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$In_{0.18}Al_{0.82}N$/AlN/GaN/Si Metal-Oxide-Semiconductor Heterostructure Field-Effect Transistors with Backside Metal-Trench Design

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Abstract : $In_{0.18}Al_{0.82}N$/AlN/GaN metal-oxide-semiconductor heterostructure field-effect transistors (MOS-HFETs) having Al_2O_3 gate-dielectric and backside metal-trench structure are investigated. The Al_2O_3 gate oxide was formed by using a cost-effective non-vacuum ultrasonic spray pyrolysis deposition (USPD) method. In order to enhance the heat dissipation efficiency, metal trenches were etched 3-μm deep and evaporated with a 150-nm thick Ni film on the backside of the Si substrate. The present $In_{0.18}Al_{0.82}N$/AlN/GaN MOS-HFET (Schottky-gate HFET) has demonstrated improved maximum drain-source current density (IDS, max) of 1.08 (0.86) A/mm at VDS = 8 V, gate-voltage swing (GVS) of 4 (2) V, on/off-current ratio (Ion/Ioff) of 8.9×10^8 (7.4×10^4), subthreshold swing (SS) of 140 (244) mV/dec, two-terminal off-state gate-drain breakdown voltage (BVGD) of -191.1 (-173.8) V, turn-on voltage (Von) of 4.2 (1.2) V, and three-terminal on-state drain-source breakdown voltage (BVDS) of 155.9 (98.5) V. Enhanced power performances, including saturated output power (Pout) of 27.9 (21.5) dBm, power gain (G_a) of 20.3 (15.5) dB, and power-added efficiency (PAE) of 44.3% (34.8%), are obtained. Superior breakdown and RF power performances are achieved. The present $In_{0.18}Al_{0.82}N$/AlN/GaN MOS-HFET design with backside metal-trench is advantageous for high-power circuit applications.

Keywords : backside metal-trench, InAlN/AlN/GaN, MOS-HFET, non-vacuum ultrasonic spray pyrolysis deposition
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