

Amptek SuperSDD and SiPIN at Low Energies

Amptek's silicon X-ray 25 mm² SuperSDD and 6 mm² SiPIN can be used to measure light elements. Their energy resolution is very good, with a noise threshold of 140 eV and about 50 eV FWHM of electronic noise for the SuperSDD. Figure 1 and Figure 2 show spectra of several different light elements, obtained with a SuperSDD. The biggest challenge in light element detection is sensitivity, arising mostly from attenuation in the Be window and in air.

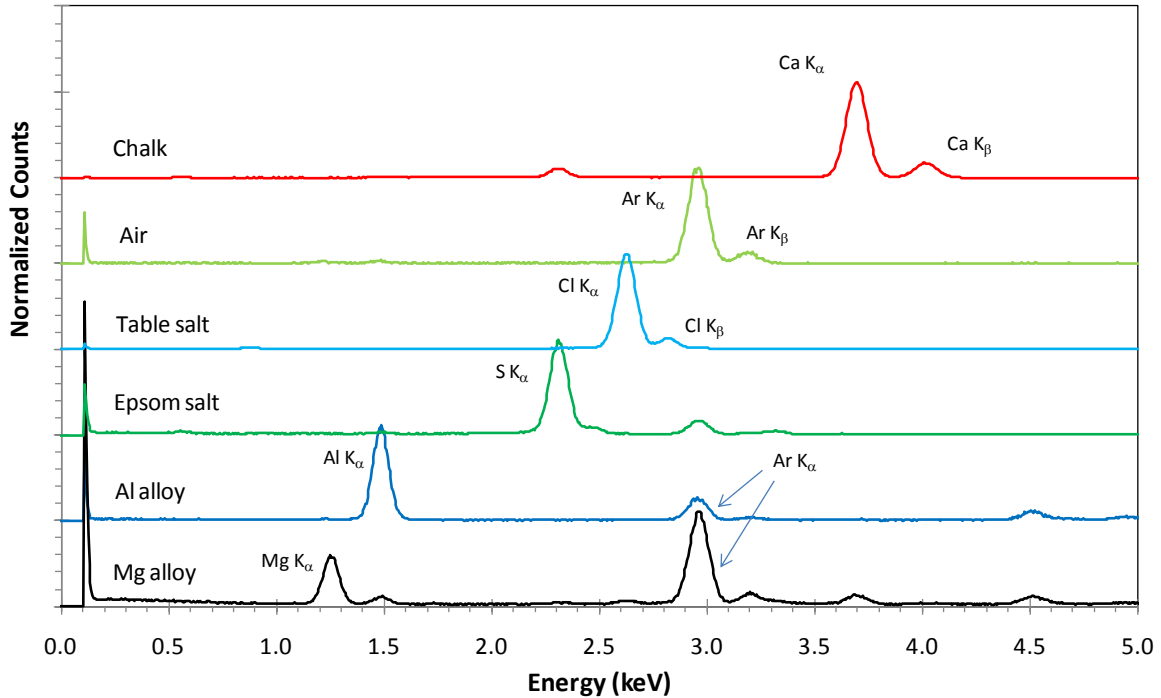


Figure 1. Plot showing spectra measured by Amptek's 25 mm² silicon drift diode (SDD) from light element samples.

