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NBTI/PBTI analysis of the memory characteristics improved by hydrogen annealing in MANOS capacitors

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We report the effect of hydrogen annealing on the gate leakage current and switching characteristics of metal-alumina-nitride-oxide-silicon (MANOS) capacitors by analyzing their negative/positive bias temperature instability (NBTI/PBTI). One sample, A, is annealed with rapid thermal annealing (RTA), and the other sample, B, is first annealed with RTA and then further annealed in a furnace, using a N_2-H_2 (2-% hydrogen and 98-% nitrogen) gas mixture. In the NBTI/PBTI experiments, the flat-band voltage shift, $\triangle V_{FB}$, is observed to be smaller; that is, the gate leakage current is reduced, for sample B at gate voltages less than ±3 V, a domain where trap-assisted tunneling is dominant. However, the $\triangle V_{FB}$increases rapidly for the same sample at gate voltages larger than ±6 V, a domain where the modified Fowler-Nordheim tunneling (MFNT) is dominant, which indicates faster program and erase characteristics. These results show that additional hydrogen annealing can improve both device reliability and switching characteristics of the MANOS-type memory, by reducing interface traps between the silicon substrate and silicon oxide layers as well as turn-on voltages for MFNT.