

In-situ Dynamic R_{ON} Measurement of 1.2 kV Vertical GaN JFET

The dynamic R_{ON} is measured using a continuous hard-switching double pulse test (DPT) with an active measurement circuit. The test circuit schematic is shown in Fig. 1 (a). A standard MOSFET driver is used for GaN HEMTs and SiC MOSFETs and an RC-interface gate driver is used for GaN JFET, which is shown in Fig. 1 (b). A voltage clipper is connected to the DUT for measuring the on-state voltage drop (V_{DS}). A photo of the prototyped circuit board is shown in Fig. 1 (c). Fig. 1 (d) shows the waveforms in one cycle of the continuous DPT for SiC MOSFET. To cancel the noise caused by clipper, the R_{ON} at moment t_0 is calculated by averaging 500 measurements of R_{ON} spanning a 200 ns period based on the equation (1). As shown in Fig. 1 (e), the measurement system and data analysis method are applied to SiC MOSFETs and GaN HEMTs for calibration and verification.

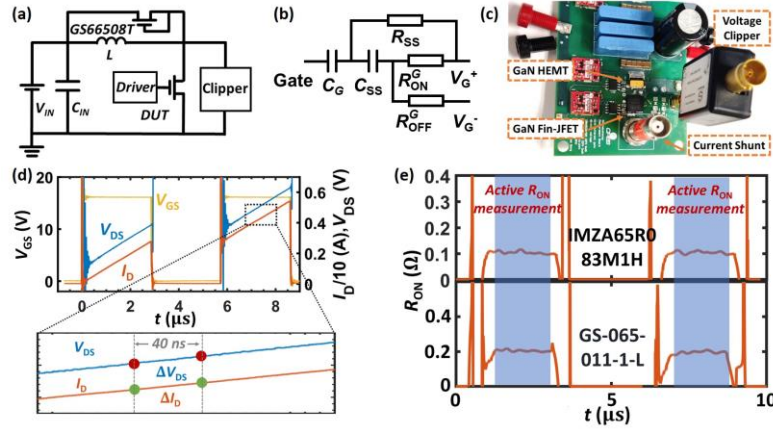


Fig. 1. (a) Circuit schematic of test setup (b) RC-interface driver (c) Photo of the test setup (d) A cycle of DPT waveforms and the illustration of the R_{ON} extraction method (e) Extracted R_{ON} of 650 V SiC MOSFET (top) and GaN SP-HEMT (bottom) in a DPT cycle at 400 V V_{IN}

$$R_{on}(t_0) = \sum_{t_i=t_0, t_0+0.4ns, \dots}^{t_0+200ns} \frac{V_{DS}(t_i + 40ns) - V_{DS}(t_i)}{I_D(t_i + 40ns) - I_D(t_i)} / 500 \quad (1)$$

Fig. 2 (a) shows the dynamic R_{ON} as a function of V_{DC} at 10 A peak turn-off current (I_{PEAK}), and Fig. 2 (b) presents the results at different I_{PEAK} with 800 V V_{DC} . The dynamic R_{ON} of GaN JFETs under various conditions are found to be only associated with the elevated junction temperature, and the normalized value remains nearly at unity under all conditions. These results demonstrate that the vertical GaN JFET is dynamic R_{ON} free.

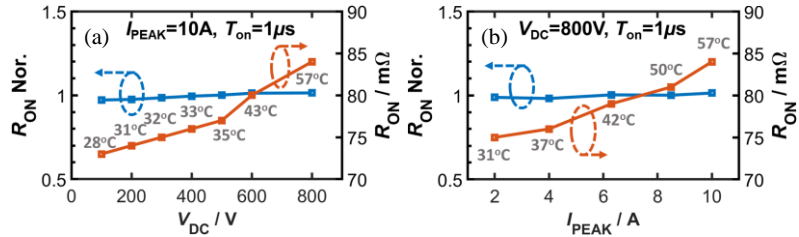


Fig. 2. Extracted dynamic R_{ON} and the normalized dynamic R_{ON} of vertical GaN JFET (a) As a function of V_{DC} at $I_{PEAK} = 10$ A (b) As a function of I_{PEAK} at $V_{DC} = 800$ V

In summary, this work presents the first experimental characterization of dynamic R_{ON} in vertical GaN JFETs. The dynamic R_{ON} is measured in-situ in a steady-state switching circuit, the 1200 V vertical GaN JFETs show negligible R_{ON} shifts in these tests, revealing significantly superior stability as compared to some GaN HEMTs. These results show the great potential of vertical GaN devices for power electronics applications.