

## Dicing Saw Devices

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### Introduction

SAW (Surface Acoustic Wave) devices are components that make use of the ability of piezoelectric materials to convert acoustic (i.e. mechanical) waves into electromagnetic signals, and vice-versa. By far, the most common SAW devices are SAW Band Pass Filters (SAW BPF) which sort signals by frequency and are used in a large variety of both wired and wireless applications, including cellular phones, cable television equipment, cordless phones, and pagers. A basic SAW filter consists of a pair of input and output transducers located on a highly polished piezoelectric substrate as shown schematically in Figure 1. When a signal of an appropriate frequency is applied across the input transducer, the varying electric field causes the surface of the device to expand and contract, thus generating an acoustic wave. The propagating wave is detected by the output transducer, which translates it back into an electric signal. The fact that the velocity of the propagating acoustic wave is much lower than that of electromagnetic waves allows for significant delay of the output signal. The operating frequency of a SAW device is determined by the geometry of the transducers. The temperature stability, acoustic wave velocity, and the bandwidth of the application are determined by the piezoelectric substrate used for the fabrication of the device. The most widely used substrates are quartz ( $\text{SiO}_2$ ), lithium niobate ( $\text{LiNbO}_3$ ) and lithium tantalate ( $\text{LiTaO}_3$ ). Quartz is typically used in narrow bandwidth applications such as IF (intermediate frequency) filters. Lithium tantalate is mostly used for medium bandwidth filters for IF and RF (radio frequency) applications, and lithium niobate is typically used for wide

bandwidth RF applications. Quartz is characterized by high temperature stability, whereas both lithium compounds have a linear frequency-temperature dependence.

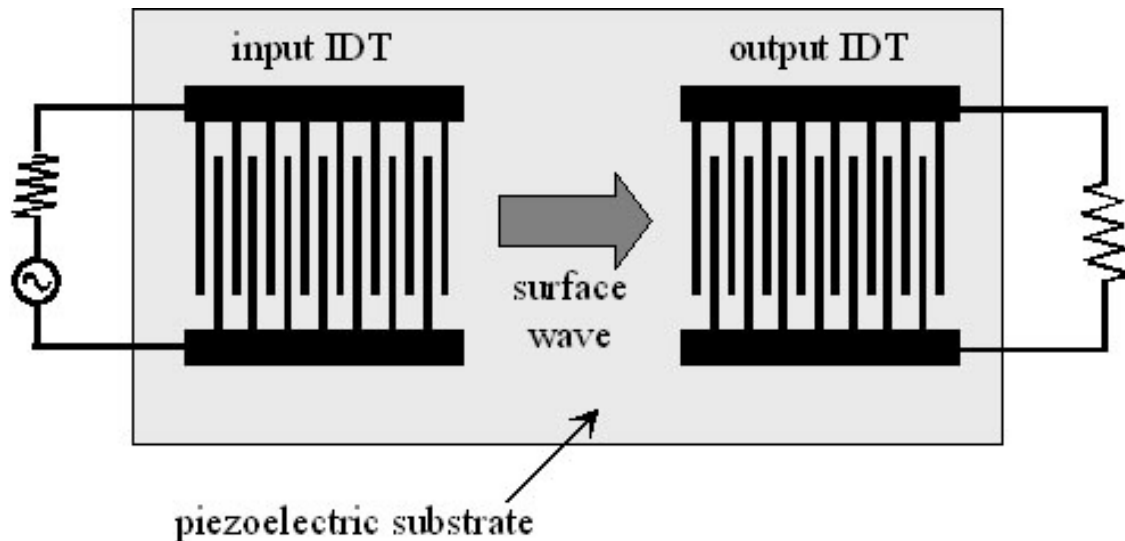


Figure 1: A schematic representation of a basic SAW filter

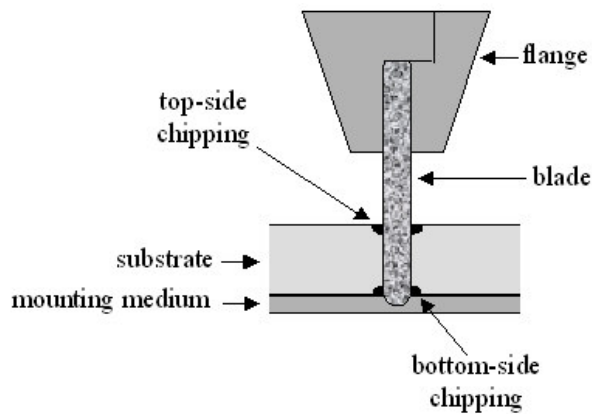
The transducers in a SAW device, which are composed of interdigital arrays of thin metal electrodes, are produced directly on the substrate by photolithographic methods, and are referred to as interdigital transducers (IDTs). In most cases, the metal transducers are made of aluminum, which is initially deposited uniformly as a 500-4000 Angstrom-thick layer over the entire substrate, typically a three- or four-inch diameter wafer, some 500 microns thick. The device is then spin-coated with a photoresist, which is baked to harden it. UV radiation is applied through a photolithographic mask, designed to shield the areas to remain metalized. A developing solution is used to remove the chemically changed material in the irradiated regions, after which the remaining photoresist is removed from the wafer. The patterned substrate is now ready to be separated into the individual die, which are then attached to the protective cases that house the final SAW

devices. The transducers are wire-bonded to the case pins and the cases are hermetically sealed.

