# In-Display Fingerprint Scanners for AMOLED Displays

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*Abstract*— **A fingerprint in its narrow sense is an impression left by the friction ridges of a human finger. Fingerprints are quickly deposited on suitable surfaces by the secretions of sweat from the glands that are present in epidermal ridges. They are referred to as "Chanced Impressions." A fingerprint sensor is prone to it, and placing it under the display makes perfect sense. The sensor works whether your finger is dry or wet, and the heat and cold do not affect performance and precision. The whole unlocking process looks like magic. It is as secure as a traditional fingerprint reader that sits under the display, or on the rear side of the phone.**

**Qualcomm is working on its solution, but so far, Synaptic might be the first to ship its solution. OLEDs are solid-state devices that are composed of thin films of organic molecules that create light with the application of electricity. OLEDs helps to provide brighter, crisper displays on electronic devices and use less power than conventional light-emitting diodes (LED), or liquid crystal displays (LCD) used today. Fingerprint scanners were mostly used on business level laptops with regular consumers ignoring it for most of the part. But, with cybercrimes soaring on one hand and user's proclivity for storing sensitive information on smartphones are increasing, on the other hand, fingerprint scanners have become a viable form of authentication.**

***Keywords*** — **Fingerprint, Chanced Impressions, Qualcomm, Synaptic-recognition**

## I. Introduction

As smartphone manufacturers shrink the bezels around a screen, there's quite less space for a fingerprint sensor on the front of the smartphone. The fingerprint sensors are used to unlock smartphones, and also helps access sensitive content like a banking app. Many Android manufacturers place the above-mentioned sensors on the back of the phone, so it doesn't affect the bezel-less trend. Some companies like OnePlus, LG, and Samsung offers facial unlocking technology via the selfie camera. Synaptic's Clear ID FS9500 is a mass-production- ready sensor the company will sell it to smartphone manufacturers. It works under OLED displays, which is utilized by most of the flagship smartphones use, and it's different from a traditional sensor. The fingerprint sensor on your phone is capacitive, applying electric current to capture your imprint. Clear ID is an ultra-thin optical sensor which captures your print with light emitting from the OLED panel on the smartphone.

The full process works like this: The OLED display lights up the finger, the sensor detects and scans the fingerprint, and the "matcher" helps verifies the image and after crosschecking it confirms the imprint is yours, granting you access. The sensor can be placed anywhere on the screen the manufacturer wants, though Synaptics offers some general guidelines. The Clear ID sensor can work on rigid or flexible displays, and the company told Digital Trends, it should work even if the phone has a screen protector, or if the screen is wet. Synaptics said the sensor is two times faster than 3D facial recognition, unlocking at about seven milliseconds, that's on par with traditional fingerprint sensors today.

## II. Related Work

Biometrics refers to technologies that help to measure and to analyse human body characteristics such as fingerprints, eye retinas, and irises, voice patterns, facial patterns, especially those unique to everyone. Therefore, it is the perfect candidate for privacy security. Regarding technical difficulties and cost issues, facial recognition and fingerprint recognition are the only two techniques that have

Implemented. Google included the facial pattern recognition technology in their flagship smartphone in 2012 However, facial recognition performs poorly under certain conditions, and the sensor has to be held at an angle of fewer than 20 degrees off to function properly. Besides, poor lighting, wearing glasses or sunglasses, long hair, or other objects partially covering the subject's face, low-resolution images, as well as variations in facial expressions result in ineffective recognition. On the other hand, Apple first implemented a fingerprint sensor in its flagship smartphone in 2013, with the sensor capturing a digital image of the fingerprint. Comparably, the fingerprint sensor suffers less from environment conditions than the facial pattern recognition technique does.

