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One dimensional x-ray detector with high spectroscopic performance based on silicon strip detector technology

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Over the last decade silicon strip detectors have become a standard in X-ray diffraction instrumentation. The primary advantage of these detectors is high measurement speed and high count rate capability achieved by fully parallel readout of multi-strip sensors. In our previous work [1] we have demonstrated that using a standard silicon strip detector technology combined with high performance front-end electronics one can build a device with energy resolution of 600 eV FWHM at room temperature. This energy resolution is sufficient to address a common problem in X-ray powder diffraction in particular, i.e. electronic suppressing the Fe fluorescence radiation from samples containing iron or cobalt while irradiated with 8.05 keV photons from an X-ray tube with the Cu anode.

Further improvement of the energy resolution of such detectors is highly desirable to enable electronic discrimination between the Kα and Kβ emission lines when using an X-ray tube. This will allow eliminating the monochromators on the primary or diffracted beam, which cause significant reduction of the beam intensity. For the commonly used Cu anode the Kα and Kβ are 8.05 keV and 8.9 keV respectively and the energy resolution better than 400 eV FWHM (corresponding to Equivalent Noise Charge of 46 el. rms) is required to suppress the Kβ line efficiently.

In the paper a new detector design that achieving a global energy resolution for the entire detector of about 350 eV FWHM at room temperature is presented. The measured global energy resolution is defined by the energy spectra summed over all strips of the detector, and thus includes charge sharing effects, electronic noise of the front-end electronics, matching of parameters across the channels and other system noise sources. The target energy resolution has been achieved by segmentation of the strips to reduce their capacitance and by careful optimisation of the front-end electronics. Excellent noise and matching performance and negligible system noise allow us to operate the detector with a discrimination threshold as low as 1 keV and to measure fluorescence radiation lines of light elements, down to Al Kα of 1.5 keV, simultaneously with measurements of the diffraction patterns.

Critical design aspects of the detector will be discussed and test results illustrating the detector performance will be presented in the paper.

[1] W. Dąbrowski, et al., Journal of Instrumentation, 7 (2012) P03002

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