International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 3, pp: 204-208 www.ijaem.net ISSN: 2395-5252

3D Ultrasonic Fingerprint Sensor

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Date of Submission: 15-07-2020 Date of Acceptance: 31-07-2020

ABSTRACT- This paper describes the technology "3D Ultrasonic fingerprint sensor" used for the security of gadgets like mobile phones and laptops etc. Earlier capacitive fingerprint technology was used for securing the devices so that an unauthorized person is not able to access or manipulate our data. But now as the technology is being advanced, it provides a much more secure, fast and accurate way to the security of Gadgets from unauthorize access which brings 3D ultrasonic fingerprint sensor which is more accurate and reliable as compared to the capacitive fingerprint scanner. This technology was first commercially developed by Qualcomm which is a semi-conductor company, basically well known for its Snapdragon model mobile processor chips. The system for ultrasonic fingerprint sensors is based on pulse-echo imaging. This technology uses a system which recognizes, processes and verifies fingerprints with the registered fingerprint. The system used to detect fingerprints consists of a 24 X 8 Piezoelectric Micromachined Ultrasonic Transducer (PMUT) array, it is bounded at the level of the wafer that enables personalized electronics to be read during a 180-nm CMOS operation. This type of strategy is to use to reduce signal attenuation with the aid of high-voltage transistor based broad parasites. This device is powered with 12V of powered signal strength which allows this sensor to takes 24µs to image a 2.3 X 0.7 mm segment of a fingerprint. This system is powered by 12V driven signal intensity which enables this sensor to take 24µs to image a fingerprint segment of 2.3 X 0.7 mm.

KEYWORDS- Transducer, Piezoelectric, CMOS, pulse-echo imaging, sensor, Ultrasound, Capacitive, Optical.

I. INTRODUCTION

[7] Public protection and privacy breaches are common. In addition to passwords that easily fit in anything, the industry needs to develop standards for improving security. A biometric identification system and in particular fingerprint recognition system is an enticing option that is mounted on several different electronic devices like mobile phones, smartwatches, and door knives to ensure secure access to the area without interrupting the user. The existing fingerprint recognition system fails to fuse applications for reliability, complexity, and customer cost issues. The optical sensors are also quickly lost and difficult to miniaturize. Strong methods that meet the expected size and expense, yet again suffer from contamination from moisture interference. [2] By comparison, ultrasonic fingerprint sensors are gaining tolerance for dirt. The regular fingerprint scanner sensor multiple piezoceramic transducers and XY mechanical scanning struggle to meet the size and cost of intangible tools for expenses. Recent findings based on capacitive micromachined ultrasonic transducer (CMUT) 2D remove the need for computer scanning, but the complex interface between central sensor configuration and electronic performance enabled Short-range assumptions are shown using piezoelectric micromachined ultrasonic transducer (PMUT) arrows, but without the integrated electronics, the readability of the person is shown. This paper presents the first full implementation by linking MEMS and CMOS wafers to achieve compact size, high signal efficiency, low tensile strength and low voltage interface for a variety of applications. The PMUT transducer elements are exposed by a 220-µm deep recess embedded in MEMS wafer after the binding cycle. Inside the open port, the Fluorinert FC-70 also acts as a connecting layer between PMUT and finger as an acoustic circuit that separates the transmitted acoustic pulse from the echo. The Fluorinert seal is preserved and covered by a 100 µm PVC cover. The PMUTs are anamorphic piezoelectrical. The voltage applied a variable pressure to the 0.8-µm thick AlN layer between upper and lower electrodes. The direct deviation and discharge of the ultrasonic wave into Fluorinert is the product of vertical pressure between the active AlN layer and

the rejection of a 5-µm Si elastic layer causing the membrane. Similarly, integrated amplifiers are the pressure wave of an incident that lowers the membrane resulting in intermittent hearing of the electrodes obtained by the electron.

II. LITERATURE REVIEW

A. Ultrasound Imaging Techniques

[1] Piezoelectricity was discovered by Jacques and Curie in 1880, the primary human application of ultrasound was credited to the French physicist Paul Langevin who, after the sinking of the Titanic [4] (1912), started experimental studies that assisted quartz to detect icebergs and submarines by providing first sound navigation and ranging (SONAR) transducers. Later on, the discovery of solid and stable piezoelectric properties in ceramic materials such as barium titanate, lead niobate and often lead zirconate titanate (PZT) gave a robust impulse to ultrasonic applications. Composed of sturdy mixtures of powders, these products can have a wide variety of operating parameters. Ultrasound today is used in many areas. Ultrasound imaging or sonography, for example, is commonly used in medicine and in the non-destructive assessment of items and systems where unseen defects are usually exposed but even artifacts are observed and distances measured. Many commercial ultrasounds use include the washing, blending, and speeding up of chemical processes.

