A GaN on SiC HFET Device Technology for Wireless Infrastructure Applications

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I. INTRODUCTION AND DEVICE STRUCTURE

This paper presents Freescale's baseline GaN device technology for wireless infrastructure applications. At 48 V drain bias and 2.1 GHz operating frequency, strong power scaling is demonstrated with 10-11 W/mm realized on 0.3 mm devices and 5.9 W/mm demonstrated for 12.6 mm devices. The technology employs an un-doped AlGaN/GaN HFET structure grown on 3" SiC semi-insulating substrates with a sheet resistance of approximately 380 ohms/sq. Device processing includes ECR mesa etch isolation, Ti/Al/Mo/Au ohmic contacts, SiN passivation, Ni-Au gates, and plated Au air-bridges. After front-side processing, the SiC substrates are thinned to a thickness of 4 mils and back-metallized using a Au plating process.

II. COMPARISON OF DC AND PULSED I-V CHARACTERISTICS

Figure 1 shows the pulsed I_D-V_D behavior of a 2x150 µm device for the case of V_G=0V showing little, if any, collapse of the knee voltage for open channel conditions. These data were taken at a quiescent drain voltage of 25 V with the channel pinched off (V_{GS}=-5V).

III. ON-WAFER LOADPULL RESULTS

Figure 2 shows representative drive-up data for six 2x150 µm devices tested at a drain bias voltage of 48 V and a frequency of 2.1 GHz. The data in the figure show a power density that ranges between 10 and 11 W/mm with associated PAE's in the range of 62-67%.

IV. PACKAGED DEVICE LARGE SIGNAL PERFORMANCE AT 2.14 GHz

Figure 3 shows 2.14 GHz CW drive up characteristics for a 12.6 mm device. As can be seen from the data, a saturated output power of 74 W (5.9 W/mm) is achieved at a drain bias voltage of 48 V. It is estimated that the down bonds used here instead of source vias reduces the gain of the device by 1.5-2 dB. Single carrier W-CDMA linearity shown in Figure 4 shows an output power of approximately 10 W under the constraint of a -40 dBc ACPR. Under these conditions, the PAE is 27% as shown in Figure 5. As shown in Figure 6, at 74 W, 5.9 W/mm, the CW performance of packaged 12.6 mm devices sets a new benchmark for power density (5.9W/mm) of a microwave device with an output power in excess of 50 W.

REFERENCES

[1] C.E. Weitzel, P. Asbeck, "Advanced Technologies for Power Amplifiers", Workshop Notes, IEEE Int'l Microwave Symposium, Long Beach, Calif., June 12-17, 2005.

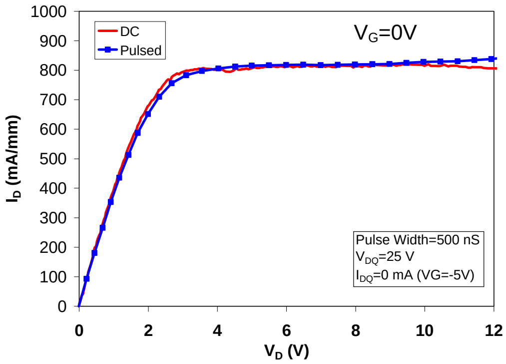

Figure 1: Comparison of DC and pulsed IV characteristics for a 2x150 µm AlGaN/GaN HFET. Quiescent drain bias is 25 V and quiescent gate bias is -5 V. Pulse length is 0.5 µS and the period between pulses is 1 mS.

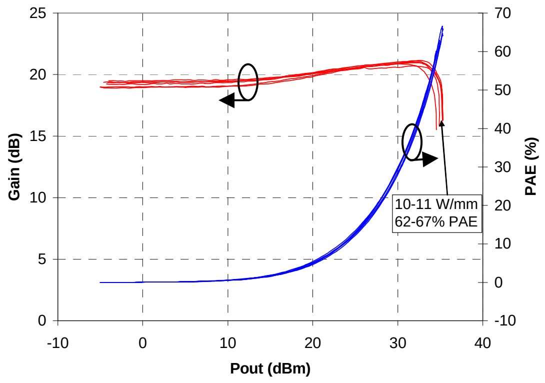

Figure 2: On-wafer saturation characteristics at V_D=48 V, I_{DQ}=40 mA for 2x150 µm device.

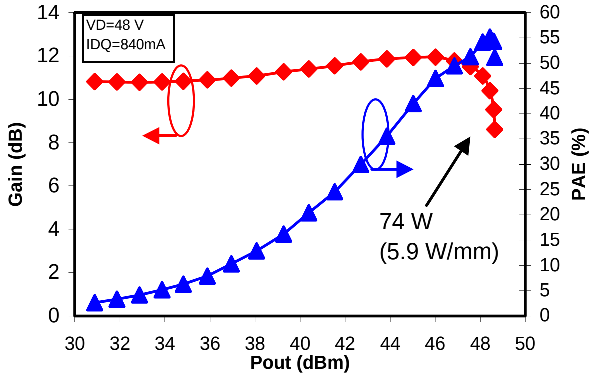

Figure 3: Packaged loadpull data at 2.14 GHz, 48 V drain bias for 12.6 mm device.

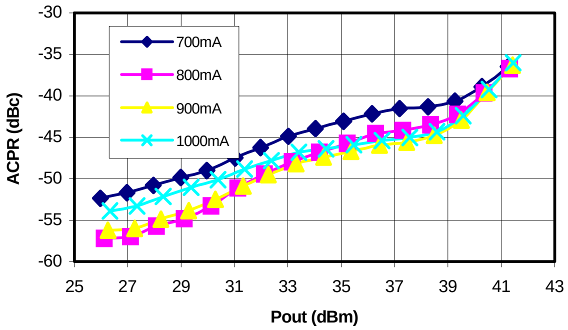

Figure 4: ACPR vs. output power data for 12.6 mm AlGaN HFET at V_D=28 V for various quiescent drain currents taken using a 3GPP signal with 8.7 dB peak to average ratio.

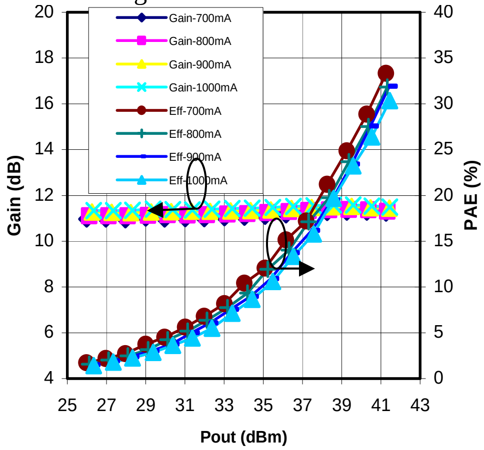

Figure 5: Gain and PAE vs. output power for 12.6 mm AlGaN HFET at VD=28 V for various quiescent drain currents.

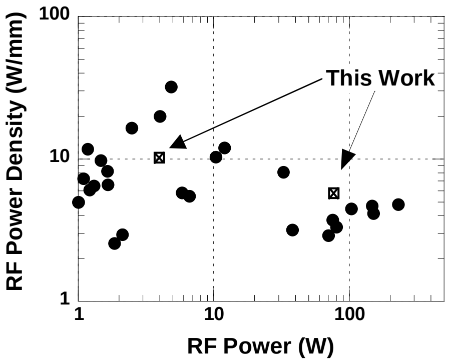

Figure 6: Comparison of RF performance in this work to published literature results for CW GaN microwave power devices [1].