Depth Profiling using XPS

While XPS is a surface sensitive technique, a depth profile of the sample in terms of XPS quantities can be obtained by combining a sequence of ion gun etch cycles interleaved with XPS measurements from the current surface. An ion gun is used to etch the material for a period of time before being turned off whilst XPS spectra are acquired. Each ion gun etch cycle exposes a new surface and the XPS spectra provide the means of analysing the composition of these surfaces.

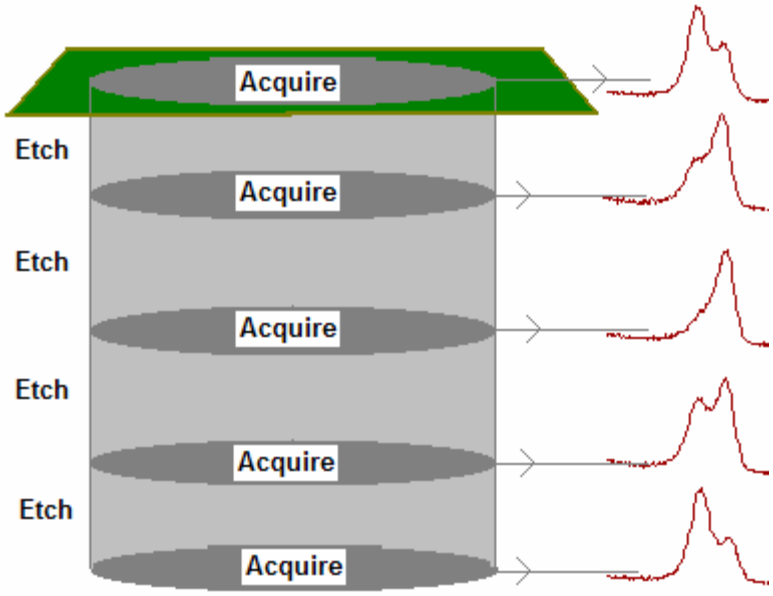

Figure 1: Segment of an XPS depth profile.

The set of XPS spectra corresponding to the oxygen 1s peaks from a depth profile experiment depicted logically in Figure 1 are displayed in Figure 2. The objective of these experiments is to plot the trend in the quantification values as a function of etch-time.

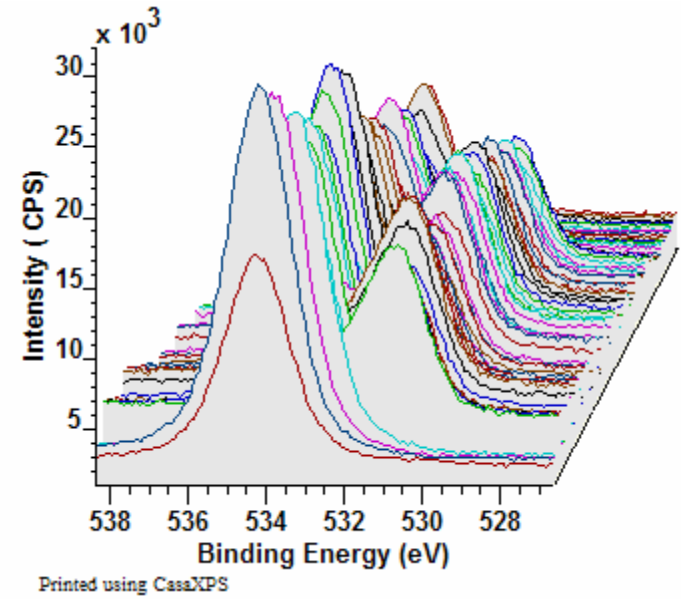

Figure 2: The set of O 1s spectra measured during a depth profiling experiment.

The actual depth for each XPS analysis is dependent on the etch-rate of the ion-gun, which in turn depends on the material being etched at any given depth. For example, the data in Figure 2 derives from a multilayer sample consisting of silicon

oxide alternating with titanium oxide layers on top of a silicon substrate. The rate at which the material is removed by the ion gun may vary between the layers containing silicon oxide and those layers containing titanium oxide, with a further possible variation in etch-rate once the silicon substrate is encountered. The depth scale is therefore dependent on characterizing the ion-gun, however each XPS measurement is typical of any other XPS measurement, with the understanding that the charge compensation steady state may change between layers.

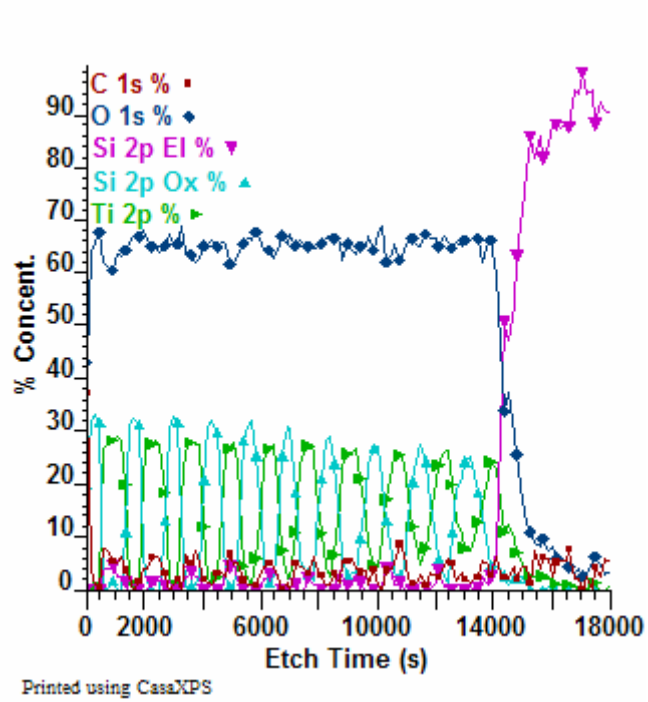

Figure 3: XPS Depth Profile of silicon oxide/titanium oxide multilayer sample profiled using a Kratos Amicus XPS instrument.