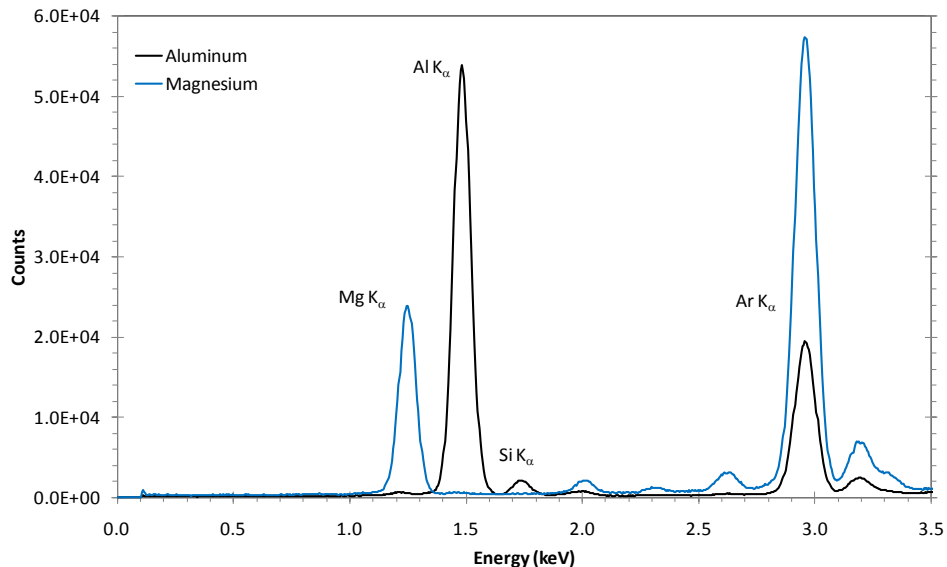


Figure 2. Plot showing spectra measured from Mg and Al samples with a SuperSDD. The clear separation between the Mg and Al K_α peaks at this low energy is critical for analysis.

Sensitivity

Figure 3 shows the sensitivity of the Si detectors as a function of energy for several different configurations. Amptek's standard products, with a 1/2 mil Be window, have a sensitivity of only 20% at Na (1.04 keV). With 1 cm of air between the sample and Be window, the sensitivity falls to 1%. For Al, at 1.49 keV, the sensitivity is 60% in vacuum but 16% with 1 cm of air. It is certainly possible to detect these low energy X-rays, even in air, but the sensitivity is very low. Since the K X-ray yield drops for light elements, and the X-rays from these elements have short attenuation lengths in the samples, the count rate is low.

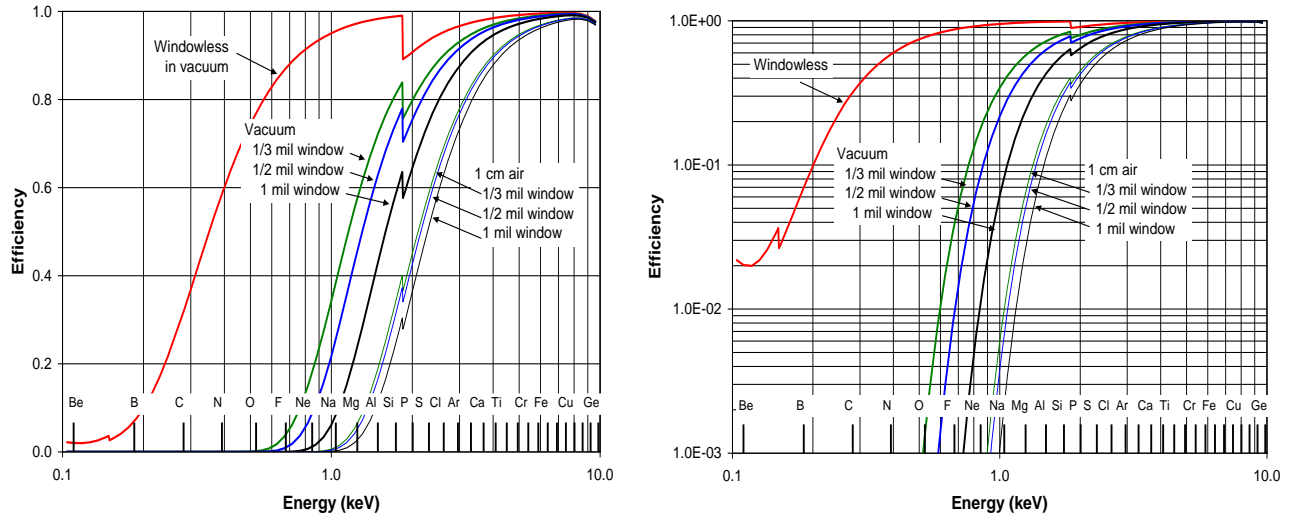


Figure 3. Plot showing computed sensitivity of Amptek's SiPIN and SDD as a function of energy for various configurations.

