

Power Optimization through Material Variation in CMOS Integrated Circuit

Urbi Sharma, Tarun Verma, Rita Jain

Abstract—This paper provides the simulation of 3 state inverter with different materials and compare the Leakage Current. Material which has the less Leakage Current is considered as better material for the designing of inverter. In previous time the mosfet is design by the combination of silicon and silicon oxide now we are using gallium arsenide and silicon dioxide as one combination and gallium arsenide and silicon nitride as another combination and different combinations of materials having high -K dielectric and semiconductor.

Index Terms—Gallium arsenide, high-k., power consumption, silicon nitride.

I. INTRODUCTION

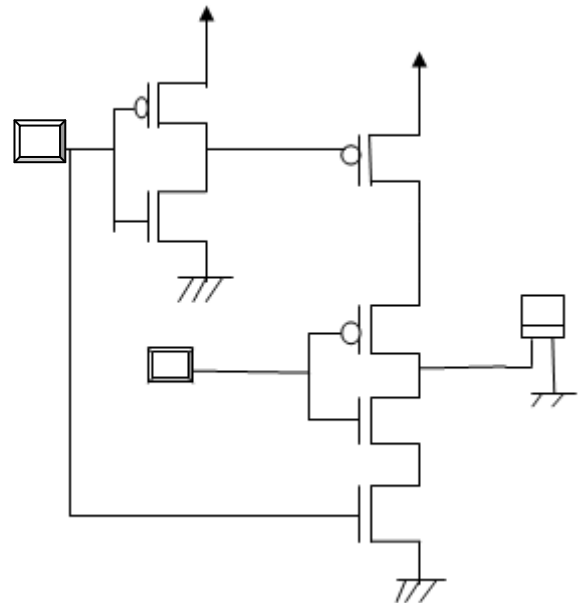
The CMOS inverter design is consist of one p-channel MOS and one n-channel MOS transistors are used as switches. All the symbols produced the value logic '0' and logic '1'. However, if several inverters share the same node, such as bus structure conflicts will rise. In order to avoid multiple access at the same time, specific circuits called 3-state inverters are used, featuring the possibility to remain in a 'high impedance' state when access is not required The 3-state inverter symbol consists of the logic inverter and an enable control circuit. The output remains in 'high impedance' (Logic symbol 'X') as long as the enable *En* is set to level '0'.

The truth table is reported below.

In	En	Out
0	0	X
0	1	1
1	0	X
1	1	0
X	0 or 1	X
0 or 1	X	X

The basic CMOS inverter is no more connected to the supply lines VDD and VSS directly. In contrary, pass nMOS and pMOS devices are inserted to disconnect the inverter when the cell is disabled .we see that when *Enable*=1 the cell acts as a regular CMOS inverter, while when *Enable*=0 the output "floats" in an unpredictable

voltage value, which tends to fluctuate at the switching of the input, mainly due to parasitic leakage and couplings.



II. PROPERTIES OF MATERIAL

2.1 Gallium Arsenide

1. It has direct band gap, which means that it can be used to emit light efficiently.
2. Higher carrier mobilities and lower resistive device parasitic.
3. GaAs is an excellent material for space electronics and optical windows in high power application.

2.2 Silicon nitride

1. Silicon nitride is an important material in microelectronics due to its high resistivity, higher dielectric constant compared to silicon dioxide, mechanical strength and chemical inertness.

2. It is used as a gate insulator in thin film transistor that are in flat panel display.

2.3 Silicon

1. Silicon is the existence of a native oxide (silicon dioxide), which is used as an insulator in electronics devices.
2. It has much higher hole mobility. This high mobility allows the fabrication of higher speed p-channel field effect transistor, which are required for CMOS logic

