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Development of Two Steradian EDX System for the HD-2700 FE-STEM Equipped with Dual X-Max^N 100 TLE Large Area Windowless SDDs

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The model HD-2700 [1] 200 kV spherical aberration (Cs) corrected dedicated Scanning Transmission Electron Microscope (STEM) has been used for analyzing nano- to subnano-area targets in the fields of nanoscience and nanotechnology with Energy Dispersive X-ray spectrometry (EDX). The Cs corrector [2] enables the formation of sub-nanometer probe size with several hundred to a thousand pico amperes of probe current, but still EDX detectors with much higher sensitivity are desired. Recent adaptation of Silicon Drift Detector (SDD) technology [3] accelerated the counting rate of detection and enhancement of detector active area. These features are suitable to improve analytical sensitivity. Using a windowless high solid angle SDD, high sensitivity elemental analysis can be achieved [4].

In this study, Oxford Instruments X-Max^N 100TLE SDD have been mounted to the HD-2700. This SDD exploits a new 100 mm^2 sensor and a windowless configuration. These features are suitable to make highly sensitive TEM/STEM/EDX system especially for light elements. Due to the shape of the SDD sensor and geometry of pole piece area, detection solid angle of over 1 sr with take-off angle of 20 degrees or higher has been achieved. Higher take-off angle is also important for the system to obtain X-ray data with higher peak to background ratio, because of different angular distributions of characteristic and continuous X rays [5]. The objective lens of the HD-2700 was modified to accommodate this detector. In response to the demand of further increment for sensitivity, objective lens modification enables a second detector to be mounted at the opposite side to the first one, with azimuth angle of 90 and 270 degrees to the specimen-tilt axis. Figure 1 shows the dual detector layout. Table 1 shows specifications of the X-Max^N 100TLE for the HD-2700. With both standard (STD) and high resolution (HR) type pole pieces, over 1 sr of detection solid angle is achieved. Dual configuration doubles the nominal solid angle.

Figure 2 shows a comparison of specimen tilt dependency of Ni-Kα line intensity acquired from a 65 nm thick Nickel Oxide specimen with a single detector and dual detectors. An HD-2700 with HR lens was used. The intensity of Ni-Kα line acquired with a single detector is increased from an input rate of 15 kilo counts per second (kcps) to 22 kcps as the specimen tilted from 0 degrees to 20 degrees, because absorption in the specimen and shading of specimen holder are reduced. Therefore, the higher tilt angle ensures improved acquisition efficiency as shown in Figure 2 (a). Some specimens, such as semiconductor devices, interfaces, or those that require crystallographic orientation may not always be analyzed with optimum tilt condition. Figure 2 (b) shows Ni-Kα spectra acquired with the dual detector setup from tilt angles of 0 degrees to -15 degrees. Negative tilt angles are disadvantageous for a single detector due to holder shading, but total input rates were constantly about 34 kcps in this tilt range, and the intensity of the Ni-Ka line at various tilt angles does not reveal big changes in contrast to the results shown by a single detector. In this geometry, tilt setting which is disadvantageous for one detector is compensated by the advantageous tilt condition of the other detector. Application data of the HD-2700 with Dual X-Max^N 100TLE system shall be introduced.

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Table 1. Specifications of the X-Max^N 100TLE Detector for the HD-2700 STEMs

Objective Lens	STD	HR
Solid Angle Single (Dual)	1.07 sr (2.15 sr)	1.04 sr (2.07 sr)
Take-Off Angle	24.8 deg.	22.8 deg.
FWHM @ Mn-K$_\alpha$	127 eV	127 eV

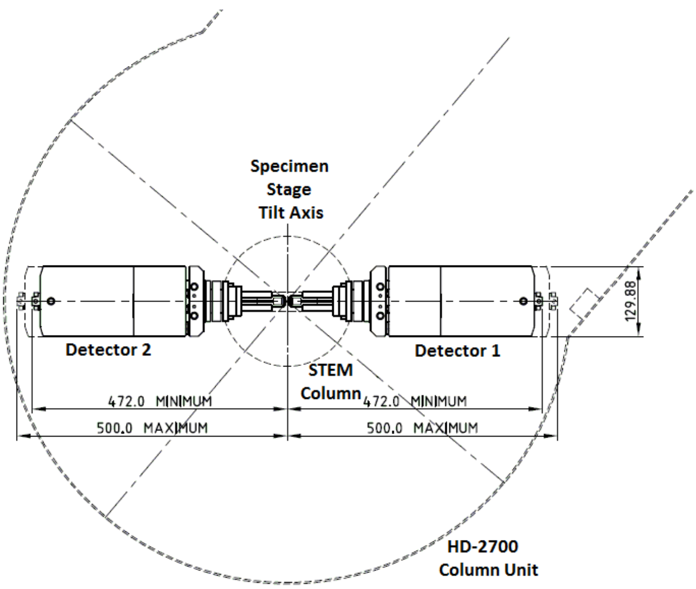

Figure 1. Dual X-Max^N 100TLEs Layout in the HD-2700 Column Unit. Detector 1 is mounted at the standard EDX port. The additional Detector 2 uses the IP-3 port. Both ports are perpendicular to the specimen stage tilt axis.

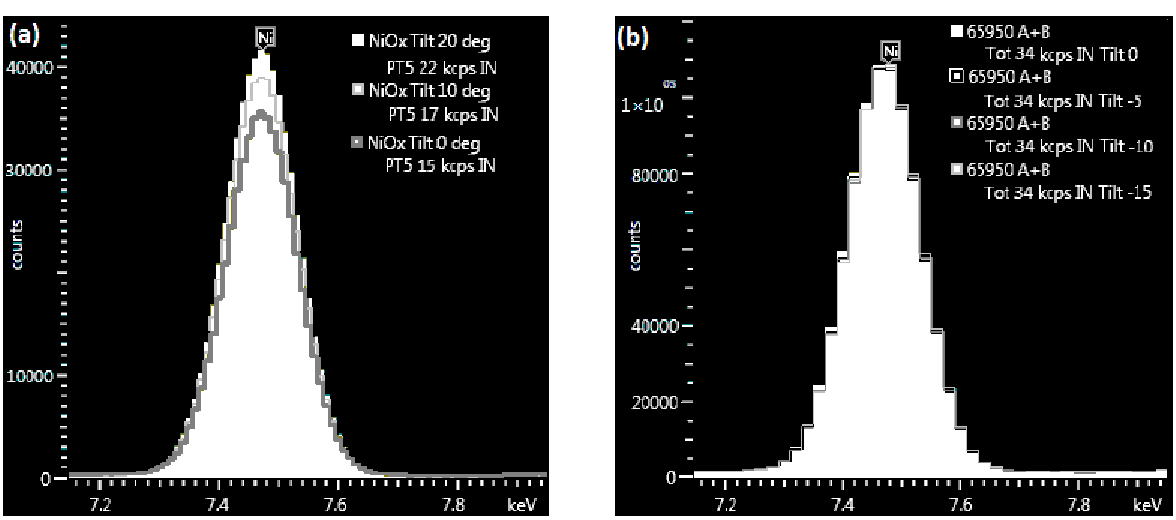

Figure 2. Comparison of specimen tilt angle dependency of Ni-Kα line intensity from a Nickel Oxide thin film specimen acquired with (a) single detector (Detector 1 only) and (b) dual detectors

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