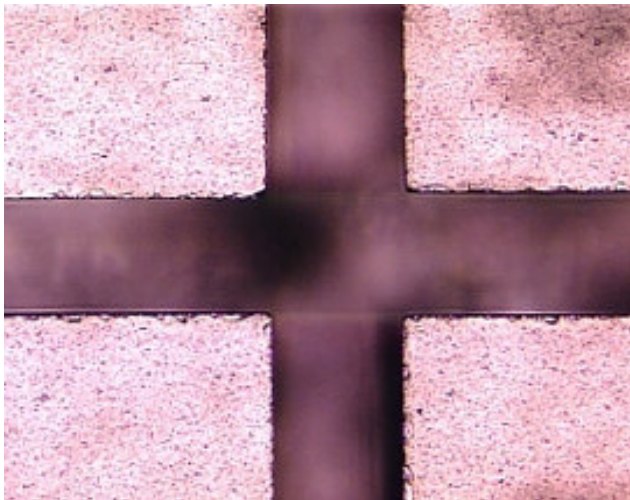
### **Dicing SAW Devices**

The dicing-blade and dicing-process parameters for sawing the wafer strongly depend on the characteristics of the piezoelectric substrate used in manufacturing the device. Quartz, lithium niobate and lithium tantalate are all very brittle materials, with quartz being harder than the two lithium compounds. Due to the brittleness of the materials, substrate chipping (see Figure 2) is a major concern. However, it is interesting to note that many end-users report that some degree of top-side chipping improves the performance of the devices. Hence, most of the attention in developing the dicing process should be given to minimizing chipping on the bottom side of the substrate. SAW devices are most often singulated on a two-inch dicing-saw, however, good results may also be obtained using a four-inch machine. Annular resinoid blades, 4-10 mils thick, are used for dicing all three materials, although lithium niobate and tantalate may also be diced using hubbed nickel blades 1.5-3 mils in thickness. The diamond grit when using resinoid blades is typically either 30 or 45 microns for quartz and somewhat smaller (15, 20 or 30 microns) for the lithium compounds. The diamond grit when dicing these substrates with hubbed nickel blades is considerably smaller (3-6 or 4-8 microns). Spindle speeds are naturally lower when dicing with a four-inch blade in comparison to dicing with a two-inch blade. Typical speeds are on the order of 10,000-12,000 RPM for four-inch resinoid blades, 30,000 RPM for two-inch resinoid blades, and 32,000-38,000 RPM for two-inch hubbed nickel blades. Bottom-side chipping may be affected greatly by the feed rate of the dicing process, which usually ranges from 2 to 10 mm/sec, depending on the acceptable cut quality. Bottom-side chipping may also be minimized by ensuring good adhesion between the substrate and the mounting medium, and by making certain that the blade undergoes sufficient dressing before dicing. Minimal chipping on the bottom of the substrate may also be obtained by performing a two-step

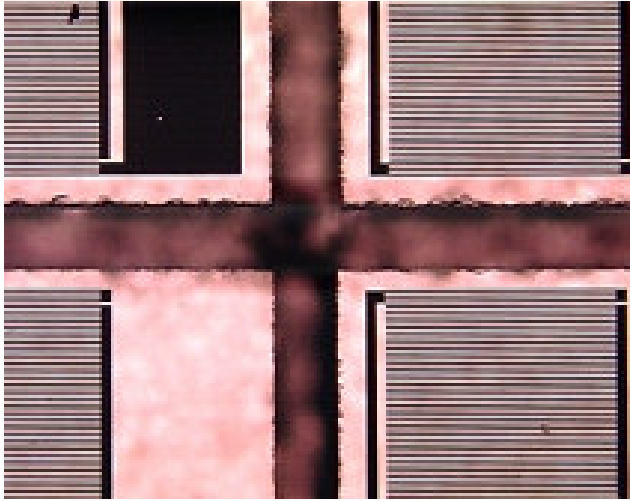
cut, in which the majority of the material is removed in the first step, and a shallow layer of substrate, on the order of 30 microns thick, is removed in a second cut. A variation on this theme is to cut deep into the substrate, leaving a layer of material on the order of 20 microns thick, and to subsequently separate the die by breaking them apart.



*Figure 2: A schematic representation of the dicing process, illustrating the formation of top-side and bottom-side chipping.*



*Figure 3: Dicing results using Resinoid blades*



*Figure 4: Dicing results using Resinoid blades*

#### **About the author**

Ramon J. Albalak is a former R&D and Engineering Manager at **ADT** - *Advanced Dicing Technologies*. Dr. Albalak's experience with dicing started in 1992. He has published a variety of technical books and papers, and holds two US patents. In addition to industrial experience, Dr. Albalak has held academic appointments at both the Technion - Israel Institute of Technology and at the Massachusetts Institute of Technology (MIT), where he spent 5 years.