In-situ Anneal of Silicon Nitride for the NO Capacitor Dielectric Film

S.H. Kang, S.T. Kim, D.H., K.H. Kim, and S.T. Ahn
Advanced Technology Center, Samsung Electronics Co.LTD.
San 24, Nongseo-Ri, Kiheung-Eup, Yongin-Gun, Kyungki-Do, Korea
TEL: 82-2-760-7864 FAX: 82-2-760-7805

As the DRAM cell size is getting more shrunk, very thin NO capacitor dielectric films are required. However, when the thickness of the silicon nitride film is reduced to below 5 nm, the nitride film can no longer block oxidation of the bottom poly-Si layer [1]. This leads to a substantial increase of the effective dielectric film thickness and thus limits further scaling down of the NO film. In this study, in-situ annealing of the LPCVD SiN film was investigated in order to improve the resistance of the film to oxidation.

Stack type capacitors were prepared first by forming the poly-Si bottom electrode. The wafers were then loaded in the LPCVD chamber for SiN and the native oxide was in-situ nitrided in NH_3 [2]. Deposition of the SiN film was begun by flowing the NH_3 and SiH_2Cl_2 gases. When half of the deposition time elapsed, the gases were turned off and the SiN film was annealed in N_2 for 1 or 2 hours. Subsequently, the second deposition step was carried out. For other samples, three deposition steps and two annealing steps (each for 30 min) in between were combined. The top oxide was formed by wet oxidation at 850°C for 30 min and the poly-Si top electrode was deposited.

Figure 1 shows the oxide equivalent thickness (Toxeq) of the NO film, with and without in-situ annealing for 1h, as a function of the SiN thickness. The steep increase of Toxeq in the thin SiN range suggests that the thin SiN film does not protect the bottom poly-Si from oxidation. One notes that in-situ annealing of SiN significantly improves the oxidation resistance. The distributions of Toxeq for the conventional and in-situ annealed SiN on a 6-inch wafer are shown in Fig. 2. The tight distribution in Toxeq of the in-situ annealed SiN is a result of improved oxidation resistance. The in-situ annealing improves electrical characteristics such as leakage current at the operating voltage and the destructive breakdown voltage, as shown in Fig. 3. Figure 4 shows that the time to breakdown characteristics are also improved by in-situ annealing.

In summary, in-situ annealing of the SiN film significantly improves oxidation resistance and electrical properties. In-situ annealing is expected to be a simple yet effective way to further scale down the NO capacitor dielectric film.

[1] M. Nakano et al., Sympo. VLSI Tech. Dig. 16 (1992)
[2] S.T.Kim et al., Proc. of the 43rd Symp. on Semicon. and Int. Cir. Tech., 126 (1992)

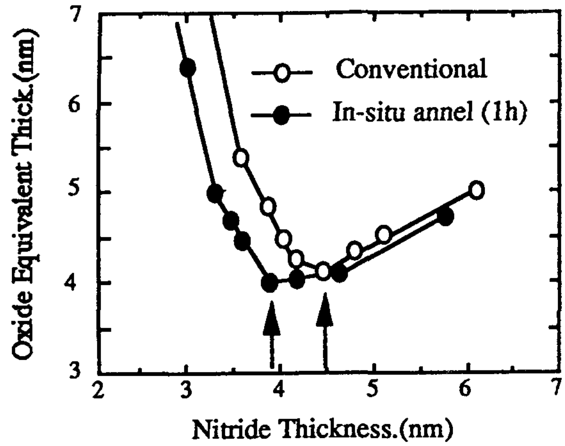

Fig.1 The oxide equivalent thickness (Toxeq) of NO capacitors as a function of the SiN thickness. Arrows indicate the critical nitride thickness below which the bottom poly-Si begins to be oxidized.

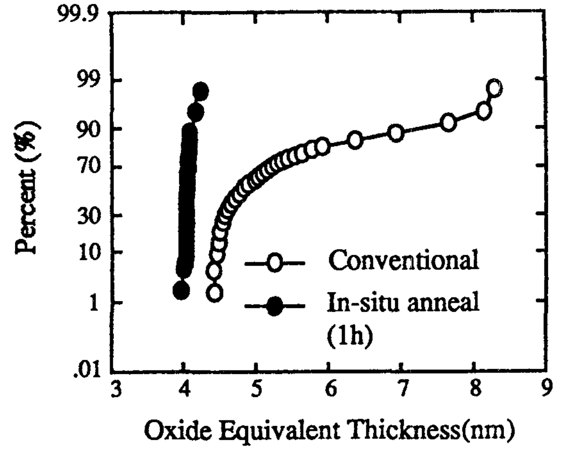

Fig.2 Toxeq distribution within a 6-inch wafer of NO capacitors with conventional and in-situ annealed nitride. The average thickness of SiN is 3.9 nm.

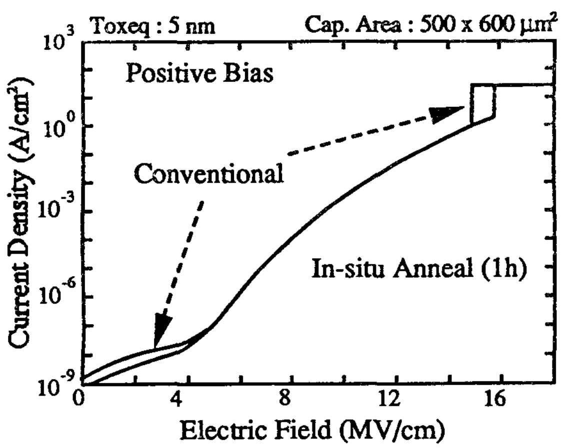

Fig.3 Plots of leakage current density vs. electric field for NO capacitors with Toxeq=5nm.

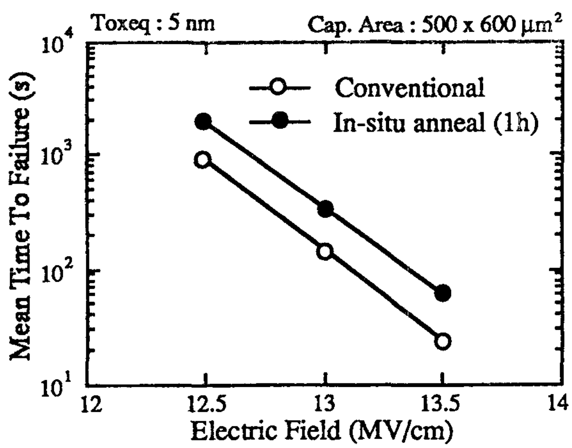

Fig.4 Time to breakdown characteristics of NO dielectric films with Toxeq=5nm.