MATERIAL CHALLENGES IN HfO_2-BASED FERROELECTRIC MEMORY DEVICES

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Ferroelectric memory devices have been considered one promising candidate for the next generation semiconductor devices for both conventional and future computing paradigm.[1-5] Especially, the discovery of ferroelectricity in fluorite-structured ferroelectrics such as HfO_2 and ZrO_2 disruptively accelerated the physical scaling down and performance improvement of the ferroelectric memory devices. The new functionality induced in the conventional gate insulator of the metal-oxide-semiconductor field-effect-transistor by adding a small amount of dopants with a subsequent crystallization annealing is highly attractive to both academia and industry. The fluorite-structured ferroelectrics enable sufficient memory window in ferroelectric field-effect-transistor even with sub-10-nm thickness owing to their coercive field as high as ~1 MV/cm and can be scaled down with sufficiently low leakage current with its bandgap higher than 5 eV. Moreover, they can be grown with atomic layer deposition with an accurate control of thickness on three dimensional nanostructures. However, there are still several challenges which require urgent solutions including limited endurance, device to device variation, and trade-off between operation speed and endurance. These issues are strongly correlated to the material properties and fabrication processes. In this presentation, therefore, the current challenges in HfO_2-based ferroelectric memory devices are reviewed and potential solutions are discussed based on a viewpoint of materials science and engineering.[6-8]

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