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A Topmetal-based and High-Performance Resistance Measurement Circuit for the Thin-Film Sensitive Gas Detection

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We present the design and characterization of a high performance resistance measurement circuit fabricated in a standard 0.35μm CMOS process. The circuit implements two exposed metal electrodes in the topmost metal layer which can be deposited the sensitive thin-film. Test pulse is injected into one electrode, the other electrode is directly fed into a low noise charge sensitive amplifier with selective feedback capacitor. Simulations and initial tests show that the circuit achieved a 100Ω˜100TΩ measuring range and a 10Ω resolution. These characteristics enable its use as the accurate resistance monitoring sensor device in future thin-film sensitive gas detection applications.

Summary

We have successfully implemented a CMOS Integrated Circuit in a standard 0.35μm CMOS technology for high precision resistance measurement that is uniquely suitable in future gas concentration monitoring through the sensitive thin-film deposition. Based on the prototype of a series Topmetal pixel sensor with directly charge collection and excellent low noise performance, the front-end of this resistance measurement circuit implements two exposed metal electrodes which can be deposited the sensitive thin-film. The first electrode that measures 200μm × 580μm area is named Topmetal. Around the Topmetal there is the second electrode named "Guard Ring, (Gring)"with 430μm × 810μm area, which is a ring electrode in the same topmost metal layer as the Topmetal but isolated from it with 42μm distance. Test pulse generated by the internal or external Digital to Analog Converter (DAC) is injected into Gring, the Topmetal is directly fed into a low noise Charge Sensitive Amplifier (CSA) to generate analog voltage signal. The CSA is a dual-input folded cascode operational amplifier with 1fF˜50pF selective feedback capacitor (Cf). For expanding dynamic range and reducing noise, all biases of the CSA could be tunable through DACs with low-pass filters, respectively. The analog signal is routed through two stage source follower and an analogue output buffer to be accessed externally. The analog signal is also sampled by a high-resolution single-bit sigma-delta Analog to Digital Converter (ADC), which has a sampling rate of 25.6MHz for 200KHz input signal bandwidth and 80dB Signal to Noise Ratio (SNR). For a resistor (Rs) to be tested, we apply a calibrated square pulse with an amplitude of VTP and a duration time of Δt to the Gring, the injected charge (Qin) from Topmetal to CSA is defined by Qin=VTP/Rs·Δt. The amplitude (VOM) response of the CSA is VOM=(VTP·Δt)/(Rs·Cf), thus the tested resistor could be derived by Rs=(VTP·Δt)/(VOM·Cf). According to our previous IC development Topmetal-II-, its Cf, maximal Qin and Equivalent Noise Charge (ENC) are 5fF, 60000e- and 13.9e-, respectively. Calculating by 10 times SNR, the effective measuring range of Rs reaches up to 100Ω˜100TΩ. Simulations and initial tests show that the VOM of CSA is changed around 10mV with a 10Ω variation of Rs, which determines the minimum measuring resolution. These characteristics enable this circuit use as the accurate resistance monitoring sensor device in future thin-film sensitive gas detection applications. Further tests regarding the thin-film coating on the electrodes and gas concentration monitoring are ongoing. We will present the overall design and detailed test results of this circuit in the conference.

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