EDS AND LIGHT ELEMENT ANALYSIS WITH LoMAX

Does your ultra-thin window EDS system detect light elements and x-rays below 1 KeV to your satisfaction? Even for minor or trace levels - down to Beryllium? What do you do if you need to quantitatively analyze Beryllium in Copper? Boron in glass or wafers? Carbon in steel? Nitrogen or Oxygen in various materials? The list is endless. Since low-energy x-rays are so strongly absorbed by the detector window and dead layer as well as in the sample matrix, not to mention low x-ray yields to begin with, light element quantitative analysis can be very impractical for EDS. Realistically, it is often enough to just be able to perform qualitative analysis. Additionally, if you need to analyze a very thin layer or very small volume that is best done at very low KV, good detector sensitivity is necessary since only low energy x-rays are available.

If performing quantitative analysis of light element with your EDS makes sense to you and you would like better EDS performance, then Parallax Research, Inc. has the unique solution. The LoMAX optic is designed to collect a large solid angle of very low energy x-rays and re-direct them into your detector so that it becomes far more sensitive for these low energies. Not only does it become much more sensitive for the very low energies, the higher energies are unaffected by the optic so you continue to use the detector in conventional fashion. For the lowest energies corresponding to Beryllium and Boron, you will get a peak intensity gain of over 10X. This gain is an inverse function of x-ray energy and above 1 KeV, the gain is unity. At that point EDS detector sensitivity begins increase anyway. A measured gain as a function of energy is shown in Fig. 1 for a prototype Lomax optic.

