A COMPACT AND HIGH OPTICAL TRANSPARENCY TOUCH SCREEN USING CHEVRON-SHAPED PIEZOELECTRIC TRANSDUCERS

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Abstract
We developed a compact and high optical transmission touch screen using surface acoustic waves and chevron-shaped piezoelectric transducers. It has a 200-dpi resolution with a frame width of 1.4 mm. Optical transmission is 98% for a single glass substrate with an AR coating on each side.

Introduction
Mobile devices such as PDAs and cell phones are becoming increasingly sophisticated and more and more popular. There have been major technological developments in two main areas. The first is the quality of LCD displays. LCDs now have higher resolution and can display more natural colors. The second is mobile computing. Devices have become more portable, user friendlier, and more convenient. Although touch screens and handwriting recognition are becoming more widely used for mobile devices, there have been no significant developments in either area for several years. Demand is increasing for touch screens with both high optical transparency and a narrow frame.

Problems with current systems
The resistive touch screen is currently the most popular type of screen for mobile devices. As shown in Fig. 1, it consists of three layers, one layer of polyethylene terephthalate (PET) film and two layers of indium-tin oxide (ITO) film. Having three layers degrades optical transparency to about 82%, and even worse, the ITO layers are slightly colored. Nevertheless, the resistive-type screen is widely used for mobile devices because it is the only one that is both compact and supports pen use.

Figure 2 shows a schematic view of a surface acoustic wave (SAW) touch screen. It has higher optical transparency. However, its wide frame, low resolution, and high writing weight make it unsuitable for mobile devices. The conventional SAW screen consists of two pair of wedge-type transducers on the corners and varying reflectors lined up along the frame. They act as transmitter and receivers, respectively. A SAW wave emitted from a transmitter is reflected twice before it arrives at a receiver. The path length of each wave must be unique to detect the waves as discrete signals. Because there is nothing on the display area, a SAW touch screen has a potential optical transparency of up to 98%.

To narrow the frame width, we tried making narrow transducers by using SAW filter technology.

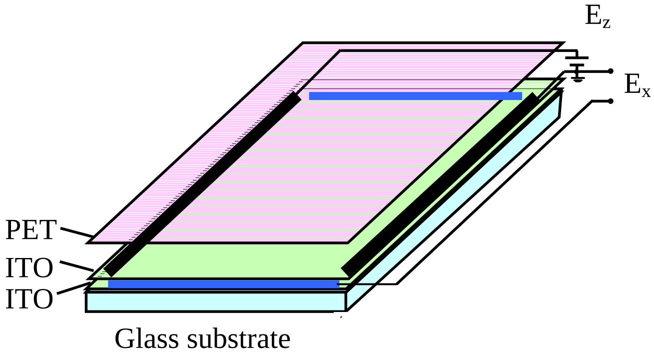

Figure 1 : Schematic view of resistive touch screen

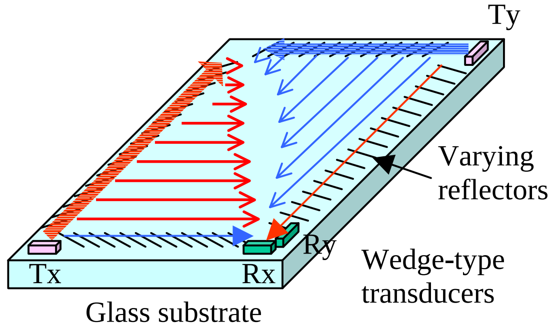

Figure 2 : Schematic view of SAW touch screen (conventional)

Table 1 : Comparison of current touch screens

System	Resistive	SAW (conventional)
Optical transparency	82%	92%
Frame width	2.3 mm	5.0 mm
Resolution	100 dpi	21 dpi
Pen input weight	20 g	70 g

Objectives
We had three objectives for the touch screen we developed. The first was high optical transparency—up to 98%. The second was a narrow frame—1.4 mm. This is the narrowest frame width of current touch screens. The third was related to pen input support—a minimum resolution of 100 dpi and a writing weight of at most 50 grams.

