Amptek Silicon Drift Diode (SDD) at Low Energies

Amptek's silicon drift diode (SDD) X-ray detectors have excellent energy resolution, with a noise threshold around 200 eV. The SDD can certainly produce very clean spectra from light elements, as shown in Figure 1. But it is very difficult to obtain quantitative results at these energies, primarily because of attenuation in the Be window and in air.

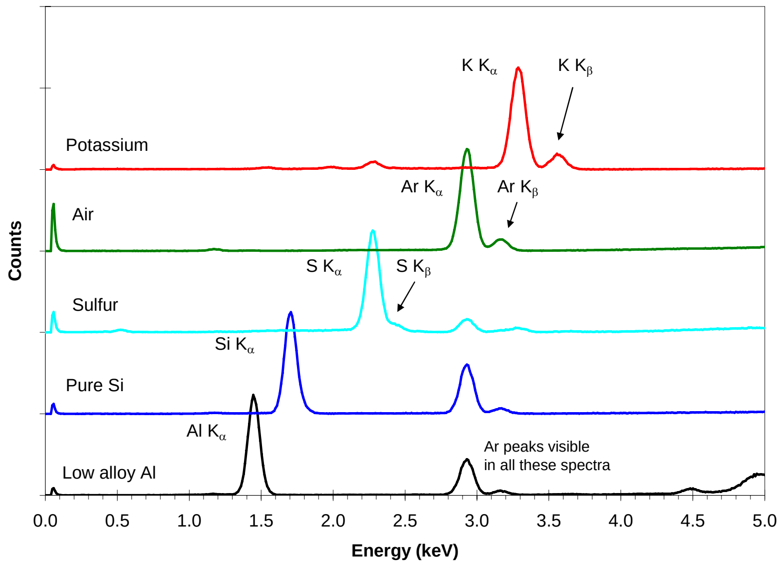

Figure 1. Plot showing spectra measured by Amptek's silicon drift diode (SDD) from light element samples.

Figure 2 shows the sensitivity of the SDD as a function of energy for several different configurations. Amptek's standard SDD, with a ½ mil Be window, has a sensitivity of only 20% at Na. But with 1 cm of air between the sample and Be window, the sensitivity falls to 1%. For Al, the sensitivity is 60% in vacuum but 16% with 1 cm of air. So it is certainly possible to detect these low energy X-rays, even with an SDD in air, but the sensitivity is very low.

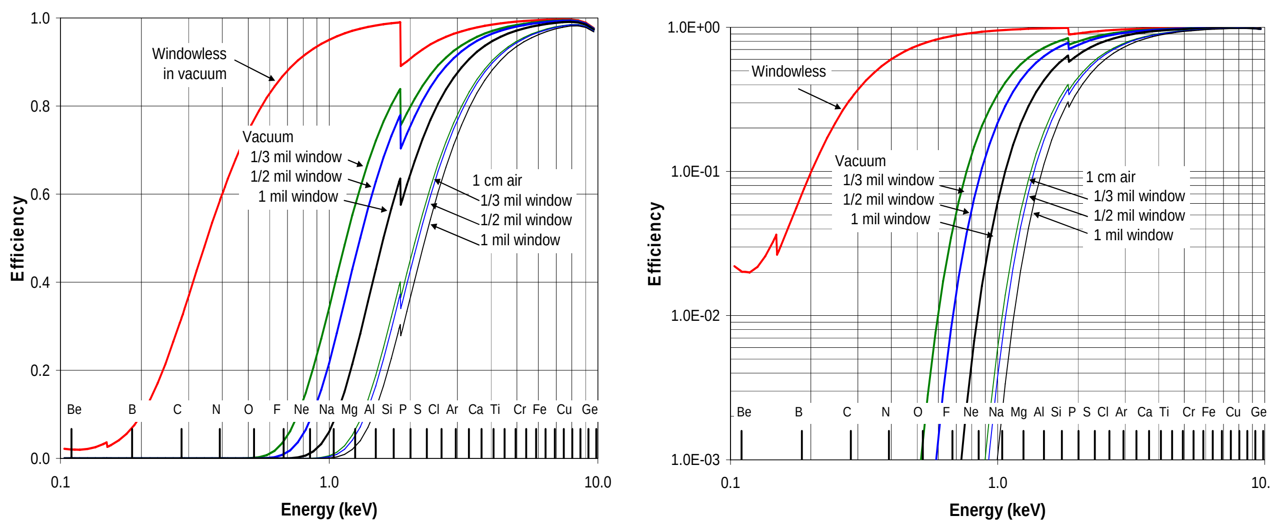

Figure 2. Plot showing computed sensitivity of the SDD as a function of energy for various configurations.