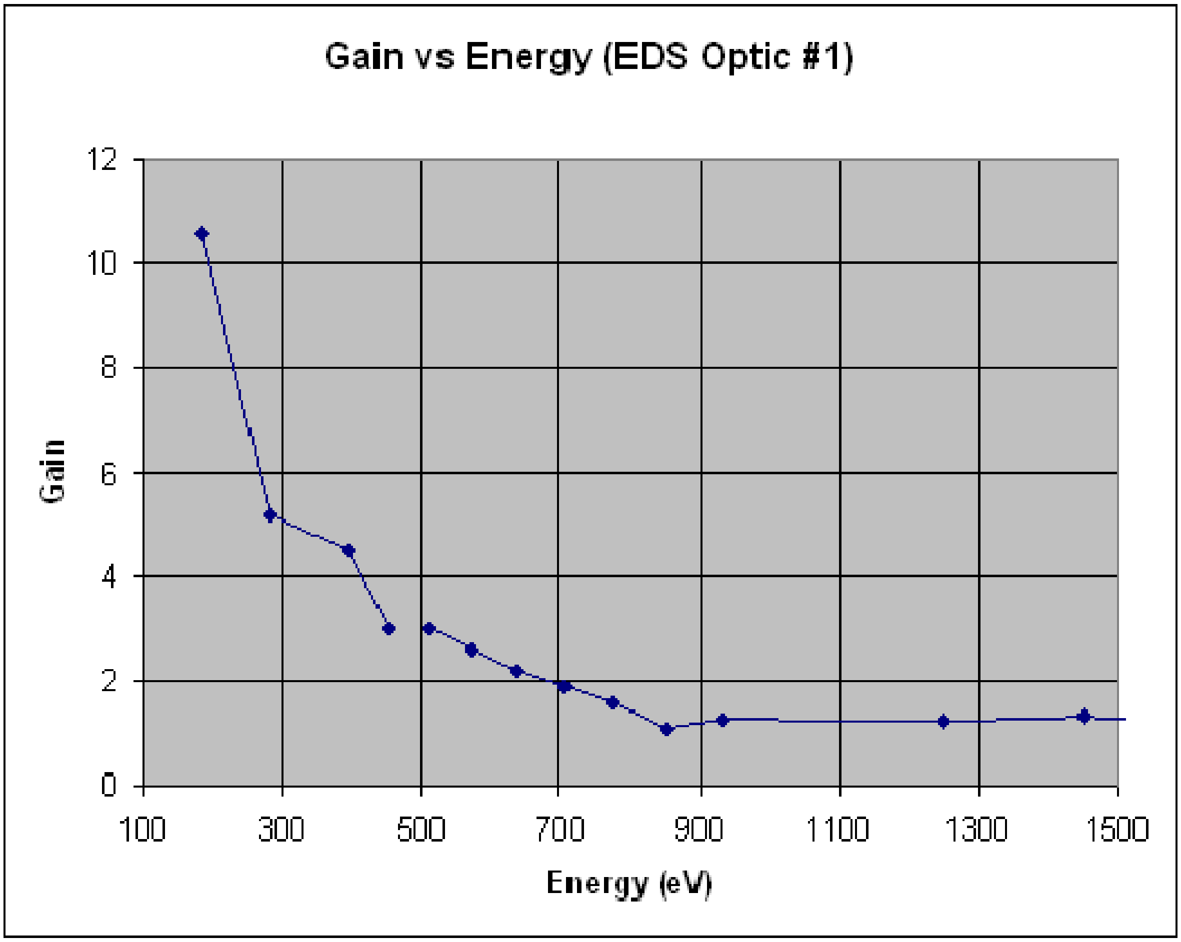

Fig. 1. Gain vs Energy measured from EDS Optic #1. Gain is the ratio of counts (WITH OPTIC)/(WITHOUT OPTIC) at the same 31 mm position from the sample.

LoMAX is designed to be easily installed and removed by the user. Fig. 2. shows various parts of the LoMAX. To install LoMAX, simply remove your existing electron trap/collimator, slide the LoMAX electron trap over your detector snout. The first time LoMAX is used, you will need to do a quick alignment, but after that you should not need to worry about this again. To remove LoMAX, simply reach in and pull out the optic, it is keyed so it will slide back in the same orientation when you want to use it again. Thus, realignment is not necessary.

LoMAX CONSISTS OF ELECTRON TRAP, X-RAY OPTIC, STANDARD GRAPHITE REPLACEMENT COLLIMATOR, AND ALIGNMENT POINTER

Fig. 2. Parts of the LoMAX. Top left inset shows conceptually how LoMAX attaches to the EDS "snout". Middle shows the LoMAX removable pointer, the optic on its gimbal that slides into the electron trap. Bottom right inset shows the electron trap and the conventional collimator to be used when LoMAX is removed.

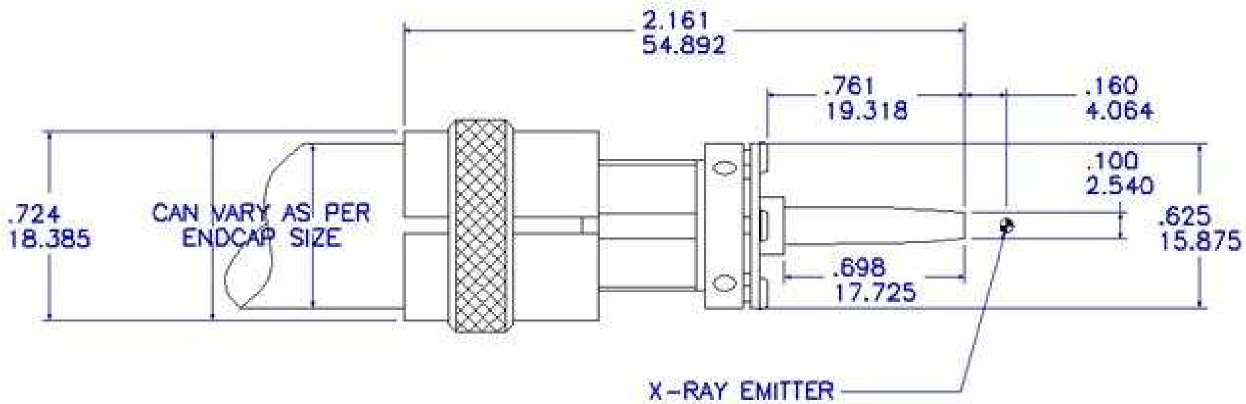

Fig. 2b. Standard LoMAX dimensions and fit on the front of an EDS endcap. Dimensions are inches and mm.

LoMAX Specifications:

- LoMAX Grazing Incidence Optic:
  Standard configuration inner Nickel reflective surface with Copper overplate. Other materials available.
- Detector sizes:
  Currently, LoMAX can be made for EDS detectors with sizes up to 30 mm^2, although the 30 mm^2 version will have approximately ½ the gain of the version for 10 mm^2 detectors.
- Source to detector distance:
  The data reported here is based on a standard working distance of source to detector window of 31mm. Shorter working distances will decrease the gain commensurately according to inverse square law.
- Source to entrance aperture distance:
  This distance can vary from 4 mm up to 7 mm depending on the users needs.
- Power requirements:
  LoMAX has no power requirements.
- Availability for various EDS vendors:
  LoMAX comes in a standard configuration designed to fit most EDS detectors. It can be customized, as necessary, to fit most systems.
- Special LoMAX Optics:
  LoMAX can be configured as a low pass or element specific optic with very high gain. For example, using Palladium instead of Nickel provides a high gain optic for Beryllium and Boron.

