XPS2 Sputter Etch and Depth Profiling Procedure
Thermo Scientific Nexsa G2

Help Resources

XPS knowledge viewer: Has information and videos on sputter depth profiling

Nexsa G2 User Manual provided by Thermo Scientific is located in the Manuals folder on the desktop

The ion sputter gun has two modes of operation:

1. Monatomic Argon+ ions (conventional ion gun)
2. Cluster Argon+ ions

Monatomic Mode

The monatomic modes are defined with ion beam energies in the range 500 – 4000 eV. When using monatomic modes, selecting a lower ion beam energy will be less damaging but the lower ion beam flux and lower energy will result in a reduced sputter rate. The monatomic beam modes allow selection of a beam current – either Low or High. The "Low" setting is designed to be 3x lower than the "High" setting to maintain the same sputter rate when using compucentric rotation.

Cluster Mode

When using a cluster mode, the ion beam energies are higher than used in monatomic mode, in the range 2000 – 8000 eV. A lower ion beam energy will usually reduce sample damage but at low energies, there may also be very little sputtering. The cluster mode allows selection of a cluster size – 75-2000 atoms. For a given cluster ion beam energy, the average energy per atom is higher for the small cluster mode and sputter rate will be higher. In the absence of other information, a typical operating condition for routine use is 6000 eV, 1000 atom cluster size

The table below summarizes the typical samples and applications where each of these guns may be used

Monatomic or Cluster?

Use of Ar clusters is usually restricted to polymer or organic based materials as Ar clusters do not effectively sputter inorganic materials where the bond strength is larger.

	Monatomic mode	Cluster mode
Energy applied	500 eV- 4000 eV	2000 eV - 8000 eV
Atom size	1	75- 2000
Energy per atom	500 eV- 4000 eV	1 eV - 100 eV
Typical samples for cleaning	Metals, metallic compounds, semiconductors	Glasses, ceramics, metal oxides, polymers, fibres, semiconductors
Typical samples for profiling	Metals, metallic compounds	Metal oxides, polymers, mixed oxide and polymer layers

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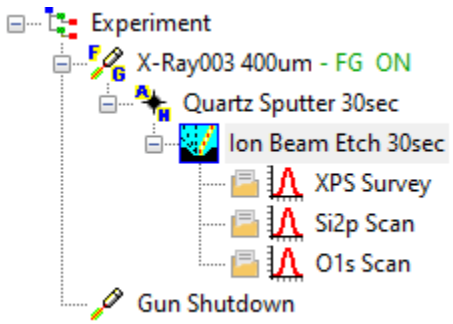
A table of SMIF measured etch rates for various ion beam conditions and materials can be found in the appendix to this procedure and on the XPS2 page on the SMIF web site.

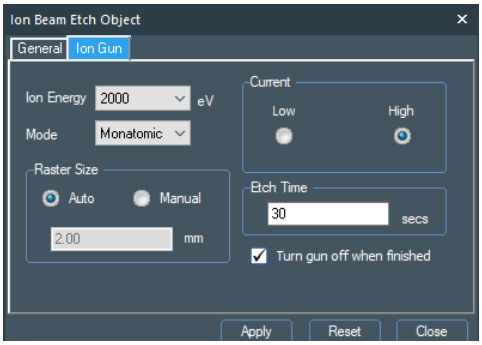
Experiment Examples for Sputter Etching and Depth Profiling

Sputter Etch – Surface Cleaning 

Monatomic Mode: Used for hard materials (e.g. metals and semiconductors) – more aggressive

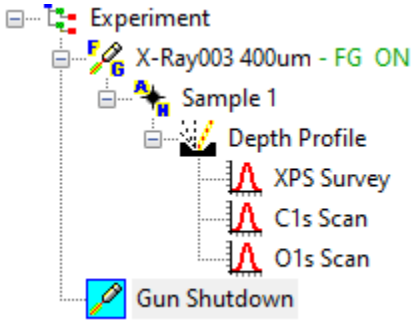
Cluster Mode: Used for soft materials (e.g. polymers) – very gentle, minimizes bond disruption