Back in the 19th century, fingerprint images were captured by coating the finger with ink and pressing the inked fingers on to papers and cards. Ink-based systems are cumbersome and messy for widespread use. Both, the optical method, using an electronic camera to detect fingerprints, and the ultrasonic method, based on differences in ultrasonic absorption between the ridges and valleys, are proven to be bulky and impossible for use in smartphones. Recently, radiofrequency (RF) image has been introduced by AuthenTec, and Apple's flagship smartphone has already implemented it. The RF imaging technique uses an array of sensors to generate live images of the skin layer's ridge and valley patterns from equipotential contours in the electrical field.

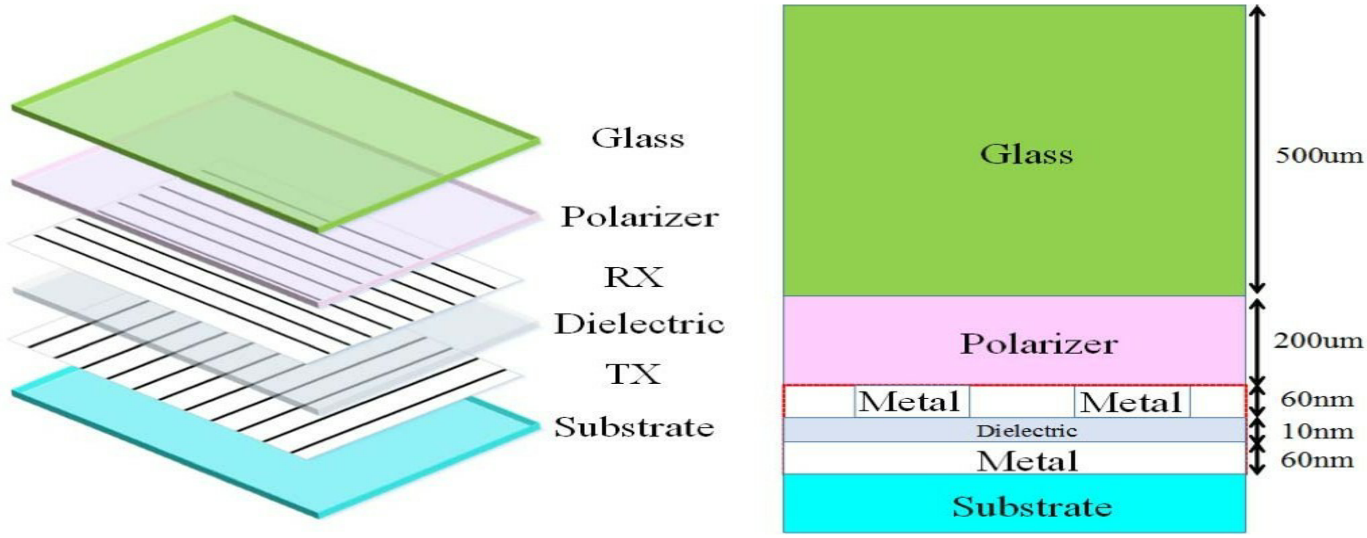


Fig. 1. A layer of conventional mutual capacitive touch screen and dimensions.

As the need for a larger interactive display grows, the size of the smartphone also increases. This means the display size has the highest priority in a smartphone. Some manufacturers have combined the fingerprint sensor and the activation button, and they have placed it on the front panel of the smartphone. Another solution is to place the sensor on the back of the smartphone to have a larger screen area on the front panel, but due to ergonomics, placement on the front panel is more natural when applied to smartphones. A third solution would be to integrate the fingerprint sensors within the display panel. To achieve this, the sensor components have to be transparent and should not interrupt the performance of the display.

