16-bit Dual-Slope Analog-to-Digital Converter

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Abstract

In this project, a CMOS-based application specific integrated circuit (ASIC) will be designed and simulated for the application of sensor interface circuit in this project. The ASIC will consist of a voltage follower, low-pass filter, and a 12-bit dual slope analog-to-digital converter (ADC). The Tanner software (L-Edit and T-Spice) will be used for the layout and the simulation of the ASIC. The ASIC will be implemented on a 1 mm × 1 mm silicon chip die and fabricated using the TSMC service. The performance of fabricated ASIC chip will be tested.

Procedures used to construct the device:

- Wet Oxidation
  - Thermal oxidation of silicon carried out in water vapor containing oxygen and is used to grow SiO_2 on Si surface.
- UV Lithography
  - Used to make patterns on a substrate. It uses UV light to transfer a geometric pattern from a mask to a light-sensitive chemical (photoresist).
- Wet Etching
  - Is a material removal process that uses liquid chemicals or etchants to remove materials from a wafer.
- Thermal Diffusion
  - Used for p-type and n-type doping.

Introduction:

- The dual slope **Analog-to-Digital Converter** (ADC) converts analog signal to digital signal. It consists of an integrator, comparator, counter, and a control logic circuit.
- The dual slope analog to digital conversion process has two phases, the charging and discharging of the capacitor, in order to minimize accuracy requirements for performance.

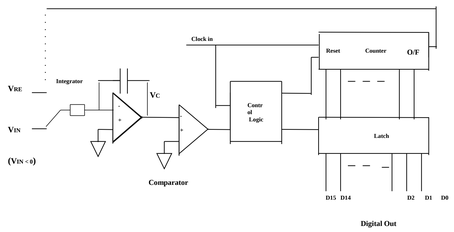
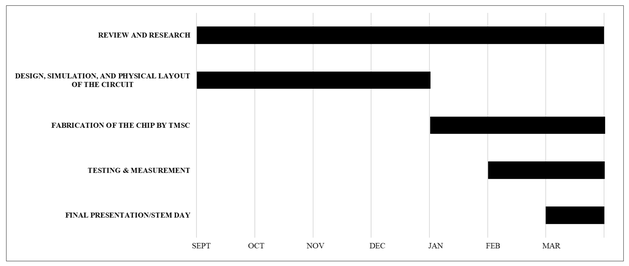


Fig. 1. A 3-stage CMOS ring oscillator.

CMOS-based Application Specific Integrated Circuit (ASIC) Schedule



Layout(s) of Key Components:

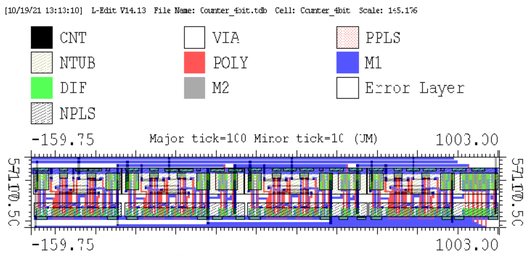


Fig.1 Layout of a 4-bit counter

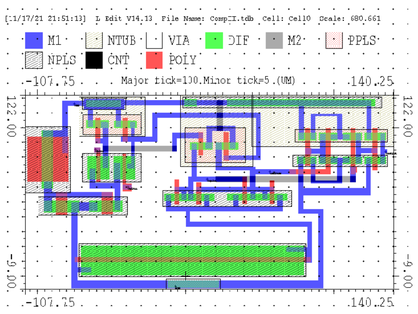


Fig.2 Layout of a Comparator

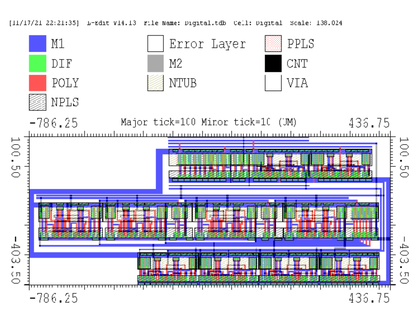


Fig.3 Layout of a 4-bit counter

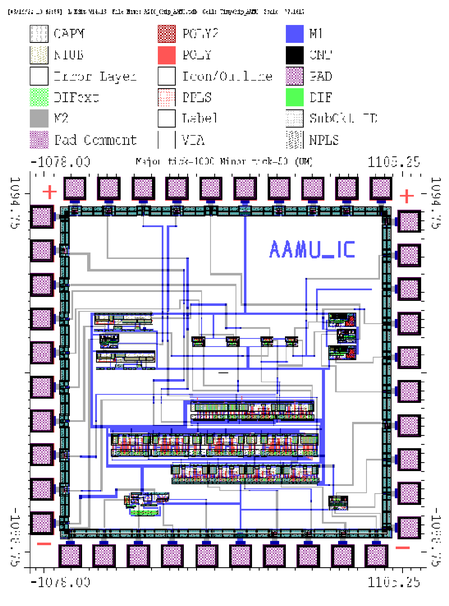


Fig.4 Layout of the ADC chip

T-Spice Simulation Results:

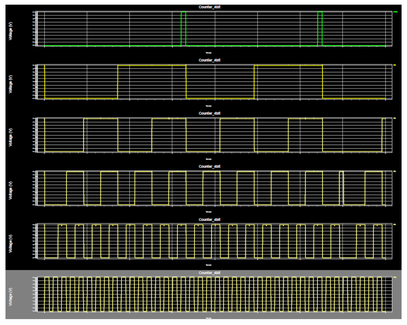


Fig.5 Simulation Waveform for 4-bit Counter

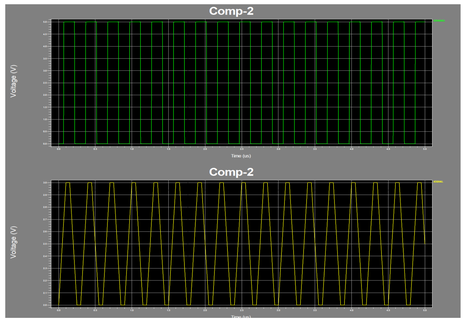


Fig.6 Simulation Waveform for Comparator

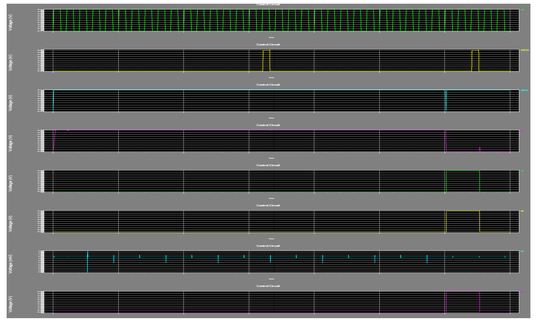


Fig.7 Simulation Waveform for Control Circuit

Summary:

- CMOS ring oscillators have been successfully fabricated with hafnium oxide as the gate oxide using the clean room-based microfabrication techniques.
- HfO_2 thin film was grow with the atomic layer deposition (ALD) method and functioned very well as the gate oxide in the CMOS devices.
- The fabricated CMOS ring oscillators demonstrated good oscillation waveforms with frequencies compatible with the simulation frequencies.

Acknolodgements:

- Special thanks to Dr. Zhigang Xiao for mentoring us to throughout this project and helping us complete our research.