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Ferroelectric Hafnium and Zirconium Oxide: Enablers for New Device Concepts

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The interest in ferroelectric (FE) HfO2 and ZrO2 based devices is growing with the recent discovery of the FE and field induced FE properties in both materials. The continuously increasing list of devices is ranging from non-volatile memory applications in FeRAM or FeFET cells, ferroelectric tunnel junctions, and steep slope negative capacitance transistors to energy harvesting devices. In order to improve structural and electrical properties of the ferroelectric layer, research is ongoing to understand the root cause of this so far unknown phase. Accordingly, the ferroelectric properties and crystal structure of these thin films are investigated for different process conditions. Piezoresponse force microscopy (PFM) in conjunction with transmission electron microscopy (TEM) measurements revealed a domain size in the order of single grains with a grain diameter of ~20-30 nm for 10 nm thick films. Layers are only slightly textured, which caused a modulation of the polarization orientation within the layer. Electrical characterization of the defects and charges confirmed the influence of oxygen vacancies on the phase stability of ferroelectric HfO2. In conclusion, different HfO_2 based device approaches are discussed and their performance is compared. A non-volatile DRAM concept based on the field induced ferroelectric properties of ZrO_2 is presented. Detailed electrical characterization showed high endurance and retention values that can be extrapolated to 10 years while providing the speed of FE memories during low power operation.

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