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Flexible TFT Using Stacked Nano Zro2/Al2o3

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Abstract:

The ever growing Semiconductor industry is turning today towards high-κ gate dielectrics in transistor manufacturing processes to meet the need for higher speed transistors while keeping power consumption under control. The thickness of silicon dioxide (SiO2) is very less so it produces the tunneling current leakage, high power consumption and produces high heat when scaling of the transistor. A technique has been developed to fabricate a Thin Film Transistors (TFT) using stacked high- κ nanomaterials. Here in this work using stacked ZrO2 and Al2O3 as high-κ dielectric nanomaterials, ITO/PET substrate which is flexible, and ZnO as a semiconducting layer provides high performance to the device. Through this proposed approach the above problems are solved and the transistor could be shrunk below 32 nm.

Keywords:*high-κ dielectric, nano – Zirconia (ZrO2), nano – Alumina (Al203), TFT.*

1.Introduction

The Complementary Metal Oxide Semiconductor(CMOS) and Field Effect Transistor(FET) are made from Silicon. The performance of the transistor is improved by using moore's law [1].The scaling of SiO2 gate oxide is very difficult because its thickness is very less. Leakage current is increasing with decreasing the thickness of SiO2. High-κ materials are having high thickness so we can scaling of gate oxide is very easy and it is not producing the leakage currents. These materials are replacing the SiO2 gate oxide. The High-κ materials are provide high performance and low power CMOS applications beyond 32 nm. The facilitating of high-performance and low gate-leakage silicon and non-silicon transistor nanotechnology research via use of high-κ gate dielectrics and metal gate electrodes is attempted in this thesis work. The Thin Film Field Effect Transistors (TF-FET) are widely used in modern electronics devices. In this work, Figure 1 and 2 portrays the structure of TFT with high-k dielectric on a ITO/PET substrate.High- κ materials are having large thickness value ,so we can shrinking the transistor below 32 nm and leakage current will be reduced. This TFET operates in high speed and consuming less power[6]. In flexible electronic applications the materials be deposited by using low-cost deposition methods. In addition, these materials have to be compatible with conventional at temperatures suitable for flexible substrates (< 150°C).

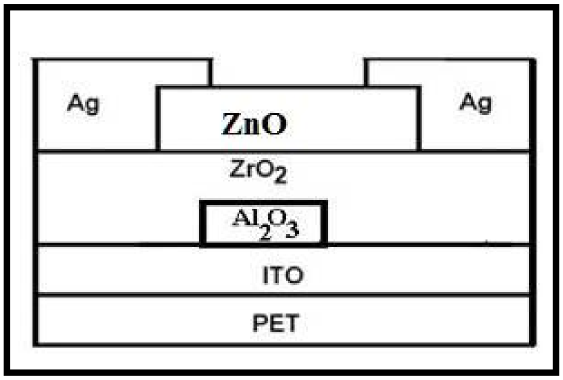

Figure1:Schematic Diagram Of The Tft With High- K Gate Dielectric

Zirconia is an extremely refractory material. Pure zirconia exists in three crystal phases at different temperatures. Cubic structure (>2370°C), a tetragonal structure(1170 to 2370°C) and the monoclinic structure(below 1170°C) . ZrO_2 has been regarded as a high-k candidate for the semiconductor industry, because of their high dielectric constant of about 25, high melting point of 2700°C, and excellent chemical stability. Other properties of ZrO_2 is high density, low thermal conductivity and high hardness. ZrO_2 is classified as a wide band gap semiconductor and tends to become more conductive with increasing temperatures.