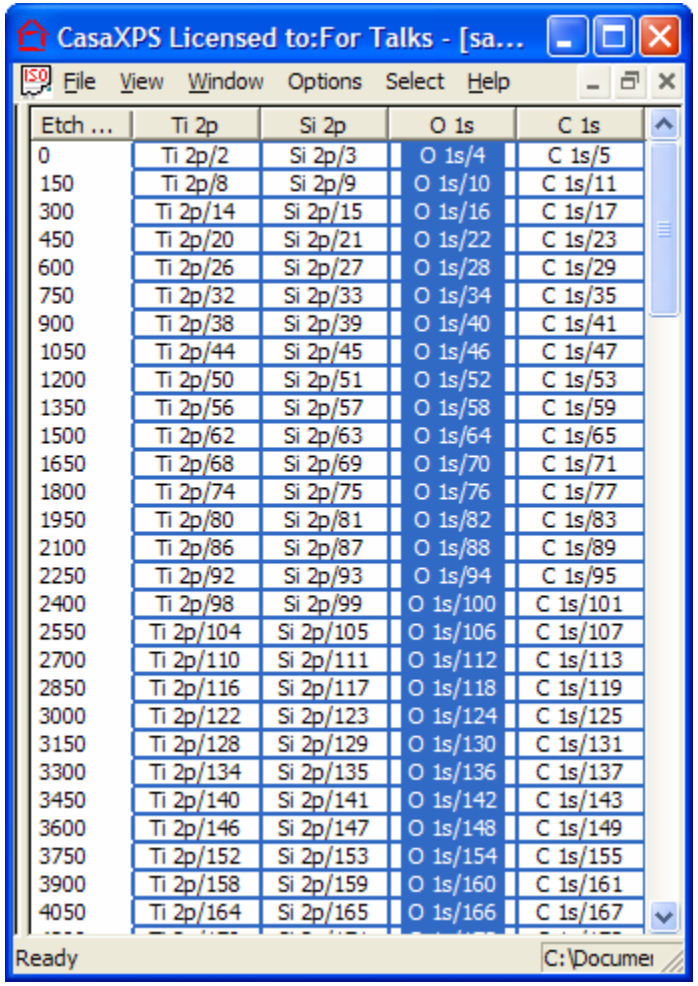

Figure 4: Logical structure of the VAMAS blocks in an XPS depth profile.

The XPS depth profile in Figure 3 is computed from the VAMAS file data logically ordered in CasaXPS as shown in

Figure 4. The O 1s spectra displayed in Figure 2 are highlighted in Figure 4. One point to notice about the profile in Figure 3 is that the atomic concentration calculation for the O 1s trace is relatively flat for the silicon oxide and titanium oxide layers, in contrast to the raw data in Figure 2, where the chemically shifted O 1s peaks would appear to be more intense for the silicon oxide layers compared to the titanium oxide layers. This observation is supported by the plot of adjusted peak areas in Figure 5, where again the O 1s trace is far from flat. The profile in Figure 3 is far more physically meaningful than the variations displayed in Figure 5. Normalization of the XPS intensities to the total signal measured on a layer by layer basis is important for understanding the sample. This example is a good illustration of why XPS spectra should be view in the context of the other elements measured from a surface.

The details of how to analyze a depth profile in CasaXPS are discussing at length in The Casa Cookbook and other manual pages available from the Help option on the Help menu.

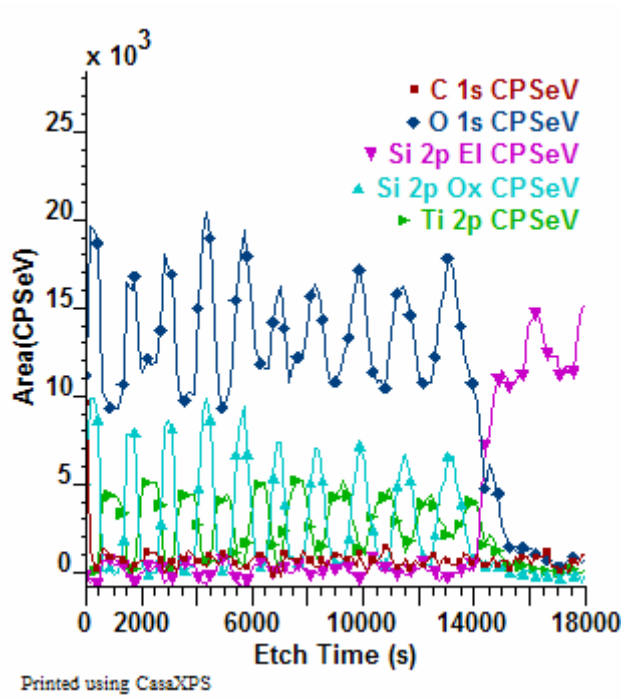

Figure 5: Peak areas scaled by RSF used to compute the atomic concentration plots in Figure 4.