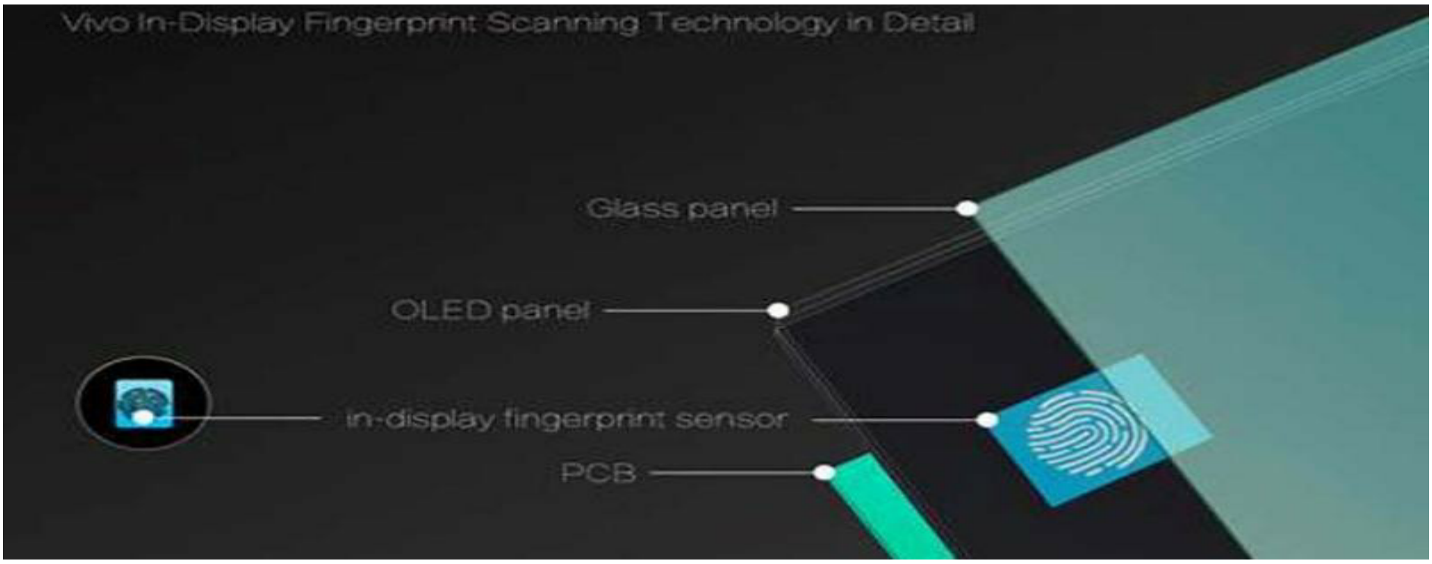


Fig. 2. In Display Fingerprint Scanning Detail.

ADVANTAGES:

1. Users do not have to pick the phone up to unlock the system.
2. It can be used for making fingerprint payments point of view.
3. It is more secure in comparison to the other fingerprint scanner technologies.
4. Fingerprint scanners are unique and highly secure, and they are more accessible, cheaper, and faster to setup.
5. The online transactions become convenient when you tap the screen with your finger for maybe a fraction of seconds.

6. The Touch ID is capable of working through glass, sapphire, and aluminium so it can be integrated into various places on the smartphone.

7. Its interface solutions offer the ease of use and intuitive interaction that users demand.

8. The small, thin size of our interface solutions enables our customers to reduce the overall size and weight of their products to satisfy consumer demand for portability.

9. The low power consumption of our interface solutions enables our customers to offer products with longer battery life or smaller battery size.

10. It interfaces solutions offer advanced features, such as force sensing, virtual scrolling, customizable tap zones, edge motion, and tapping and dragging icons, to enhance the user experience.

11. The reliability of its interface solutions satisfies consumer requirements for dependability, which is a significant component of consumer satisfaction.

## III. Under Display Fingerprint Technology

Among various types of touch screens, capacitive touch screens are popularly used in mobile devices. There are a self-capacitance type and a mutual capacitance type for the capacitive touch screens. The mutual capacitance type is more widely applicable since the self-capacitance type is weak in resolving position, causing the ambiguity in the situation of multi-touch. In a mutual capacitance touch screen, there are several layers: the cover glass, the polarizer film, the sensing layer, the dielectric, and the driving layer, which are all shown in Fig. 1. A conventional capacitive touch screen has a vertical pattern with sensing and driving electrodes which are made of indium tin oxide (ITO). Mutual capacitance is created at the intersection of the sensing and the driving electrode. The mutual capacitance is built up of static capacitance, which occurs between the two electrodes and fringing capacitance that occurs at the side of a wire. The change in the fringing capacitance is used to identify a touch action.

