PEALD ZnO Thin Film Transistors for Memory, Sensing, and Biomedical Devices

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Zinc oxide thin film transistors (ZnO TFTs) can be fabricated at relatively low temperatures and on different substrates. We grow ZnO semiconductor and aluminum oxide (Al_2O_3) films by plasma enhanced atomic layer deposition (PEALD) at 200 °C and have demonstrated bottom gate TFT devices with near zero turn on voltage and a field effect mobility of 20 $cm^2/V{\cdot}s$. Two process flows are used in our device fabrication: trilayer and non-trilayer processes. The non-trilayer ZnO TFT fabrication process uses an Al_2O_3 passivation layer grown separately from the Al_2O_3 gate oxide and ZnO semiconductor film stack. This passivation method can lead to a negative shift in the turn on voltage and increased device variation. The trilayer bottom gate process consists of a sequence of PEALD Al_2O_3 gate oxide, ZnO semiconducting layer, and Al_2O_3 passivation layer depositions without breaking vacuum. This process has been shown to improve device uniformity and reproducibility as compared to the non-trilayer process.

We are investigating ferroelectric trilayer ZnO TFTs (FeFETs) for 3D non-volatile memories using AlBN and $Hf_{1-x}Zr_xO_2$ ferroelectric materials. Our low temperature ZnO TFT deposition makes it possible to fabricate ZnO TFTs on a variety of substrates, which makes these devices suitable for use in wider sensing and biomedical applications. We are investigating the usage of trilayer ZnO TFTs on ultra-low-expansion substrates for temperature sensing in space telescopes, with a demonstrated sensitivity of 5 mV/°C, and as pixel control switches in active figure correction x-ray mirrors. We are also investigating ZnO TFTs on flexible polymer substrates as control circuitry for an array of thin film ultrasound transducers for brain neuromodulation.