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High EDS Count Rates Achieved by Design Improvements for an Analytical Transmission Electron Microscope.

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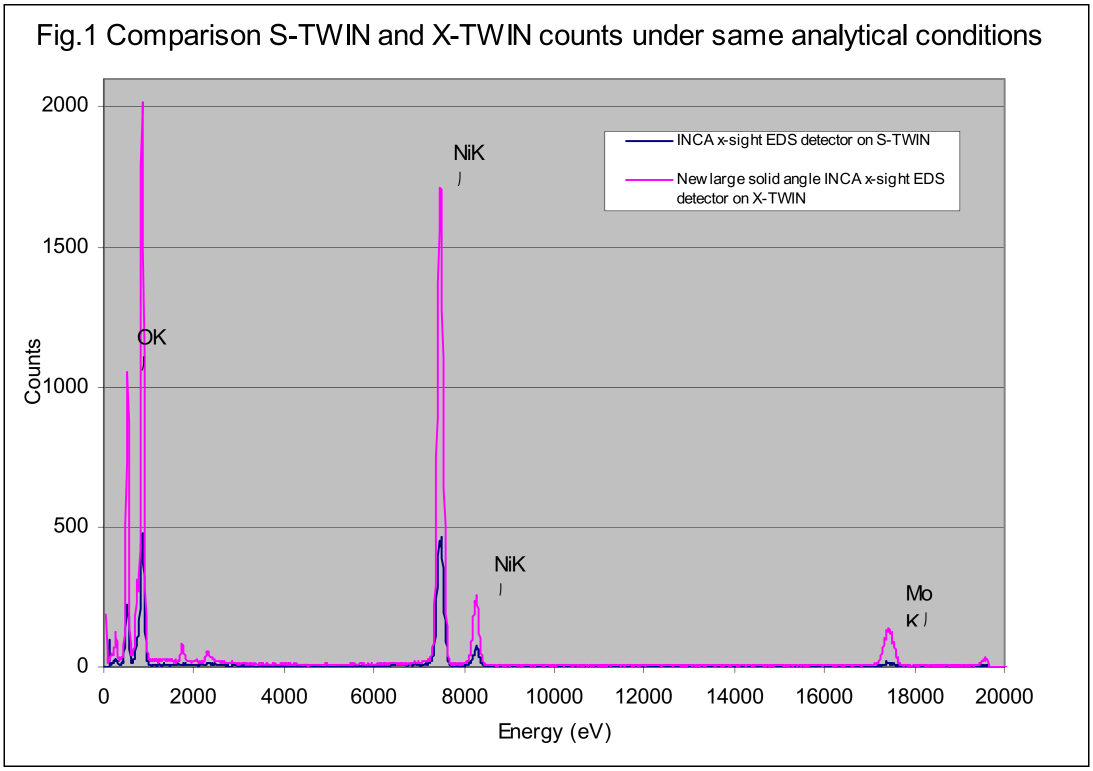
Solid angle of collection of the X-ray detector is an important parameter in EDS analysis on an Analytical Transmission Electron Microscope (ATEM) since it determines the rate of signal acquisition. Until recently, the solid angle has largely been dictated by a combination of the objective lens pole-piece design and the effective area of the Si(Li) detector. In general, the higher the resolution of the objective lens the narrower the gap between the pole-pieces. Hence there is less space to insert a detector therefore limiting the attainable solid angle of collection.

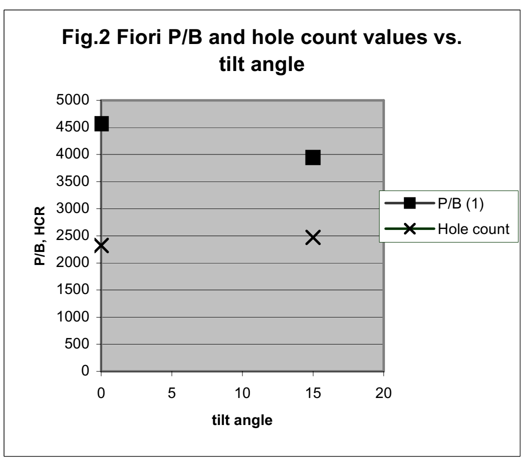
An increase in solid angle can be attained by, i) using as larger detector crystal and / or ii) changing the geometry of both the detector and pole-piece to allow the crystal to be closer to the sample area. It is important that the detector collimation is designed correctly so that stray X-rays do not enter the detector and cause spectral artifacts, and that the optimum number of X-rays is collected from the specimen. Furthermore, the objective lens performance should not be compromised in any way due to such a design change. It is also desirable that the detector is protected from electron flux when crossing grid bars or working in low magnification mode.

