An integrated Silicon Drift Detector System for FEI Field Emission Transmission Electron Microscopes

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Silicon Drift Detectors (SDD) [1] are rapidly replacing Si(Li) detectors for EDX microanalysis in SEM, but have yet to have an impact in the S/TEM world. Main reason for this difference is the low count rate created by thin S/TEM samples compared to the bulk samples in SEM . These low count rates make EDX mapping a very slow process in S/TEM. However, the recent introduction of higher brightness electron sources [2] and probe Cs-correctors has led to significantly increased beam currents in small electron probes and, potentially, to higher EDX count rates. Since a key advantage of the SDD is the high count rate capability, the throughput improvement compared to the Si(Li) detectors will be considerable in these new instruments.
Compared to SEM, the smaller excited volumes obtained with the atomic-scale probes in the new S/TEM instruments can lead to radiation damage of beam-sensitive materials before the analysis is completed. Therefore S/TEM microanalysis needs not only the higher count rate capability, but also higher collection efficiency of the X-rays generated, in order to reduce the dose on the sample.
In this paper we present a new EDX detector system for an FEI 200kV TEM/STEM, in which FEI has integrated a detector system consisting of multiple SDDs, placed symmetrically around the electron beam axis in the objective lens chamber without affecting the S/TEM resolution. The SDDs with a total active area of 120 mm^2 were designed by PN Sensor GmbH to fit into the FEI design to achieve a quantum leap in solid angle of collection compared to previous designs in S/TEMs. The SDDs are cooled to achieve the optimum energy resolution, typically below 130 eV. The windowless design allows for better sensitivity for light-element detection than conventional thin-window detectors. The specially designed front-end electronics and ultra fast multi-channel pulse processor are provided by Bruker AXS MA in collaboration with FEI. The processor is capable of fast mapping with pixel dwell times down to a few microseconds and >100 kcps count rates per channel.
Compared to currently available Si(Li) detectors the anticipated count rates will be an order of magnitude higher with the new detector. Additionally, the new FEI high brightness gun (X-FEG) [2] increases the brightness of the electron source compared to conventional Schottky sources, leading to a further increase in count rate, and an equivalent significant decrease in mapping time at the same spatial resolution. This improvement is illustrated in Fig. 1 where the relative minimum detectable mass MDM ~ $(t.P.P/B)^{-1/2}$ (t=analysis time, P=elemental peak counts, P/B = peak-to-background ratio) [3] is shown for conventional and new EDX detector count rates at the same spatial resolution. Fig.1 also compares the MDM with EELS and, for the specific case of strontium titanate, shows that the new EDX detector is expected to be more sensitive than EELS. These improvements together with a spherical

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aberration corrector will facilitate atomic resolution EDX mapping which is currently limited by low S/N ratio and long exposure times with conventional detectors, as shown in Fig. 2. Further results will be reported at the conference.

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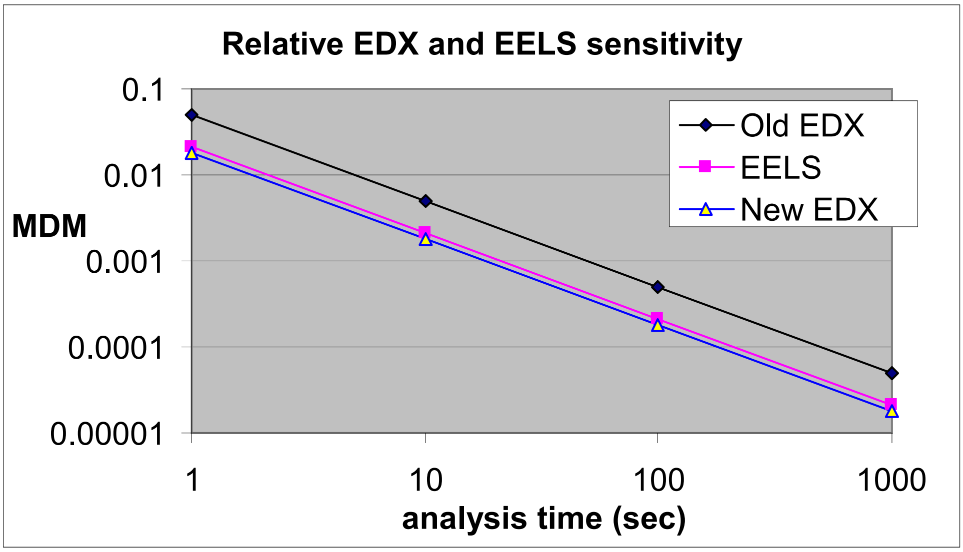

Figure 1. Comparison of relative minimum detectable mass, MDM vs. analysis time t by EDX with conventional and new detectors and by EELS (50nm SrTiO3 sample, data source: FEI)

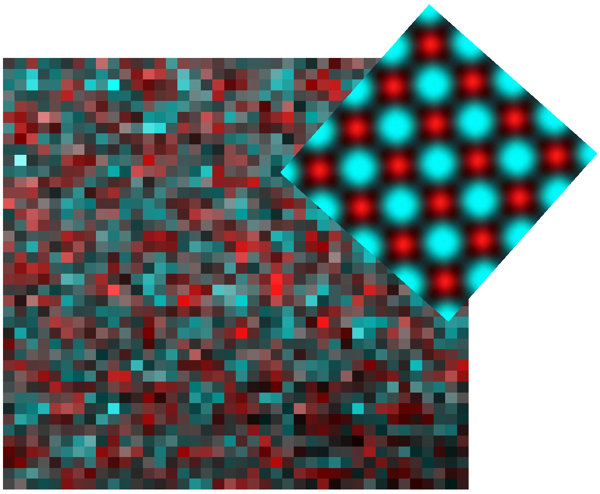

Figure 2 Composite EDX map and simulation (top right insert) for Sr (blue) and Ti (red) atom columns in strontium titanate at 300kV (thickness 50nm, acquisition time = 53 minutes, conventional EDX detector on FEI Titan). The simulations are courtesy of A. J. D'Alfonso and L. J. Allen, University of Melbourne.

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