenum diselenide

Composition: MoSe₂

Form: Polycrystalline solid

Structure: Hexagonal

History & Significance: Air exposed bulk MoSe₂ sample

As Received Condition: Bulk MoSe₂

Analyzed Region: Same as specimen

Ex Situ Preparation/Mounting: The sample was mounted on the sample holder using double sided conductive tape.

In Situ Preparation: None

Charge Control: Low-energy electrons (1 eV, filament 1.1 A) and low-energy Ar⁺ ions (100 eV)

Temp. During Analysis: 300 K

Pressure During Analysis: < 2×10⁻⁷ Pa

^{a)}Electronic mail: olivier.renault@cea.fr

Pre-analysis Beam Exposure: 0 s

INSTRUMENT DESCRIPTION

Manufacturer and Model: ULVAC-PHI Quantex

Analyzer Type: spherical sector

Detector: multichannel resistive plate

Number of Detector Elements: 32

INSTRUMENT PARAMETERS COMMON TO ALL SPECTRA

■ Spectrometer

Analyzer Mode: constant pass energy

Throughput ($T=E^N$): The energy dependence can be modeled using the following equation: $\frac{A}{E_p} = \left(\frac{a^2}{a^2+R^2}\right)^b$, where a and b are constants, E_p is the pass energy, A is the peak area and R is the retard ratio equal to E/E_p , where E is the kinetic energy. Three spectral regions are recorded on a sputter cleaned sample at different pass energies. The values of a and b are then determined by a linear least square fit of the data applying the equation described above.

Excitation Source Window: Al

Excitation Source: Cr K_α monochromatic

Source Energy: 5414.8 eV

Source Strength: 50 W

Source Beam Size: 100 μm x 100 μm

Signal Mode: multichannel direct

■ Geometry

Incident Angle: 22 °

Source-to-Analyzer Angle: 46 °

Emission Angle: 45 °

Specimen Azimuthal Angle: 0 °

Acceptance Angle from Analyzer Axis: 0 °

Analyzer Angular Acceptance Width: 20 ° x 20 °

■ Ion Gun

Manufacturer and Model: ULVAC-PHI Quantex

Energy: 2000 eV

Current: 0.001 mA

Current Measurement Method: Faraday cup

Sputtering Species: Ar

Spot Size (unrastered): 100 μm

Raster Size: 3000 μm x 3000 μm

Incident Angle: 45 °

Polar Angle: 45 °

Azimuthal Angle: 45 °

Comment: Differentially pumped ion gun used for pre-sputtering of the sample and to prevent reoxidation during analysis.

DATA ANALYSIS METHOD

Energy Scale Correction: The decrease of photoionization cross-sections in HAXPES (Refs. 1 and 2) leads to a very low intensity of the C 1s core-level peak which is often used to correct the energy scale. Also, in the case of metals, great care must be taken regarding the reliability of energy scale correction relying on the C 1s binding energy of adventitious carbon (Ref. 3). Therefore, the binding energy correction of the data of pure Mo was performed by first considering the binding energy of the Mo 3d_{5/2} peak recorded with Al K_α radiation on the sputter-clean surface referenced to the Fermi level, as determined from a fitting of the band onset. Then, the correction factor was found by aligning on this value the Mo 3d_{5/2} binding energy measured with Cr K_α radiation. Doing so, the Mo 3d_{5/2} binding energy was 227.8 eV, in agreement with an average of 24 binding energy values published in the NIST Database (Ref. 4). The spectra recorded with the Cr K_α source were then rescaled by shifting the Mo 3d_{5/2} to 227.8 eV. Regarding bulk MoSe₂, the C 1s peak in HAXPES is too weak to be considered for correction of the energy scale. In XPS, the strong Se Auger line completely overlaps the C 1s core line. Therefore, the energy correction of the HAXPES data is made by applying to all spectra an energy shift which is the difference between the Mo 3d_{5/2} binding energy measured by XPS and the Mo 3d_{5/2} binding energy measured by HAXPES. Doing so, the Mo 3d_{5/2} binding energy was 228.9 eV, in good agreement with other data (Ref. 5). The spectra recorded with the Cr K_α source were then rescaled by shifting the Mo 3d_{5/2} to 228.9 eV.

Recommended Energy Scale Shift: -0.6 eV for bulk Mo and +0.4 eV for bulk MoSe₂.

Peak Shape and Background Method: Shirley background was employed for peak area determination. No curve fitting was performed on the spectra.

Quantitation Method: PHI Multipak software Version 9.9.0.8 was used to perform quantification. The determined intensities were checked for repeatability by comparing, before and after acquisition, the intensities of the Mo 2s core-line of both samples on the one hand, and on the other hand the intensity of the Ag 3d line of a sputter-clean, bulk silver sample mounted on the same holder. In all cases the standard deviation in intensity was below 6%. Empirically determined sensitivity factors (RSFs) were provided by the software, from the most recently released RSF database. The RSFs were derived from the pure-element relative sensitivity factor as defined in ISO 18118:2015 (Ref 6) which were measured on pure element samples using a Cr K_α source. They therefore account for the decrease of cross-section and different escape depth of photoelectrons using higher energy photons. RSFs are reported proportional to the RSF of F 1s equal to 1. Using the determined pure element RSF's leads to quantification error of ~5% for the MoSe₂ compound.

ACKNOWLEDGMENTS

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AUTHOR DECLARATION

The authors have no conflict to disclose.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available within the article and its supplementary material.

REFERENCES

1. M.B. Trzhaskovskaya and V.G. Yarzhemsky, *At. Data Nucl. Data Tables* **119**, 99 (2018).
2. M.B. Trzhaskovskaya and V.G. Yarzhemsky, *At. Data Nucl. Data Tables* **129-130**, 101280 (2019).
3. G. Greczynski, L. Hultman, *Progress in Material Science* **107**, 100591 (2020).
4. NIST X-ray Photoelectron Spectroscopy Database, ver 4.1, <http://dx.doi.org/10.18434/T4T88K>.
5. C. Vergnaud, M. Gay *et al.*, *2D Materials* **6**, 035019 (2019).
6. International Organization for Standardization 2015, *Surface chemical analysis - Auger electron spectroscopy and X-ray photoelectron spectroscopy - Guide to the use of experimentally determined relative sensitivity factors for the quantitative analysis of homogeneous materials*, ISO 18118:2015.

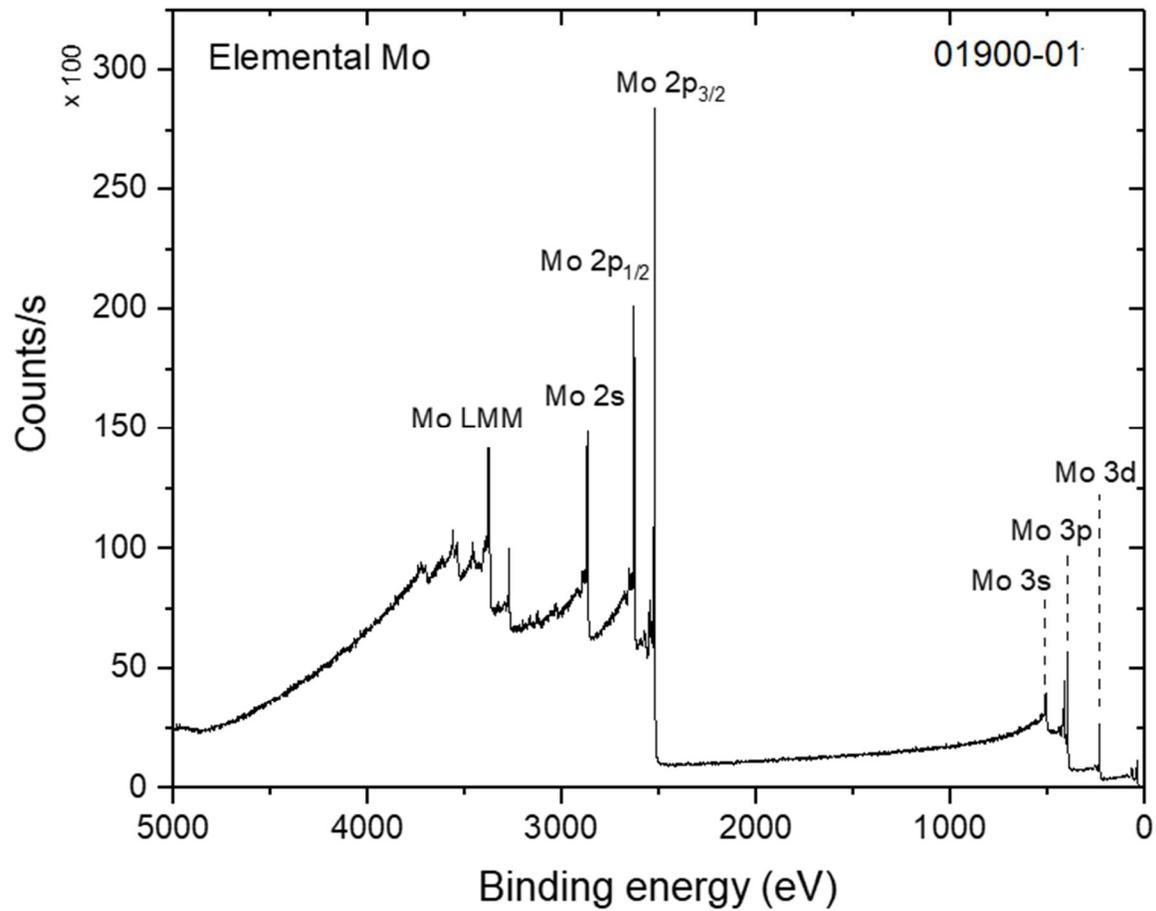
SPECTRAL FEATURES TABLE							
Spectrum ID #	Element/ Transition	Peak Energy (eV)	Peak Width FWHM (eV)	Peak Area (eV x cts/s)	Sensitivity Factor	Concentration (at. %)	Peak Assignment
01900-02	Mo 2p _{3/2}	2521.0	2.36	36812	9.584	...	...
01900-03	Mo 2p _{1/2}	2625.8	2.40	20306	4.969	...	...
01900-04	Mo 2s	2866.7	4.17	16358	3.805	...	...
01900-05	Mo 3d	227.8	1.26	3360	1.103	...	...
01900-06	Mo 3p _{3/2}	393.7	2.81	7093	2.063	...	...
01900-06	Mo 3p _{1/2}	411.0	2.60	3222	1.134	...	...
01900-07	Mo 3s	505.3	6.25	3969	0.971	...	...
01900-08	Mo 4s	62.7	4.76	1158	0.284	...	...
01900-09	Mo 4p	35.4	3.54	1558	0.425	...	...
01901-02	Mo 2p _{3/2}	2521.9	2.37	7307	9.584	...	...
01901-03	Mo 2p _{1/2}	2626.9	2.36	3897	4.969	...	...
01901-04	Mo 2s	2867.9	4.47	3459	3.805	...	...
01901-05	Mo 3d, Se 3s	229.1	2.34	1610	1.103, 0.708	...	...
01901-06	Mo 3p _{3/2}	394.7	2.86	1311	2.063	...	...
01901-06	Mo 3p _{1/2}	412.3	2.58	803	1.134	...	...
01901-07	Mo 3s	506.8	4.93	734	0.971	...	...
01901-08	Mo 4s	63.2	3.04	149	0.284	...	...
01901-08	Se 3d	54.9	1.75	216	1.245	...	...
01901-09	Mo 4p	36.9	3.49	311	0.425	...	...
01901-10	Se 2p _{3/2}	1433.7	1.69	6956	5.135	...	...
01901-11	Se 2p _{1/2}	1474.6	1.69	3915	2.773	...	...
01901-12	Se 2s	1653.7	4.85	5183	3.355	...	...
01901-13	Se 3p _{3/2}	161.0	2.16	841	0.809	...	...
01901-13	Se 3p _{1/2}	166.6	2.24	357	0.436	...	...

