3P3-4

Effect of Additional Thin Film of Piezoelectric Materials on Frequency Response of Surface Acoustic Devices

圧電材の追加積層の有無による弾性表面波デバイスの周波数特性の変化

Shinya Rikimaru‡, Sunao Murakami, Kanato Kitamura, and Takahiro Ito (Grad. School Computer Sci. Systems Eng., Kyushu Inst. of Tech. (Kyutech))

力丸 真也‡，村上 直，北村 奏人，伊藤 高廣 (九州工業大院 情工)

1. Introduction

Surface acoustic wave (SAW) devices are one of the piezoelectric microdevices which are widely used as RF filters and resonators, and have received attention as the potential substitutes for physical and chemical sensing [1]. In SAW devices, interdigital transducers (IDTs) work as the micro-transducer between the electrical signals (input and output signals) and the SAW (mechanical vibration wave). It is also known that the peak frequency of the SAW propagating through the device substrate can be controlled by the geometry and size of the electrodes in the interdigital region [2]. The controllability of the peak frequency is one of the technical advantages of SAW devices. However, it is likely that the control of the frequency properties only by the geometry and size in the IDTs does not permit wide ranges of flexibility.

Therefore, we have attempted to increase the flexibility in controling the frequency properties of the propagating wave by the additional combination of multiple piezoelectric materials in SAW devices. In this paper,, we have firstly tried to modify the frequency properties of the SAW devices fabricated on the conventional ST-cut quart (ST-Q) substrate by combining piezoelectric thin film of aluminum nitride (AlN).

2. Microfabrication of SAW Devices

Figure 1 shows the schematic of the SAW device which we have fabricated on AlN thin film depositted on ST-Q substrate in this paper. We have fabricated the same interdigital micropatterns of metal thin film on both the ST-Q substrates with or without AlN thin films. We used AlN thin film depositted on ST-Q substrates as the bilayered piezoelectric materials because of the advantages such as higher SAW velocity and higher electromechanical coupling coefficient than those of only ST-Q substrate [3]. In this paper we have designed and fabricated SAW devices icluding IDTs with 50 electrode pairs, and the wavelength (designed values) of the fundamental vibration mode was 20 μm.

Figure 2 shows the microfabrication process of the SAW device on AlN thin film deposited on the ST-Q substrate in this study. We firstly deposited AlN thin film on the ST-Q substrates using RF reactive sputtering process with aluminum target (99.99%; 4N) in Ar-N_2 gas mixture (Fig.2-(a)). And, we also deposited metal thin film on the AlN thin film using conventional DC sputtering process (Fig.2-(b)). After that, we prepared the etching mask of photoresist using photolithography (Fig.2-(c)), and then fabricated the micropatterns of metal thin film including the IDTs on the substrate using selective etching process (Fig.2-(d)). Finally we removed residue of the photoresist mask (Fig.2-(e)).

Figure 3 shows micrographs of the IDTs of nickel (Ni) thin film in the SAW devices fabricated on the ST-Q substrate (without AlN thin film) [for SAW devive-(i)] (Fig.3 (a)) and the AlN thin film

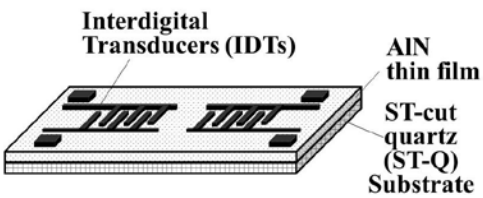

Fig. 1 Schematic of the SAW devices fabricated on AlN thin film deposited on ST-Q substrate.

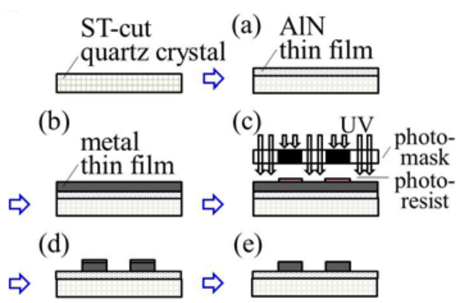

Fig. 2 Microfabrication process of SAW device on AlN thin film deposited on the ST-Q substrate.

deposited on ST-Q substrate [for SAW device-(ii)] (Fig.3 (b)). When we measured the distances between the adjoining electrodes in the interdigital regions of the IDTs with the micrographs of the each SAW device, the average distances between the adjoining electrodes were calculated to be 10.0 +/- 0.1 μm (n = 20) [SAW device-(i)] and 10.1 +/- 0.1 μm (n = 20) [SAW device-(ii)]. That means we have successfully fabricated almost the same micropatterns of the IDT with uniform configration on the ST-Q substrates (without AlN thin film) [for SAW device-(i)] and the ST-Q substrate deposited with AlN thin film [for SAW device-(ii)].