Figure 4 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 millimeter, significant errors result. This is not unique to these particular detectors, of course, but is an intrinsic limitation of measurements carried out in air. This is why low energy XRF is usually carried out under a He purge or in vacuum. Figure 4 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.

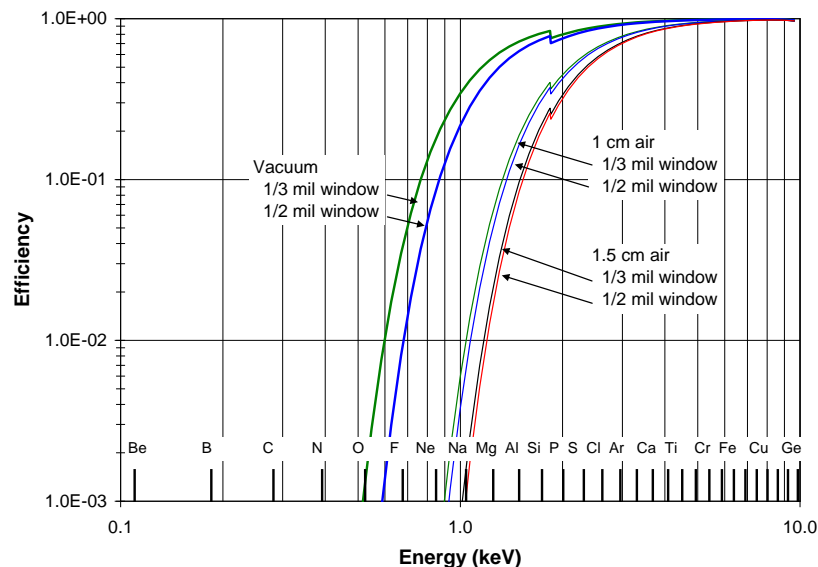


Figure 4. Plot showing the efficiency of Amptek's SiPIN and SDD behind 1/2 and 1/3 mil Be windows in vacuum and with 1 and 1.5 cm air paths.

Figure 5 compares a Mg spectrum, measured in air, with the result of exciting only an air column. Argon is an important component of air, yielding the strong peak at 3.0 keV, present in essentially all measurements. Note the proximity of the Ar escape peak (1.21 keV) is to the Mg K_{α} peak (1.25 keV). High energy resolution is critical for processing such spectra.

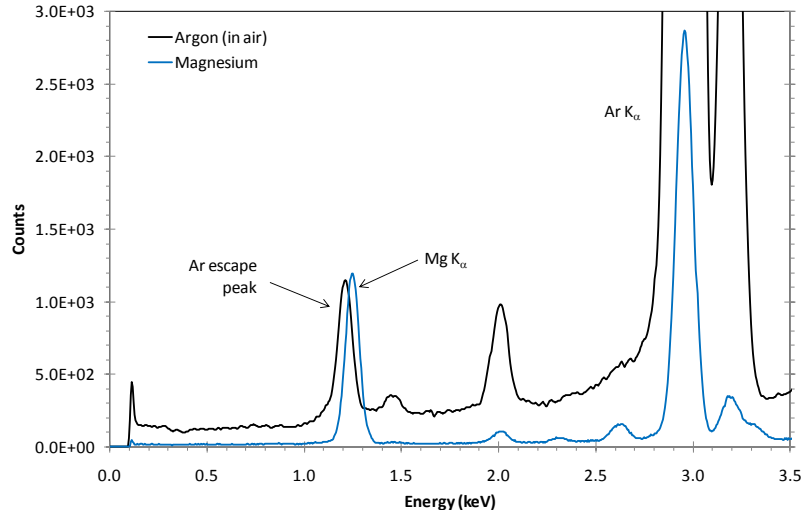
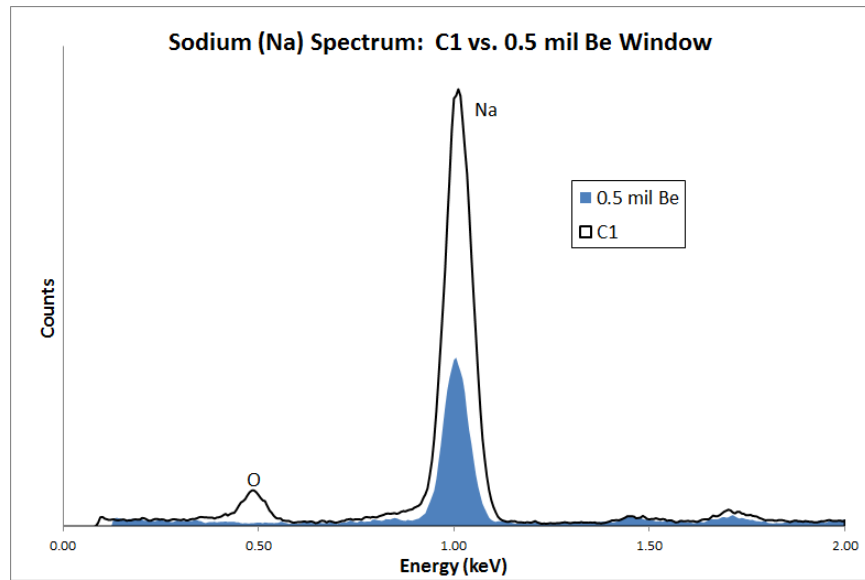