ANALYZER CALIBRATION TABLE							
Spectrum ID #	Element/ Transition	Peak Energy (eV)	Peak Width FWHM (eV)	Peak Area (eV x cts/s)	Sensitivity Factor	Concentration (at. %)	Peak Assignment
...	Ag 3d _{5/2}	368.17	1.00	724121	...	...	...
...	Cu 2p _{3/2}	932.61	0.99	65630	...	...	...
...	Au 4f _{7/2}	83.96	0.83	73825	...	...	...

Comment to Analyzer Calibration Table: The spectra in the analyzer calibration table were recorded using Al K_α photons.

GUIDE TO FIGURES

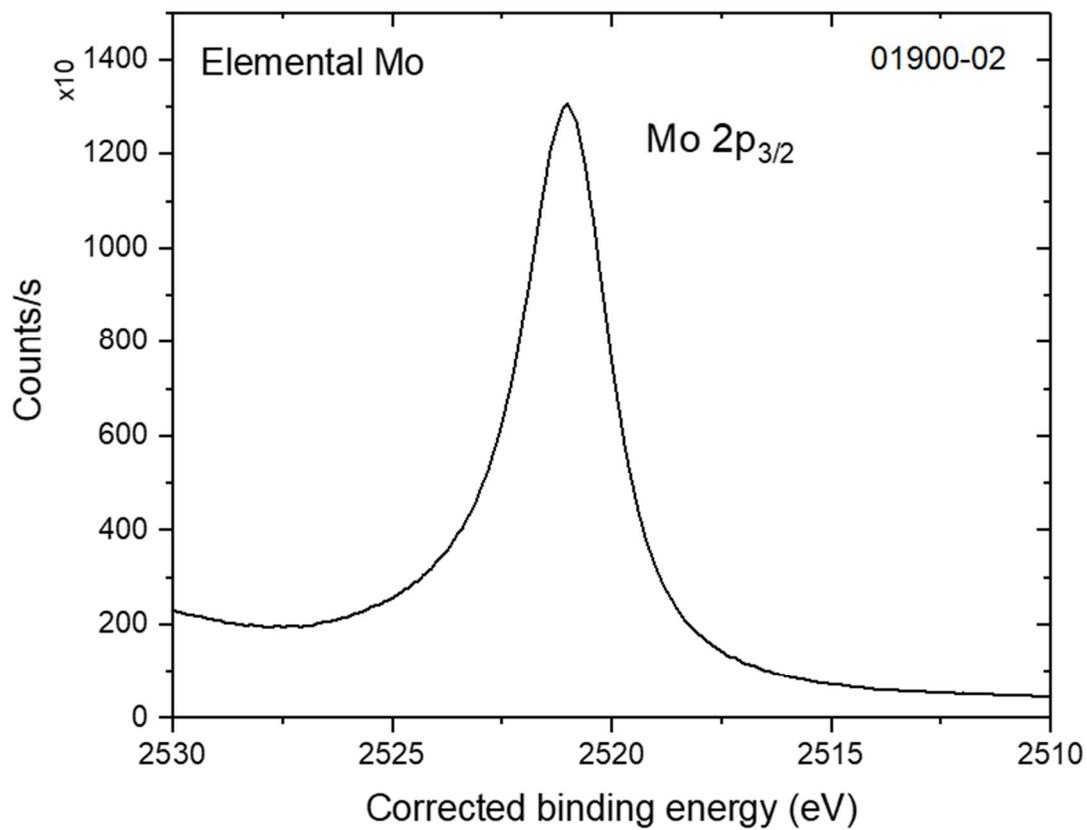
Spectrum (Accession) #	Spectral Region	Voltage Shift*	Multiplier	Baseline	Comment #
01900-01	Survey	0	1	0	...
01900-02	Mo $2p_{3/2}$	+0.6	1	0	...
01900-03	Mo $2p_{1/2}$	+0.6	1	0	...
01900-04	Mo 2s	+0.6	1	0	...
01900-05	Mo 3d	+0.6	1	0	...
01900-06	Mo 3p	+0.6	1	0	...
01900-07	Mo 3s	+0.6	1	0	...
01900-08	Mo 4s	+0.6	1	0	...
01900-09	Mo 4p	+0.6	1	0	...
01901-01	Survey	0	1	0	
01901-02	Mo $2p_{3/2}$	-0.4	1	0	
01901-03	Mo $2p_{1/2}$	-0.4	1	0	
01901-04	Mo 2s	-0.4	1	0	
01901-05	Mo 3d, Se 3s	-0.4	1	0	
01901-06	Mo 3p	-0.4	1	0	
01901-07	Mo 3s	-0.4	1	0	
01901-08	Mo 4s, Se 3d	-0.4	1	0	
01901-09	Mo 4p	-0.4	1	0	
01901-10	Se $2p_{3/2}$	-0.4	1	0	
01901-11	Se $2p_{1/2}$	-0.4	1	0	
01901-12	Se 2s	-0.4	1	0	
01901-13	Se $3p_{3/2}$, Se $3p_{1/2}$	-0.4	1	0	



Accession #

01900-01

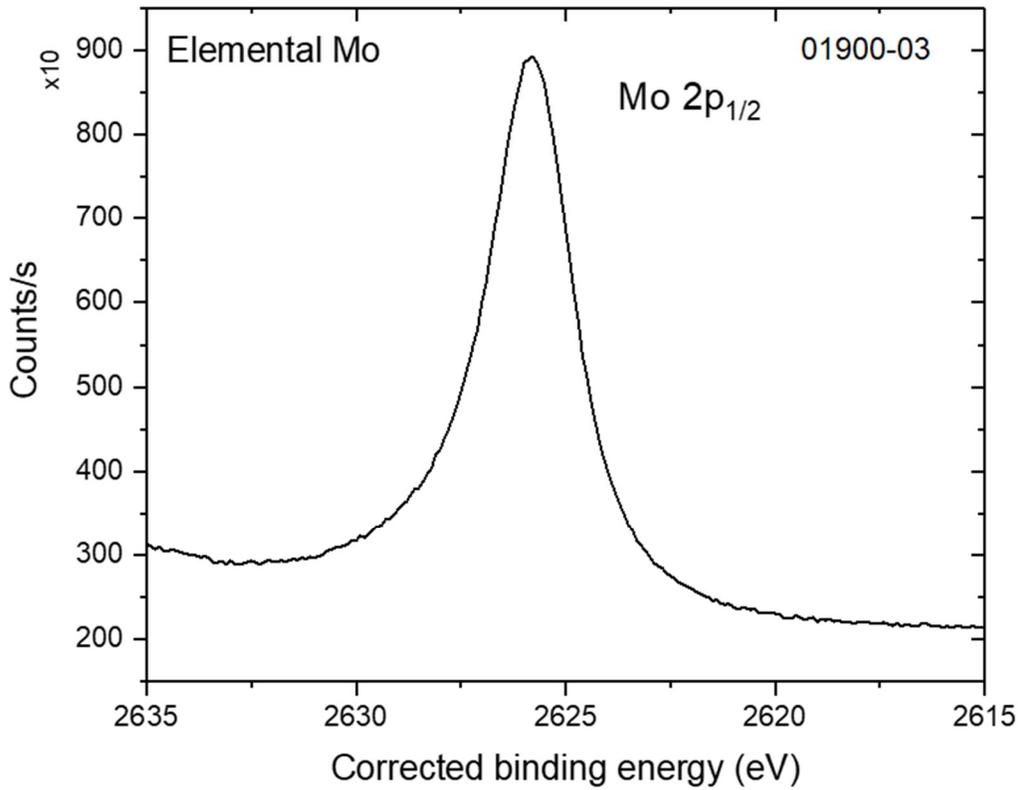
■ Specimen	Mo
■ Technique	XPS
■ Spectral Region	Survey
Instrument	ULVAC-PHI Quantes
Excitation Source	Cr K_{α} monochromatic
Source Energy	5414.8 eV
Source Strength	50 W
Source Size	0.1 mm x 0.1 mm
Analyzer Type	spherical sector analyzer
Incident Angle	22°
Emission Angle	45°
Analyzer Pass Energy	280 eV
Analyzer Resolution	2.33 eV
Total Signal Accumulation Time	5205 s
Total Elapsed Time	5760 s
Number of Scans	10
Effective Detector Width	31 eV



