

The Sensing Performance of Undoped-AlGa_N/Ga_N/Sapphire HEMT Hydrogen Gas Sensor

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Abstract

The hydrogen sensing characteristics of undoped-AlGa_N/Ga_N/sapphire circular Schottky diodes are systematically studied and compared over wide hydrogen concentration and temperature ranges. High purity hydrogen gas was exposed to the sample together with the ambient gas of either air or pure nitrogen or without ambient gas (vacuum) at pressure in the range of 50 Torr to 200 Torr was used for both types of ambient gases. The sensing characteristics at different hydrogen concentration are investigated. The sensitivity to hydrogen gas was also investigated in dependence of various catalytic metals thickness and operating temperatures.

Keywords: wide bandgap; Sensor; catalytic metal

1. Introduction

Increasing regulations on the release of gases or other chemicals into the environment have led to the increased attention on the development of advanced sensors. Until now, there have been many reports on chemicals sensors using metal-oxide compound semiconductors, such as SnO₂ and ZnO[1,2]. However, the sensing mechanism of these compound semiconductors is related to various defects such as oxygen vacancy and metal vacancy. In addition, these materials are also not suitable for high temperature.

In this paper, AlGa_N/Ga_N HEMT is studied for hydrogen gas sensing at elevated temperature. The 2DEG concentration and mobility of our sample are around $1 \times 10^{13} \text{ cm}^{-2}$ and $1000 \text{ cm}^2/\text{Vsec}$, respectively. The sensitivity to hydrogen gas was investigated in dependence of various catalytic metals thickness and operating temperatures. The sensing characteristics at

different hydrogen concentration are also investigated.

2. Experimental

Fig. 1 illustrates the material structure of the sensor devices. All the structure as shown in Fig. 1 (a), (b) and (c) were grown by metal organic chemical vapor deposition (MOCVD) on 430 μm c-plane sapphire substrates. After epitaxial growth, the devices were etched by an inductively-couple-plasma reactive ion etching (ICP-RIE) system for mesa isolation. Fig. 2 (a) and (b) was shown the structure of sensor device. For FET type as shown in Fig. 2(a), a four-layer Ti/Al/Ni/Au for ohmic contacts was evaporated on the wafer, followed by annealing at 860 $^{\circ}\text{C}$ for 30s in N₂ ambient. The Schottky contact was produced by evaporating 20 nm thick catalytic Pt metal. The gate dimension of the device is $5 \times 400 \mu\text{m}^2$. Finally, Ti/Au was evaporated as interconnection contacts

For circular Schottky diode type as shown in Fig. 2(b), the Ohmic contact, formed by evaporated 100 nm-thick Ti/Al/Ti/Au metals was subsequently annealed by a rapid thermal treatment at 900 $^{\circ}\text{C}$ for 90s in N₂ ambience. Finally, the evaporated Schottky contact was produced by evaporating a 75nm-thick catalytic Pt metal.

After the fabrication of the sensor device was completed, gas sensing characteristics were measured in a chamber as shown in Fig. 3 with a base pressure of 0.5 Torr. Samples were fixed on a ceramic heater. High purity hydrogen gas was supplied into the chamber together with the ambient gas of either air or pure nitrogen or without ambient gas (vacuum). The total pressure in the range of 50 Torr to 200 Torr was used for both types of ambient gases. Current-voltage (I-V) characteristics and time transients of currents (I-t) of

the Schottky diodes were measured in various atmospheres using an Agilent semiconductor parameter analyzer. Capacitance-Voltage (C-V) characteristics were measured using Agilent LF impedance analyzer. The value of Schottky Barrier Height (SBH) was determined by extrapolating either straight portion of the forward log I-V curves or those of the reverse C-2-V plots.

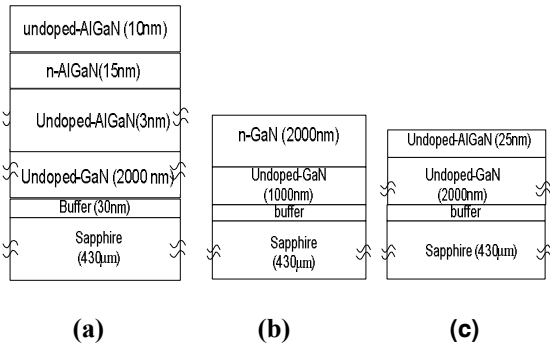


Fig. 1. Material structure

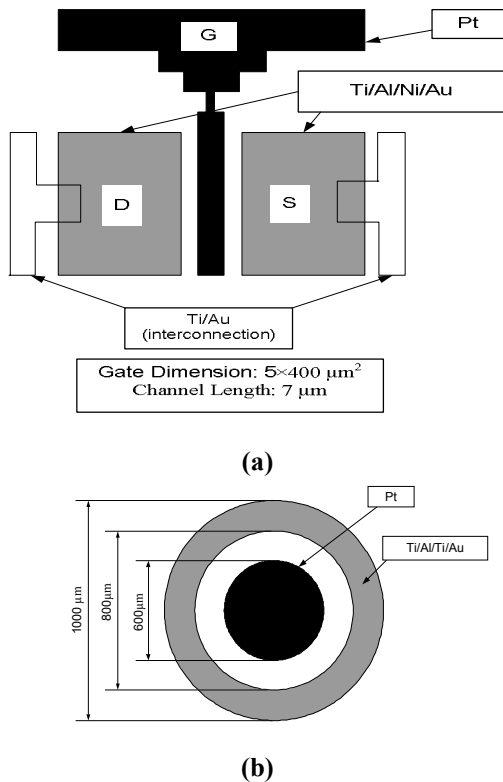


Fig. 2. Device Structure: (a)FET type and (b)Schottky diode type

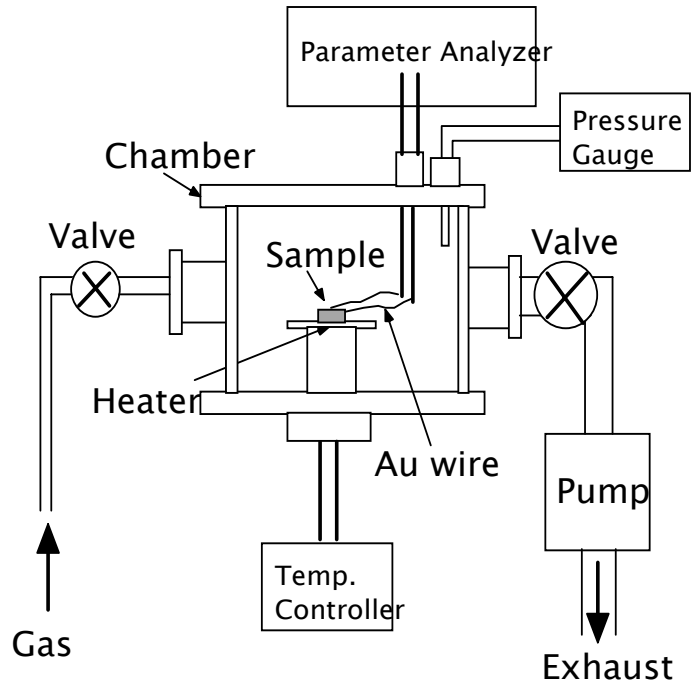


Fig. 3. Measurement setup

4. Results and Conclusion

Current-Voltage (I-V) characteristics, time transients of current (I-t) and capacitance-voltage (C-V) are measured in various pressures. At this moment, the analysis is still on the way and their results will be presented during the conference.

5. Reference

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