Low Turn-On Voltage Schottky Diode in InGaP/GaAs HBT/BiFET Processes

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InGaP/GaAs heterojunction bipolar transistors (HBT) and bipolar field effect transistor processes are widely used for wireless applications since they offer excellent features such as high power density and high efficiency. In typical InGaP/GaAs HBT/BiFET processes, Schottky diode turn-on voltage is approximately 0.7V. Given the complexity of today's circuits used in wireless applications, a lower turn-on voltage diode is desired in addition to the regular Schottky device for added design flexibility.

The standard Schottky device is formed by use of the first metal interconnect layer or the FET gate metal layer directly on an n-doped GaAs layer. Given the work functions of the metals used in GaAs processes such as Au, Pt, W, Ni, and Ti, the resulting Schottky barrier height may be between 0.7V and 1V[1]. Skyworks' current InGaP/GaAs processes use a Ti/Pt/Au stack for the first metal interconnect which results in a Schottky diode with a barrier height of 0.8V and a turn-on voltage of 0.7V at a current density of 10 $\mu A/\mu m^2$.

For some applications (e.g., diode voltage drops, detectors, and mixers), a lower turn-on voltage is desirable. A lower turn-on Schottky diode can be configured as a planar doped barrier diode detector [2]. However, such a design typically involves materials generally not compatible with the fabrication of HBTs. Similarly, barrier-lowering schemes which involve the growth of a thin layer of opposite doping polarity are also generally not compatible with HBT processes.

In this work, we propose a novel Schottky diode structure in an InGaP/GaAs HBT/BiFET process with a reduced turn-on voltage. The new device uses Tantalum Nitride (TaN) as the anode material and barrier between the first metal interconnect and the n-type GaAs, the cathode. Figure 1 shows a diagram of the structure. The device has the same definition as Skyworks' current Schottky diode except for the addition of the TaN layer, with an active area defined by the TaN plate size. This device is fabricated in Skyworks' standard InGaP/GaAs HBT/BiFET processes with no added cost, such as additional masks, processing, or materials, since it uses the TaN module regularly used for our precision thin-film resistors.

Similar TaN Schottky devices have only been reported so far on Silicon [3] and Germanium [4] with barrier heights of 0.5V for n-Si, between 0.54V and 0.67V for p-Si, and 0.45V on n-Ge.

Skyworks' novel device has a turn-on voltage of approximately 0.42V (please see Figure 2). A typical diode I-V characteristic is depicted in Figure 3. The full paper will discuss the diode characteristics while further analysis of device parameters such as the barrier height and the Richardson constant will be included (Figure 4).

In conclusion, with this work we report on a novel Schottky diode with a lowered barrier height and turn-on voltage in InGaP/GaAs HBT/BiFET processes based on the use of TaN as the anode material. The new device adds flexibility to analog designs in III-V materials.

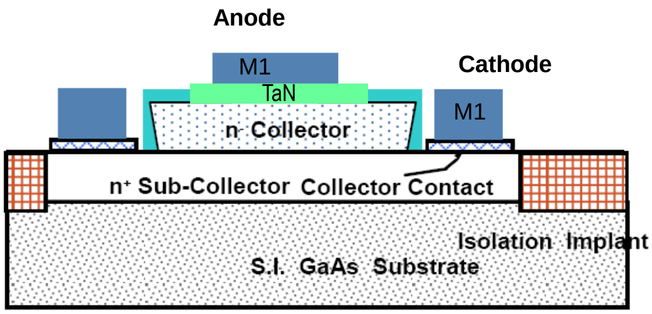
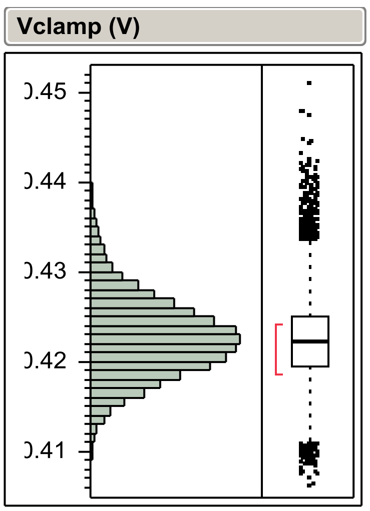


Figure 1. Schematic of the TaN Schottky diode.



Moments

Mean	0.4226646
Std Dev	0.0045216
Std Err Mean	3.5853e-5
Upper 95% Mean	0.4227349
Lower 95% Mean	0.4225944
N	15905

Figure 2. Distribution of measured diode turn-on voltage across a large sample.

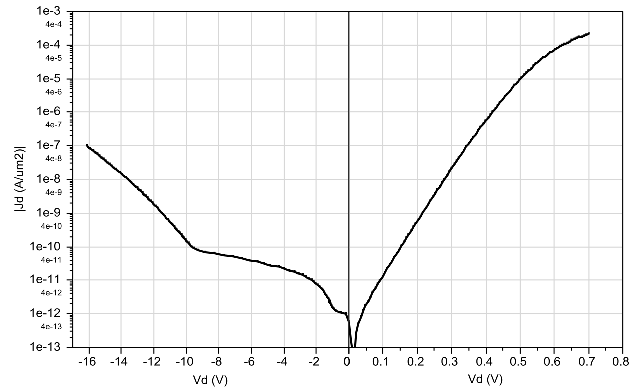


Figure 3. Forward and reverse I-V curves of the TaN Schottky diode (absolute values).

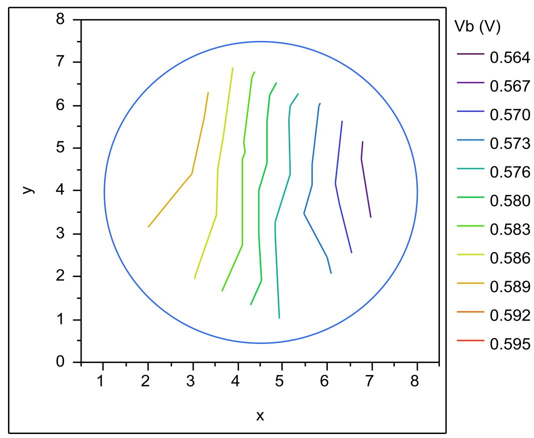


Figure 4. Averaged barrier height variation across wafer.

References

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