IDT layout for detecting touch points

We attempted to replace the wedge-type transducers and varying reflectors with a small interdigital transducer, or IDT. As shown in Fig. 3, an IDT consists of two bus bars and several electrode fingers on piezoelectric film. An IDT must be ten times as wide as the wavelength of the SAW. Figure 4 shows the layout of IDTs for detecting touch points. They are aligned facing each other, and the spacing between them is varied. This difference in spacing enables the received signals to be distinguished.

This trial was not successful because the IDT layout could not solve both the resolution and frame-width problems. The waves are received as discrete signals, and the spacing between the IDTs determines the period of the discrete signals. The frame width depends on both the IDT length and the number of IDTs. If the wavelength and the IDT spacing difference are both 150 um on a 60-mm-square glass substrate, a 5.5-mm frame width is needed. The maximum resolution was thus only about 17 dpi. This is far from the required 100 dpi or more for handwriting recognition.

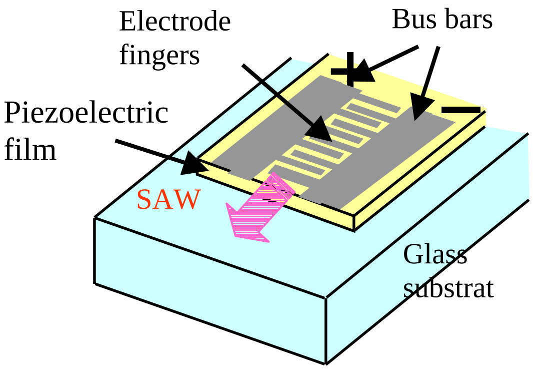

Figure 3 : Schematic view of IDT

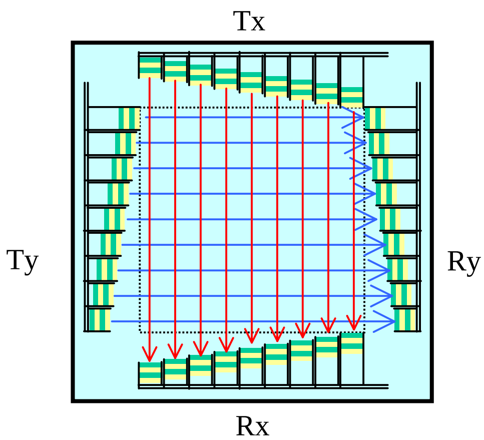

Figure 4 : Layout of IDTs for detecting touch points

Chevron-shaped transducer

To solve these problems, we developed a chevron-shaped transducer. As shown in Fig. 5, chevron-shaped transducers are big and have many V-shaped electrode fingers. They thus provide both high resolution and a narrow frame simultaneously. Being close together, the electrode fingers line up in a linear matrix that provides a continuous received signal. Figure 6 shows the directions of the SAWs emitted from one chevron-shaped transducer. The V-shaped electrodes enable SAWs to be emitted in two directions simultaneously and to be received from two directions as well. This contributes to a narrow frame.

Because each driver can emit SAWs in two directions and each receiver can receive SAWS from two directions, to scan the whole region of the screen, the drivers must be driven in turn.

As shown in Fig. 7, a continuous received signal is obtained. When the screen is touched, the attenuation in the received signal causes the voltage to dip. The touch point can thus be calculated by comparing the received signal with the waveform in memory, which is a received signal stored in advance.