Figure 5. Spectrum of an Mg target compared to an air spectrum, showing the proximity of the Ar escape peak to the Mg K_{α} peak.

Super Low Energy

Spectra of Sodium (Na) in vacuum, with 0.5 mil Be and C1 window.



Resolution

Figure 6 (left) shows the energy resolution of the 25 mm² SDD for the light elements, at several different peaking timings. The 6 mm² SiPIN at its optimum, 32 μs, is comparable to the SuperSDD at 0.8 μs. The energy resolution arises from Fano broadening and electronic noise, which add in quadrature. Fano broadening is the dominant term for elements above Na, for T_{peak}=11.2 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 6 (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.

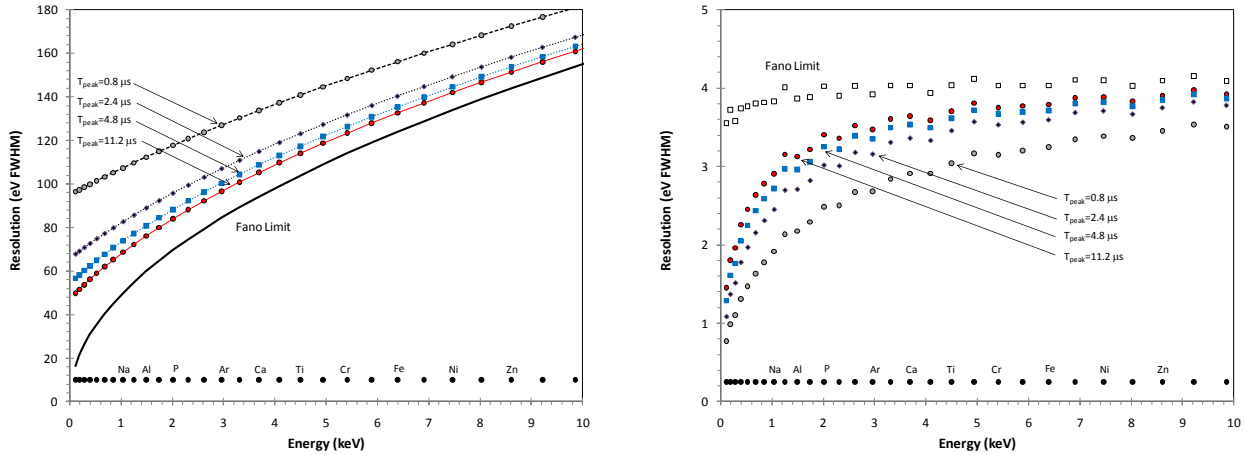


Figure 6. Plots showing the resolution of the SDD as a function of energy and peaking time. The plot on the left shows the raw resolution values. The plot on the right shows the ratio of the energy resolution (eV FWHM) to the spacing between nearest K_α lines. This is a measure of the resolvability of the peaks.