Nitrogen-Doped SiO_2 Gate Insulator for Enhanced Stability in ALD-IGZO TFTs

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AA13: Display Application: Thin Film Transistor, Diodes, Thin Film Encapsulation for OLEDs/QDs…

Silicon nitride (SiN_x) has gained attention as an insulating layer for oxide thin-film transistors (TFTs) due to its high dielectric constant and density, though its high hydrogen content can degrade device reliability. To address this, silicon oxynitride (SiO_xN_y) structures have been explored, leveraging the benefits of both SiO_2 and SiN_x through nitrogen incorporation. Among various doping techniques, atomic layer deposition (ALD) is particularly effective due to its low-temperature process, superior step coverage, and ability to minimize hydrogen-related bonds like Si–OH.

This study proposes a nitrogen doping strategy for SiO_2 gate insulators (GI) using a nitrous oxide (N_2O) plasma reactant to optimize the active layer/GI interface and bulk properties in top-gate bottom-contact (TG-BC) IGZO TFTs. Increasing N_2O plasma power from 100 to 300 W raised the nitrogen concentration in SiO_2 from 0.7 to 2.2 at% but also increased trap densities, leading to a U-shaped threshold voltage (V_{TH}) shift from -4.1 to 4.9 V under positive bias temperature stress (PBTS). Hydrogen annealing effectively reduced the V_{TH} shift from -2.1 to 0.0 V by chemically trapping hydrogen with nitrogen atoms. A hybrid GI structure using N_2O plasma at 150 and 300 W further improved PBTS stability and hydrogen resistance, highlighting the effectiveness of this approach in enhancing IGZO TFT reliability.

References

[1] IEEE TRANSACTIONS ON ELECTRON DEVICES,VOL. 69, NO. 6, JUNE 2022

[2] IEEE TRANSACTIONS ON ELECTRONDEVICES, VOL. 67, NO. 10, OCTOBER 2020

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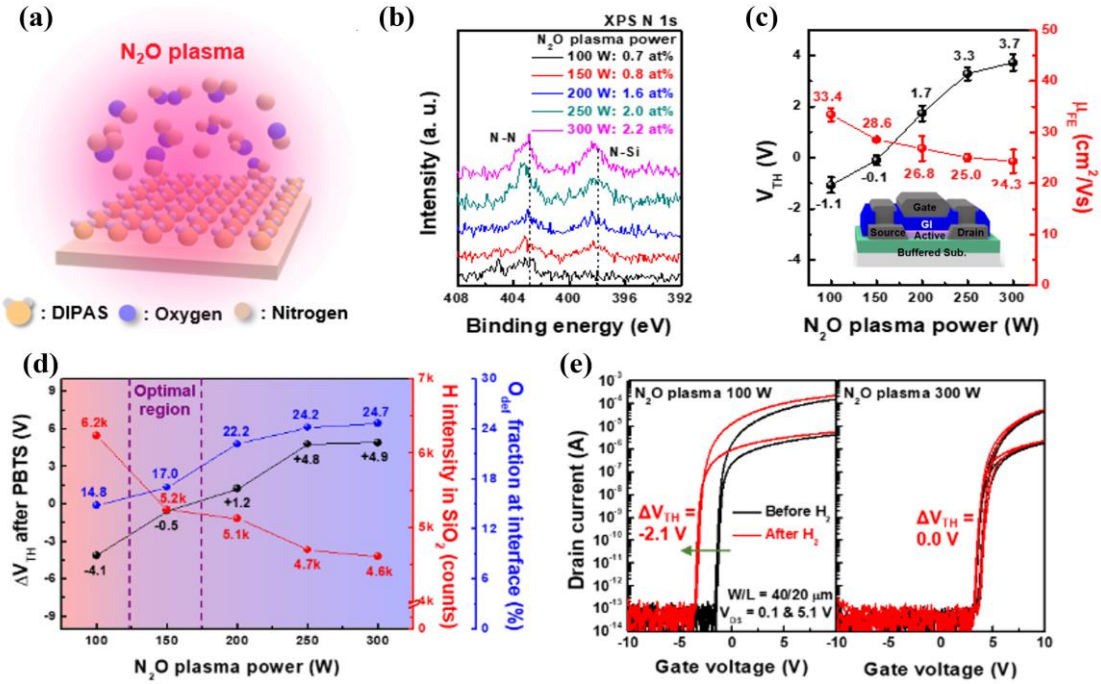

Figure1 (a) Schematic of the deposition process for N-doped SiO_2 films using N_2O plasma. X-ray photoelectron spectroscopy (XPS) spectra of (b) N 1s. (c) V_{TH} and μ_{FE} variations with N_2O plasma power during gate insulator (GI) deposition. (d) Variations in ΔV_{TH} after PBTS, H intensity in N-doped SiO_2, and O_{def} fraction at the active channel layer. (e) Transfer curves before and after H_2 annealing

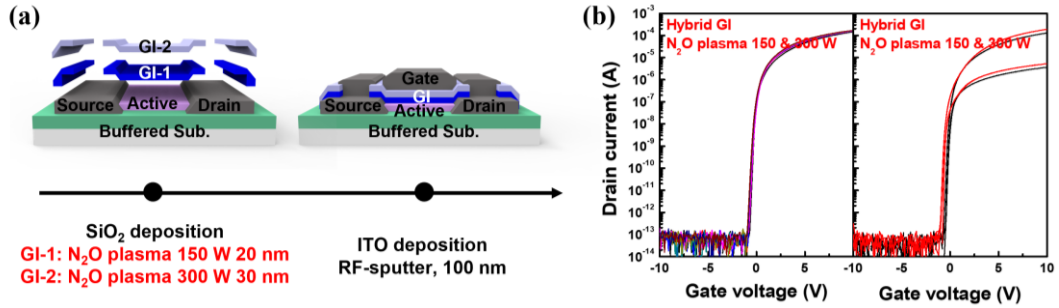

Figure2 (a) Schematic of the hybrid GI design consisting of a 20 nm N-doped SiO_2 film deposited with 150 (GI-1) and 300 W (GI-2) N_2O plasma power. (b) resistivity with H_2 annealing of devices