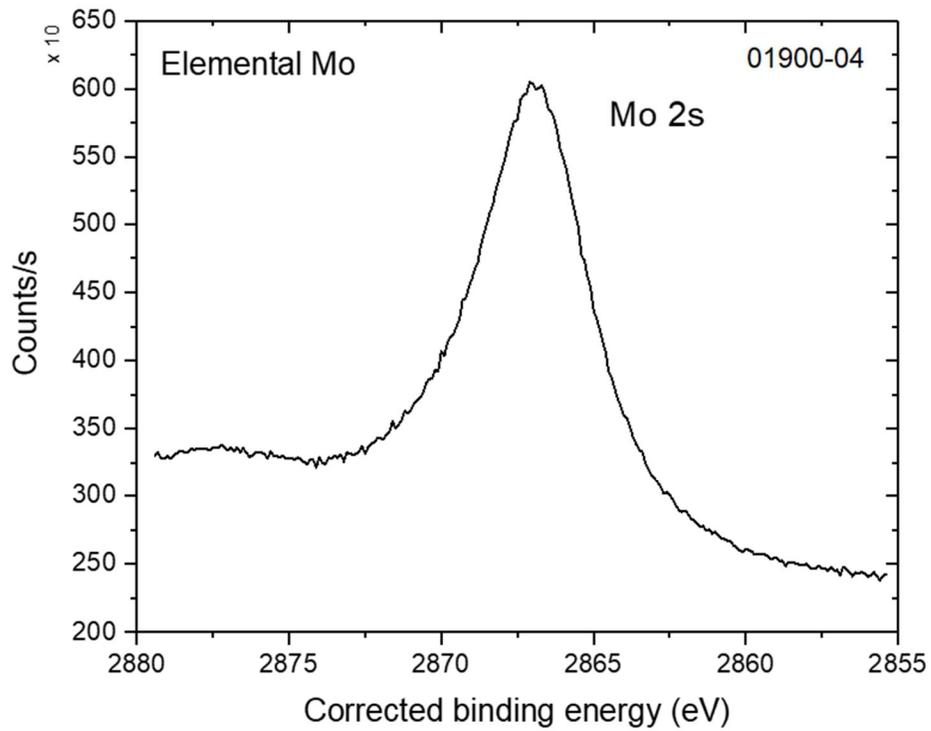
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■ **Technique:** XPS
■ **Spectral Region:** Mo
2p_{3/2}
Instrument: ULVAC-PHI
Quantes
Excitation Source: Cr *K_α*
monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1
mm
Analyzer Type: spherical
sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112
eV
Analyzer Resolution: 1.17
eV
Total Signal Accumulation
Time: 3606 s
Total Elapsed Time: 3978 s

Number of Scans: 27

Effective Detector Width:
12.4 eV



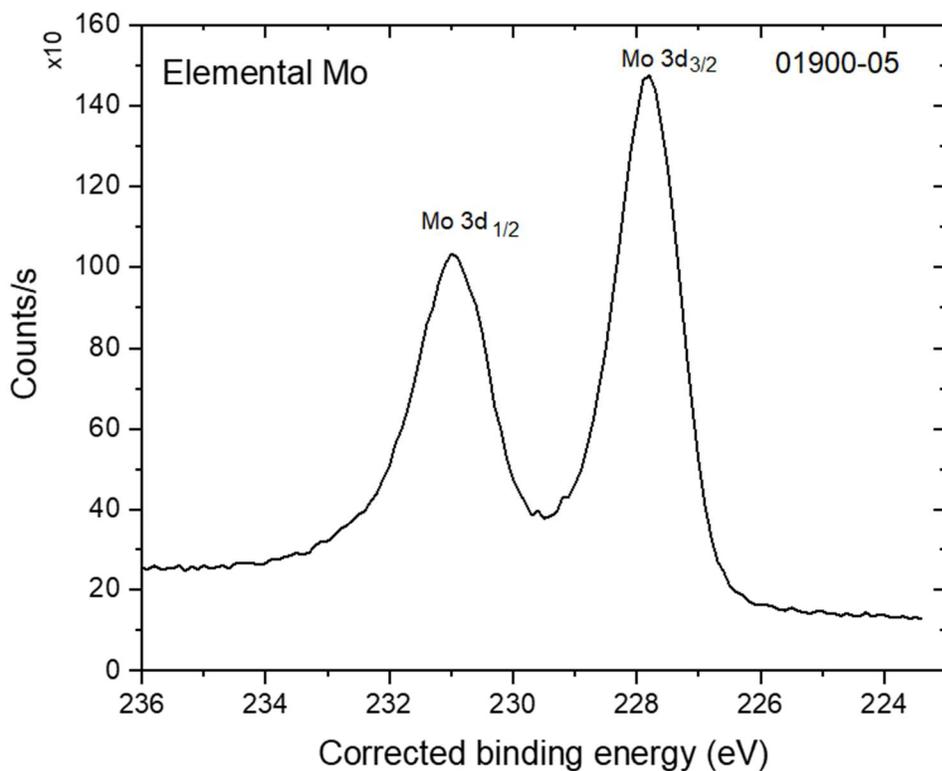
■ **Accession #:** 01900-03
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■ **Technique:** XPS
■ **Spectral Region:** Mo 2p_{1/2}
Instrument: ULVAC-PHI Quantes
Excitation Source: Cr K_α monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1 mm
Analyzer Type: spherical sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112 eV
Analyzer Resolution: 1.17 eV
Total Signal
Accumulation Time: 3606 s
Total Elapsed Time: 3978 s
Number of Scans: 27
Effective Detector Width: 12.4 eV



■ **Accession #:** 01900-04
■ **Specimen:** Mo
■ **Technique:** XPS
■ **Spectral Region:** Mo 2s
Instrument: ULVAC-PHI
Quantes
Excitation Source: Cr K_{α}
monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1 mm
Analyzer Type: spherical sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112 eV
Analyzer Resolution: 1.17 eV
Total Signal Accumulation
Time: 876 s
Total Elapsed Time: 960 s

