Extrapolating the Valence Spectral Limit in EELS

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With developments in field emission technology, the ability to resolve low-lying spectral features using electron energy loss spectroscopy (EELS) has been expanded [1]. The ability to resolve features such as band gaps and optical transitions in materials in the spectral region greater than ~3 eV has been demonstrated. However, extracting such information relies on addressing the observed experimental broadening and broad tails of the zero-loss peak to further expand the spectral limit and resolve energetic transitions even closer to the zero point energy.

As discussed in the literature [2-5], reciprocal space models and simplistic scaled curve fitting that extrapolate the expected behavior of the zero-loss peak are not enough to fully address the spectral limit and resolution in EELS. Using reciprocal space models artificially induces artifacts and the loss of spectroscopic information is observed as these techniques amplify high frequency components due to reciprocal space division in the processed spectra. On the other hand, whilst avoiding reciprocal space transforms, scaled curve fitting also does not fully address the issue as fitting without taking into account the detector response lacks functional characteristics associated spectral acquisition.

To address these issues, we have performed a quantitative comparison between different processing methods for performing zero-loss peak removal to address both spectral expansion and resolution on a variety of transmission electron microscopes ranging from Schottky to cold field emission. For each technique we have considered in our research, the zero-loss peak subtraction (ZLPS) method as outlined by Reed et. al [6,7] has outperformed the other methods, as shown in Figure 1 in the case of the TEAM 0.5 microscope, with respect to the extrapolated spectral limit over the other methods. Across all these techniques, the need for tracking low lying spectral peaks has been addressed, but due to the use of an actual acquired appropriately scaled zero-loss beam profile, ZLPS offers the increased benefit of resolving features for all microscopes considered to within a few hundred meV of the energy resolution defined by the vacuum zero-loss beam profile.

Based on the results of this study we plan to present a quantitative comparison of zero-loss peak removal for range of microscopes varying in emission character. By means of the comparison we will highlight the increased benefit of each method to further enhance the ability to track valence and optical-related peaks in the latest aberration corrected and energy filtered microscopes by addressing spectral limitations.

References:

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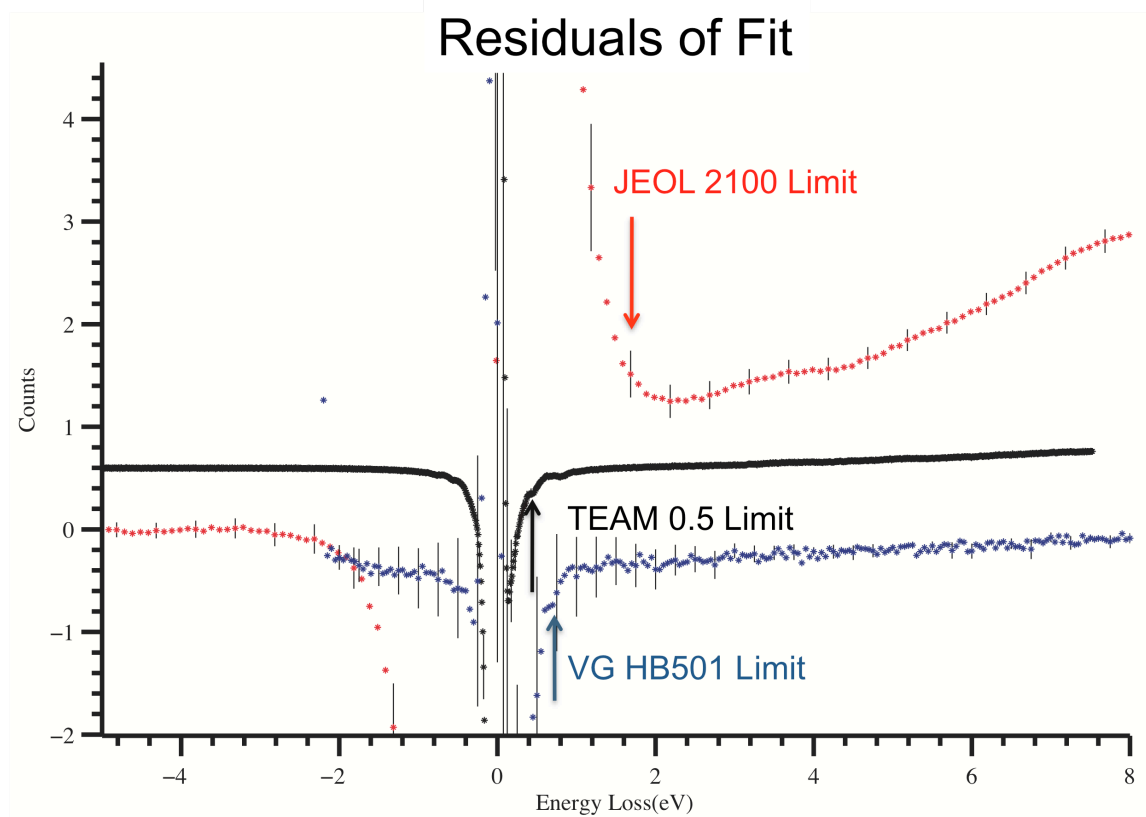
Figure 1: Comparing the resolved spectral limit for three microscopes using scaled zero-loss peak subtraction as outlined by Reed et. al [6,7].