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TOPIC:

AlGaN/GaN HEMT Devices for RF Applications

ABSTRACT:

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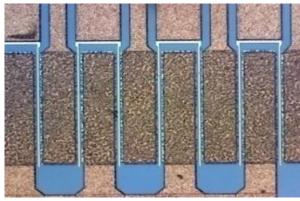
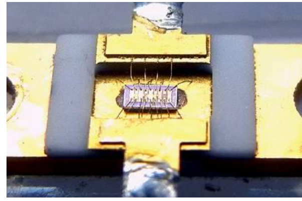
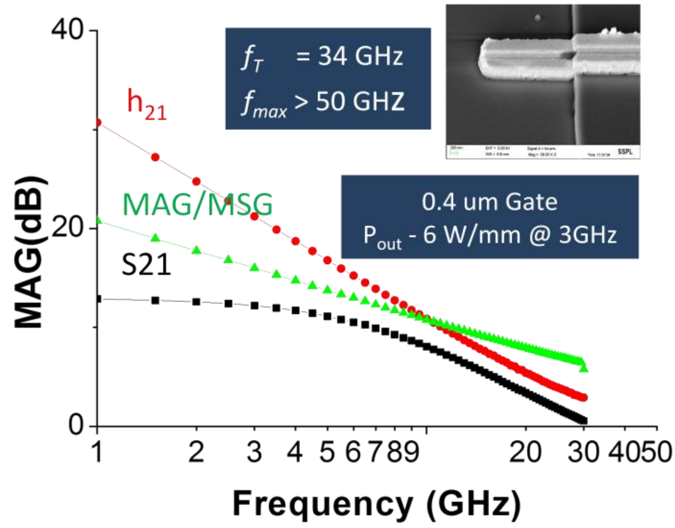
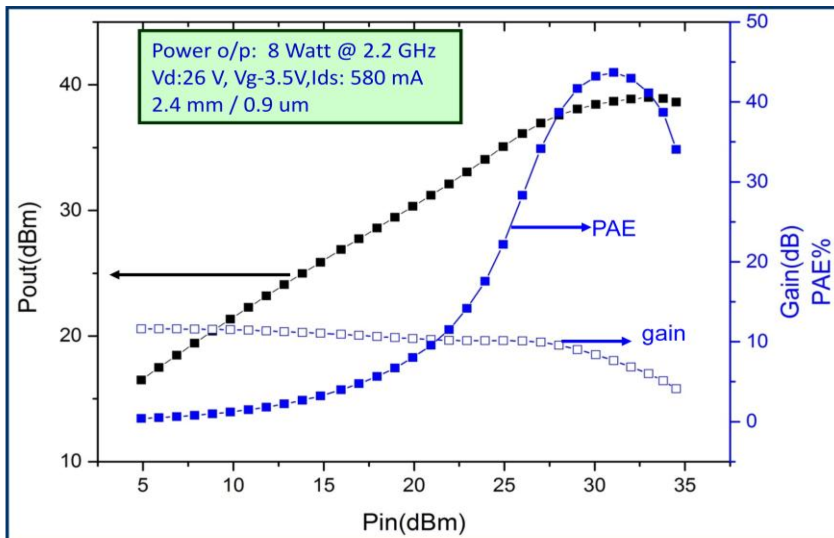
This paper presents an overview of our GaN High electron mobility transistor (HEMT) development program on SiC substrates. The optimization of device technology and performance is targeted towards RF applications up to 10 GHz. We use two different approaches towards device processing. The first one is our baseline process using optical lithography with a gate length of 0.9 µm and has been found suitable for L and S band applications. The second one uses electron beam direct write and a T gate formation in the passivation layer with gate length of 0.4 µm for C and X band applications. The metal stack of annealed Ti/Al/Ni/Au ohmic contact for source drain formation has been developed with Rc values between 0.3-0.6 ohm-mm. The pre nitride annealing of Ni/Au schottky gate contacts results in reduction in gate leakage current by two orders to 5 µA/mm @ 60 V. BCl3/Cl2 based ICPRIE process has been developed to get smooth morphology and desired slope of side walls. The critical process of surface passivation using Si3N4 films with in-situ surface treatment has been developed using both PECVD and ICPCVD techniques. The 0.4 µm gates are defined by etching a slit in Si3N4 of desired shape and covering this slit with T shaped Ni/Au metal. The thermal, physical and chemical effect on the surface during device processing has been investigated to maintain the high output power level. Good control over the high frequency current collapse and knee walk out phenomenon has been achieved while retaining the Vboff of >40 V. S-parameter measurement of devices were measured after electrical stress. Devices with knee walk out show an increased access resistance which confirms the activation of traps under high electric field. Bias stablization circuit has been developed to test large periphery packaged devices. The 2.4 mm gate width/0.9 µm gate length device achieves saturated Pout of 8 W at 2.2 GHz with power added efficiency of ~45% and associated gain of 7 dB. The developed HEMTs with 0.4 µm gate demonstrate extrapolated RF power of 4.5 W/mm at 10 GHz and a device cut-off frequency of 34 GHz.







f_T = 34 GHz
f_{max} > 50 GHZ
h21
MAG/MSG
S21
0.4 um Gate
P_{out} - 6 W/mm @ 3GHz
MAG(dB)
Frequency (GHz)



Power o/p: 8 Watt @ 2.2 GHz
Vd:26 V, Vg-3.5V,Ids: 580 mA
2.4 mm / 0.9 um
PAE
gain
Pout(dBm)
Gain(dB)
PAE%
Pin(dBm)