Number of Scans: 25

Effective Detector Width: 12.4 eV



■ **Accession #:** 01900-05

■ **Specimen:** Mo

■ **Technique:** XPS

■ **Spectral Region:** Mo 3d

Instrument: ULVAC-PHI
Quantes

Excitation Source: Cr K_{α}
monochromatic

Source Energy: 5414.8 eV

Source Strength: 50 W

Source Size: 0.1 mm x 0.1
mm

Analyzer Type: spherical
sector

Incident Angle: 22 °

Emission Angle: 45 °

Analyzer Pass Energy 112 eV

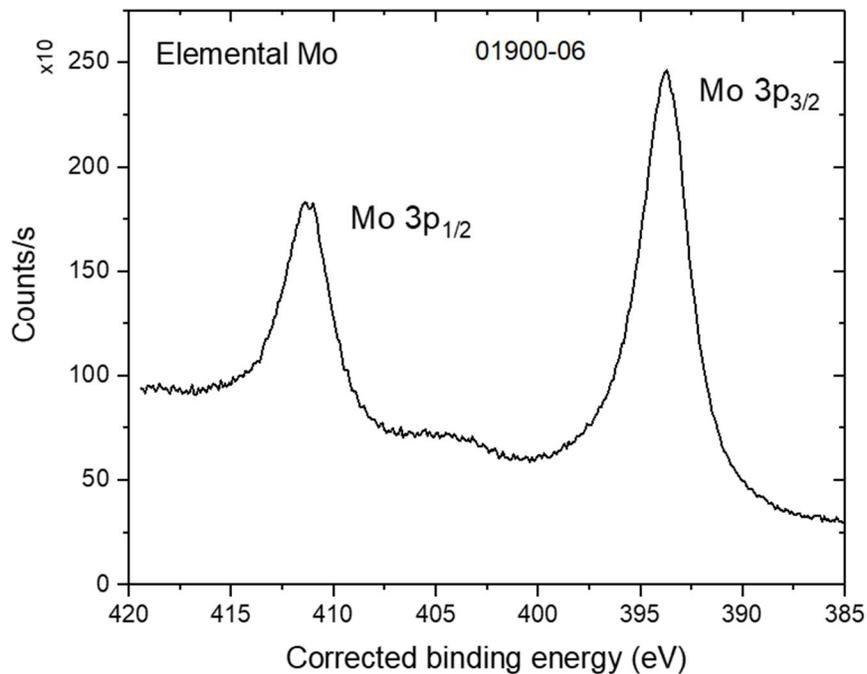
Analyzer Resolution: 1.17 eV

Total Signal Accumulation
Time: 3660 s

Total Elapsed Time: 4032 s

Number of Scans: 36

Effective Detector Width: 12.4
eV



■ **Accession #:** 01900-06

■ **Specimen:** Mo

■ **Technique:** XPS

■ **Spectral Region:** Mo 3p

Instrument: ULVAC-PHI
Quantes

Excitation Source: Cr K_{α}
monochromatic

Source Energy: 5414.8 eV

Source Strength: 50 W

Source Size: 0.1 mm x 0.1 mm

Analyzer Type: spherical sector

Incident Angle: 22 °

Emission Angle: 45 °

Analyzer Pass Energy 112 eV

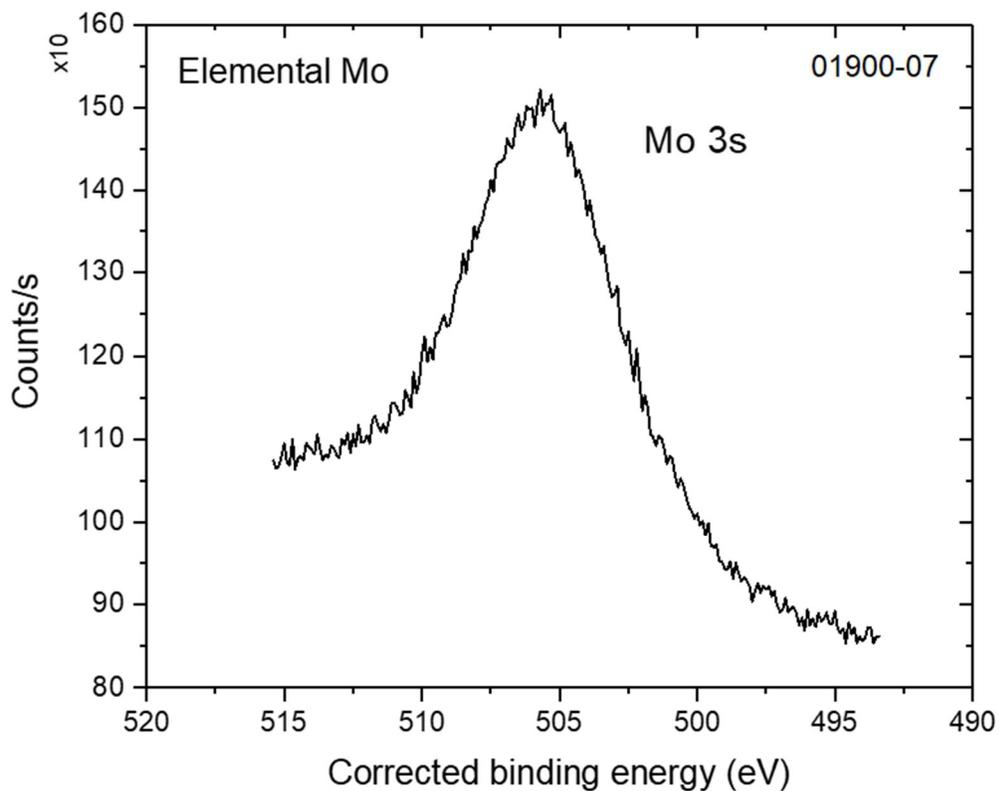
Analyzer Resolution: 1.17 eV

Total Signal Accumulation Time:
3600 s

Total Elapsed Time: 3966 s

Number of Scans: 19

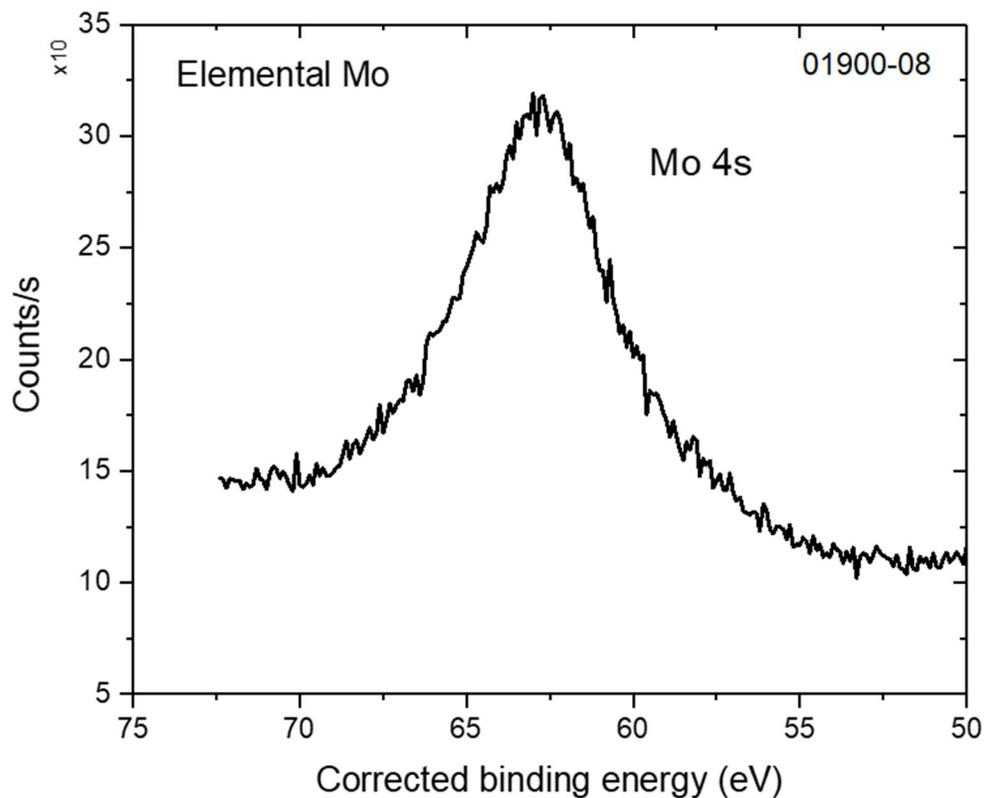
Effective Detector Width: 12.4
eV



■ **Accession #:** 01900-07
■ **Specimen:** Mo
■ **Technique:** XPS
■ **Spectral Region:** Mo 3s
Instrument: ULVAC-PHI
Quantes
Excitation Source: Cr K_{α}
monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1 mm
Analyzer Type: spherical sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112 eV
Analyzer Resolution: 1.17 eV
Total Signal Accumulation Time: 3576 s
Total Elapsed Time: 3942 s