III. RESULT

DIELECTRIC CONSTANT	OXIDE	SEMICONDUCTOR1	SEMICONDUCTOR2	CURRENT 1	CURRENT 2
K=3.9	SiO ₂	GaAs	Ge	0.422mA	0.049 mA
K=7.5	Si ₃ N ₄	GaAs	Ge	0.422mA	0.049 mA
K=9	Al ₂ O ₃	GaAs	Ge	0.418mA	0.049 mA
K=22	Ta ₂ O ₅	GaAs	Ge	0.419mA	0.049 mA
K=25	HfO ₂	GaAs	Ge	0.418mA	0.049 mA
K=30	LaAlO ₃	GaAs	Ge	0.414mA	0.049 mA

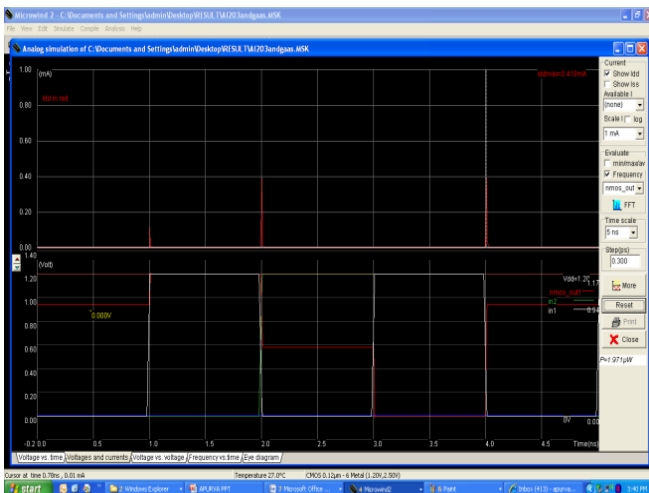
OUTPUT RESULT :-

GALLIUM ARSENIDE = 0.414
 GERMANIUM = 0.049
 ERROR = 0.365

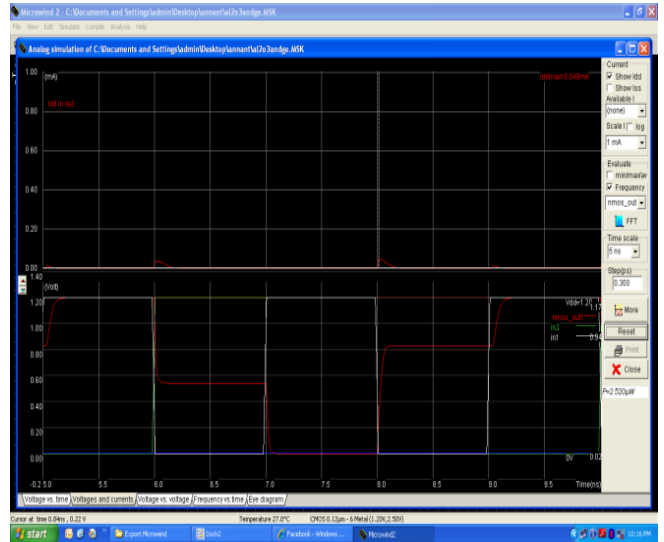
$$\text{OUTPUT IN PERCENTAGE} = \frac{0.365}{0.049} \times 100 = 88 \%$$