Below are several methods for providing ultrasonic systems.

B. Pulse-Echo Imaging

The fundamental pulse-echo imaging modality is that the amplitude (A) mode: the signal emitted by a transducer propagates across the body and reflected echoes give information about the depth of tissue interfaces. The main aim of producing a two-dimensional image is to transfer the single transducer in a direction while collecting several A-modes. A cross-sectional image is obtained after processing of the A-line signals and a black scale brightness (B)-mode image is also rendered with some additional processing. Usually, B-mode images are obtained by using a variety of transducers, which is quicker and easier due to electronic scanning and allows for beam-forming techniques such as concentrating, guiding and anodization.Likewise,three-dimensional ultrasound images are often obtained either by using one transducer and scanning mechanically in two orthogonal lines or by using a linear array and doing one mechanical scan. One option is focused on using 2D transducer arrays, which therefore means significant technical problems. A C-mode image may also be an orthogonal 2D image to a B-mode image, from the transducer at a given distance. Once a volumetric image is obtained it is also possible to remove some B-mode or C-mode signal.

C. Transducer Technologies

[6] This is used in medical diagnostic imaging; ultrasonic transducers can produce and receive brief pulses in the MHZ frequency range, with high sensitivity and spatial resolution. Piezoceramic materials like that are strong candidates because they have a high factor of electromechanical coupling. We have a high acoustic impedance (about 30 MRayl) while that of the human body is about 1.5 MRayl. Nowadays, assisted piezocomposite transducers are those that are utilized in most applications, while the new technologies of micromachined ultrasonic transducers (MUTs) are proving very enticing, largely due to their ability to integrate transducer and electronics into a single chip.

III. ULTRASONIC FINGERPRINT SENSOR TECHNOLOGY

A fully designed 3D ultrasonic fingerprint scanner is the quickest and easiest way to avoid unwanted access to the data and the different tools. The system consists of a 110\times 56 piezoelectric micromachined ultrasonic transducer (PMUT) array bonded [3] in a 180-nm CMOS process with an optional HV (24 V) transistor at the wafer level to tailor read electronic fabrication. The ultrasonic fingerprint reader acts to create a 3D image by reflecting a sonic pulse wave off the fingertip. This is much better than in-display optical sensors, which can work even though the fingers are greasy, dusty or wet. This is much more reliable than an optical in-display sensor, where a high-quality picture or fingertip scan will (and has) fooled. It's also much quicker and competes with the normal capacitive sensor pace. As a plus, sound waves "bounce" slightly across dirt and grime (and even olive oil) even if your hands are a little dirty, things will still work just fine. Not even the capacitive system will boast of that. The ultrasonic fingerprint sensor uses an ultrasonic pulse which produces an extremely accurate 3D fingerprint replication where conventional fingerprint scanners use photographic sensors that produce 2D fingerprint scans.

Fig 1: Image of Ridge and Valley of Fingerprint

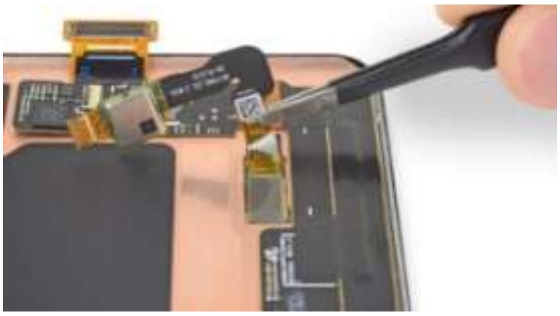

Fig 2: Hardware component Ultrasonic Fingerprint Scanner

IV. COMPARISION

Table 1: Different between Capacitive, Optical, Ultrasonic.

CAPACITIVE	OPTICAL	ULTRASONIC
Capacitive Fingerprint Scanner uses the capacitive scanning device to scan the fingerprint.	• [5] Optical Fingerprint Scanner technology uses a camera to capture a 2D optical image of the finger and the sensor analyzes the ridges and valleys of the fingerprint.	Ultrasonic fingerprint scanner uses an ultrasonic transmitter and receiver to analyzes the fingerprint.
The capacitive fingerprint scanner uses an array of tiny capacitor circuits. This capacitor circuit uses electrical currents to scan and generate an image of ridges and valleys of a finger.	The optical fingerprint scanner uses optical scanning technology called a charge-coupled device (CCD). This CCD captures an image of a finger with the help of LEDs to illuminate the surface of the finger.	Ultrasonic fingerprint scanner uses an ultrasonic transmitter and receiver to generate and transmit pulse. Ultrasonic transmits the pulse against the finger, some pulse gets absorb while some bounce back to the sensor.

V. ADVANTAGES AND DISADVANTAGES

Table 2: Pros and Cons.

