THE TRIAL OF NUMBER MEASUREMENT OF THE POLLEN OF CRYPTOMERIA JAPONICA USING PHOTOACOUSTIC MICROSCOPE

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It is known that the Cryptomeria japonica (CJ) is an evergreen needle-leaved tree and induce allergic reaction function in the eyes and nose. For the purpose of measurement of the number of CJ pollen particles, photoacoustic (PA) microscopic imaging was applied. A modulated laser beam is focused on the CJ pollen specimen fixed on a slide glass. The PA signal detected with a high-sensitive microphone at every point of the scanning was reconstructed to produce an image. The 2D PA image integrated over the specimen surface was plotted as a function of pollen mass or particle numbers. The results showed that the coefficient of correlation of the calibration curve is more than 0.97. Furthermore, it was possible to visualize the individual CJ pollen particle clearly by the PA imaging. As a result, even one CJ pollen particle could be measured with the present method.

Session: P3N
SAW FILTERS AND TRANSDUCERS I
Chair: G. Kovacs
EPCOS AG

UNIDIRECTIONAL INTERDIGITAL TRANSDUCERS USING VERY THIN FILM GRATING SAW SUBSTRATES AND APPLICATION TO WIDE BAND LOW LOSS FILTERS

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Surface acoustic wave (SAW) filters employing the conventional interdigital transducer (IDT) show inherent minimum insertion loss of 6 dB, because of bidirectionality, and strong passband ripple due to triple-transit echo and secondary effects. In order to avoid these flaws, many types of unidirectional interdigital transducers are proposed. These unidirectional transducers have small transducer efficiency. Therefore it is difficult to obtain wide band and low loss filters. In this paper we describe a new single-phase unidirectional transducer (UDT) with about $\lambda/4$ electrode width, because the interdigital transducer with $\lambda/4$ electrode width have good transducer efficiency. The new UDT is fabricated on the very thin dielectric grating SAW substrates. The electromechanical...
couplings ($k^2$) of electrodes on thin dielectric gratings are drastically decreased. The $k^2$ of the electrodes on SiO$_2$ layers of thickness of $H/\lambda=0.01$ using LiNbO$_3$ SAW substrates is about 1/2 $k^2$. Therefore the thickness of SiO$_2$ for 1/2$k^2$ is about 0.4$\mu$m and 0.04$\mu$m at the center frequency of about 100MHz and 1GHz devices, respectively. The calculation results show the wide band low loss filters with various $k^2$ materials. The experimental results showed the below 2dB insertion loss and wide band filters at the center frequency of around 1GHz.

**P3N-2**

**SAW FILTER BASED ON PARALLEL-CONNECTED CRFS WITH OFFSET FREQUENCIES**

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Coupled resonator filters (CRF) have recently regained their popularity compared to their ladder-type counterparts. Based on 42-LiTa leaky-wave substrates with the metallization thickness $h/\lambda$ ranging from 8% to 10%, they demonstrate passband widths and minimum insertion losses comparable to those of ladder filters, simultaneously providing better rejection levels. In the 1-2 GHz range, however, the relatively large aperture of CRF designs causes problems due to increasing resistivity losses. For filters on quartz, the same problem may exist, since the relative thickness of the aluminum metallization cannot be chosen too high to avoid strong transverse-mode generation. A natural approach to solving this problem is to connect two or more filters in parallel, simultaneously reducing the aperture of each track. We demonstrate that improved results can be obtained if the tracks are not equivalent, but there is a small offset of the center frequencies. A similar approach has been discussed in [1]. The correct offset between the track frequencies is required to achieve a three-pole-type filter-performance curve. This is achieved by flipping the polarity of one of the output transducers. A three-pole passband is sufficiently wide even if two-transducer CRF structures are used. This allows a simplified topology of interconnections compared to the three-transducer geometry typically employed in current CRF design. The 868-MHz ISM-band filter on quartz discussed in this work was designed according to the described approach. Both tracks are optimized independently. To generate the necessary frequency shift between the tracks, the difference between the pitches of the corresponding periodic transducer structures must be very small, on the order of 1.5 nm. The experimental results for a matched filter show a minimum insertion loss below 5 dB and a passband width of about 2 MHz at the #5dB level. The same approach on 42-LiTa allows one to increase the passband width, to minimize losses, and to improve rejection levels. An example of the achievable performance will be presented. [1] Y. Yamamoto, R. Kajihara, and S. Yoshimoto, “SAW synthesized resonator filters with two composite longitudinal mode 2-port resonators”, Proc. 1998 IEEE Ultrasonics Symposium, pp. 91-95.

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LOW-LOSS NSPUDT SAW FILTERS WITH INCLINED REFLECTIVE ARRAYS

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Low-loss NSPUDT SAW filters require directivity reversal of one of NSPUDT [1]. This involves technological complications and reduces design flexibility. Another way to obtain low-loss assumes the turning of SAW propagation direction without reversal of NSPUDT directivity. In this case inclined NSPUDTs are used and SAW transmission between them is provided by a single reflection of SAW from the polished edge of a piezoelectric substrate [2]. However this solution can be used only when the IDTs are placed symmetrically at specific angles equal to +/- 25° in relation to the X-axis on ST-quartz. These features limit design flexibility and application area of NSPUDT filters. This publication presents another design concept of low-loss NSPUDT SAW filters, which uses SAW propagation direction reversal without reversal of NSPUDT directivity. In this design the input and output NSPUDTs are placed in parallel acoustic tracks. SAW transmission between these tracks and propagation direction reversal is provided by a double reflection of SAW from a pair of inclined reflective arrays. Quartz and langasite crystal orientations were chosen where SAW unidirectional radiation is possible by the conventional IDTs with the λ/4 electrodes.

