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AN EXPERIMENT OF TWO DIMENSIONAL MONOLITHIC CRYSTAL FILTERS

二次元配置モノリシック・フィルタの一実験

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1. Introduction

Electrodes of a conventional monolithic filter are located along one and only one direction. In the case of rotated Y-cut of quartz crystal, this direction is usually taken along either the X axis or the Z' axis. The dominant elastic wave which couples the modes of vibration trapped under adjacent electrodes is the thickness-shear (TS) mode or the thickness-twist (TT) mode, respectively. This kind of electrode pattern is called one-dimensional pattern. One of the authers proposed the use of two dimensional pattern, in which electrodes were located along both X and Z' axis and both TS and TT couplings were used.(1) Its advantages over the one dimensional pattern are the followings:

1) The size of wafer is smaller and more round which makes the grinding easier.

2) Transmission poles can be introduced by overcoupling between non-adjacent electrodes.

Ashida and Jumonji conducted a few experiment of one of the proposed pattern and confirmed the above points.(2) This paper presents a further experiment of the same pattern. As an additional advantage, it is found that the adjustment of passband characteristics is easier, which suggests this filter is suitable for mass production.

2. Electrode configuration

Fig. 1 shows the configuration of four electrodes. The couplings k_{12} and k_{34} are provided by the thickness-twist mode and k_{23} by the thickness-shear mode. The TT mode yields less coupling than the TS modes does for the same electrode width and the same gap distance. This sometimes makes the gap distance for the TT mode too small for making reproducible evaporation mask. In order to overcome this difficulty, one side of the gap is coated, so that wider gap distance can be used without increasing the width of electrode. Hence it becomes possible to use nearly square shape for each electrode. The design is based on Ashida's theory.(3) Principal dimensions are included within the figure.

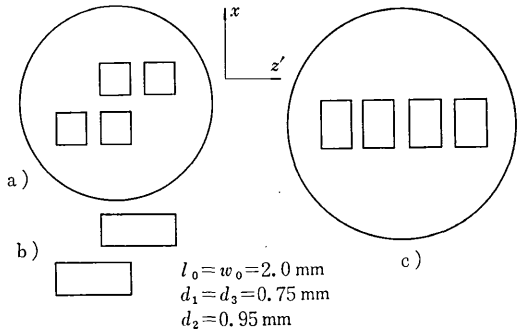

Fig. 1 Electrode configuration
a) front surface
b) back surface
c) conventional one-dimensional filter

3. Experiment

Fig. 2 shows measured coupling factors as functions of the plateback. It is seen that k_{12}, k_{23}, and k_{34} become nearly the same due to the abovementioned gap coating. The overcoupling k_{13} and k_{24} are about one order smaller. They yield a pole only at the high frequency side of the passband. This is because these coupling are due to evanescent mode and hence the phase is independent on the gap distance. A pole at the low

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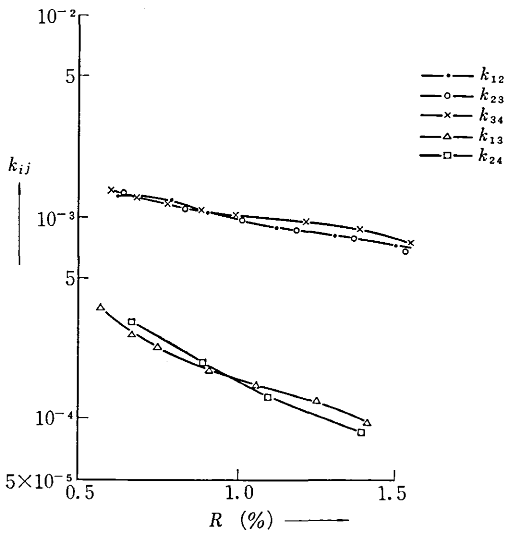


Fig. 2 Coupling factors k_{ij} as functions of electrode plateback R

frequency side may be obtained by a slight electrostatic coupling between the input and the output, if desired. The overcoupling k_{14} is the order of 2×10^{-6} and can be neglected. Passband characteristics show four peaks, of which frequencies are called f_1, f_2, f_3 and f_4 as shown in Fig. 3.

