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Development of slew rate limited time-over-threshold (ToT) ASIC for multi-channel silicon based ion detector

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High-resolution Elastic Recoil Detection Analysis (HERDA) is one of the promising methods of quantitative analysis of hydrogen. The depth distribution of hydrogen can be obtained from the energy of recoiled hydrogen ions by irradiation of ion beams. HERDA consists of a magnet and a position sensitive detector for detecting the recoiled ions. Micro channel plates (MCP) are mainly used as the position sensitive detector, however, it takes long time to acquire one hydrogen distribution spectrum because of the limitation of count rate (~ 1000 cps). Also the system based on MCPs suffers from noises of dark current and stray ions in a chamber. For solving these problems to achieve higher sensitivity, the detection system using multi-channel Si based position sensitive detector has been developed. In this study, a slew rate limited time over threshold (ToT) ASIC was designed and characterized for low noise, parallel and fast readout from multi-channel silicon based ion detectors. The designed ASIC has 48 sets of a preamplifier with adjustable gain (high/low gain) and a slew rate limited shaping amplifier and a comparator and was fabricated using $0.25\ \mu\text{m}$ TSMC's 2.5/3.3 V CMOS process. The size of the chip die is 2.2×4.3 mm. This circuit measured the energy by ToT, which is the method that the information corresponding to pulse height is digitally obtained with time width. Moreover, in the resistive part of the shaping circuit, the voltage is reduced with a constant current, and the output of ToT is linearized. The measured equivalent noise charge (ENC) of preamplifier is approximately 3×10^2 electrons. The dynamic range of ToT is confirmed over 60 fC in high-gain mode although that of pulse height saturates at approximately 30 fC. Besides, the other characteristics and results combined with multi-channel silicon strip detector will be reported.

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