Trap Characterization And Microwave Power Performance In Buffer-Free AlGaN/GaN-On-SiC MISHEMTs

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Introduction: Absence of the doped GaN buffer in a traditional HEMT stack promises fewer trapping centres. For the first time in buffer-free stack, drain current transient (DCT) studies are undertaken to quantify trap activation energies and predict trap locations.

Method: We first optimized the fabrication by depositing 3 nm ex-situ SiNx via MOCVD as the gate dielectric (10 nm Al0.3Ga0.7N barrier and 200 nm GaN channel without buffer). 2x50 μm devices had 0.22 μm long gates.

In first DCT study, filling pulse (VGS,F = -5V, VDS,F = 30V) was applied for 100s, followed by unbiased recovery of 100s. Drain current was measured during recovery at logarithmically spaced intervals by applying 1μs wide pulses in linear region (VGS,M = -1V, VDS,M = 0.7V) for 40–160C, and fit using stretched exponential. Second DCT study applied different filling pulse-width from 10μs to 100s at 293K.

Results: Ex-situ MOCVD SiN raised 2DEG density from ~7E12 cm-2 to ~1E13 cm-2, and reduced gate lag from ≥25% to 6%.

Trap activation energy of 0.24 eV with 6E-19 cm-2 cross section was obtained, presumably from line defects arising near nucleation layer-channel interface. This was also corroborated by time-constants obtained when using different filling pulses.

Under 28V Class-B operation at 6 GHz and 10 GHz, an output power of 8.1 W/mm (PAE 68%) and 5.2 W/mm respectively were measured at 3dB compression for pulsed loadpull.

Conclusion: Record microwave power was demonstrated and trap signatures were identified in buffer-free GaN HEMT stack.