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Fabrication and characterization of WSi_2 nanocrystals memory device with SiO_2 / HfO_2 / Al_2O_3 tunnel layer

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High-k dielectric materials such as HfO_2, ZrO_2 and Al_2O_3 increase gate capacitance and reduce gate leakage current in MOSFET structures. This behavior suggests that high-k materials will be promise candidates to substitute as a tunnel barrier. Furthermore, stack structure of low-k and high-k tunnel barrier named variable oxide thickness (VARIOT) is more efficient.[1] In this study, we fabricated the WSi_2 nanocrystals nonvolatile memory device with $SiO_2/HfO_2/Al_2O_3$ tunnel layer. The WSi_2 nano-floating gate capacitors were fabricated on p-type Si (100) wafers. After wafer cleaning, the phosphorus in-situ doped poly-Si layer with a thickness of 100 nm was deposited on isolated active region to confine source and drain. Then, on the gate region defined by using reactive ion etching, the barrier engineered multi-stack tunnel layers of $SiO_2/HfO_2/Al_2O_3$ (2 nm/1 nm/3 nm) were deposited the gate region on Si substrate by using atomic layer deposition. To fabricate WSi_2 nanocrystals, the ultrathin WSi_2 film with a thickness of 3-4 nm was deposited on the multi-stack tunnel layer by using direct current magnetron sputtering system [2]. Subsequently, the first post annealing process was carried out at 900^oC for 1 min by using rapid thermal annealing system in nitrogen gas ambient. The 15-nm-thick SiO_2 control layer was deposited by using ultra-high vacuum magnetron sputtering. For SiO_2 layer density, the second post annealing process was carried out at 900^oC for 30 seconds by using rapid thermal annealing system in nitrogen gas ambient. The aluminum gate electrodes of 200-nm thickness were formed by thermal evaporation. The electrical properties of devices were measured by using a HP 4156A precision semiconductor parameter analyzer with HP 41501A pulse generator, an Agillent 81104A 80MHz pulse/pattern generator and an Agillent E5250A low leakage switch mainframe. We will discuss the electrical properties for application next generation non-volatile memory device.

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