Number of Scans: 26

Effective Detector Width: 12.4 eV



■ **Accession #:** 01900-08

■ **Specimen:** Mo

■ **Technique:** XPS

■ **Spectral Region:** Mo 4s

Instrument: ULVAC-PHI Quantes

Excitation Source: Cr K_{α} monochromatic

Source Energy: 5414.8 eV

Source Strength: 50 W

Source Size: 0.1 mm x 0.1 mm

Analyzer Type: spherical sector

Incident Angle: 22 °

Emission Angle: 45 °

Analyzer Pass Energy 112 eV

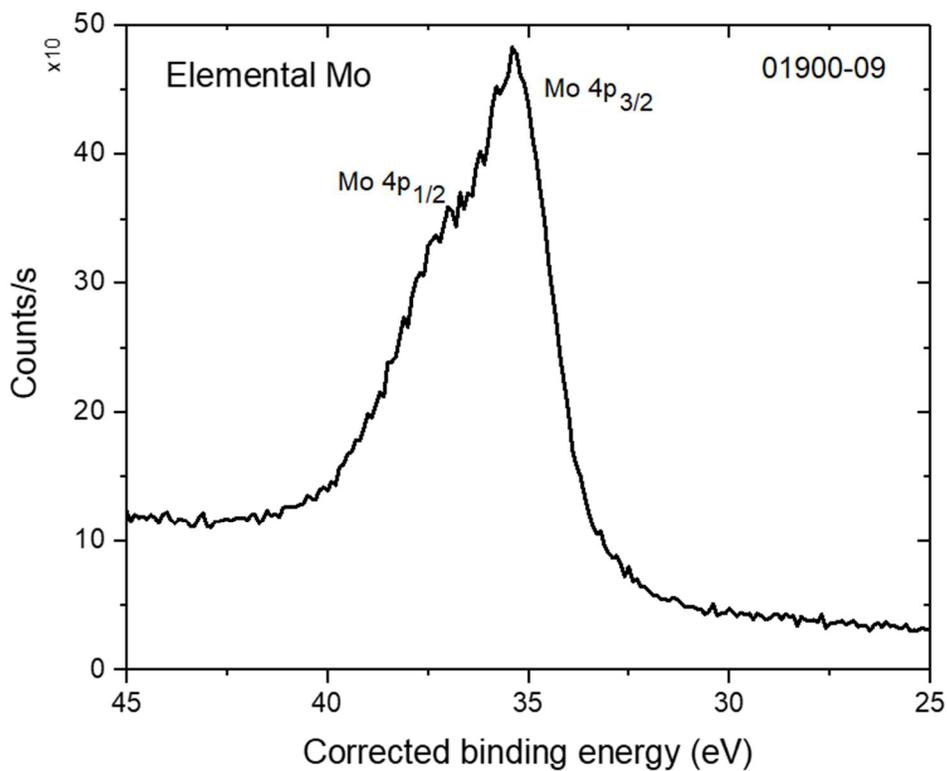
Analyzer Resolution: 1.17 eV

Total Signal Accumulation Time: 3684 s

Total Elapsed Time: 4056 s

Number of Scans: 26

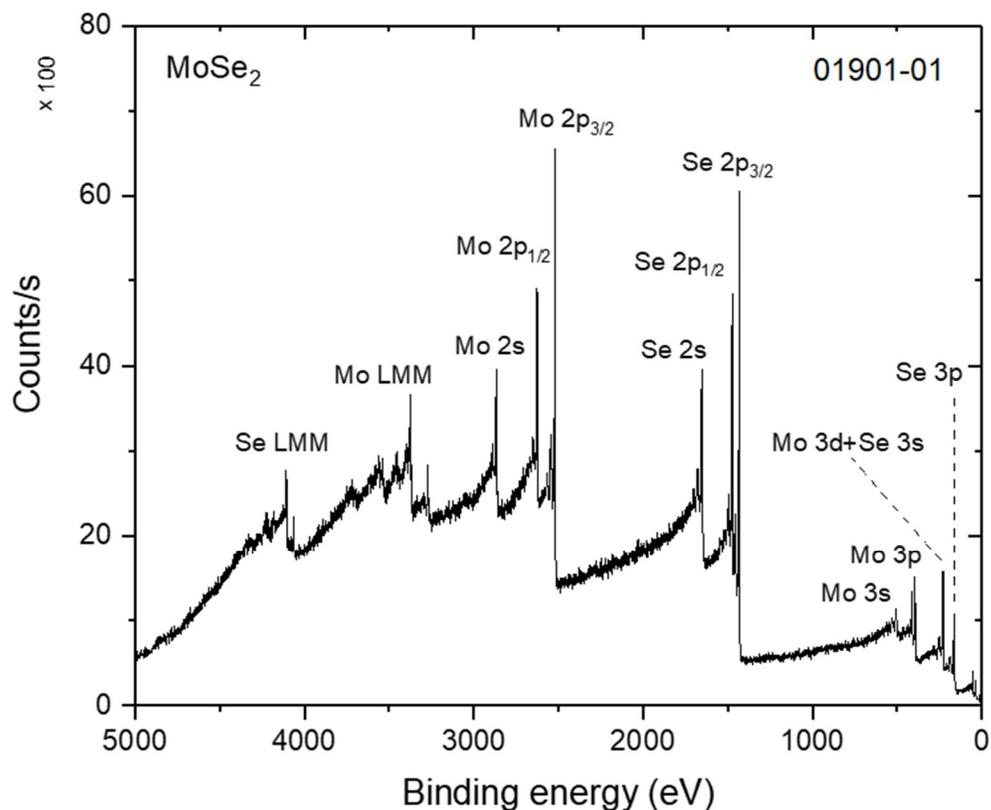
Effective Detector Width: 12.4 eV



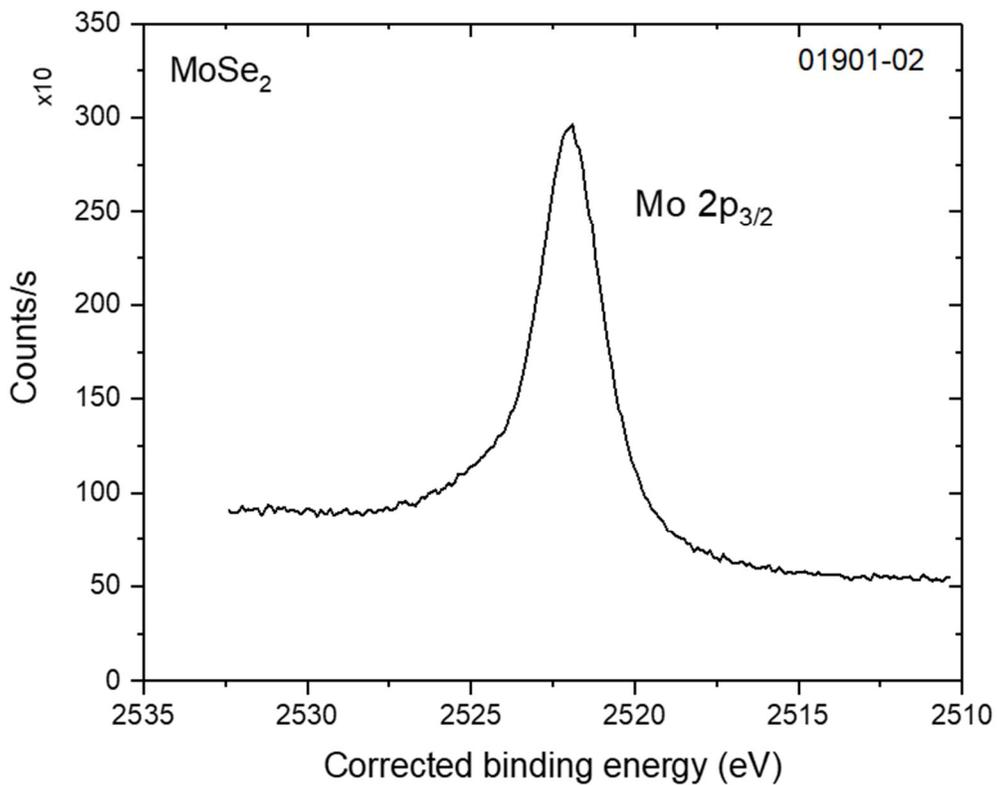
■ **Accession #:** 01900-09
■ **Specimen:** Mo
■ **Technique:** XPS
■ **Spectral Region:** Mo 4p
Instrument: ULVAC-PHI
Quantes
Excitation Source: Cr K_{α}
monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1
mm
Analyzer Type: spherical
sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112 eV
Analyzer Resolution: 1.17 eV
Total Signal Accumulation
Time: 3576 s
Total Elapsed Time: 3942 s

Number of Scans: 26

Effective Detector Width: 12.4
eV



Accession #	01901-01
■ Specimen	MoSe ₂
■ Technique	XPS
■ Spectral Region	Survey
Instrument	ULVAC-PHI Quantes
Excitation Source	Cr K _α monochromatic
Source Energy	5414.8 eV
Source Strength	50 W
Source Size	0.1 mm x 0.1 mm
Analyzer Type	spherical sector analyzer
Incident Angle	22°
Emission Angle	45°
Analyzer Pass Energy	280 eV
Analyzer Resolution	2.33 eV
Total Signal Accumulation Time	5238 s
Total Elapsed Time	5760 s
Number of Scans	10
Effective Detector Width	31 eV