If you used your detector to look at light element standards before you installed LoMAX, you will see an immediate and large increase in these low energy x-ray counts after it is installed. See Figure 3. Because the gain is really a simple function of energy, the amount of analyte giving the low energy count rate is approximately 1/Gain for what your software reports.

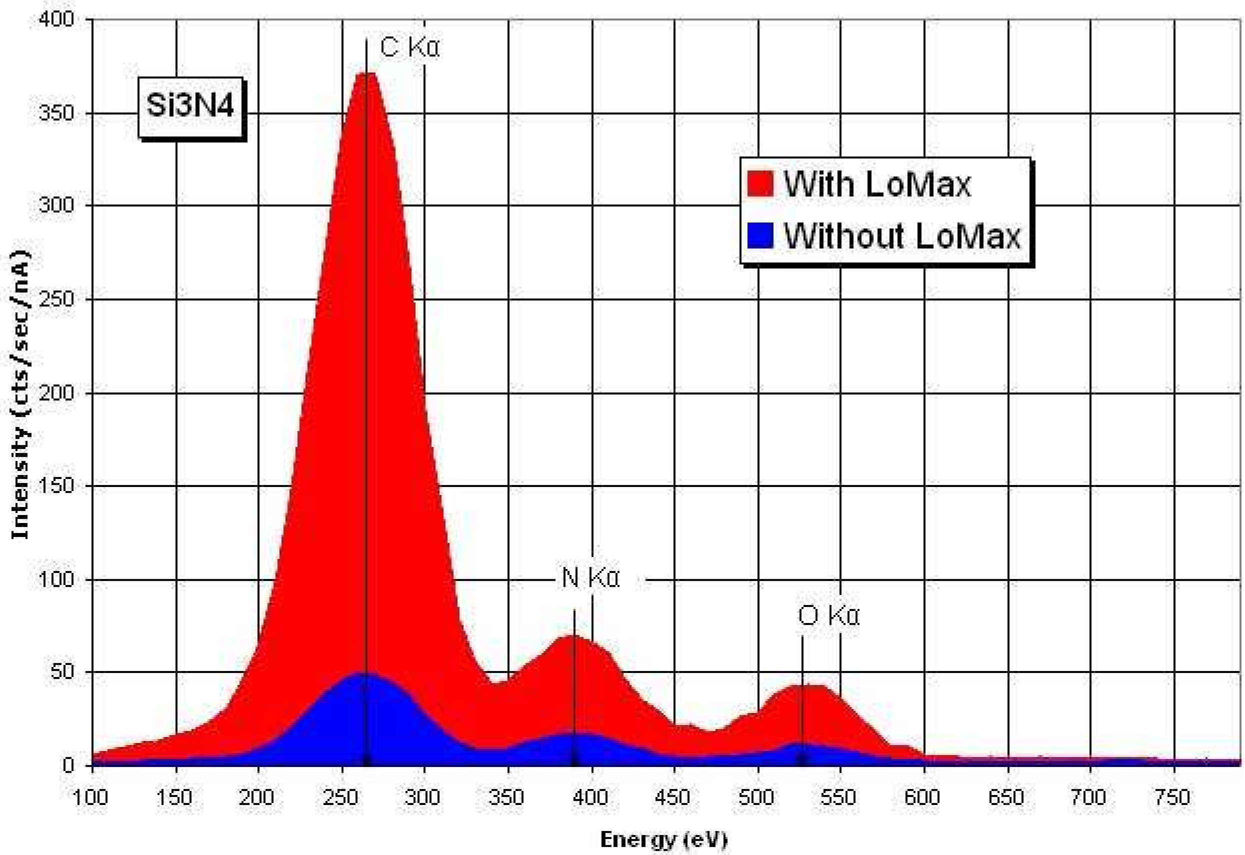

Fig. 3. Silicon Nitride spectra taken with and without LoMAX

LoMAX is a non-imaging optic so it does not have a focal point. This means that it is relatively insensitive to the x-ray emission point. By "relatively insensitive", we mean 250 microns or a quarter of a mm, a huge latitude compared to WDS systems and focusing optics. Fig. 4 shows measured count rates for 2 energies as a function of sample height showing the relative insensitivity to sample height.

