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Selecting a Silicon Drift Detector

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It used to be simple, hardware was hardware and software was software. Today, the line between hardware and software is blurred by the presence of sophisticated and configurable firmware on hardware and by algorithms which manipulate the raw data on the software side. Nowhere is this truer than with the modern silicon drift energy dispersive spectrometer. All modern silicon drift detectors (SDD) consist of a detector module with analog amplifiers and a pulse processor which consists largely of digital electronics and logic. Simple changes to the firmware and changes to the firmware's configuration can change the hardware's performance in ways that were impossible with analog only electronics. Furthermore, sophisticated software allows the quantitative algorithms to compensate for hardware shortcomings in ways that sometimes seem like magic. The net result is that x-ray detectors are far less transparent and far more complex than the analog systems of twenty years ago.

How then, when so much is going on behind the scenes, are we supposed to evaluate and purchase an SDD? The trick is to differentiate between what is important for your particular application from what is simply marketing hype. By keeping a razor focus on your ultimate metrology goals, you can distinguish between useful features and marketing talking points.

The first step is therefore to anticipate your measurement needs. What types of samples do you analyze? Which elements do you need to measure? Are your samples easily damaged by the electron beam? Are your samples bulk/particulate/unsupported thin film? Do you want a detector ideally suited for a specific application or do you want a general workhorse? Do you primarily collect point spectra for quantification or x-ray spectrum images for visualization?

The next step is to perform market research. Some information will be readily available in product literature. Unfortunately, some of the most important information generally isn't. You will need to ask the vendor to collect some spectra for you on readily available materials and to provide you with schematics showing exactly how and where the detector will be mounted in your instrument. Spectrum simulation using software like NIST DTSA-II [1] can also help to anticipate your final systems performance.

There are four metrics that are particularly worthwhile to focus on: 1) low energy performance; 2) coincidence rejection; 3) collection efficiency; and 4) detector resolution. Of these, detector resolution is usually the easiest to determine but detector resolution is probably the least useful. The benefits of small improvements in detector resolution are quickly swamped by the benefits of improved throughput.

The low energy performance of a modern SDD is typically amazing. Some vendors report being able to detect the L lines in sulfur. Many boast being able to see beryllium. However, being able to see an x-ray and being able to generate meaningful quantitative results using this x-ray are two entirely different things. Claims of being able to quantify B or Be should be viewed with suspicion. Regardless if low Z materials are of interest, low energy performance should be a consideration. Typically, low energy performance comes at the cost of throughput.

Ultimately, counts are everything in x-ray microanalysis. More counts mean more precise measurements and better x-ray spectrum images. How to optimize count throughput will depend upon your sample. Some samples are robust under an electron beam and can generate a large number of x-rays. For these samples, coincidence events, x-rays that arrive at almost the same time, are the Achilles' heel. For most detectors at most process times, coincidence events will place a practical limit the maximum throughput. Other samples are susceptible to beam damage or don't have much mass and can't generate many x-rays. For these samples, a detector which optimizes collection efficiency by reducing the sample-detector distance or increasing the detector size will be more suitable. To make this optimization however, you will need to know the sample-detector geometry. This will depend upon the instrument geometry, the detector snout design, the electron trap design and is information the vendor should provide for your specific system.

In this presentation, we will discuss the basic operation of an SDD and how this understanding can be applied to the process of selecting an SDD optimized for your measurement needs. We will present a worksheet which can be used to collect the necessary data and to evaluate the performance metrics. Guidance will be provided on using these metrics to optimize a system for various types of measurements.

[1] Ritchie, N.W.M. (2009). *Spectrum simulation in DTSA-II*. Microc. Microanal. **15**, 454–468.