■ **Accession #:** 01901-02

■ **Specimen:** MoSe₂

■ **Technique:** XPS

■ **Spectral Region:** Mo
2p_{3/2}

Instrument: ULVAC-PHI
Quantes

Excitation Source: Cr K_α
monochromatic

Source Energy: 5414.8 eV

Source Strength: 50 W

Source Size: 0.1 mm x 0.1
mm

Analyzer Type: spherical
sector

Incident Angle: 22 °

Emission Angle: 45 °

Analyzer Pass Energy 112
eV

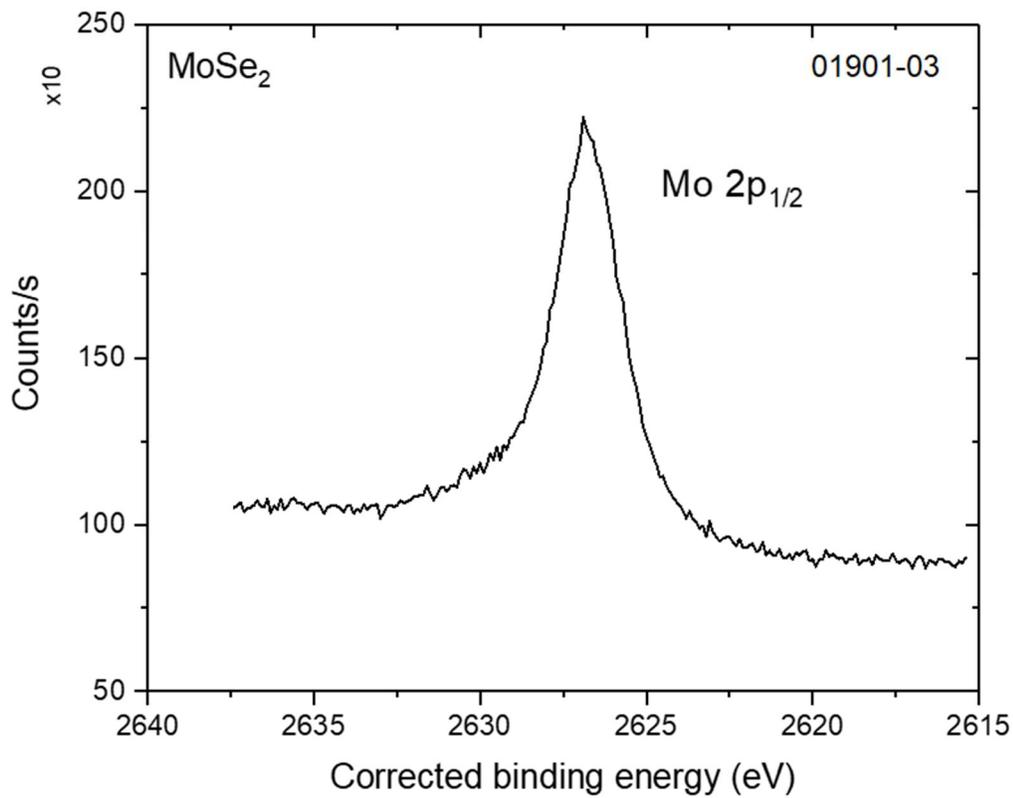
Analyzer Resolution: 1.17
eV

Total Signal Accumulation
Time: 3300 s

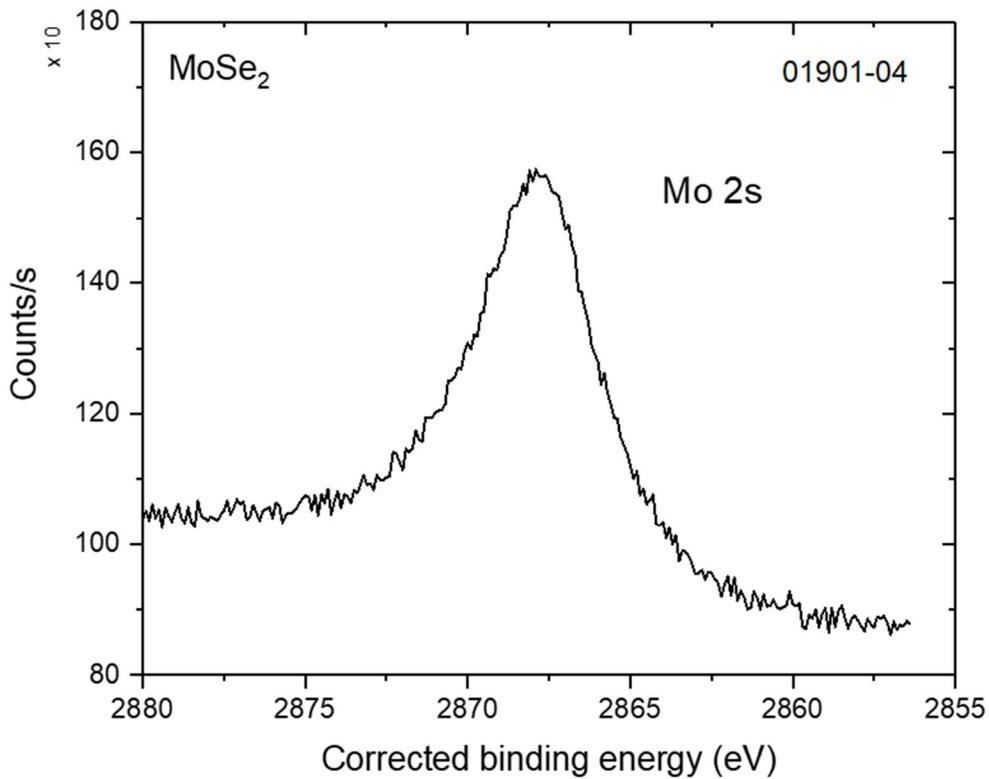
Total Elapsed Time: 3642 s

Number of Scans: 24

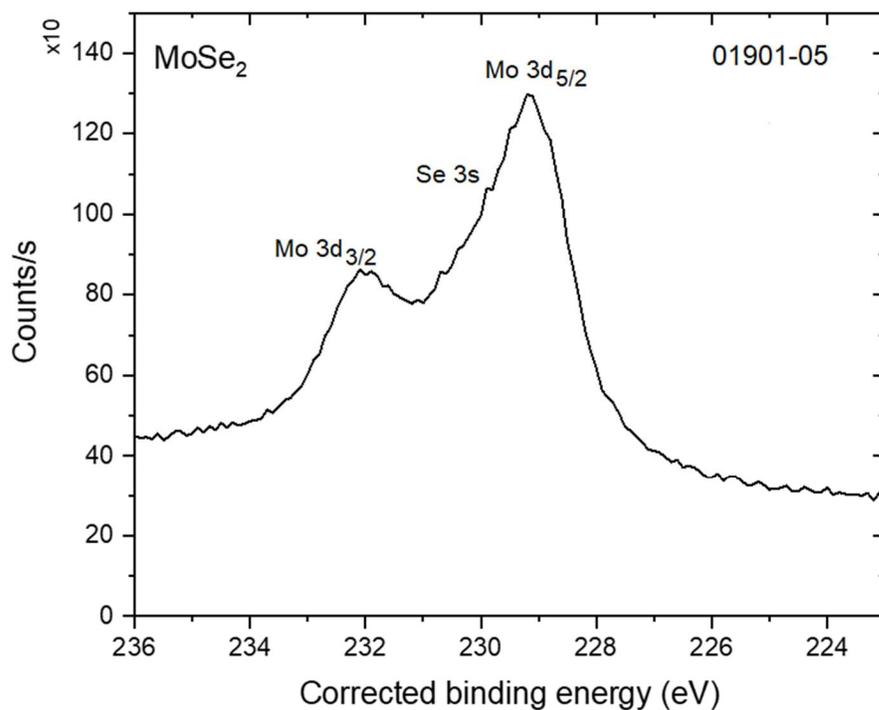
Effective Detector Width:
12.4 eV



■ **Accession #:** 01901-03
■ **Specimen:** MoSe₂
■ **Technique:** XPS
■ **Spectral Region:** Mo 2p_{1/2}
Instrument: ULVAC-PHI Quantes
Excitation Source: Cr K_α monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1 mm
Analyzer Type: spherical sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112 eV
Analyzer Resolution: 1.17 eV
Total Signal Accumulation Time: 3300 s
Total Elapsed Time: 3642 s
Number of Scans: 24
Effective Detector Width: 12.4 eV



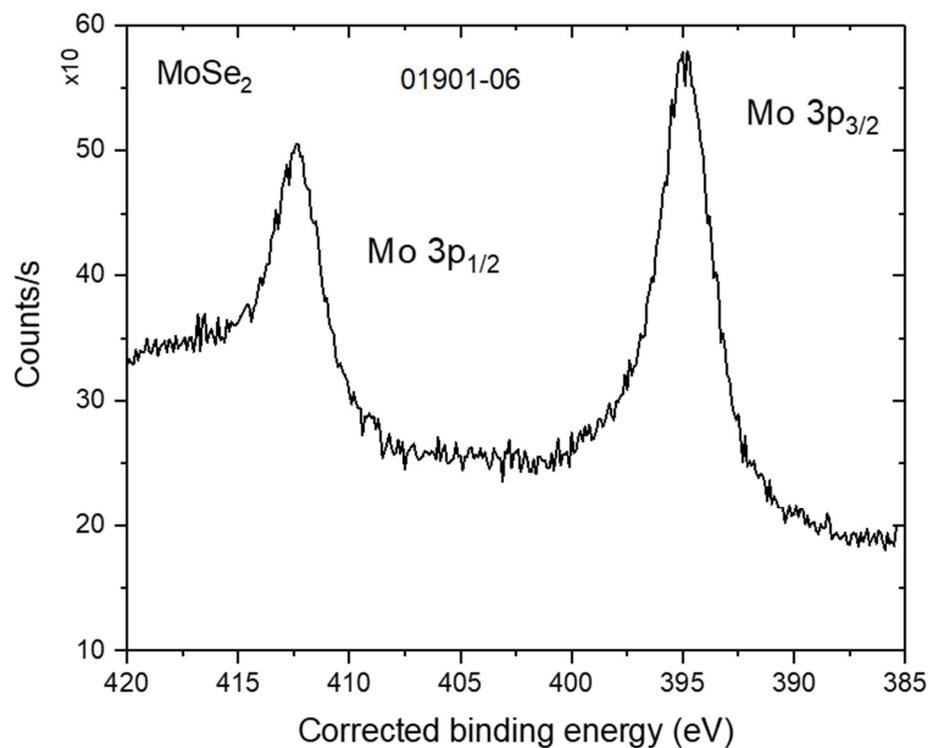
■ **Accession #:** 01901-02
■ **Specimen:** MoSe₂
■ **Technique:** XPS
■ **Spectral Region:** Mo 2s
Instrument: ULVAC-PHI
Quantes
Excitation Source: Cr K_α
monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1
mm
Analyzer Type: spherical
sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112
eV
Analyzer Resolution: 1.17
eV
Total Signal Accumulation
Time: 3492 s
Total Elapsed Time: 3852 s
Number of Scans: 24
Effective Detector Width:
12.4 eV



■ **Accession #:** 01901-05
■ **Specimen:** MoSe₂
■ **Technique:** XPS
■ **Spectral Region:** Mo 3d, Se 3s
Instrument: ULVAC-PHI Quantes
Excitation Source: Cr K_α monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1 mm
Analyzer Type: spherical sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112 eV
Analyzer Resolution: 1.17 eV
Total Signal Accumulation Time: 7146 s
Total Elapsed Time: 7878 s