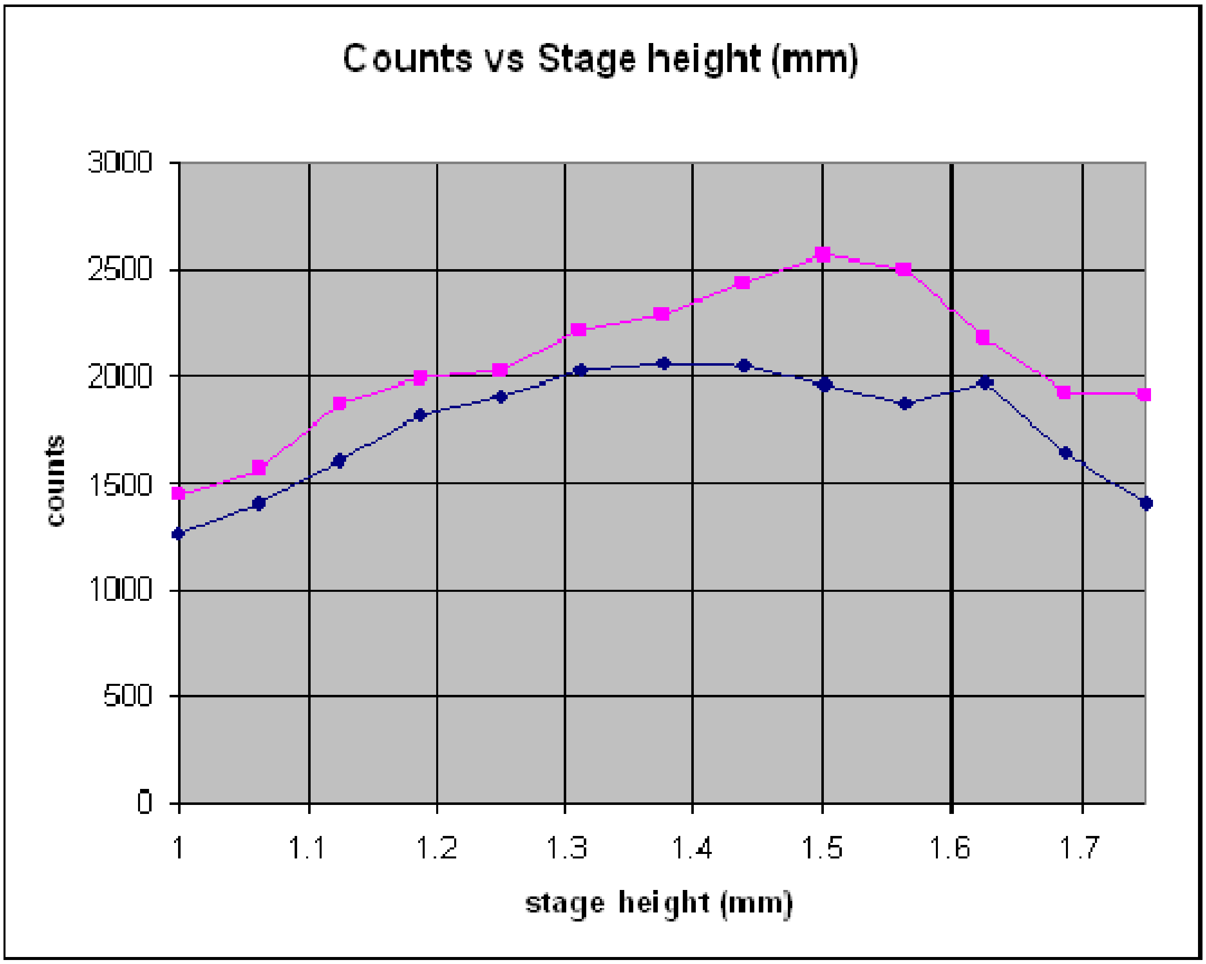

Fig. 4. Counts vs. stage height (mm) for Oxygen (top curve) and Carbon (bottom curve.)

Below, Figure 5 shows the lack of sensitivity to movement of the optic in and out along the EDS detector axis. A movement of +/- 1 mm is ok before count rates drop appreciably.