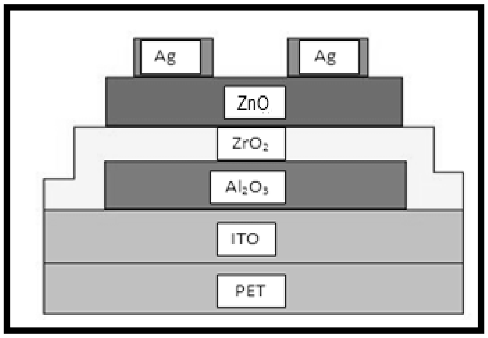

Figure 2: Optical Image Of The Final TFT Device

Al_2O_3 is also the high-κ dielectric material and its κ value is 9 [1]. Alumina is the most cost effective and widely used material engineering ceramics. For reducing atmosphere and oxidizing the purity alumina can be used. It is having good thermal conductivity, excellent size and shape capability and high potential for coating process.zinc oxide is an n type semiconductor. To vary the conductivity in a wide range by doping of other elements can be done instead of Zinc and Oxygen. Zinc Oxide (ZnO) is a wide band gap semiconductor . It has shown Hall effect mobilities up to 200 $cm^2/V \cdot s$ (single crystals) [4]. Important property of ZnO is the conductivity increases when irradiated with light. The Zirconia and Alumina nanoparticles are Characterized by using X-ray diffraction(XRD), Scanning Electron Microscope(SEM) images.In this work the nano particles are synthesized by using Combustion process. Combustion synthesis is very simple , safe and rapid production process. Combustion process is also low cost method for preparation of nanomaterials. This method is described as a quick, straightforward preparation process to produce homogeneous, oxide ceramic powders, without the intermediate decomposition and/or calcination step.

2.Experimetal Details

2.1.Preparation Of Nano Zro2 By Using Combustion Process

The synthesis of the ZrO2 by Using Combustion process [2]. Since the Zirconyl nitrate(Zro(No3)2), Glycine(NH2CH2COOH) are the raw materials used to synthesis the zirconia nanoparticles. Firstly, 2.3 g of the Zro(No3)2 is added in 0.83 g of Glycine and 5 ml distilled water is added, followed by 5 min of stirring with 400C. This mixed solution is kept in the furnace with 5500C and the solution is converted into foam product. This foam product contains ZrO2 and impurities. To remove the impurities the foam product is kept in 8000C at 6 hours we are getting pure ZrO2. Size of the zirconia nanoparticles are measured by using X-ray diffraction(XRD), Scanning Electron Microscope(SEM) images. Fig. 3 and 4. Shows SEM and XRD image of the ZrO2 nanoparticles by prepared using Combustion process.

2.2.Preparation Of Nano Al2o3 Using Combustion Process

Aluminum nitrate Al(NO3)3 and glycine(NH2CH2COOH) with 98 and 98.5% purities, respectively (vendor specification) are used as the starting material [3]. Both were capable of being mixed with minimum amount of deionized water. The solution is heated continuously without any previous thermal dehydration. Afterwards the solution became transparent viscous gel which auto ignited automatically, giving a voluminous and foam product of combustion. Under continuous intense heating, the precursor mixture auto-ignited at approximately 750-8000C and underwent combustion spontaneously forming a powder which did not contain crystalline phases. Size of the Alumina nanoparticles are measured by using X-ray diffraction(XRD), Scanning Electron Microscope(SEM)

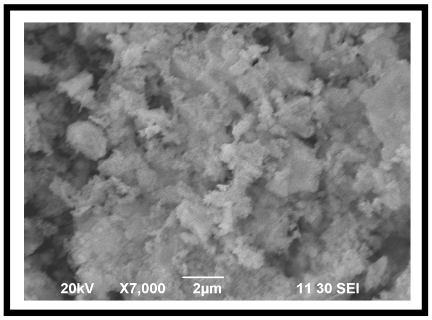

Figure 3:SEM Image Of Nano Zirconium Dioxide (Zro2)

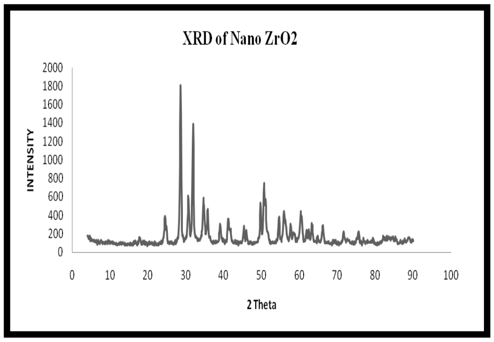

Figure 4: XRD Plot Of Nano Zirconium Dioxide (Zro$_2$)

images. Fig. 5 and 6. Shows SEM and XRD image of the ZrO2 nanoparticles by prepared using Combustion process.