Number of Scans: 64

Effective Detector Width: 12.4 eV



■ Accession #: 01901-06

■ Specimen: MoSe₂

■ Technique: XPS

■ Spectral Region: Mo 3p

Instrument: ULVAC-PHI

Quantes

Excitation Source: Cr K_{α}
monochromatic

Source Energy: 5414.8 eV

Source Strength: 50 W

Source Size: 0.1 mm x 0.1
mm

Analyzer Type: spherical
sector

Incident Angle: 22 °

Emission Angle: 45 °

Analyzer Pass Energy 112
eV

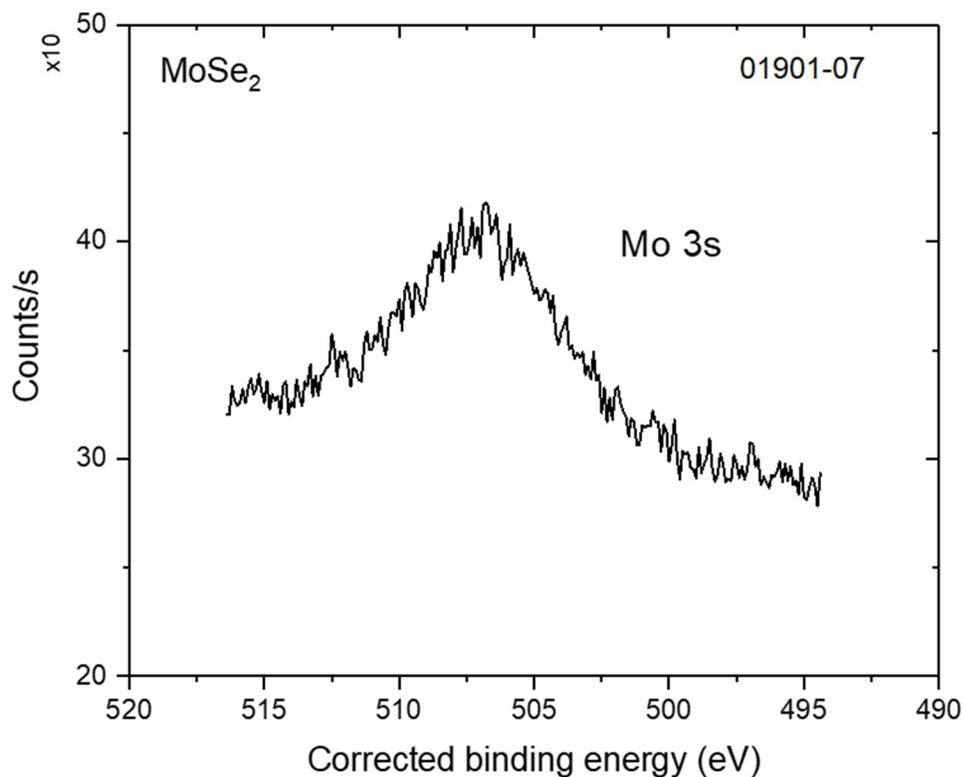
Analyzer Resolution: 1.17 eV

Total Signal Accumulation
Time: 3792 s

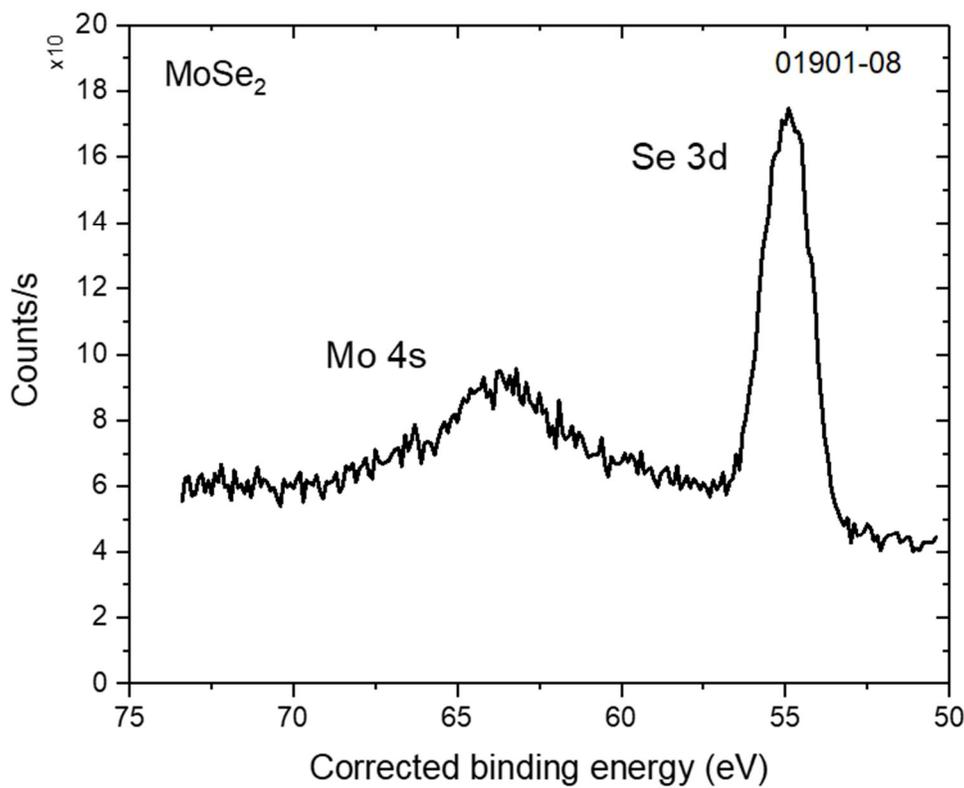
Total Elapsed Time: 4176 s

Number of Scans: 20

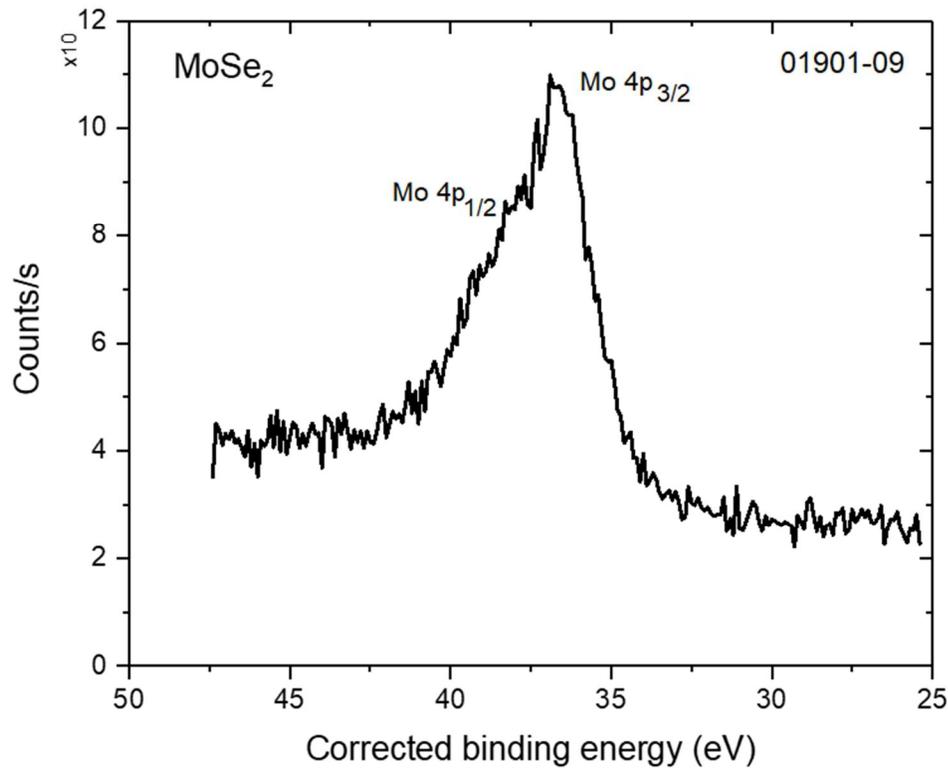
Effective Detector Width:
12.4 eV



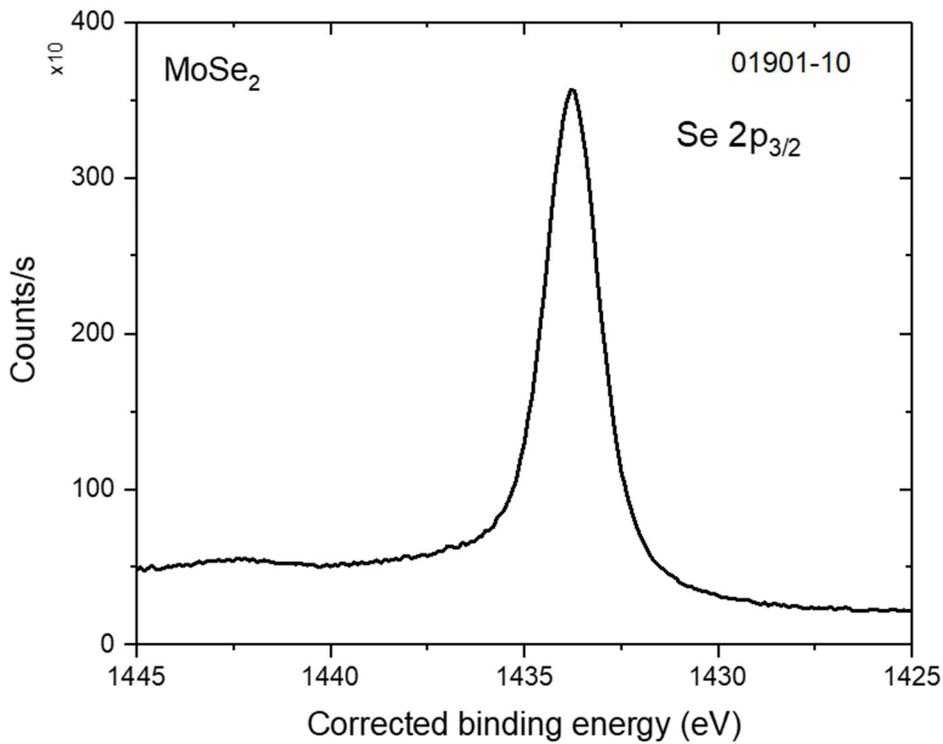
■ **Accession #:** 01901-07
■ **Specimen:** MoSe₂
■ **Technique:** XPS
■ **Spectral Region:** Mo 3s
Instrument: ULVAC-PHI
Quantes
Excitation Source: Cr K_α
monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1
mm
Analyzer Type: spherical
sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112
eV
Analyzer Resolution: 1.17
eV
Total Signal Accumulation
Time: 3300 s
Total Elapsed Time: 3642 s
Number of Scans: 24
Effective Detector Width:
12.4 eV



■ **Accession #:** 01901-08
■ **Specimen:** MoSe₂
■ **Technique:** XPS
■ **Spectral Region:** Mo 4s, Se 3d
Instrument: ULVAC-PHI Quantes
Excitation Source: Cr K_α monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1 mm
Analyzer Type: spherical sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112 eV
Analyzer Resolution: 1.17 eV
Total Signal Accumulation Time: 3396 s
Total Elapsed Time: 3744 s
Number of Scans: 24
Effective Detector Width: 12.4 eV