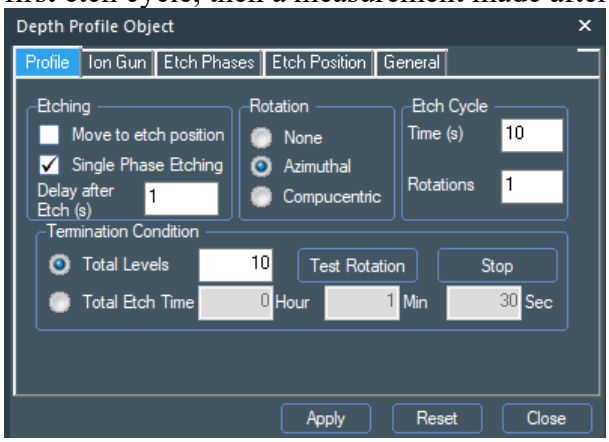


In the Ion Gun tab, select Monatomic or Cluster mode and the desired ion energy. Selecting Auto for raster size will set the etch area to be 5x the X-Ray spot size.

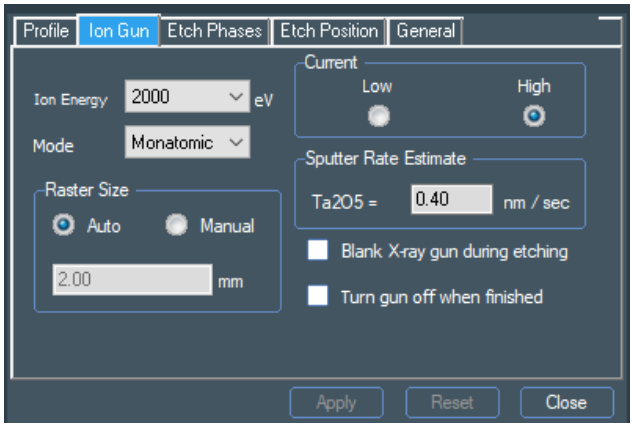
Sputter Etch – Depth Profile



In the profile tab, select the number of total levels and the etch cycle time. Note: The number of levels is the number of measurements made, including a measurement prior to sputter etching. For example, 10 total levels would result in a measurement prior to the first etch cycle, then a measurement made after each of 9 etch cycles.



In the Ion Gun tab, select Monatomic mode and the desired ion energy. Selecting Auto for raster size will set the etch area to be 5x the X-Ray spot size. Note that an estimated etch rate for Ta2O5 is shown.

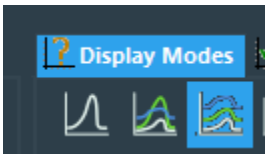


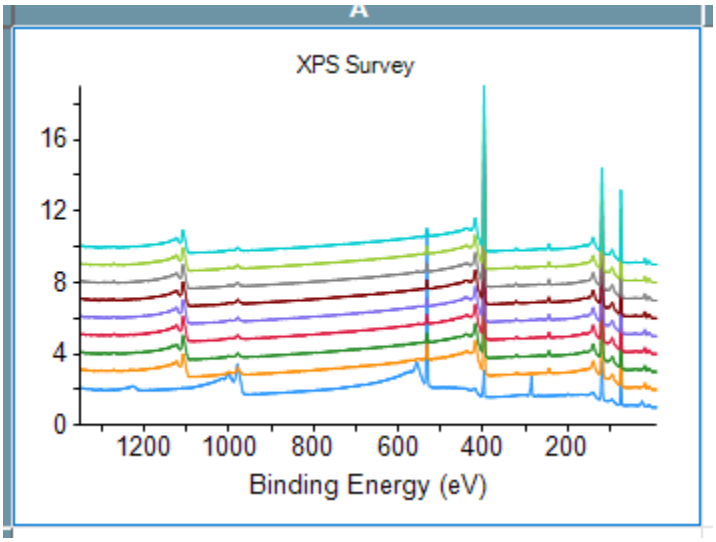
Displaying and Data Processing for Depth Profile Data
(processing a multi-level data space)

