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Design of Low Noise and Low Area Preamplifier-Shaper in Readout ASICs for CdZnTe Semiconductor X-ray and γ-ray Detectors

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CdZnTe detectors are good candidates for high-efficiency, high-resolution, and room-temperature nuclear radiation detectors, and are especially suitable for the detection of the X-ray and γ-ray in the energy range of 20-800 keV. They are being widely used in environmental monitoring, medicine, industrial non-destructive testing, security inspection and space science. We report the study on the design of low noise and low area preamplifier-shaper in readout ASICs for CdZnTe detectors. We focus on the preamplifier-shaper configurations with proper shaping times and filtering frequencies for obtaining low noise, and several realizations of the feedback resistor (including poly resistor, single MOS resistor, serial MOS resistors and a resistor circuitry) in the shaper are studied for achieving low area. These circuits were realized in three experimental chips and were fabricated in 0.35 μm processes. The design with poly resistor achieves the lowest noise and the best linearity, but takes the largest area. The design with single MOS resistor achieves the lowest area, but the gain of the shaper is limited for keeping a good linearity. The designs with serial MOS resistors and with the resistor circuitry also work well with gain limitations of the shapers. In order to get a proper gain for the whole circuits, an additional amplifying stage followed the shaper has been included in each design. The gain linearity of the whole circuits and the equivalent noise charge (ENC) were tested. The test results indicate that the gain linearity is above 99.9% and ENC is around 200e@5pF for each design. With a radiation source of 241Am and a CdZnTe detector of 3 × 7 × 3 mm3, the tests of energy spectrums are being conducted. The expected energy resolution is below 5% for 59.5 keV.

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