Current State-of-the-Art of Gallium Oxide Power Device Technology

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Recently, gallium oxide (Ga_2O_3) has emerged as a new competitor to SiC and GaN in the race toward next-generation power devices by virtue of the excellent material properties and the relative ease of mass wafer production. Following a short introduction of material properties and features of Ga_2O_3, this presentation will review our recent development progress in device processing and characterization of Ga_2O_3 metal-oxide-semiconductor field-effect transistors (MOSFETs) and Schottky barrier diodes (SBDs).

Ga_2O_3 MOSFETs were fabricated with unintentionally-doped (UID) Ga_2O_3 epitaxial layers grown on semi-insulating Fe-doped β-Ga_2O_3 (010) substrates by ozone molecular beam epitaxy [1]. Selective-area Si-ion implantation doping of the UID Ga_2O_3 epitaxial layer formed the device channel and ohmic contacts [2], while the high resistivity of UID Ga_2O_3 was utilized for planar device isolation without mesa etching. SiO_2-passivated depletion-mode MOSFETs with a gate-connected field plate (FP) demonstrated a high off-state breakdown voltage (V_{br}) of 755 V, a large drain current on/off ratio of over nine orders of magnitude, DC-RF dispersion-free output characteristics, and stable high temperature operation against thermal stress at 300°C.

We also fabricated and characterized Pt/Ga_2O_3 FP-SBDs on n^--Ga_2O_3 drift layers grown on n^+-Ga_2O_3 (001) substrates [3], owing to the success of halide vapor phase epitaxy for high-speed growth of high-quality Ga_2O_3 thin films [4, 5]. The illustrative device with a net donor concentration of 1.8×10^{16} cm^{-3} exhibited a specific on-resistance of 5.1 $\mathrm{m\Omega\cdot cm^2}$ and an ideality factor of 1.05 at room temperature. Successful FP engineering resulted in a high V_{br} of 1076 V. Note that this was the first demonstration of V_{br} of over 1 kV in any Ga_2O_3 power devices.

In summary, the FP-MOSFETs and FP-SBDs revealed excellent device characteristics and demonstrated great potential of Ga_2O_3 devices for power electronics applications.

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