# The Miniaturization of Particle Detection Circuits Composing the Direct Observation System for Wave-Particle Interactions

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"Wave-Particle Interaction Analyzer (WPIA)'' is proposed for a direct and quantitative analysis of wave-particle interactions. We aim to integrate the WPIA on one-chip by using the ASIC (Application Specific Integrated Circuits). In order to realize the one-chip WPIA, small-size particle detection circuits are required which continuously output a detection signal derived from each plasma particle.
The operation of the particle detection circuit consists of two stages. Since the plasma particle cannot be detected directly, the pre-stage converts and amplifies electric charge detected by a sensor to voltage first, enabling the post-stage to detect the voltage signal. The input waveform to the pre-stage circuit appears as a current pulse with its pulse width of a few tens of nano-seconds. In order to keep an enough response to the short time pulse in converting the electric charge to the voltage, we chose a current conveyor and a latch comparator for the pre-stage and post-stage circuits, respectively. First, we designed a current conveyor. The response of the current conveyor depends on mutual conductance ($g_m$) of MOSFETs and the output impedance ($Z_{out}$). With a large value of $g_m$ and $Z_{out}$, we designed a high response current conveyor circuit. Simulation results show that when the amplitude of the input current pulse was 103 uA, the output was raised from -12.7 mV to 316 mV at about 1.8 ns and converged at about 16.2 ns. The operational performance of the current conveyor circuit was also verified by the measurement and simulation results. Next, we designed a latch comparator. Adjusting the current and the aspect ratio of MOSFETs on the latch circuit, we designed a high response latch comparator with the delay time of less than 2 ns. The measurement results, however, showed the delay time of about 200 ns, due to the time constant increased by parasitic capacitance at the output port, which was improved by decreasing $Z_{out}$ in simulation.
In this presentation, we introduce the design and evaluation of the small particle detection circuit on a chip and propose a direct observation system for wave-particle interactions including the designed particle detection circuits.

Keywords: Wave-Particle Interaction, Wave-Particle Interaction Analyzer(WPIA), Particle Detection, Application Specific Integrated Circuits(ASIC)

 