Development of GaN HEMTs based Biosensor

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Introduction

In recent years, AlGaN/GaN HEMTs structure has drawn the substantial attention of researchers for biosensing applications. This is primarily due to its outstanding properties such as high n_s, high μ, higher chemical and thermal stability, higher sensitivity, and non-toxicity to the living cells. In this paper, we are reporting on the development of GaN HEMTs based biosensor for sensing/bio sensing applications.

Aim of the study

Aim of the study is to optimize various processing steps for the development of GaN HEMTs based biosensor for various relevant applications. At the end, to develope GaN HEMTs biosensor chip and package. Technology modifications are aimed in the direction to achieve high transconductance/high sensitivity and low response time on large area devices required in the sensing applications.

Methods

To develope the GaN HEMTs biosensor, device and epitaxial designs were first simulated, keeping in mind the best possible parameters for high I_{ds} and g_m at large $L_{sd.}$ Different methods and techniques were used to optimize critical levels in the processing. Various metal stacks, variations in the thicknesses of the metals stacks along with different surface treatments were incorporated in the optimization process of Ohmic and Schottky contacts. To isolate the device, RIE and ion implantation were used having different combinations of the gas and ions. Several energies were simulated and implemented to increase the isolation resistance. In order to realise the sensing layers, hard masks were used based upon the high-k and low-k dielectric materials.

Results

GaN HEMTs based biosensors of 2x50 μm and 2x125 μm areas were designed and fabricated on chip and package level. Optimized Ohmic contacts showed a very low ρc of 6×10^{-6} ohm-cm^2. A barrier height around 1.0 eV was achieved on the Ni based Schottky contacts. An isolation resistance of 0.6 MΩ was recorded on the RIE samples. Among the deposited high k and low k dielectric materials, Al_2O_3 proved best in improving the current collapse. The fabricated 2x50 μm devices delivered a drain current of 0.5 A/mm @ V_{gs} = 1.0 V (shown in Fig.1) and transconductance of 160 mS/mm, which are actually pretty good figures for the L_{sd} of 50 μm. Devices pinched at around -4.2 V as shown in Fig.2.

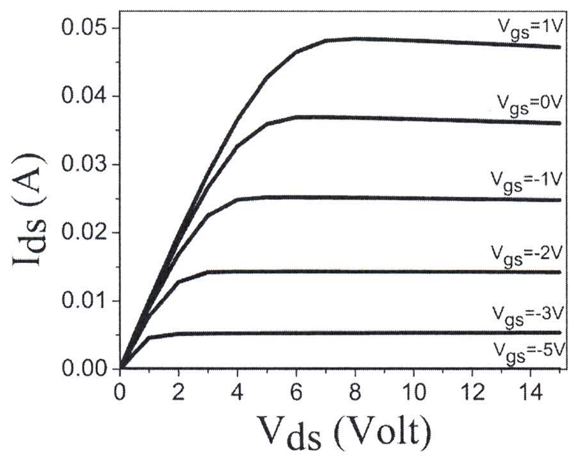

Fig.1 Output Characteristics of GaN HEMT

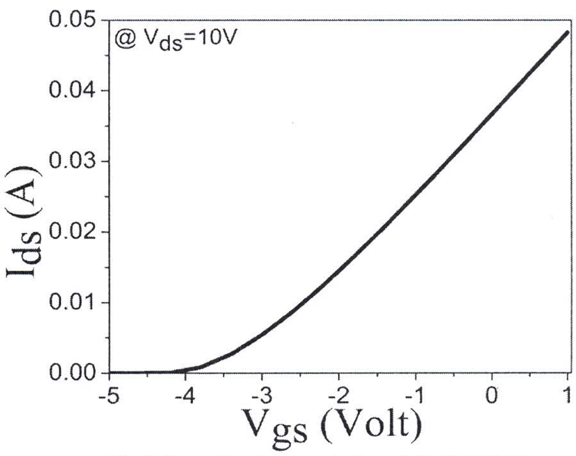

Fig.2 Transfer characteristics of GaN HEMT

Sensor chip was characterized at 1 V before and after packaging. Fig. 3 shows the packaged sensor and on package characterization results. Drain current in the range of mA and repeatability during pulse measurements show the performance best suitable for the development of relevant electronics. Two versions of the sensors namely gateless and gated were used for the femtolevel salt detection in the water and cancer cells.

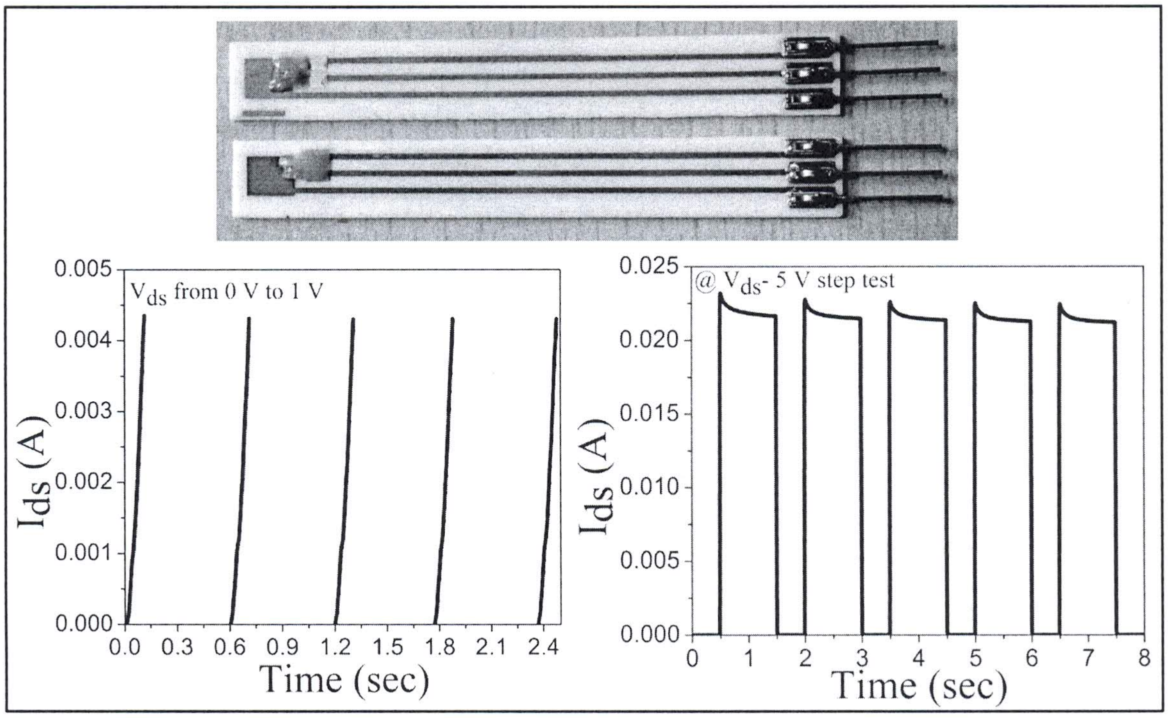

Fig.3 On package results

Conclusion

GaN HEMTs based biosensors are designed and fabricated using various technology optimization steps. Devices showed very good repeatability in continuous and pulse mode mesaurements at package level. Gate less and gated version of the sensors were used for the salt and cancer cell detection.

Key words

HEMTs, GaN, Sensor, biosensor, Ohmic