IV. SIMULATION

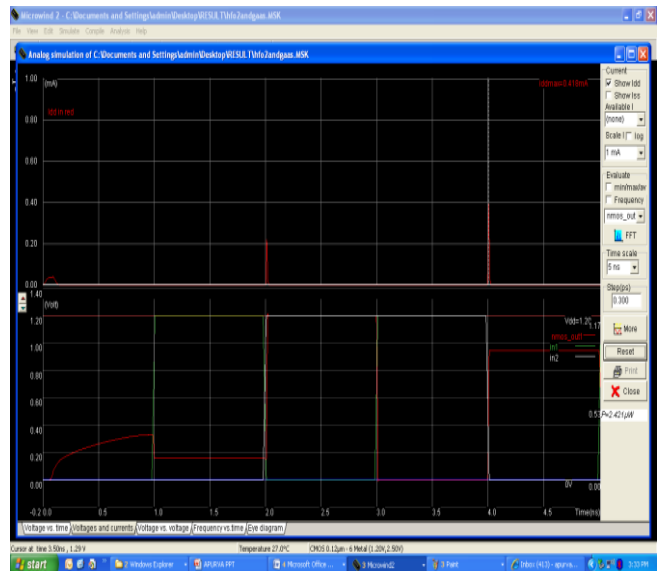
3.1 GaAs and Al₂O₃



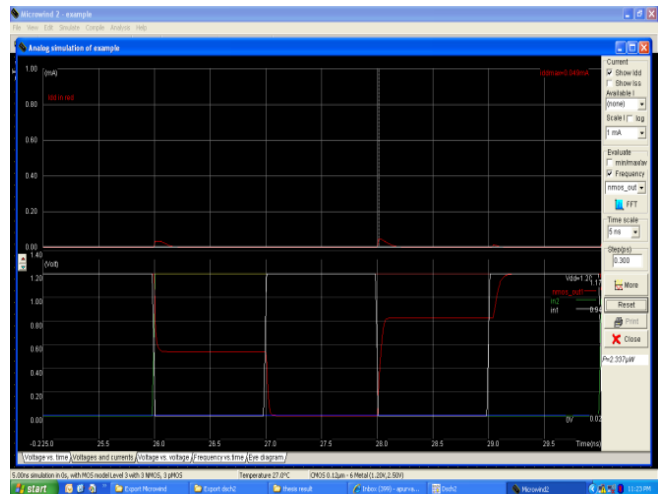
3.2 Ge and Al₂O₃



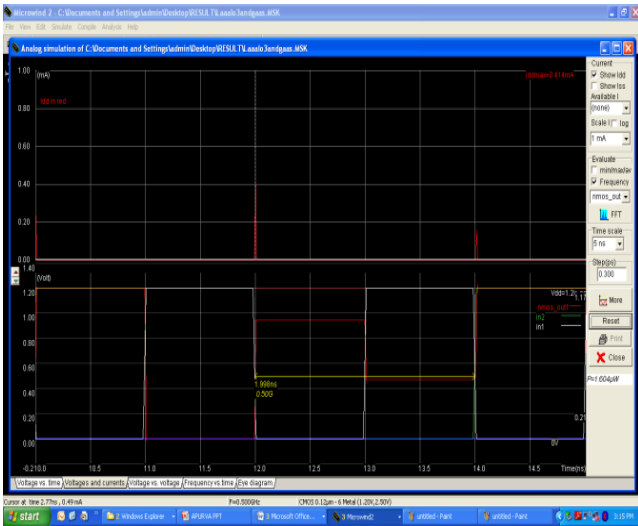
3.3 GaAs and HfO₂



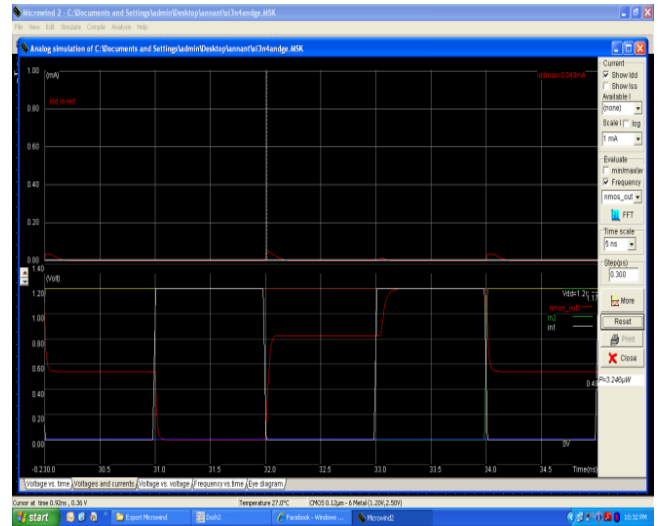
3.4 Ge and HfO₂



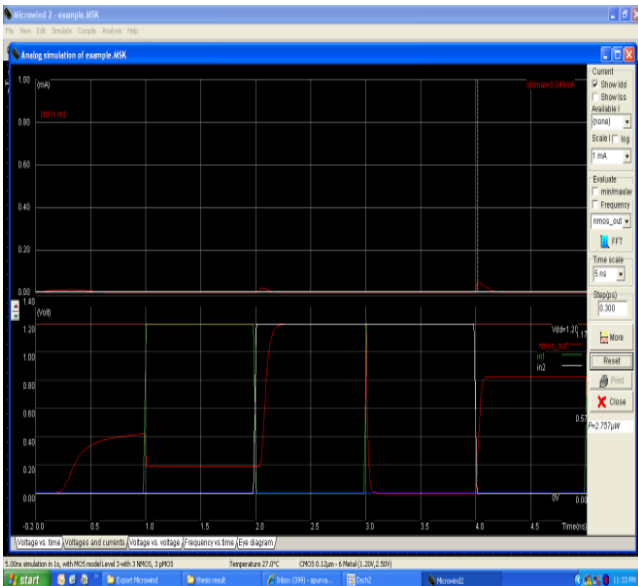
3.5 GaAs and LaAlO₃



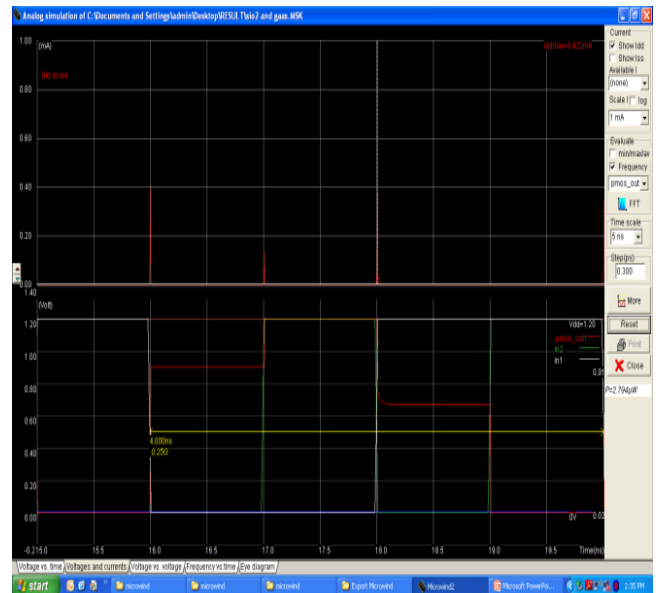
3.8 Ge and Si₃N₄



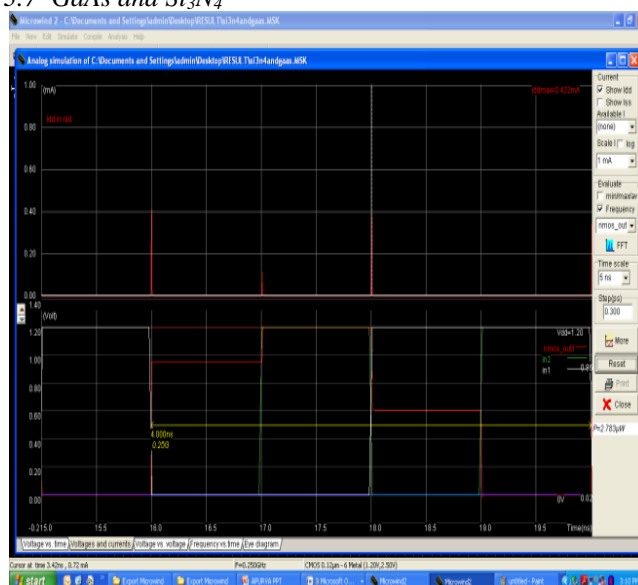
3.6 Ge and LaAlO₃



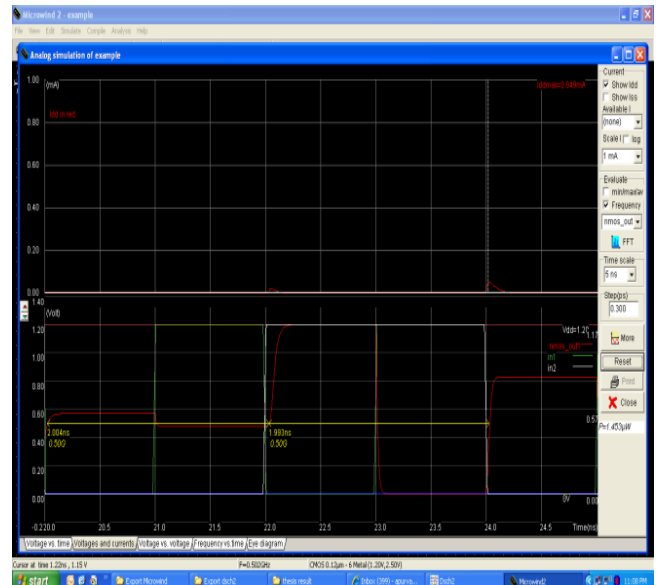
3.9 GaAs and SiO₂



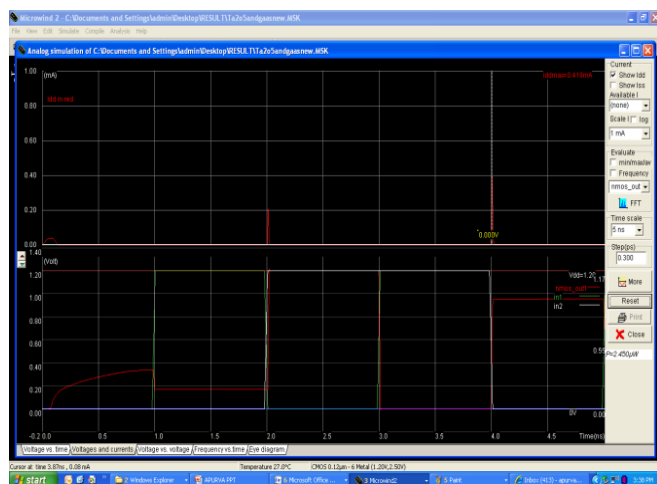
