

## A Double Silicon Drift Type Detector System for EDS with Ultrahigh Efficiency and Throughput for TEM

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For elemental analysis with energy dispersive X-ray spectroscopy (EDS) in transmission electron microscopy (TEM), the demand for the improved efficiency of X-ray detection, a higher counting rate, is very strong, because the improvement not only results in high throughput, but also extends the method to the specimens fairly susceptible to electron beam damage. We have already developed and introduced into the market an advanced commercial EDS system with a large area silicon drift type detector (SDD). The sensor area of this SDD is as large as 100 mm<sup>2</sup>. The detection efficiency of X-ray in this system increases by approximately four times with respect to the one with a conventional Si (Li) type detector.

This time, a new system for analysis with EDS has been developed which is about twice as efficient as the former high efficiency system. The new system consists of the two large area SDDs (SDD1 and SDD2). This paper describes the characteristic features of this system. Figure 1 shows a schematic diagram of the system for a field emission TEM (JEM-2800). The SDD1 was located on the right side of the specimen holder rod in the same way as the former single SDD system whereas the SDD2 was located in the direction between the opposite side of the SDD1 and the axis of the specimen holder rod as shown in the figure. For the second detector of SDD2, a new port was added to the JEM-2800. Besides, a new specimen holder for the analysis was developed to make shorter the distance between a specimen and the detectors. All the following experiments were carried out at 200 kV.

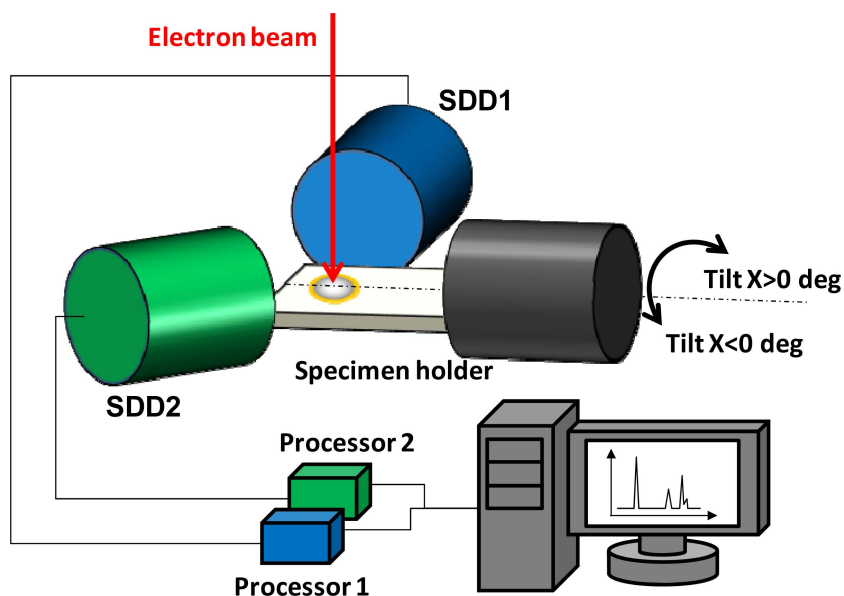
Observed features of this system are as follows:

### 1. High acquisition efficiency, counting rate of the X-ray

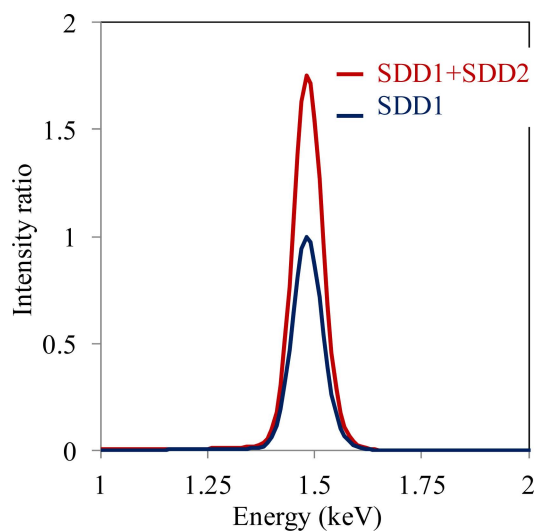
The acquisition efficiency of the X-ray in this system was expected to almost double with the addition of one more detector, SDD2, without any increase in the probe current. Besides the addition of SDD2 the shape of the specimen holder and the geometry of the SDD was redesigned to improve the efficiency. In this system, the peak intensity of Al-K acquired from an aluminum foil with the SDD1 and SDD2 double detectors was about 1.7 times as high as that acquired with the SDD1 single detector, as shown in figure 2.

### 2. Acquisition of X-ray intensities independent of insensitive to specimen tilt angle

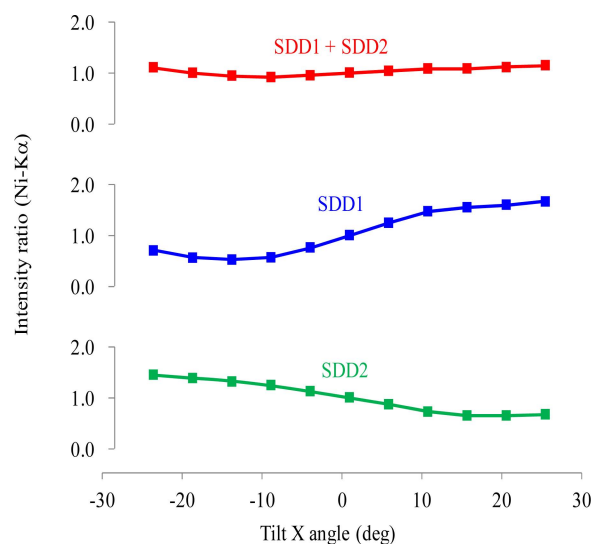
In the conventional single SDD system, the counting rate is highest at a certain optimum tilt angle of the specimen holder. In the present double SDD system, however, the counting rate was expected to be rather insensitive to the specimen tilt angle, because the second detector, SDD2, is located nearly opposite to the first detector, SDD1. The measured dependence of the intensity of Ni K $\alpha$  acquired from a nickel deposited film with a uniform thickness is shown figure 3. The intensity variation due to the specimen tilt angle was substantially smaller in the double SDD system than in either single SDD1 or SDD2 system. In fact, the intensity variation in each single system largely canceled out each other. The double SDD system assures that specimen tilting does not lead to any substantial change in the X-ray intensity.



**Figure 1.** The EDS double detector system of ultrahigh efficiency and throughput for JEM-2800.



**Figure 2.** EDS spectra from an Al foil. A red and blue line was obtained with the double detector system with SDD1 + SDD2 and the single detector system with SDD1 respectively. The intensity was normalized with respect to the peak intensity of the Al K with the SDD1.



**Figure 3.** The dependence of the Ni  $K\alpha$  intensity on the specimen tilt angle for three settings; two single detector settings with SDD1 and SDD2 and one double detector setting with SDD1 + SDD2. The intensity was normalized with respect to the sample position without any tilt. A Ni deposited film was used as a sample for these measurements.