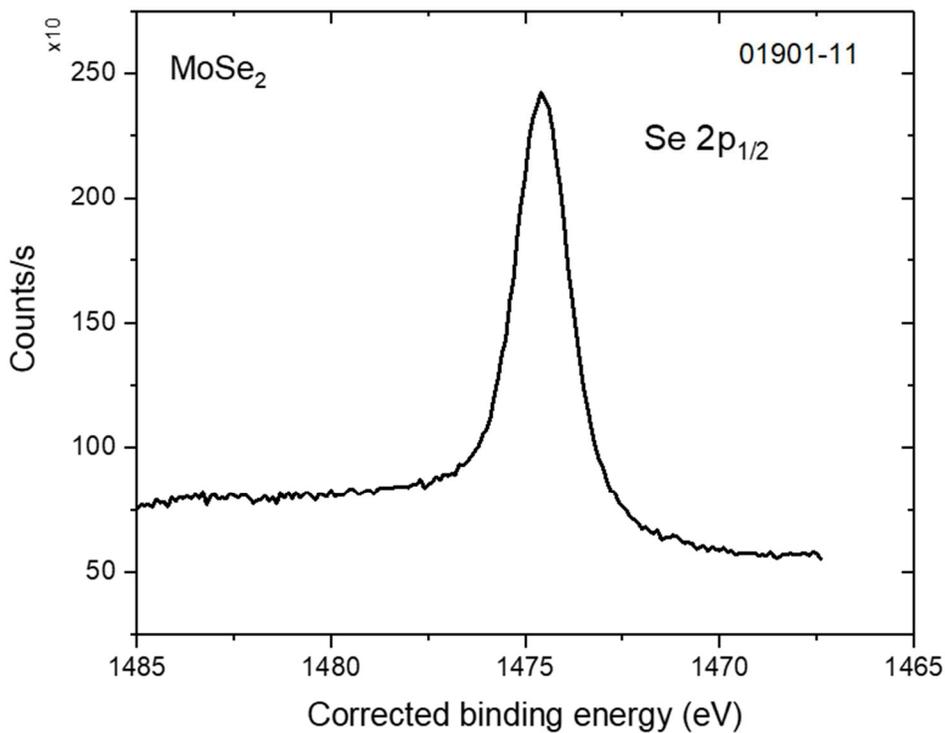


■ **Accession #:** 01901-09
■ **Specimen:** MoSe₂
■ **Technique:** XPS
■ **Spectral Region:** Mo 4p
Instrument: ULVAC-PHI
Quantes
Excitation Source: Cr K_α
monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1 mm
Analyzer Type: spherical sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112 eV
Analyzer Resolution: 1.17 eV
Total Signal Accumulation Time: 3300 s
Total Elapsed Time: 3642 s
Number of Scans: 24
Effective Detector Width: 12.4 eV



■ **Accession #:** 01901-10
■ **Specimen:** MoSe₂
■ **Technique:** XPS
■ **Spectral Region:** Se 2p_{3/2}
Instrument: ULVAC-PHI Quantes
Excitation Source: Cr K_α
monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1 mm
Analyzer Type: spherical sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112 eV
Analyzer Resolution: 1.17 eV
Total Signal Accumulation Time:
3588 s
Total Elapsed Time: 3954 s

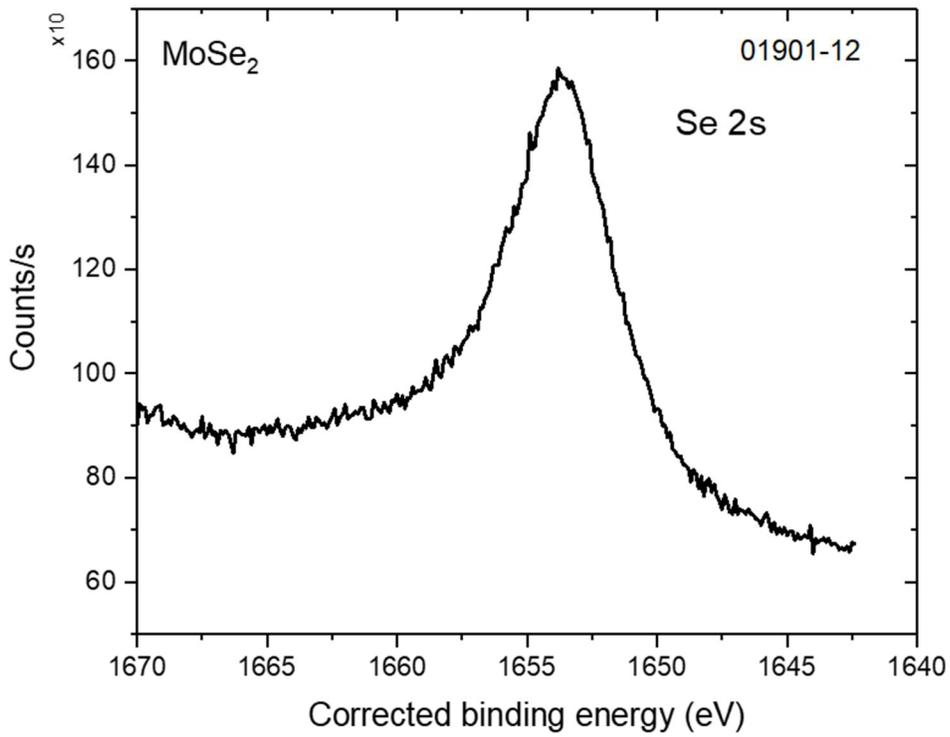
Number of Scans: 24
Effective Detector Width: 12.4 eV



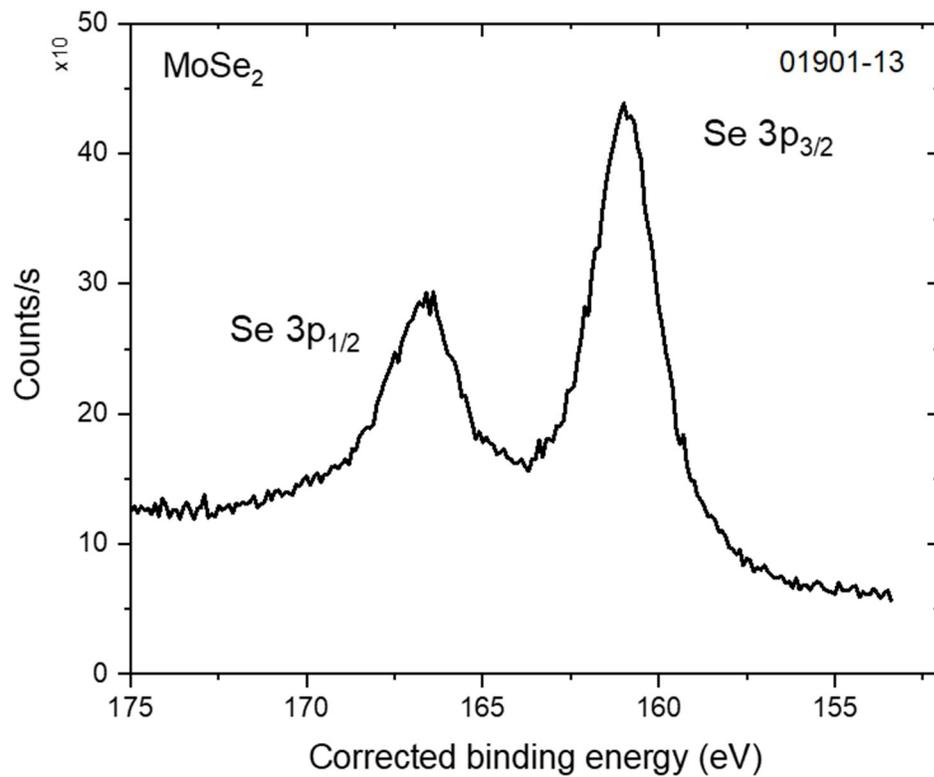
■ **Accession #:** 01901-11
■ **Specimen:** MoSe₂
■ **Technique:** XPS
■ **Spectral Region:** Se 2p_{1/2}
Instrument: ULVAC-PHI Quantes
Excitation Source: Cr K_α
monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1 mm
Analyzer Type: spherical sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112 eV
Analyzer Resolution: 1.17 eV
Total Signal Accumulation Time:
3630 s
Total Elapsed Time: 4002 s

Number of Scans: 28

Effective Detector Width: 12.4 eV



■ **Accession #:** 01901-12
■ **Specimen:** MoSe₂
■ **Technique:** XPS
■ **Spectral Region:** Se 2s
Instrument: ULVAC-PHI Quantes
Excitation Source: Cr K_{α}
monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1 mm
Analyzer Type: spherical sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112 eV
Analyzer Resolution: 1.17 eV
Total Signal Accumulation Time:
3234 s
Total Elapsed Time: 3564 s
Number of Scans: 20
Effective Detector Width: 12.4 eV



■ **Accession #:** 01901-13
■ **Specimen:** MoSe₂
■ **Technique:** XPS
■ **Spectral Region:** Se 3p
Instrument: ULVAC-PHI Quantes
Excitation Source: Cr K_α
monochromatic
Source Energy: 5414.8 eV
Source Strength: 50 W
Source Size: 0.1 mm x 0.1 mm
Analyzer Type: spherical sector
Incident Angle: 22 °
Emission Angle: 45 °
Analyzer Pass Energy 112 eV
Analyzer Resolution: 1.17 eV
Total Signal Accumulation Time:
3492 s
Total Elapsed Time: 3852 s
Number of Scans: 24
Effective Detector Width: 12.4 eV