Figure 3 shows the sensitivity for no air path, for 1 cm, and for 1.5 cm. For Al, the sensitivity falls from 16% for 1 cm of air to 9% for 1.5 cm of air. Only 5 mm of air attenuates the signal by a factor of two. This makes it very difficult to obtain quantitative results: if the geometry of the sample under test and of the calibration reference changes by a fraction of a mm, significant errors result. This is not unique to the SDD, of course, but is an intrinsic limitation of measurements out in air. This is why low energy XRF is usually carried out under a He purge or in vacuum. Figure 3 also shows that, with 1 cm of air, the 1/3 and 1/2 mil windows yield negligibly different sensitivities. The 1/3 mil window is advantageous only if the measurement is in vacuum or a He purge.

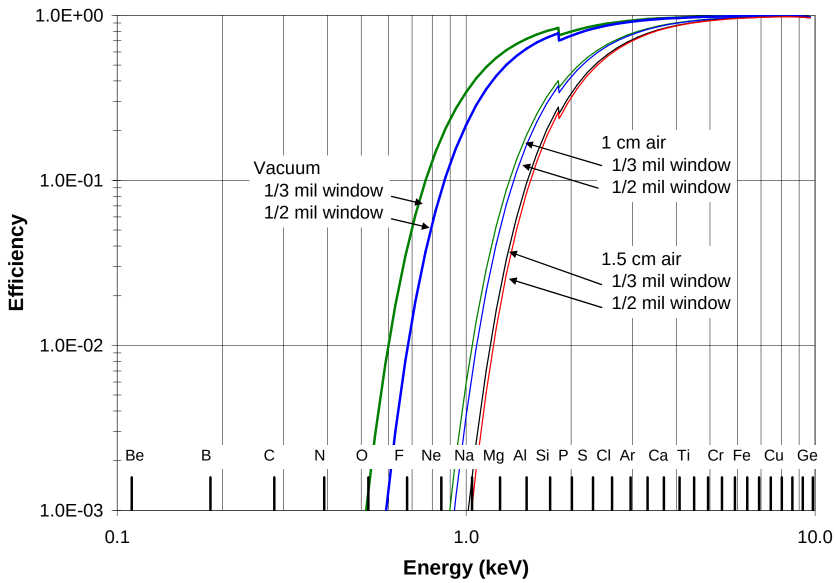

Figure 3. Plot showing the efficiency of the SDD behind 1/2 and 1/3 mil Be windows in vacuum and with 1 and 1.5 cm air paths.

Resolution

Figure 4 (left) shows the energy resolution of the SDD for the light elements, at several different peaking timings. The energy resolution arises from Fano broadening and electronic noise, which add in quadrature. Fano broadening is the dominant term for elements above Ca, for T_{peak}=25.6 μsec. For heavier elements, the noise is less important, so the resolution does not depend as much on the signal processing settings. To run at high count rates, one should use a short peaking time. This will degrade the resolution most for the light elements. Figure 4 (right) plots, on the vertical axis, the ratio of the energy resolution (eV FWHM) and the spacing between the K_{α} lines of adjacent elements. This is an indicator of the ability of the system to resolve the lines of closely spaced peaks.

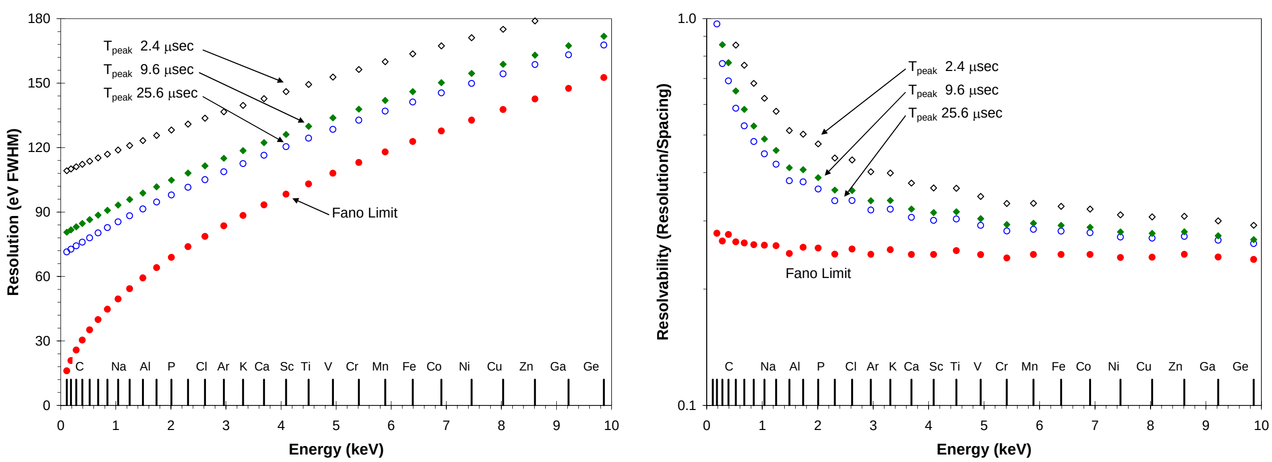

Figure 4. Plots showing the resolution of the SDD as a function of energy and peaking time. The plot on the left shows the raw resolution values. The plot on the right shows the ratio of the energy resolution (eV FWHM) to the spacing between nearest K_{α} lines. This is a measure of the resolvability of the peaks.