BGS Devices

Introduction

Surface acoustic wave (SAW) devices are used in various consumer products, generally above 30MHz because of device size and cost factors. Murata has recently applied a fundamental technology called BGS that significantly reduces size and cost of certain SAW devices. BGS is a combination of the initials of the three scientists who developed the technology for use on PZT ceramics (Bleustein, Gulyaev, and Shimizu). Use of PZT ceramic was not considered practical for mass production because of a number of material related problems, including a large deviation of PZT material quality and the limited availability of PZT ceramics with both a small temperature coefficient and a large coupling factor. There were also fabrication related problems, but Murata has successfully solved these problems, allowing us to develop several new products. With the BGS technology we are able to make resonators, traps, and filters based on a resonator configuration. BGS filters can replace some SAW filters, but availability of the filters is limited by material.

How Does It Work

The idea behind a SAW resonator is to create a standing wave across the substrate and have a single interdigital transducer (IDT) act as both the receiving and transmitting antenna. Conventional SAW filters and resonators utilize what is called a Rayleigh wave (Figure 104). This consists of a wave that displaces in two dimensions (X and Z in Figure 104). If you imagine a rectangular table, the first part of the wave would be a variation in the thickness of the table (the SV wave). The second part would be compressing the table in the same direction that the wave is traveling (the L wave). This would be like pushing and pulling on the ends of the table. The problem with this kind of wave is that it does not reflect well at the free edge of the substrate. As can be seen in Figure 104, when the SV wave reflects, a spurious P(L) wave component is generated. Likewise, a spurious SV wave is generated when the P(L) wave is reflected. This leads to signal distortion and loss of energy due to the creation of the spurious waves..

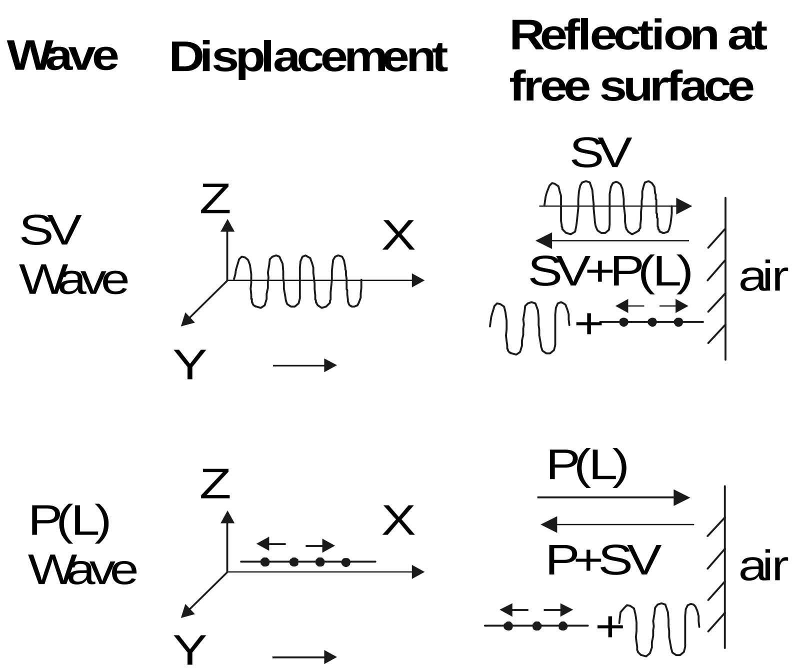

Figure 104: Rayleigh Wave Components

To solve this problem, large reflectors are placed on either end of the substrate to guarantee 100% reflection of the Rayleigh wave and a stable standing wave along the substrate (Figure 105). A very large area of substrate must be used to accomodate these reflectors. The larger substrate results in a larger part size and an increased cost.