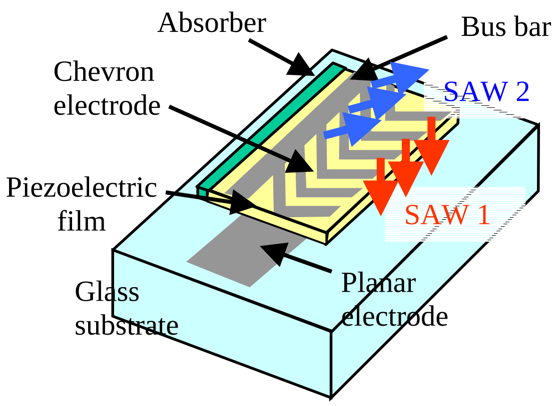

Figure 5 : Schematic view of chevron-shaped transducer

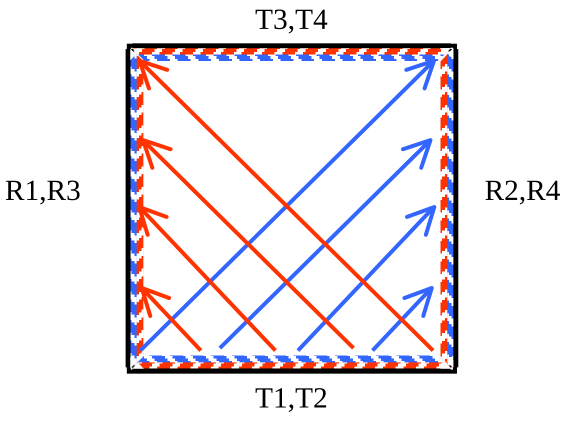

Figure 6 : Transmission of SAWs

Prototype screen

We made a prototype screen to examine its performance. Figure 8 shows our prototype touch screen, and Figure 9 shows a partial view of a chevron-shaped transducer. We designed the electrodes with 150-um spacing to meet the requirement for over 100 dpi. The designed frame width is 1.4 mm. The diagonal length of the panel is 95 mm, a common size for current PDAs.

