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A Basic Study on SAW Resonator with AlGaN/GaN Film

AlGaN/GaN 弾性波共振器に関する基礎検討

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１． Introduction

AlGaN/GaN film not only is good semiconductor material for realizing high-performance active semiconductor devices such as high electron mobility transistors (HEMTs) to be applied in high speed communication systems and high power control systems, but also it has strong piezoelectric properties for realizing surface acoustic wave (SAW) passive devices such as filter, resonator. Many research results are reported so far.[(1)-(4)] To make use of merits of AlGaN/GaN film, we can monolithically integrate SAW devices and active HEMTs on AlGaN/GaN hetero-structure to obtain functional module with high-performance and small size for front end circuit in mobile communication systems. In this paper, we investigate fabrication process and basic characteristics of SAW resonator and HEMTs with AlGaN/GaN film.

2. Monolithic functional devices with AlGaN/GaN film

There are many kinds of monolithic functional devices integrating semiconductor active devices and passive SAW devices such as oscillator, VCO circuit, convolver, programmable correlator, phase shifter, duplexer etc. The simplest one is oscillator consisting of a SAW resonator and amplifier of HEMTs as shown in **Fig. 1**.

Figure 2 shows a simple fabrication process using AlGaN/GaN film. Firstly, we fabricate HEMTs, form the drain and source electrode of HEMTs and obtain ohmic contact, after that form Schottky electrode of gate. Then, we etch AlGaN layer for SAW resonator, and form electrode of IDT and grating. Finally, we finish wiring between HEMTs and SAW resonator.

Here, we must investigate influence of two dimension electron gas (2 DEG) existed between AlGaN/GaN inteface for SAW resonator because the conductivity of 2 DEG for HEMTs devices and the conductivity of 2 DEG for SAW resonator are completely different. This difference is very important to design function devices configuration and fabrication processes. As basic study, we briefly fabricated HEMT and SAW resonator with AlGaN/GaN film, and investigated characteristics of two-port SAW resonator under different thickness of AlGaN layer and electrode structure of SAW resonator.

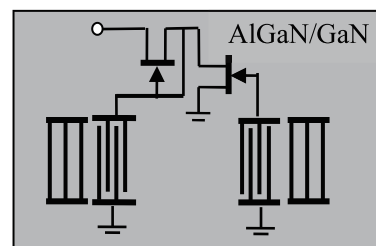

Fig.1 Oscillator consisting of SAW resonator and HEMT with AlGaN/GaN film

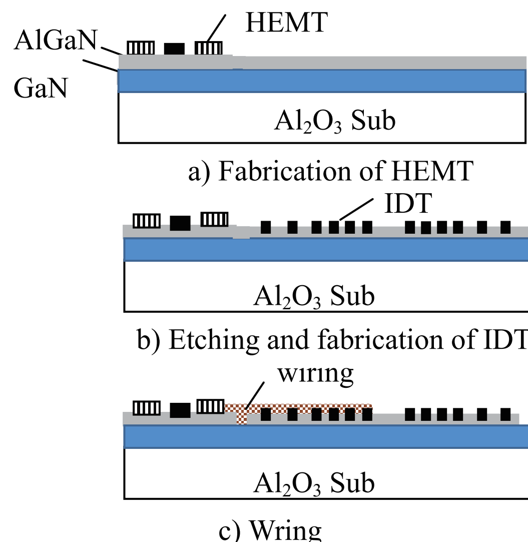

Fig.2 Fabrication process of the oscillator with AlGaN/GaN film

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3. Experimental and result

Table 1 shows parameters of AlGaN/GaN film, and parameters of HEMTs and two-port resonator in our basic experiments. An AlGaN/GaN film was deposited on a (0001) sapphire substrate by metal organic chemical vapor deposition. We formed electrode pattern by liftoff method. The Ohmic contact used Ti/Al material and heated sample at 800℃,45s. The Schottky electrode and IDT grating electrode used Al material. Dry etching process is used to control thickness of AlGaN layer for SAW resonator. We used a semiconductor parameters analyser and a network analyzer (Anritsu MS4623B) to estimate the characteristics of test devices. **Fig. 3** shows characteristics of HEMTs and modulation effect by gate bias is confirmed. **Fig.4** shows frequency characteristics for SAW resonator under difference thickness of AlGaN layer.

4. Conclusion

In order to realize monolithic functional devices using AlGaN/GaN film, we fabricated a HEMT and SAW resonator on AlGaN/GaN film, and estimated basic characteristics. We observed change in resonance characteristics for difference AlGaN layer thickness and bias condition. Based on these results, we are designing monolithic functional oscillator configuration and optimum fabrication processes.

Acknowledgment

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Table 1. Parameters used for the experiments

Substrate	$Al_{0.255}GaN$ / GaN / Al_2O_3
Thickness of AlGaN film	0.02 µm
Thickness of GaN film	2 µm
HEMT	
Gate length	12
Distance of D-S	200
Resonator	
Thickness of AlGaN film	0.02
IDT line &space	2µm:2µm
Overlap. length	200 µm
Number of pairs	50-50 pairs
Prop. length	2.608 mm
Number of pairs of grating	50-50 pairs

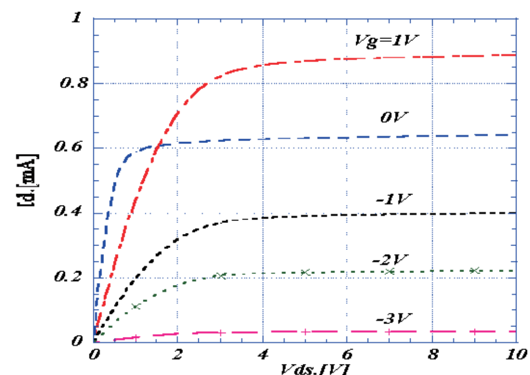

Fig. 3 Statics characteristics of AlGaN/GaN HEMT.

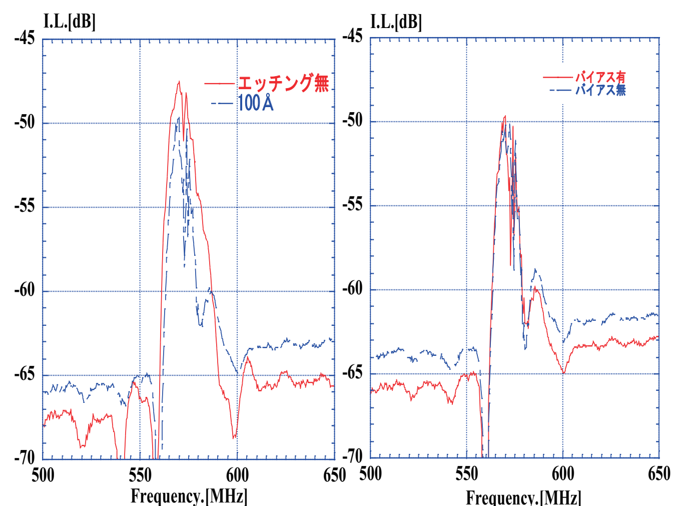

Fig. 4 Frequency characteristics of AlGaN/GaN SAW resonators.