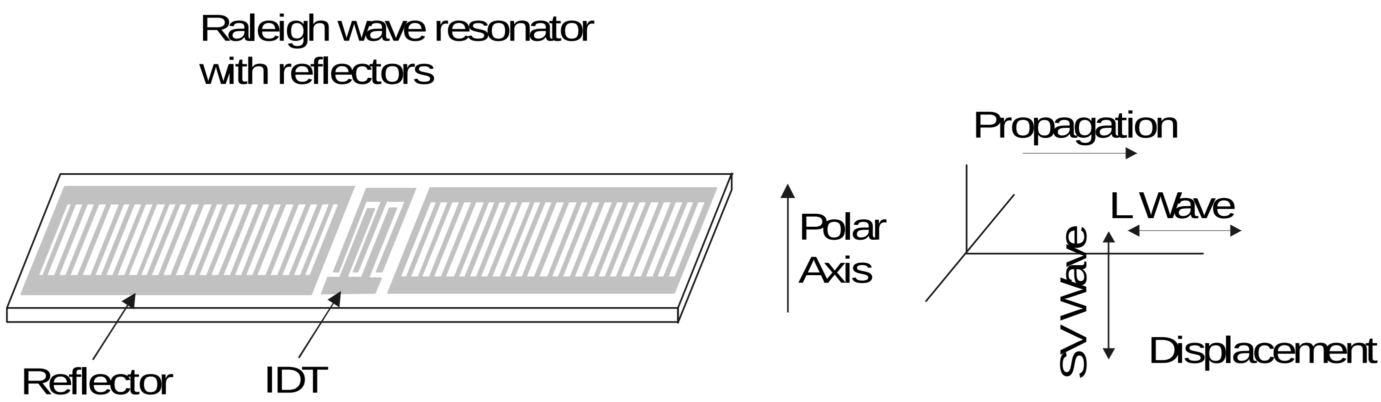

Figure 105: Rayleigh Wave Resonator

The BGS devices use a third kind of wave called the SH wave and do not have the SV or L waves. The SH waves have a displacement parallel to the surface of the substrate, and perpendicular to the direction of propogation. This wave can be simulated by sliding your hand from side to side as you move from one end of the table to the other (Figure 106).

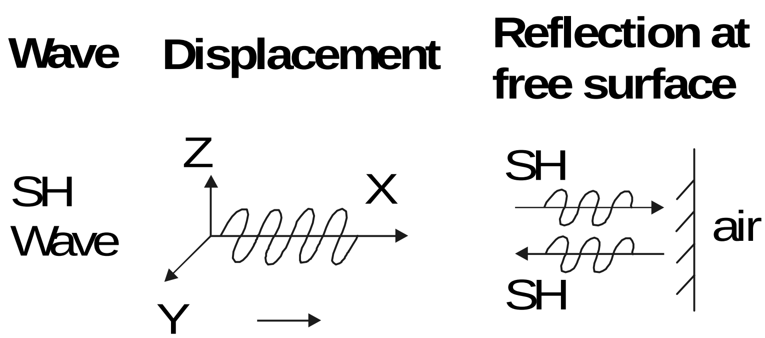

Figure 106: SH Wave Component

The SH wave can achieve 100% reflection at the free edge of the substrate, allowing us to remove the reflectors from the BGS and SH wave devices. This means we can achieve a 50% to 75% reduction in size (3.8 x 3.8 x 1.5mm typical size for BGS devices). The smaller substrate also allows us to realize a cost reduction over conventional SAW devices (Figure 107).

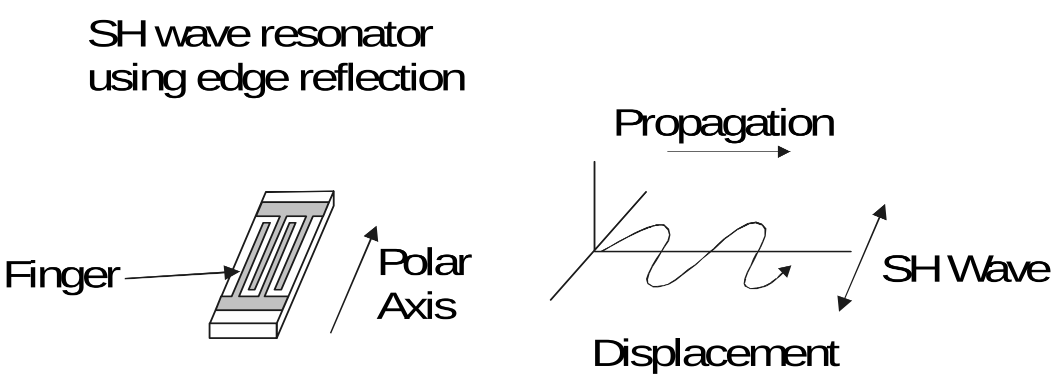

Figure 107: BGS and SH Wave Resonators

Currently Murata is developing this technology on three different substrates; piezoelectric ceramic ($PbZrTiO_4$ or PZT), Lithium Tantalate ($LiTaO_3$ or LT), and quartz crystal (X'tal). We refer to the PZT substrate devices as BGS devices and the other two as SH wave devices, though they all work in the same way.
We are able to achieve a wide range of frequencies and bandwidths with these materials. The following table gives a breakdown of the characteristics.

Substrate Material	Center Frequency Range (MHz)	Bandwidth Range (%)	Temperature Variation (ppm/oC)	Impedance Variation (Ω)
PZT	20 - 70	1 - 4	7	50 (No inductor required)
LT	100 - 200	1 - 2	-30	200 - 600 (Inductor required)
X'tal	110 - 300	0.05 - 0.08	1	1k - 1.5k (Inductor required)

Table 13. Characteristics of the BGS and SH Wave Devices

Parts

Murata currently offers BGS VCO resonators as well as traps for television, cable television, and VCR applications. We are developing resonator based BGS filters for 1^{st} IF in cellular applications (GSM and CDMA2000) and actively looking for new markets and applications for this product.