See Avantage Data Analysis Manual pages 100-105 and XPS Knowledge under XPS Experimentation -> Depth Profiling -> Advanced Depth Profile Processing (click link for "multi-level data processing)

1. You can view the data from each individual etch level using the NavBar arrows at the bottom of the data display window

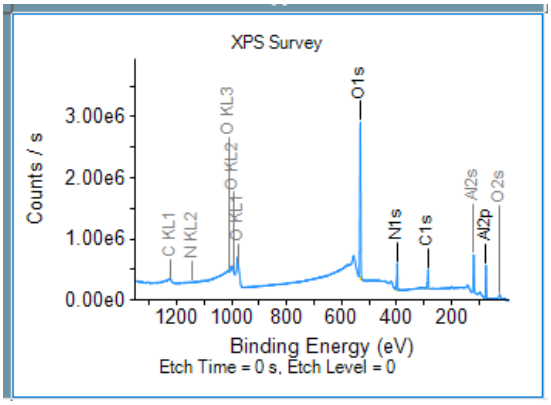
2. You can display an overlay of all of the etch level data using the "Display selected data in Stacked Chart Mode" button under the Display Modes menu heading



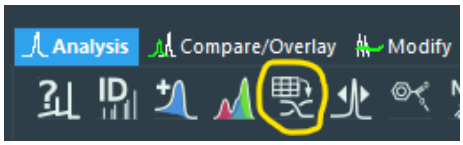


3. Create a peak table from the survey scan data or individual region scan data per the instructions found in the Data Processing and Reporting Procedure. *Note: when you perform the element ID and/or peak fitting for one of data sets in the etch series, the processing and results will propagate to all of the data sets in the etch series.*

	Name	Peak BE	Height CPS	FWHM eV	Atomic %	Q
	O1s	532.31	2464985.81	3.24	44.30	☑
	Al2p	74.81	497658.99	2.74	29.36	☑
	N1s	398.08	379057.26	3.14	11.12	☑
	C1s	285.84	302284.71	3.12	15.22	☑

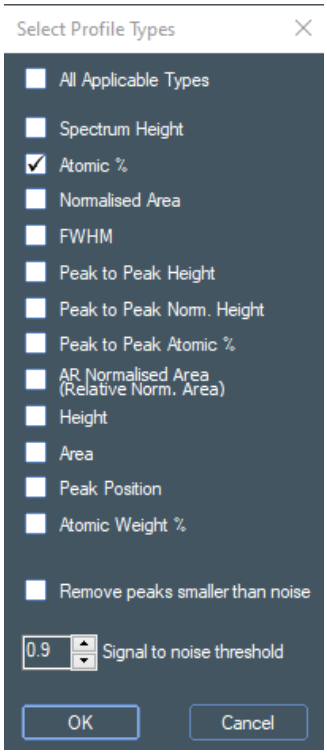


4. Select the “Peak Table Profile” icon to create a plot as a function of etch time

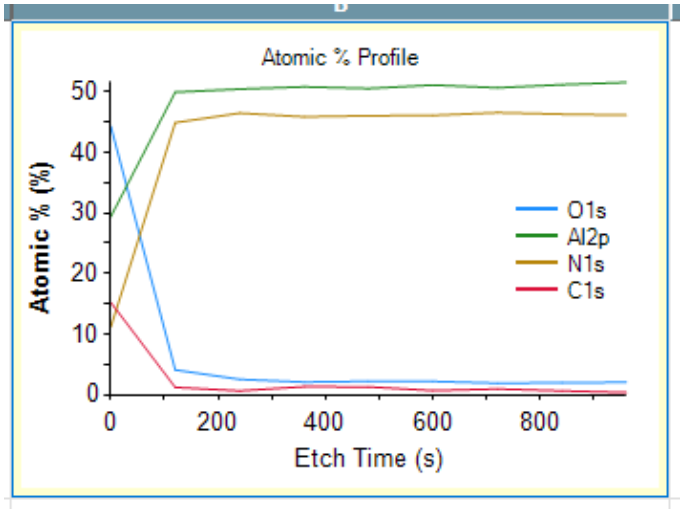


5. A dialog box is displayed that allows selection of the variable to be plotted (on the y axis) as a function of etch time (on the x-axis). A typical selection would be “Atomic %” to plot the elemental concentration as a function of etch time.

