Investigation of Gate Oxide Wear out Using Polysilazane-base Inorganic as Shallow Trench Filling

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The floating gate (FG) crystallization and extrinsic gate oxide breakdown (V_{bd}) using polysilazane-base inorganic material SOD (Spin-On-Dielectric) as shallow trench isolation (STI) filling is investigated. The pinholes are found along the FG grain boundary in wide active regions because of tensile stress induced by SOD material in STI process, thus gate oxide wears out by following wet cleaning steps. The chemical oxide formation during FG deposition can effectively inhibit gate oxide early breakdown. Moreover, FG sheet resistance (R_s) in 550°C/air deposition condition can significantly reduce about 20% in comparison with 520°C/O_2 and 400°C/N_2 conditions.

The FG1 phase transformation combined with FG2 deposition which used 400°C boat-in temperature in N_2 ambient; is no interface found in the floating gate. Unfortunately, the tensile stress that comes from SOD material will induce FG pinholes on a large active area by top-view SEM check. In order to circumvent chemical solvent flow into pinholes along the FG grain boundary and inducing the gate oxide V_{bd} problem, the discontinuous poly grain between FG1 and FG 2 is investigated by various FG2 furnace boat-in conditions and verify by accumulated probability of breakdown voltage in Pwell and Nwell capacitors. The results elucidate that either 550°C boat-in in air ambiance or 520°C boat-in in oxygen ambiance in FG 2 deposition can absolutely improve early V_{bd} except for 400°C boat-in in nitrogen ambiance due to oxygen ambience and formed discontinuous poly grain between FG 1 and FG 2. The cumulative probability of FG R_s by various FG2 deposition conditions, it is realized that 520°C boat-in in O_2 has higher R_s because of the chemical oxide between FGs. Moreover, 550°C boat-in in air condition reduces 20% of R_s compared with 400°C boat-in in nitrogen.

We propose a recovery process to inhibit gate oxide early breakdown by means of optimal FG2 deposition condition. The chemical oxide and discontinuous grain boundary formation within a floating gate can prevent solvent flow through the grain boundary and keep gate oxide from being directly damaged. Cumulative probability of floating gate R_s by higher temperature boat-in with air or oxygen ambience show acceptable R_s for memory cell operation.

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