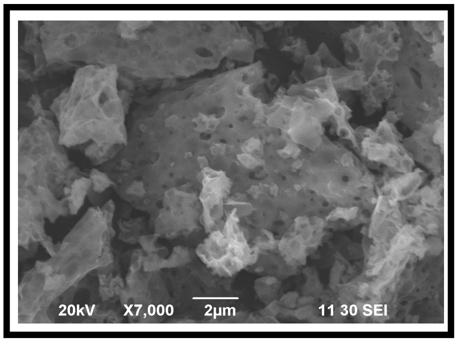

Figure 5:SEM Image Of Nano Aluminium Dioxide (Al2O3)

The stacked Al_2O_3 and ZrO_2 is the gate electrode materials. PET is the insulator which is used to gives the flexibility and ITO is the conducting material. The fabrication process starts with 100 nm of Al_2O_3 deposited using dip coating and subsequently patterned to define the gate contact(fig.1).

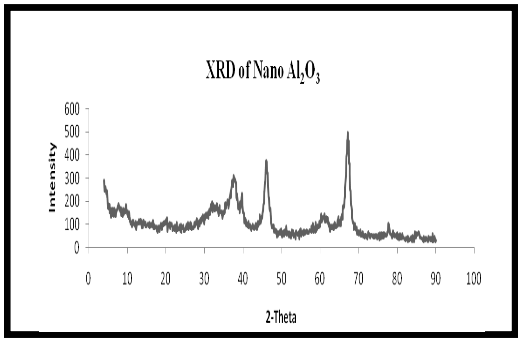

Figure 6: XRD Plot Of Nano Zirconium Dioxide (Al2O3)

A 90-nm-thick ZrO2 gate dielectric is deposited using atomic layer deposition at 1000 C. This is the maximum temperature step during the entire TFT fabrication process. 100-nm ZnO films at 70° C on top of the ZrO2 [4], as shown in Fig. 1. The ZnO thickness was measured using atomic force microscopy. Ag films were deposited immediately after the 30-nm ZnO deposition to analyze the ZnO–metal interfaces using SEM. The S-D electrodes were then defined using a lift-off process, resulting in devices with channel width W = 120 µm and channel lengths of L = 80 µm. The final structure is shown in Fig. 2. shows an optical image of the final TFT device.

3.Results And Discussion

The gate voltage is kept constant and the graph is drawn between Vds and Id for Vds = 0V to 10 V. At constant gate voltage, the Vds Vs Ids is drawn to obtain its knee voltage and to study the switching mode of the transistor. Figure 7 shows I-V characteristics of the Al2O3/ZrO2 TFT where the drain current, Ids, is plotted as a function of source–drain voltage, Vds, for different gate bias, VG. It can be seen that the device exhibits typical n-type field effect transistor characteristics with clear pinch-off and current saturation, indicating that the entire channel region under the gate metal can be completely depleted.When the gate voltage is 1.323V, the knee voltage is found to be 5.307V. Therefore, when the gate voltage is applied to 1.323V, IOFF state will be switched into ION state to 5.307V and vice versa. Similarly, the device operates for the various gate voltages.Thus, this fabricated field effect transistor act perfectly as a normal operation of a transistor.

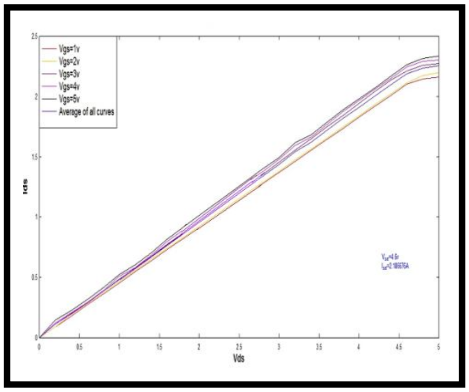

Figure 7:I-V Characteristics Of Vds Vs Ids At Constant Vg

4.Conclusion

In summary, we reported the fabrication of a TFT with Al2O3/ZrO2 gate dielectric. Then, fabricated field effect transistor is characterized at room temperature. The V-I characteristics are hence studied thoroughly. Threshold voltage Vt = 0.406V it shows that the performance of the FET is higher and consumes less power when compared to Silicon gate dielectric. In near future we plan to reduce the size of less than the proposed structure.

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