CAPACITIVE	OPTICAL	ULTRASONIC
PROS	PROS	PROS
The capacitive fingerprint scanner is easy to implement due to economies of scales stemming from the availability of outsourced manufacturers	The optical scanner can be placed within a capacitive display screen enabling in-display fingerprint scanning. Allowing manufacturers to develop a device with a larger screen and minimum bezel.	Ultrasonic fingerprint scanner enables to captures highly detailed three-dimensional image of the fingerprint.
CONS	CONS	CONS

The major drawbacks of the capacitive fingerprint scanner are that they cannot be compatible with capacitive touch input technology such as IPS or OLED Display. As manufactures are moving towards bezel-less display so capacitive fingerprint scanner is not efficient in this area.	The main disadvantages of optical fingerprint scanner are that it uses CCD components for fingerprint recognition and most CCD components cannot always distinguish between a picture of a finger and the finger itself.	The main disadvantages of the ultrasonic fingerprint scanner are scanner used in in-display fingerprint scanners do not work effectively with some screen protectors because the ultrasonic pulse cannot travel through a thick surface.

A. Images of Sensor

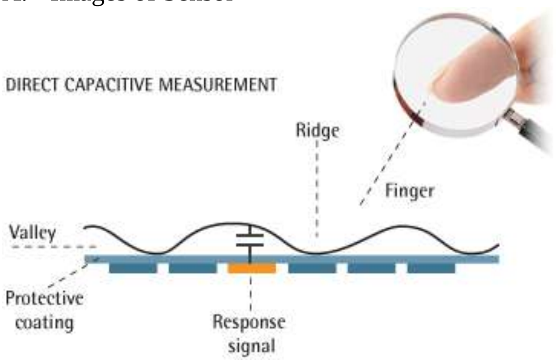

Fig 3: Capacitive Fingerprint Scanner

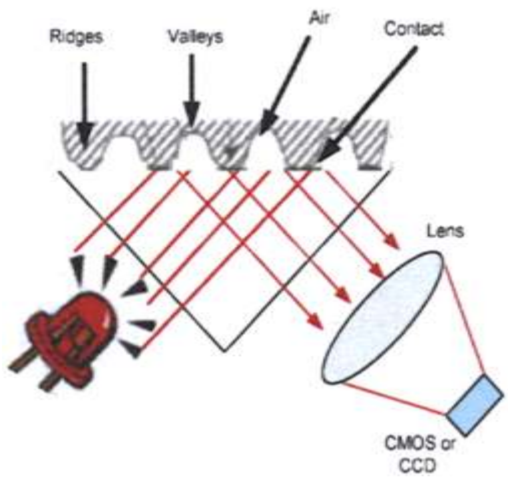

Fig 4: Optical Fingerprint Scanner

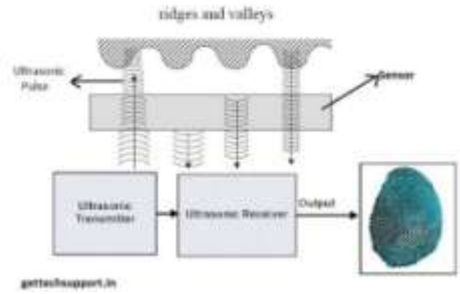

Fig 5: Ultrasonic Fingerprint Scanner

VI. CONCLUSION

The present work reviewed the technology that deals with the transducer or systems based on ultrasound for biometric recognition purposes. This technology was used to overcome the problems that were faced by using the capacitive and optical fingerprint scanner like those technologies was not effective in a certain condition for example if the finger is wet or some dirt on it then it was not able to recognize the fingerprint, it does not work on the moist condition. An optical fingerprint scanner was not able to differentiate between the finger image and the actual finger. The capacitive fingerprint scanner was good and accurate but as the manufacturers move towards to make the bigger screen and bezel-less technology the capacitive fingerprint scanner did not fit into it, as it was not able to fit under the display as an in-display fingerprint scanner, it was only able to work on the hard and physical surface.

Now, this ultrasonic fingerprint scanner technology is used in the mobile phone (Samsung mobile) to unlock the screen, this sensor was developed by QUALCOMM which 3D scan the fingerprint by transmitting the ultrasonic sound frequency (22 MHZ) which is generated by the piezoelectric micromachined ultrasonic transducer (PMUTs). This technology transmits the ultrasonic sound wave towards the finger and the ultrasonic sound wave bounces back with the necessary details to the receiver and the process takes place in the receiver, it processes the details form the bounced wave and create the 3D image of the fingerprint, it processes all the ridges and valley of the fingerprint and after send the process image and data to the processor to compare the register fingerprint matches with the currently placed fingerprint. This technology is more efficient than optical and capacitive as it can recognize if the finger is greasy, dirty or wet. The ultrasonic fingerprint sensor uses 3D scanning and can be used for the in-display fingerprint scanner.

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