The New FEI X-TWIN objective lens on a Titan or Tecnai FEG TEM and the new Oxford Instruments EDS detector combines a unique pole-piece and detector design which allows for increased solid angle to 0.3sr. using a 30mm^2 detector without compromising the imaging or analytical capabilities of the ATEM. This includes the ability to use a built in shutter to protect the detector from high electron flux situation.

Experimental data in Fig. 1 demonstrates that count rates are more than 3 times higher than would be expected from the conventional pole-piece (S-TWIN) and detector design. Likewise Fig. 2 demonstrates that hole counts and Fiori numbers are as expected in a modern ATEM. Fig. 3 shows the effect of sample holder tilt, demonstrating an only ± 10% change in count rate over a wide range of tilt angles towards the EDS detector. This is a result of the high elevation angle of the detector (25 deg). which leads a reduction in shadowing by the analytical sample holder.

The ability to accumulate more X-ray counts in a shorter time has obvious applications advantages. Such a system will greatly reduce the time to collect X-ray spectrum images, maps and linescans. Fig. 4 shows x-ray maps collected over a very small area on a semiconductor sample in only 17 minutes. Features, such as oxide layers, that are no more than 4nm in diameter are easily discerned in a matter of minutes rather than a number of hours that would normally be necessary in a conventional TEM.





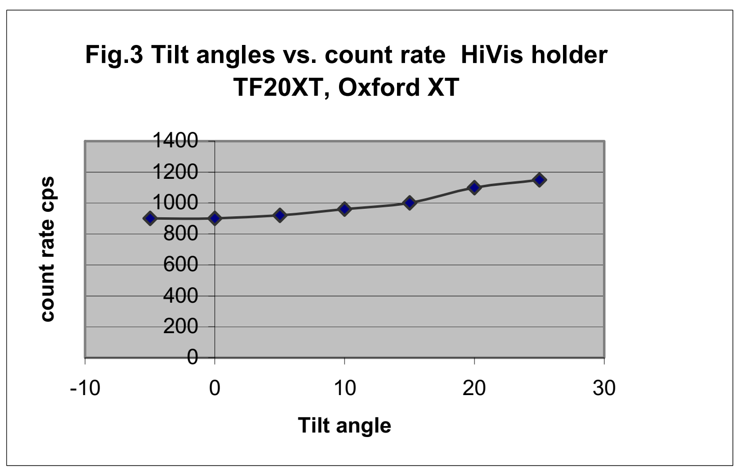
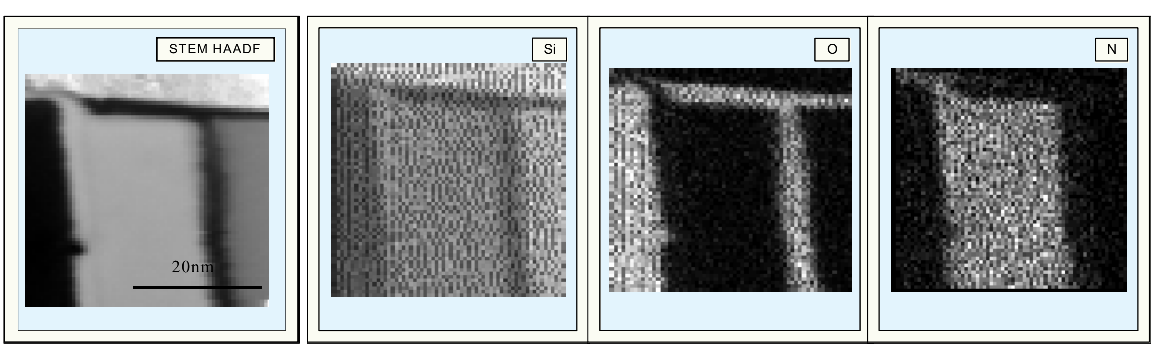


Fig. 4 X-ray mapping data 4nm. Oxide layer in semiconductor device.



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