Estimation of Input Power Handling Capability of Next-Generation GaN Schottky Diodes for Millimeter Wave Frequency Multipliers

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***Abstract*—This abstract is on the estimation of input power handling capability of GaN Schottky diodes developed till date. The destructive reverse breakdown voltage is characterized as -69.5 V for the diodes developed with the epitaxy having active epilayer thickness 590 nm and doped at 6.6×10^{16} cm^{-3} on 6H-SiC substrate. Simulations based on a 2-anode varactor doubler with optimized efficiency show that an input power as high as 500 mW can be applied to a single GaN Schottky diode until the diode voltage swing reaches the limit of reverse destruction.**

Keywords—doubler, GaN Schottky, local oscillator, millimeter wave, power handling, reverse breakdown voltage.

I. Introduction

Schottky diodes play a key role in local oscillator (LO) and detector systems in the instruments for planetary and Earth sciences [1]. GaAs technology is the solution so far for the millimeter wave and sub-millimeter wave bands. But, exploration of GaN Schottky technology is a promising one for the LO power generation at millimeter wave band in view of excellent power handling capability [1], [2].

Recently, GaN Schottky diodes with small anode sizes are developed and characterized on 6H-SiC substrate after rigorous and successful development on Sapphire substrate through e-beam lithography [3]. Destructive reverse breakdown voltage is characterized to be -69.5 V for an epitaxy of active epilayer thickness 590 nm and doping density of the n^- layer as 6.6×10^{16} cm^{-3}. Mobility of the epitaxy is determined as ~ 400 $cm^2/V.s.$ which is substantially low. This low mobility is attributed to the high defect density of the crystal inherent to the large mismatch between GaN and the substrate [4]. In homoepitaxy context, the GaN electron mobility can reach 1000-1200 $cm^2/V.s.$ and better results can be expected on GaN substrate particularly for the breakdown voltage.

Parameters of the diode after DC measurements are listed in Table 1. Aim of the present abstract is the estimation of input power handling capability of the developed GaN Schottky diode. The frequency of operation is chosen as 105-120 GHz to fit the atmospheric absorption bands in addition to the potential application for the low frequency LO stages, for an example 1.06 THz LO source [5]. A 2-anode varactor doubler configuration is considered for the simulations due to limited commercial availability of driver source having power level 1 W or more.

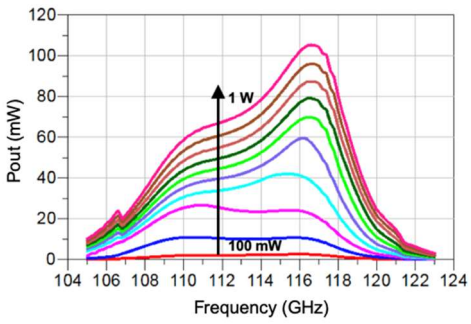

Fig. 1. Simulated performance of a 2-anode GaN Schottky varactor.

TABLE I. Parameters of GaN Schottky Diode

Diameter (μm)	*Destructive Reverse Breakdown Voltage (V)*	C_{j0} *(fF)*	R_S *(Ω)*
6	-69.5	27.3	34.7

II. Doubler Simulation

Simulated performance of the 2-anode GaN Schottky doubler in electromagnetic environment for different input power level is shown in Fig. 1. Reverse bias of the varactor doubler is optimized to achieve the best efficiency with the experimentally obtained diode parameters. Input power is increased but to keep the voltage swing across each diode well below the destructive reverse breakdown voltage. It is seen that an input power as high as 500 mW/anode can be applied. However, the best efficiency of the doubler is achieved over a certain input power level. Further GaN Schottky diodes for multiplier application with the objectives of input power handling capability and efficiency while operating at multiple frequency bands are under fabrication for experimental verifications.

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