4. Frequency response of fabricated SAW devices

Furthermore, we also examined the frequency properties of two types of SAW devices described above (SAW devices-(i) and (ii)). **Figure 4** shows the measurement set up of the frequency responses of the SAW device. The transmission coefficient S_{21} was measured using vector network analyzer (VNA) at room temperature. For ST-Q substrate, the calculated peak frequency of the SAW device (SAW device-(i)) was *ca*. 155 MHz.

Figure 5 shows the frequency response (S_{21}) of the fabricated SAW devices. The shift of the peak frequency was observed in case of the SAW devices fabricated on AlN thin film deposited on ST-Q substrate (SAW device-(ii)) in comparison with the peak frequency measured in SAW devices fabricated directly on ST-Q substrate (without AlN thin film). The result shows the potentials in the control of the peak frequency of SAW devices with AlN thin film deposited on ST-Q substrate.

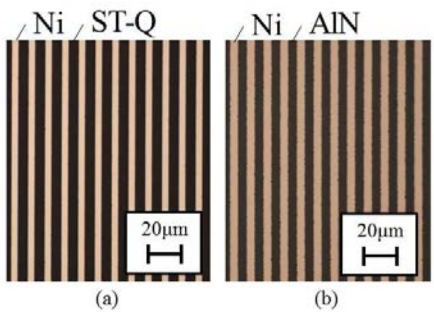

Fig. 3 Micrographs of IDTs of metal (nickel) thin film fabricated on ST-Q substrate (a) and ST-Q substrate deposited with AlN thin film (b).

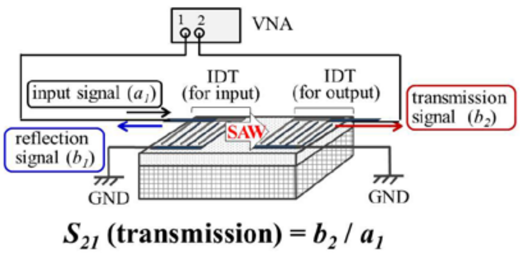

Fig. 4 Schematic diagram of test setup for measurements of frequency responses.

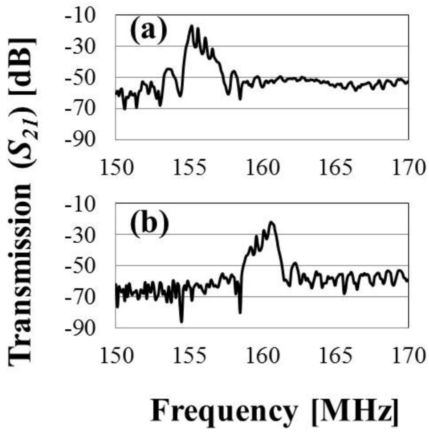

Fig. 5 Frequency response S_{21} of fabricated SAW devices. ((a) SAW device-(i): SAW device fabricated on ST-Q substrate (without AlN thin film), (b) AlN thin film deposited on ST-Q, (b) SAW device-(ii): SAW device fabricated on AlN deposited on ST-Q substrate)

5. Conclusion

In this paper, we have fabricated the same interdigital micropatterns of metal thin film on ST-Q substrates with or without AlN thin films. Though we have successfully fabricated almost the same micropatterns of the IDT with uniform configuration, the frequency properties of the propagating wave was increased by the additional combination of AlN thin film on ST-Q substrate.

Acknowledgment

This work was supported by JSPS KAKENHI Grant Number JP15K21225.

References

1. M.C. Horrillo *et al.*: Thin Solid Film **467** (2004) 234.
2. H. Wohltjen and R. Dessy: Anal. Chem. **51** (1979) 1458.
3. S. Wu *et al.*: J. Mater. Sci. Lett. **20** (2001) 1779.