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A Basic Study on Mode Coupling SAW Device with Face to Face Bonding

対面張り合わせによるモード結合 SAW 素子に関する基礎検討

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1． Introduction

Recently, as development of packaging technology of semiconductor devices such as system in package (SiP), system on chip (SoC) and progress of fabricating technology of microelectronic mechanical system (MEMS), the package technology of surface acoustic wave (SAW) devices also have developed.(1)-(3) In previous research, we proposed the face to face bonding (FFB) technology, in which, two SAW devices substrates is bonded in face to face by various bonded methods such as fusion bonded, adhesive bonded.(4) This bonding technology not only could realize smallest size package, but also it would form the structure of the packaging close enough to couple with each other and new functional device using coupling mode could be expected. In this paper, we will investigate possibility of fabricating mode coupling SAW devices using this bonding technology.

2. Mode Coupling SAW devices with face to face structure

Figure 1 shows a concept of mode coupled SAW devices using FFB. It is one of waveguide coupled device, similar to the (multistrip coupler) MSC devices, when the separation of the surfaces of two propagation path is closed. It is clear that the same functional devices as that of MSC devices could be formed. Fig. 1 (b) illustrates its operation principle. The MSC device is coupling of SAW propagation in X-Y plane. The Coupling SAW device with FFB is coupling in X-Z plane. This coupling method is not only to change propagation path length of upper substrate and lower substrate, but also it can adjust the gap between upper substrate and lower substrate. As a basic study, we propose fabricating process

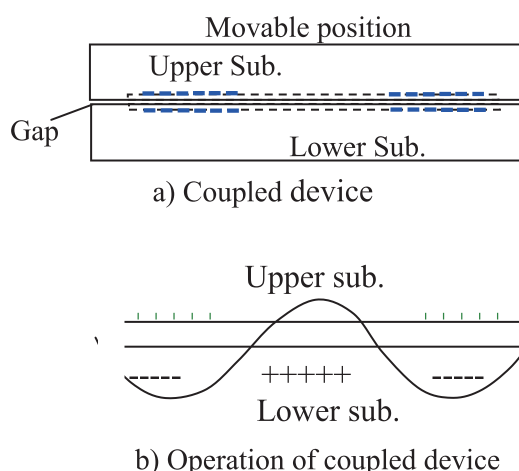

Fig. 1 Concept of mode coupling SAW devices with FFB structure

and investigate process conditions. We also estimate the frequency characteristics of test devices for different gap thickness.

3. Fabrication process of test device and experimental result

We propose the typical fabrication process of coupled SAW device with FFB as shown in Fig. 2 by adhesive bonded method. The process step is as follows.

1) First, we form a dent structure on piezo substructure same as IDT pattern by plasma etching method.
2) Then, we deposit metal material and form IDT by photolithography or lift-off process.
3) Then, we form post pattern for bonding using lower melt material.
4) We bond the two substrates using bonding equipment with heating and aligning after adjusting precise position of two substrates.

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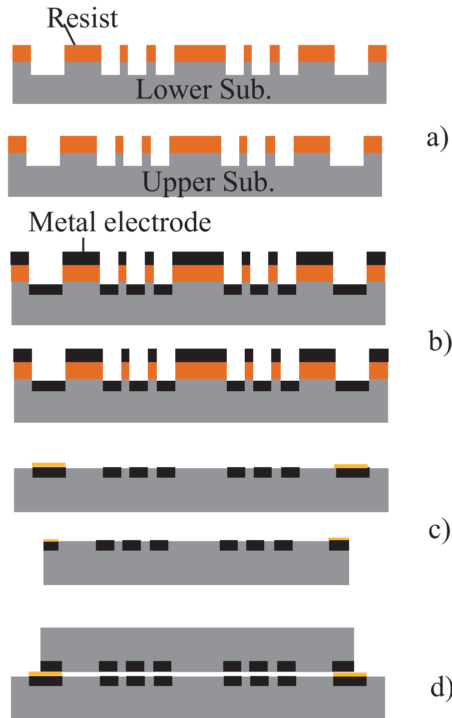

Fig. 2 Fabrication process of coupled device.

Table 1 shows parameters of test devices, and Tab. 2 shows some process conditions. The test devices photograph show in Fig. 3. We used a network analyzer to estimate the characteristics of test devices. Fig. 4 shows frequency characteristics of coupled SAW devices for different gap thickness. We found that insertion and band width of the device vary with increasing of gap thickness from 60 nm to 100nm. We will discuss experimental results based on mode coupled theory.

4. Conclusion

We proposed fabrication process of mode coupled SAW device with FFB structure and investigated basic process conditions. We estimated frequency characteristics of test devices. We observed change of insertion and band width varying with gap thickness. The results confirmed possibility of realizing coupled SAW devices with FFB by changing gap between two substrates.

Acknowledgment

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Table 1 Test device parameters

Substrate:	Quartz ST cut, Thickness 0.3mm
IDT line & space	3µm:3µm
Electrode material	Al thickness 60nm
Depth of dent	100nm
Overlap. length	Original devices: 250 µm
Number of pairs	100-100 pairs

Table 2 Fabrication process conditions

Plasma etching condition	Gas Ar:CF_4 5[sccm]:5[sccm] Power 100[W], Etching time 2[min]
Bonding Condition	Heating Temp.90℃～120℃, 20min～40min

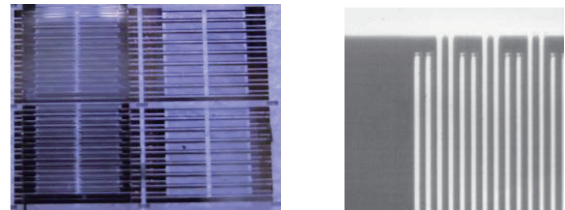

Fig. 3 Photograph of test device.

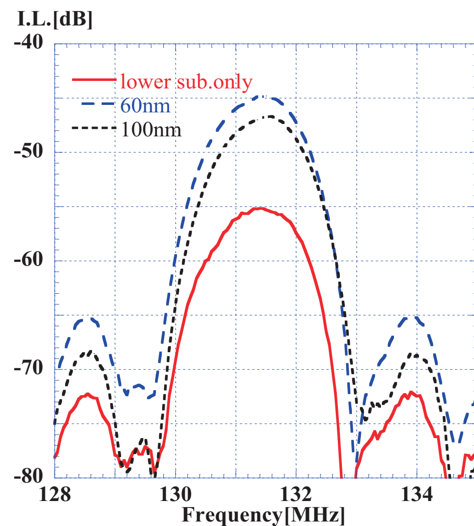

Fig. 4 Frequency characteristics of coupled SAW