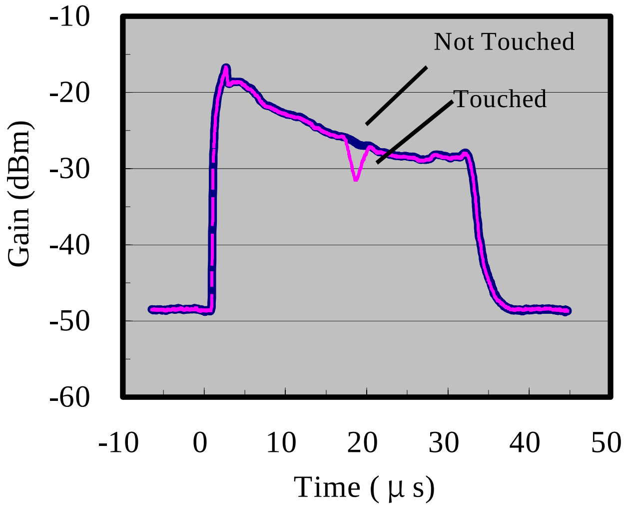

Figure 7 : Received signal

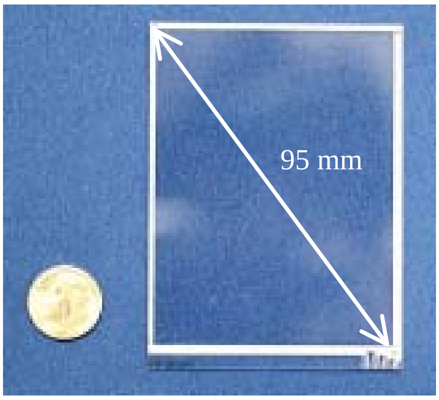

Figure 8 : Top view of prototype

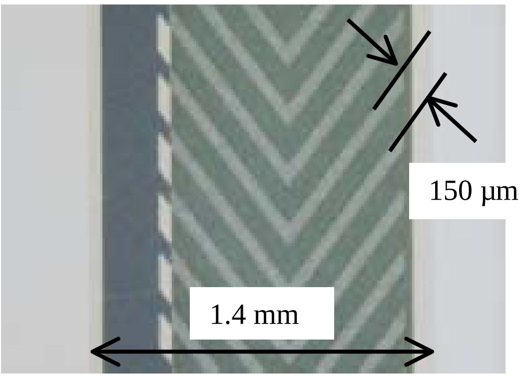

Figure 9 : Partial view of chevron-shaped transducer

Control system

We developed an electric circuit to control the prototype screen and to demonstrate that it supports pen input. As illustrated in Fig. 10, the system consists of parallel receivers and custom logic. The key feature of the chevron-shaped transducer is that two signals can be received simultaneously with one driving. To utilize this advantage, there are two receivers to enable parallel processing. The parallel processing enables fast signal processing, so the circuit can detect the touched point accurately even with fast pen movement. A dip detector compares the received signal with the waveform in memory to determine the touched point. The dip detector must be highly sensitive since the dip in the received signal caused by a pen touch is very small. To make it highly sensitive, we designed the control circuit to feed back the changes in the received signal to wave memory, since the received signal changes slightly with changes in the environmental conditions, such as the temperature. As a result, the system supports an input weight of 20 g. Figure 11 shows the result of drawing the "at" sign with a pen. As you can see, the new touch screen with this control circuit clearly detected the smooth curved drawing.

Results

We placed an AR coating on each side of the glass substrate and measured the optical transparency. As you can see in Fig. 12, the transparency was about 16% higher than that of the resistive-type screen and about 5% higher than that of the conventional one.

As shown in Table 2, our touch screen matched or exceeded the specifications of the other two.

Table 2 : Specification of new SAW touch screen

System	SAW (new)
Optical transparency	98%
Frame width	1.4 mm
Resolution	200 dpi
Pen input weight	20 g

Conclusion

In conclusion, we have developed a touch screen for mobile devices that is based on SAW filter technology. Although the screen is compact, it has high optical transparency and meets all the requirements for pen use. The optical transparency is 98%, based on the SAW system using a single glass substrate with an AR coating applied to each side. The newly developed chevron-shaped transducer enables both a narrow frame and higher resolution. A prototype screen with a control circuit supporting parallel processing and with a highly sensitive detector enables smooth pen input. It is promising for mobile information and communication applications.

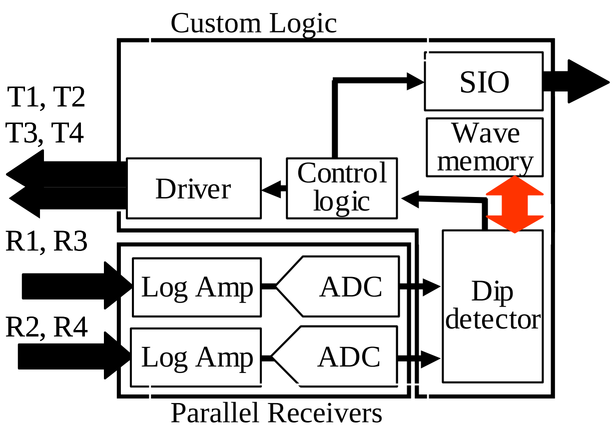

Figure 10 : Function diagram of control system

Figure 11 : Result of drawing "at" sign

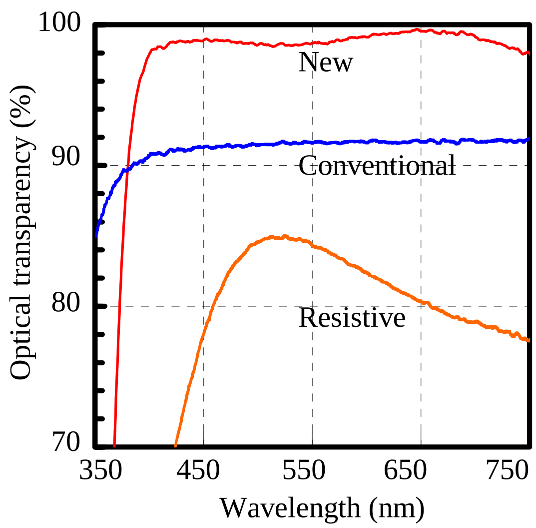

Figure 12 : Comparison of optical transparency

References

[1] T. Katsuki, et al., “A Compact and High Optical Transmission SAW Touch Screen with ZnO Thin-film Piezoelectric Transducers,” IEEE International Ultrasonics Symposium (SAW System Applications), 2003, accepted.