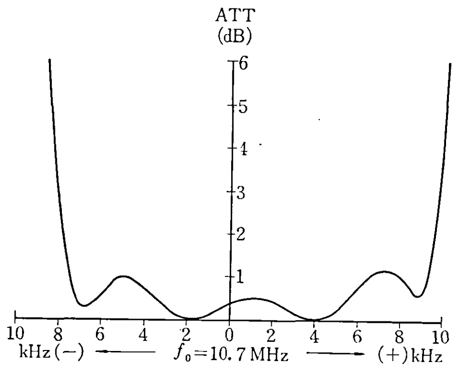


Fig. 3 Schematic of passband characteristics

Experiments show that for plating upon electrodes 1 and 4, the most influenced two are f_2 and f_3, less influenced is f_1, and f_4 almost does not change. But for plating upon electrodes 2 and 3, f_4 is greatly changed, f_1-less and f_2 and f_3-very little. Whereas the use of a full electrode for TT-modes and a divided one for TS-mode yields, by adjustment of the grounded electrode, the frequency difference Δf_{14} to be lowered while at the same time the frequency difference Δf_{13} to be increased. Thus, by a separate and independent adjustment of each electrode, a satisfactory ripple in the passband can be comparatively easily obtained. No corresponding observation is not obtained for one-dimensional filters. Fig. 4 shows a typical characteristics

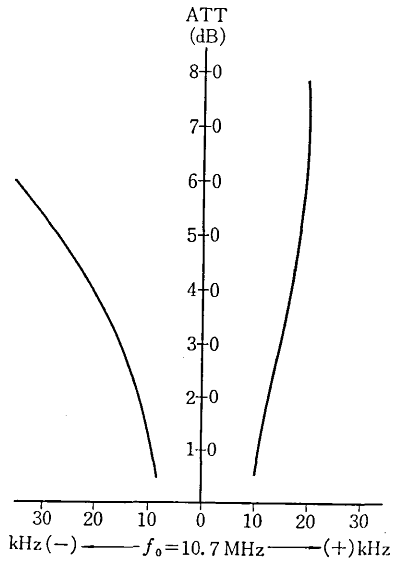
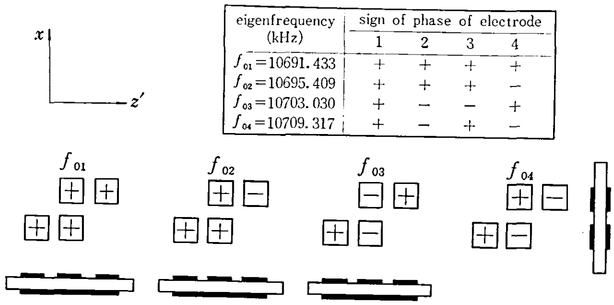


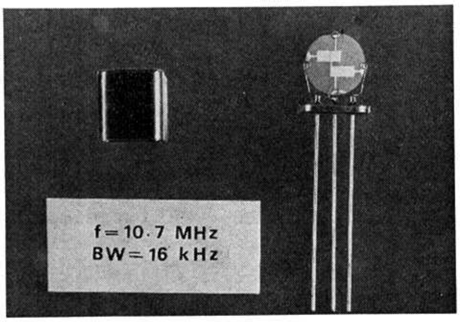
Fig. 4 Filter characteristics



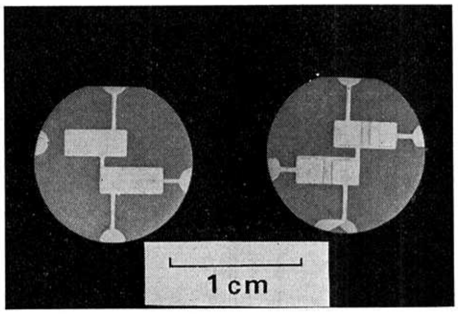
eigenfrequency (kHz)	sign of phase of electrode 1	2	3	4
f_{01}=10691.433	+	+	+	+
f_{02}=10695.409	+	+	+	−
f_{03}=10703.030	+	−	−	+
f_{04}=10709.317	+	−	+	−

Fig. 5 Polarity of induced charge at eigenfrequencies

after final adjustment. The explanation of the above observation is now being studied and will be reported elsewhere. Fig. 6 shows the polarity of induced charge at each eigenfrequency. It is interesting to note the first three look similar to the pattern for one-dimensional 3-pole TT mode filter, whereas the last is similar to the pattern for one-dimensional 2-pole TS mode filter. Fig. 6 is a photograph of typical filter.



(a) complete filter with holder



(b) electrode patterns: front (right) and (left)

Fig. 6

Literature

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