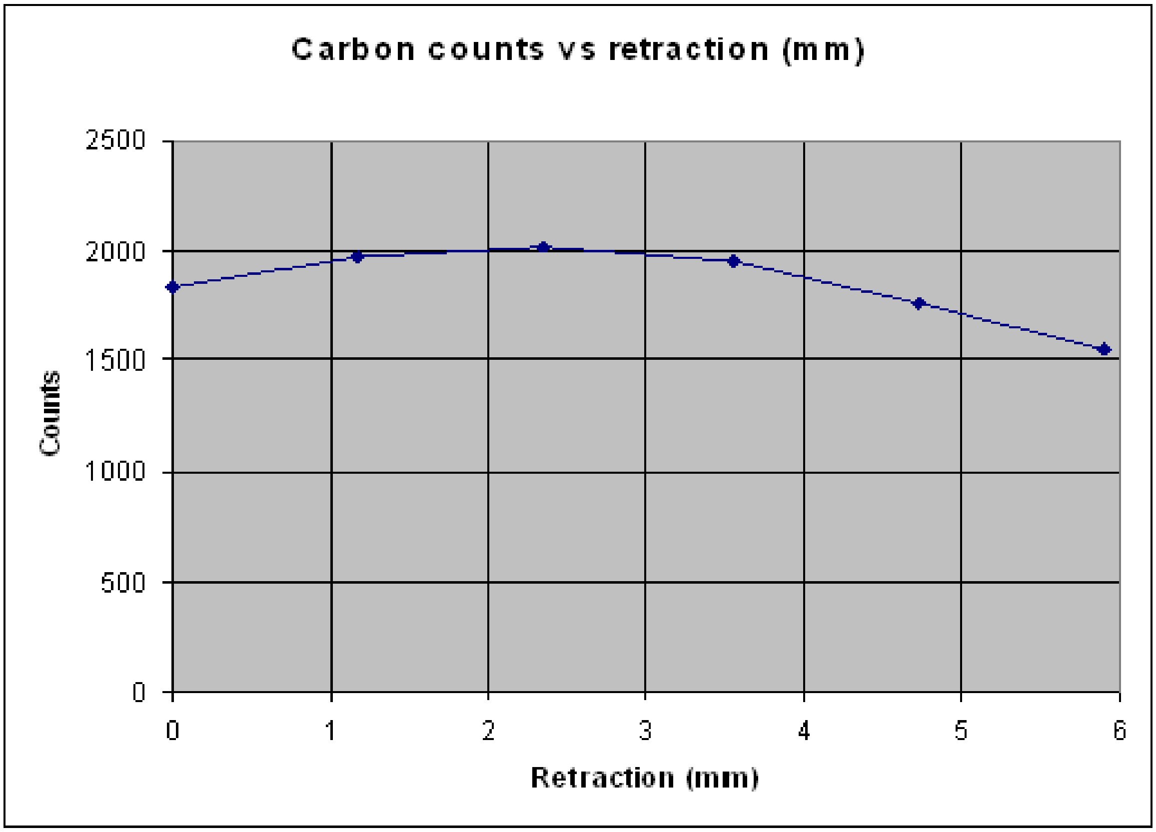

Fig. 5. Carbon counts vs. retraction of the detector. Counts decrease for very close distance because the x-ray grazing angles on the optic become too large.

Mapping with LoMAX

Mapping samples with low energies can take huge amounts of time due to the insensitivity of most EDS detectors for these low energies. Using LoMAX can greatly aid in rapidly obtaining good spectral maps. The following figures 6a and 6b show a backscattered electron image of carbon inclusions in wrought iron, the carbon spectral image obtained WITH LoMAX and the figure on the right is the same spectral map WITHOUT LoMAX. By using LoMAX, the inclusions show features that would not be visible without LoMAX.