The technological and constructional features of suggested low-loss NSPUDT SAW filter are considered: the relationship between the directivity of NSPUDT and the thickness of aluminum electrodes, the relationship between the insertion loss and the reflective arrays design including inclination angle, array shapes and number of reflectors. Experimental filters with central frequencies 172 MHz and 146 MHz have been studied. Identical input and output transducers contained 200 and 100 electrode pairs on quartz and on langasite correspondingly. The transducers have demonstrated 10-15 dB directivity. The filters with reflective arrays on quartz had 8-10 dB insertion loss (with electrical matching), 0.3% relative bandwidth and low ripple in the passband. The proposed structure increases the flexibility and reduces the complexity of NSPUDT filters design on different substrates orientations.

RSPUDT FILTERS BASED ON DIFFERENT WIDTH SPLIT FINGERS

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RSPUDT filters have drawn a lot of attention in recent years because of its small size and low insertion loss. Many papers have been published on RSPUDT filters based on DART SPUDT structure [1]. In order to further reduce the insertion loss of RSPUDT filters, SPUDT structures based on different-width split finger (DWSF) are investigated. The finger structure is similar to the well known Hanma-Hunsinger SPUDT, i.e., includes finger pairs of 1/16 and 3/16 wavelength widths. The application of DWSF SPUDT allows us to further reduce the insertion losses of an RSPUDT filter comparing to an equivalent DART based RSPUDT filter. In order to provide effective resonant cavities inside transducers, center positions of fingers of the SPUDT coincide with those of equal width split fingers of the bi-directional transducers. In this case gaps between fingers vary according to the local reflection. The synthesis procedure for the filter design was based on the algorithm applied for RSPUDT filters of DART SPUDT. In order to adopt the model and to improve simulation accuracy, parameters such as reflection, energy storage and scattering coefficients for the DWSF SPUDT structure were obtained using experimental results of special test structures. The analysis of experimental results shows that modeling accuracy, especially for out-of-band rejection, depends on the simulation accuracy of charge distribution on fingers. The synthesis algorithm includes the exact analysis routine of local finger configuration in order to provide adequate simulation accuracy of responses for the filter structure. The synthesis algorithm also includes the analysis of parasitic STW generation. In addition, the algorithm controls fingers layout under a filter synthesis procedure to exclude very small gaps. Several RSPUDT filters based on DWSF SPUDT were designed on quartz and LiTaO3 substrates. The comparison with equivalent RSPUDT filters based on DART SPUDT shows that the DWSF SPUDT can reduce insertion losses by 2 to 4dB.


FABRICATION OF TIMING EXTRACTION CIRCUIT INTEGRATING PHOTODETECTOR AND SAW FILTER ON PIEZOELECTRIC SUBSTRATE

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Surface acoustic wave (SAW) devices are widely used for radio and optical communication systems because of their high probability of intercept, and their simultaneous processing of multiple signals in real-time. They also have many merits such as simple structure, light weight and low cost. Recently, to realize optical transmission system with larger capacity and high-speed, an optical module with high performance, low cost and small size is strongly required. In this paper, we propose a timing extraction circuit as an optical receiver module, in which optical photodetector and SAW filter are monolithic integrated on the piezoelectric substrate. The timing extraction circuit consists of SAW filter and compound semiconductor photodetector such as InP photodiode. We fabricated the timing extraction circuit using film bonding technology. The epitaxial film of the semiconductor photodetector is released from their growth substrate by etching and is bonded on the LiTaO$_3$ substrate using a water glass as an adhesive material. Then, we formed electrodes of the photodetector and interdigital transducer (IDT) electrodes of SAW filter. Where, the electrode pattern of photodetector and IDT are designed to be same. We measured basic characteristics of the test circuit. When modulated optical pulses signal is received by photodetector, the electrical signal outputed at photodetector can directly induce IDT of input port, the timing extraction signal is obtained at IDT of output port. We discussed the method of timing extraction of signal with high efficiency, quantum efficiency of the photodetector and induced efficiency for different piezoelectric substrates, electrodes configuration of IDT and structure of photodetector, and give optimum circuit parameters.

Session: P30
SAW FILTERS AND TRANSDUCERS II
Chair: B. Abbott
Triquint Semiconductor

P30-1

BALANCED WIDEBAND THREE-TRANSUDCER LOW-LOSS SAW FILTERS USING TAPERED IDTS
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The tapered SPUDTs are widely used in the SAW filters for obtaining the fractional bandwidth over 10 % and reducing an insertion loss. But a sufficiently large insertion loss of 8-10 dB and narrow electrodes $\lambda/8$ or $\lambda/6$ limit the application of these filters. In this connection the use of a three-transducer structure containing the conventional tapered input IDT and two output IDTs placed symmetrically around the input IDT is very perspective. Theoretically an insertion loss of the three-transducer structure with full matching is 3 dB. Because this structure has the conventional $\lambda/4$ electrodes it may be used readily in the frequency range up to 1 GHz. A passband ripple of the tapered three-transducer structure is controlled by an inclination of the output IDTs and may