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# High-Electron-Mobility-Transistor AlGaN/GaN pH Sensor

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**Abstract-** The sensitivity of GaN HEMTs upon exposure of the gate space to phosphate solution (PBS) has been explored. Output characteristic of the device reveals that the drain current decreases linearly with hydrogen ion concentration values. Higher hydrogen ion concentration contains less $H^+$ concentration and that is tends to lower the drain current. A high sensitivity of 4.32 µA/mm-pH at $V_{ds}$= + 1V is obtained.

**Index Terms-**Gallium nitride HEMTs, pH sensor characterization, pH measurement, Response time, Sensitivity.

## 1. INTRODUCTION

AlGaN/GaN high-electron-mobility-transistor (HEMT) are very use-full for liquid device (pH device, salinity sensor), gas device and as a biosensor due to its outstanding properties like chemical stability, low toxicity, and superior physical phenomenon due to the high saturation speed and high sheet carrier concentration of the two-dimensional lepton gas (2DEG) layer during a AlGaN/GaN heterostructure[5]. Furthermore, pH sensors fictitious from the GaN material area unit principally of nice importance in chemical and biological experiments in area applications. In this paper, we have a tendency to area unit coverage on the event of GaN HEMTs primarily based pH device.

## 2. AIM OF STUDY

Main aim of the study is to through an experiment check and appraise the performance of GaN based mostly pH sensing element. Varied pH solutions were checked to validate and verify the technology.

## 3. METHODOLGY

The AlGaN/GaN HEMTs structure consisted of two nm AlN nucleation layer, followed by a 2.3 µm thick unintentionally doped GaN buffer layer, and at last followed by a 25nm thick n-type $Al_{0.25}Ga_{0.75}N$ layer. Supply and drain resistance unit contacts were obtained by e-beam metallization of Ti/Al/Ni/Au stack. Multi-energy particle implantation processes were used for the device isolation. Ni-based Schottky contacts with Au as a high layer were used for gate contact. Devices were interconnected victimization Ti/Au. Laborious mask was wont to encapsulate the source/drain regions except the gap for bias. Channel space was unbroken hospitable permit the liquid solutions of various pH to pass and react with the channel surface as shown in Fig.1a.

## 4. OUTCOME

In order to research the drain current response of $H^+$ concentration, PBS with pH scale four, pH scale seven and pH scale ten were utilized in the channel space. The output drain current in Fig.1b showed the upper pH scale solutions that contained less $H^+$ concentration resulted lower current. This development may be explained by mistreatment site-binding model [6].

$$MOH \leftrightarrow MO^- + H^+ \quad (1)$$
$$MOH + H^+ \leftrightarrow MOH_2^+ \quad (2)$$

It was accounted that amphiprotic radical team (MOH: M might represent Ga) area unit fashioned at the compound surface in-tuned with liquid solutions. The amphiprotic radical team is also neutral, protonized or deprotonized, reckoning on the $H^+$ concentration. Increase in $H^+$ concentration on the surface resulted a lot of charged ions as a result of $MO_2^+$ formation, and 2DEG concentration multiplied so as to compensate the evoked charge within the surface. The reverse development occurred by decreasing $H^+$ concentration.

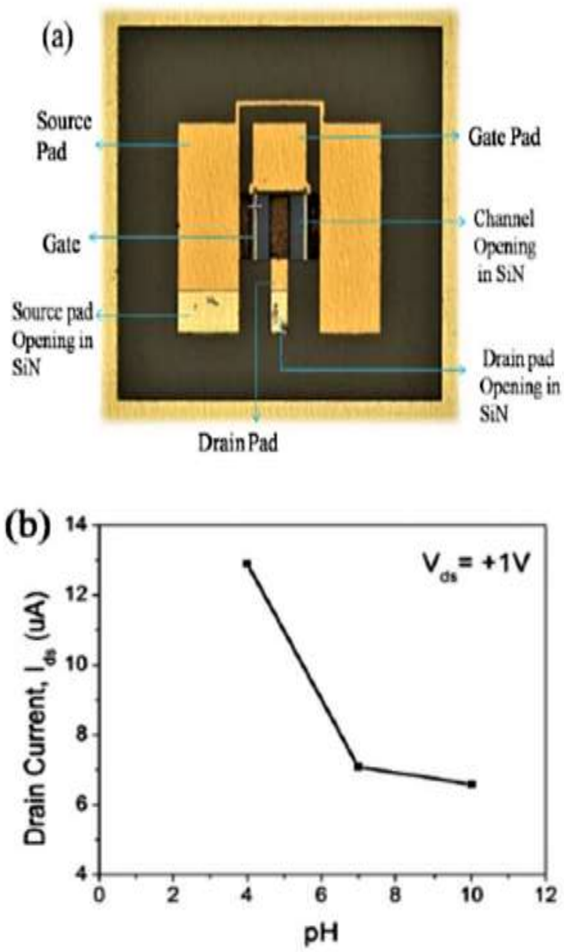


Fig.1. (a) Image of fabricated device $W_G$= 125µm, $L_G$= 1µm, Source-drain length ($L_{SD}$=50 µm)
(b) Drain current Vs pH measured at $V_{DS}$ = +1 V.

## 5. CONCLUSION

The sensitivity of GaN HEMTs upon exposure of the gate space to phosphate solution (PBS) was explored. Output drain characteristic of the device unconcealed that the drain current decreased linearly with pH values. Higher pH contained less $H^+$ concentration that tends to lower the drain current. A high sensitivity of 4.32 µA/mm-pH at $V_{ds}$= + 1V was recorded.

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