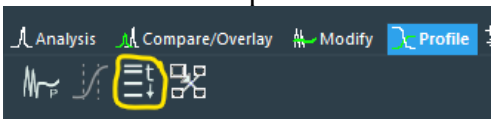
   The Signal to noise threshold setting can be used to help reduce noise on the zero atomic % baseline, particularly for low intensity noisy peaks.



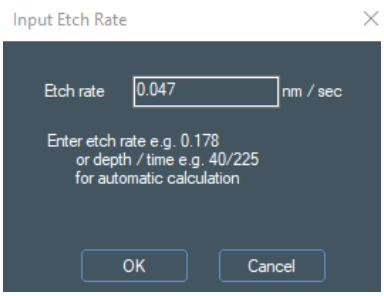
6. Click “OK” in the dialog box and the resulting plot will be created



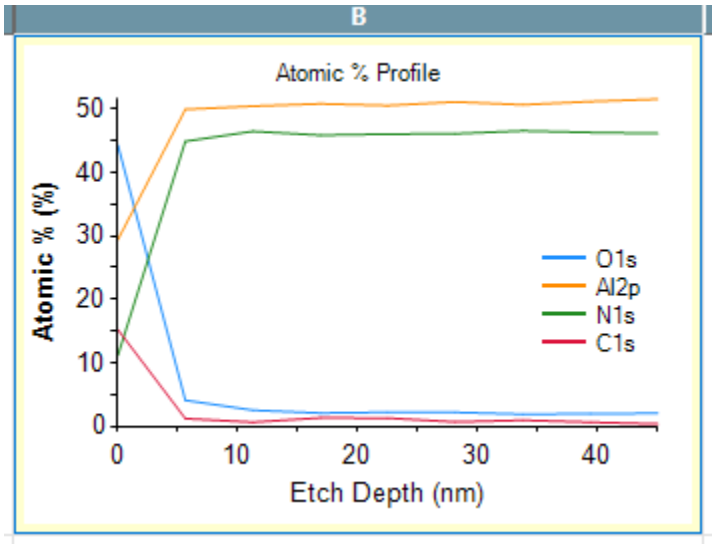
7. If the etch rate of the sample material is known or can be estimated, the etch time axis can be converted to an etch depth axis.
   a. Select the “Time to Depth Conversion” icon under the Profile menu heading



   b. A dialog box will appear. Enter the known or estimated etch rate in nm/sec



c. Click OK in the dialog box and a plot of Atomic % vs Etch Depth will be generated



Appendix: Measured Sputter Etch Rates in XPS2

Sputter Etch Rates in XPS2

Etch rates determined by measuring film thickness before and after etching

Monatomic Argon Etch Rates

Mode	Ion energy (eV)	Current	X-Ray Spot Size (um)	Raster Size (mm)	Material	Etch Rate (nm/sec)
Monatomic	4000	High	400	Auto	SiO2	0.17
Monatomic	2000	High	400	Auto	SiO2	0.18
Monatomic	1000	High	400	Auto	SiO2	0.085
Monatomic	1000	High	400	Auto	AlN	0.047
Monatomic	1000	High	400	Auto	WC	0.043
Monatomic	500	High	400	Auto	SiO2	0.073

Cluster Argon Etch Rates

Mode	Ion energy (eV)	Cluster Size	X-Ray Spot Size (um)	Raster Size (mm)	Material	Etch Rate (nm/sec)
Cluster	4000	1000	400	Auto	PMMA	0.17