3.7 GaAs and Si₃N₄



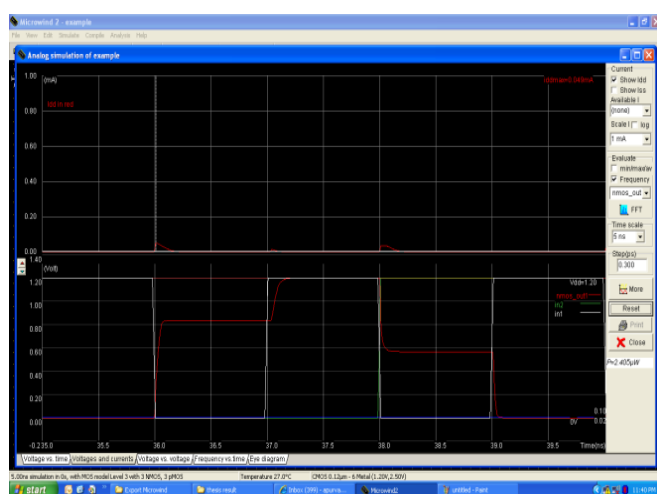
3.10 Ge and SiO



3.11 GaAs and Ta₂O₅



3.12 Ge and Ta₂O₅



V. CONCLUSION

CMOS technology has seen an excellent high speed performance achieved through improved design, use of high quality materials and processing innovations over the past decade. Silicon dioxide gate dielectric is replaced with various high-k dielectric materials. The choice of the high-k dielectric and the knowledge of its physical properties helps in changing the various characteristics of the oxide layer in respect to power, current and the layout area covered. It is observed that the leakage of the device decreases by about 88%. The study of the properties of these material was used in modeling the tri-state inverter and its various parameters were tabulated. The modeled inverter with high-k dielectric as gate dielectric material can be used for high gain and for low power applications in various electronic fields. Lanthanum is considered as better dielectric material.

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