ABSTRACT

Front -end Circuits

for Chemical and Molecular Sensing. (August 2005)

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This research demonstrates two building blocks for CMOS integrated sensor IC for molecular or chemical sensing. One of them for molecular sensing is the capacitance sensing circuit to detect the change of the dielectric constant of novel nanowell devices. The size of nanowell (10nm-100nm) enables high fidelity detection and analysis through Broadband Dielectric Spectroscopy (BDS) of the parallel-plate capacitor formed by the nanowell and the targeted molecules. The signal tranduction is done by a novel, continuous-time detection circuit using a low-noise lock-in architecture which generates the current output containing the information about the admittance of the sensor as a function of the frequency for BDS. This current signal is processed in the current domain by a low power current-mode A/D converter. The current signal transducer has a quasi-linear capacitance resolution of 164pA/aF (at 1Ghz) and power consumption of only 30uW in 0.18um TSMC CMOS technology.

Another building block is a low noise front end for feature extraction for gas and nanoparticle detection using Van der Waals sensors. The output of such a sensor consists of particle specific information in the low frequency range from 0 to 100 KHz in the form of stochastic fluctuations. Such detection schemes are termed as fluctuation enhanced sensing, which exploit the statistics of the noise in the low frequency spectrum. The front end consists of a low pass filter bank to process the amplified signal from a low-noise transimpedance amplifier. It handles the noise-like information signal from

the sensor with filters having increasing cut-off frequencies. It is designed to operate at temperature as high as 200C with low leakage currents to maximize the stochastic fluctuation noise generation. The front-end system was fabricated with TSMC 0.18um technology and tested. The gain of the front-end circuit is at least 87dB and its power consumption with one transimpedance amplifier and 10 filters is just 1.1mW. Moreover, the worst-case maximum input current signal is 0.2uApp while satisfying 5% THD and the equivalent input current noise level is under 7nA. The front-end circuit demonstrates the considerably high dynamic range with the low noise input range suitable for applications for sensing using fluctuation enhanced techniques.