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P1.40: The Nupix-S, a silicon pixel sensor for non-interceptive real-time beam monitoring.

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As the leading research platform of heavy-ion science in China, the heavy-ion physics and heavy-ion applications at the Heavy Ion Research Facility in Lanzhou (HIRFL) drive the development of physics research, especially in the fields of nuclear physics and high-precision medical imaging. Therefore, the beam monitoring system is essential to ensure the quality of the beam delivery. Hence, we have designed a non-interceptive beam monitoring system named Hi'beam. The key component of the Hi'Beam system is the Nupix-S silicon pixel sensor. The heavy ions generate the charge by ionizing the gas while passing through the detector, and the charge is collected by the Nupix-S pixel sensor under the drive of the electric field. With this process, the Nupix-S can record the heavy ions' energy, position, and arrival time to reconstruct the beam track.

The total size of the Nupix-S is 4 mm × 5 mm, including a pixel matrix of 64 (row) × 120 (column) with a pixel pitch of 37 μm and the periphery circuit. The charge is directly collected by the charge collection electrode, which is the exposed area of the topmost metal layer of each pixel. The size of the charge collection electrode is 23 μm, and it is implemented as a probe-PAD located at the center of each pixel.

The in-pixel circuit mainly consists of a low-noise Charge Sensitive Amplifier(CSA) and peak holding circuit (Peak Holding) to establish the signal for the energy reconstruction, and a discriminator with a Time-to-Amplitude Converter (TAC) for the Time of Arrival (TOA) measurement. The analog signal from each pixel is accessible through time-shared multiplexing over the entire pixel array. Furthermore, The charge conversion gain is about 98.6 μV/e⁻ the output dynamic range is 1.48 V, the time accuracy is less than 50ns, and the Equivalent Noise Charge (ENC) is about 34 e⁻. This paper will present the design and performance of this Nupix-S pixel sensor.

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