

The Topmetal-CEE Prototype, a Direct Charge Sensor for the Beam Monitor of the CSR External-target Experiment

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The Cooler-Storage-Ring External-target Experiment (CEE) which is being constructed since 2020 is a spectrometer to study the properties of nuclear matter at high baryon density region. An online beam monitor that is based on the time projection chamber detection principle is being developed for the CEE to accurately determinate the beam incidence position. The Topmetal-CEE sensors are used as the anode array collecting electrons in the beam monitor.

The Topmetal-CEE prototype has been designed in a standard CMOS 130 nm process and is being fabricated. The sensor has 180 channels with a pitch of 100 μm . In each channel, electrons are collected by a charge collection electrode which is a top-most metal exposed the surrounding media, amplified by a charge sensitive amplifier, and then feed into a discriminator. The output of the discriminator is split into two path. One records time-of-arrival (ToA). The other records time-over-threshold (ToT). ToA information is recorded in a 8-bit register counter at 40 MHz and can be refined by a time-to-amplitude convertor (TAC). TOT is also recorded by a TAC. In order to reduce the dead time, 180 channels are split into two separate parts and then the information in each part is read out by a data-driving priority readout scheme independently. Each channel has its own address encoded by an address encoder. The analog amplitude of each TAC is digitized by a 13-bit pipeline Analog-to-Digital Convertor (ADC). The output codes of the ADC are grouped with the corresponding counter and address, and then they are transferred off chip with a serial speed of 4.4 Gbps.

In the conference, we will present the detailed design and preliminary test results of the Topmetal-CEE prototype.

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