Title

Design of gate driver monolithically integrated with power p-GaN HEMT based on E-mode GaN-on-Si technology

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Abstract

We report on the design of a gate driver, monolithically integrated with power p-Gallium Nitride gate High Electron Mobility Transistor (p-GaN HEMT) and based on Enhancement mode GaN-on-Si technology developed in IMEC.

[Problem statement]

GaN HEMTs have fast switching speeds which have never been reached by other Si-based MOSFETs, consequently they enable decreased switching energy loss and high power efficiency. It is desirable to operate at MHz switching frequency because small size and volume is desirable for power electronics circuits. However, GaN-HEMT's fast switching performance has been limited by parasitic inductance and capacitance which mainly originate from the path between the gate of HEMT and the gate driver. We verified the parasitic issue of the gate driver by experiment, by designing a switching circuit around the p-GAN HEMT, with a separated gate driver. As a result, the maximum switching frequency was 5 MHz at 50 V of OFF-state drain-source voltage, and 5 A of drain current.

[Description of methodology, Key results]

We propose monolithic integration of the HEMT with gate driver in p-gate enhancement mode GaN-on-Si technology in order to overcome aforementioned problem.

The gate driver circuit has a 2-stage structure. In the first stage, a GaN HEMT's and resistors are configured as a pair of inverters. The HEMTs have small input capacitance, thereby delivering a signal with high rise and fall time to the second stage. The second stage consists of a pair of HEMTs with enough capability to supply current for the power HEMT.

The monolithically integrated circuit has been evaluated by the ADS (Advanced Design System) circuit simulator from Keysight. The p-GaN HEMT model is developed based on MVSG-HV (MIT Virtual Source GaNFET-High Voltage) compact model. Model parameters are fitted by both of DC and switching characteristics from experimental results, this guaranteeing reliable simulation results. The results show that the gate driver circuit can operate the power HEMT.

[Conclusion]

In conclusion, the monolithic integration circuit of the gate driver and power HEMT has been proposed to achieve more than 10 MHz switching frequency. We established a reliable design environment with MVSG-HV model calibrated by measurement data. The integration circuit is verified by the simulation.