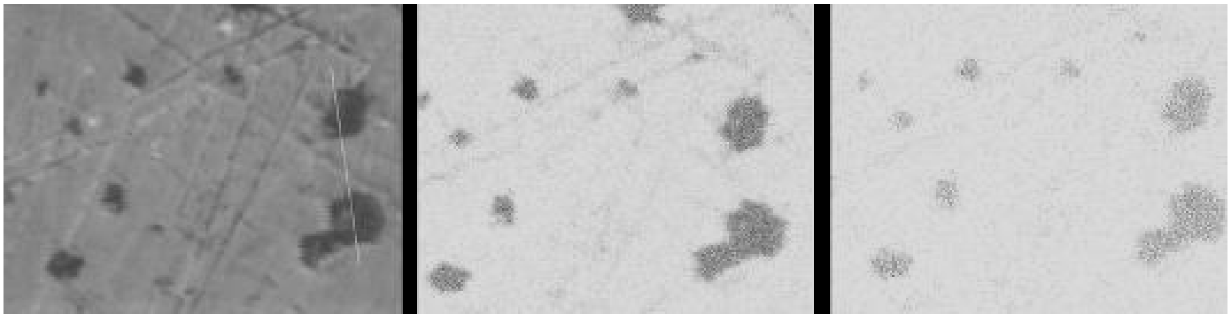

FIG. 6a. Secondary electron image and spectral maps at C Kα with and without LoMAX, respectively, for a mild steel sample (R to L). The white line on the right of the SEI designates the line scan shown in Fig. 7b.

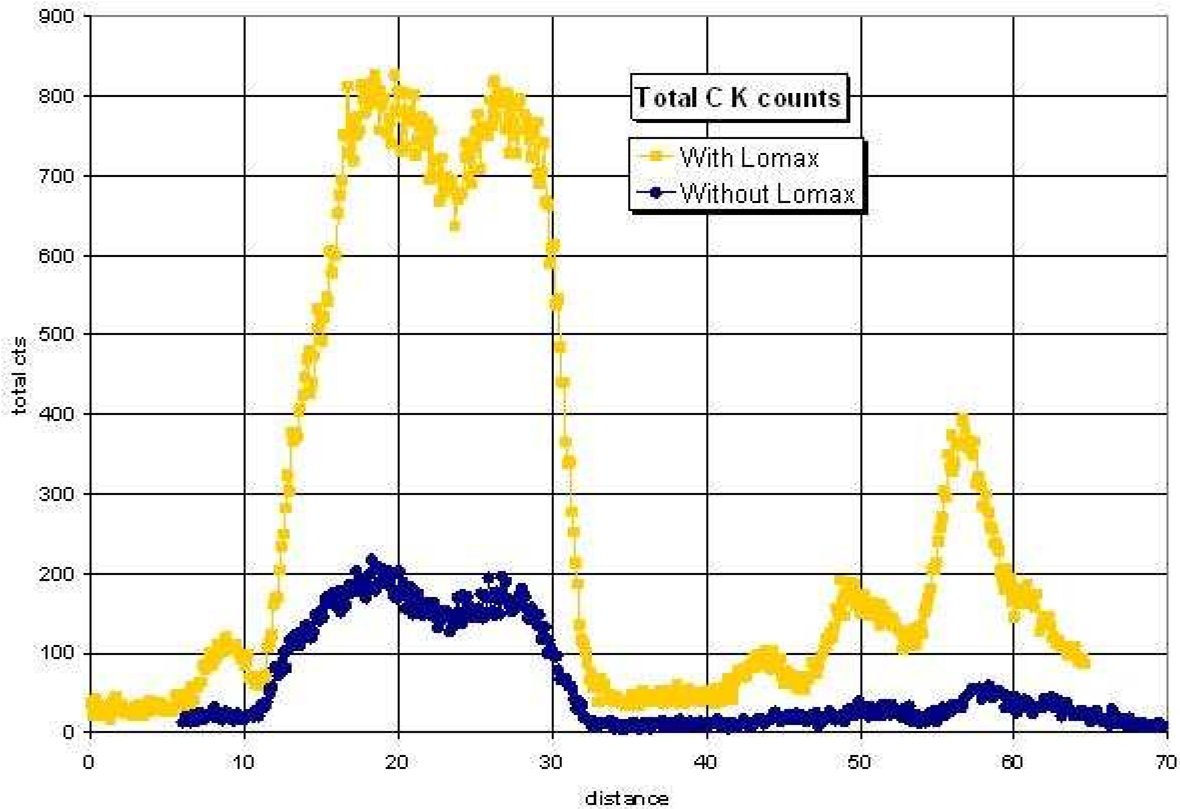

FIG. 6b. Line scan of C Kα intensity, acceleration potential of 5 KV, 0.4 nA of current, characteristic time of 25.6 μs, 200 ms dwell time.

Thin Film Analysis with LoMAX

Analysis of thin films containing oxides, nitrides or boron can be problematic with EDS because of the insensitivity of EDS to these energies. By using LoMAX and varying the electron beam energy one can more effectively analyze film thickness. Measuring count rate as a function of beam voltage enables one to do modeling with software such as "Casino" to predict the shape of the count vs. energy curve so to obtain a film thickness.