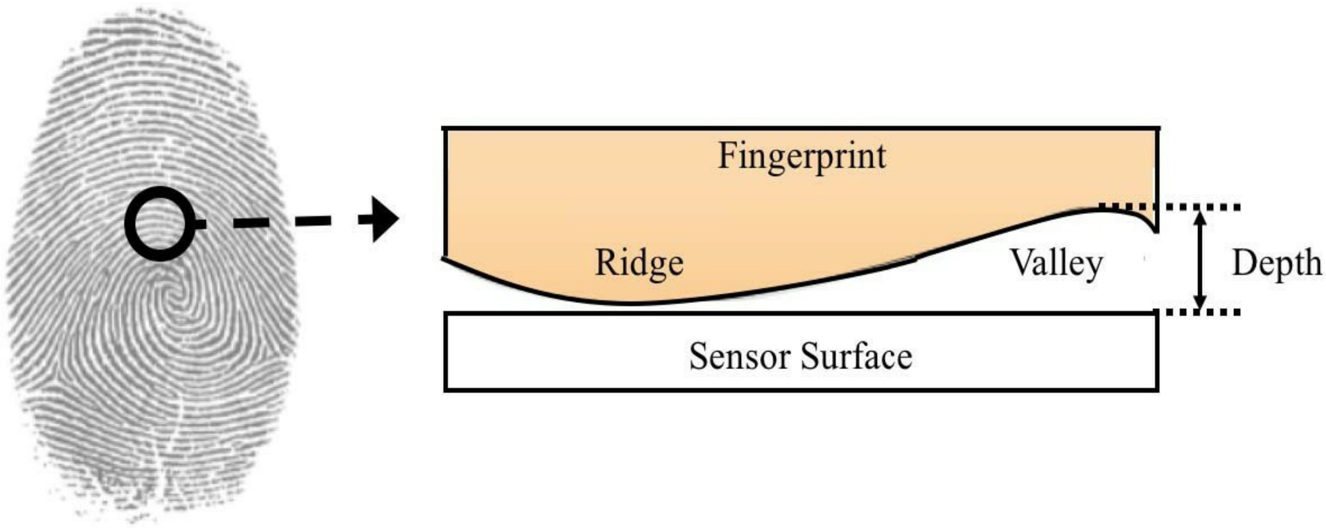


Fig. 3. The shape of the fingerprint with ridge and valley.

Since a human body brings fringing capacitance change to the touch-screen panel, the touch action is recognized by sensing variations of the mutual capacitance.

The human skin is classified into two layers: dead, dry skin and live skin. Dead dry skin is the outer skin and is considered as a dielectric material. Live skin is the inner skin and is regarded as a conductive material. When a finger touches the screen panel, the live surface draws the fringing field from the driving electrode, causing a reduction of the effective mutual capacitance. The fringing field is induced between the driving electrode and the sensing electrode. As shown in Fig. 2, the skin at the fingerprint is uneven because of ridges and valleys in the surface. The width of a peak is around 100 to 400µm, the depth of a valley from the edge of a ridge is around frequency signal to drive the high- resolution capacitive sensors on demand. Additionally, as the electrode becomes as shown in Fig. 1, there is a cover glass and a polarizer film above the sensing layer. The cover glass protects the touch screen from damage due to outer elements, and the polarizer film passes only light of specific wavelength to express colour. The cover glass in conventional touch screen panels is very thick. The overall thickness of the cover glass and the polarizer film in a traditional smartphone is 700 µm, which is almost ten times larger than the minimum depth of a valley. As the thickness of the cover glass and the polarizer film is relatively more substantial than the bottom of the valley, the difference of the sensed capacitance between ridge and valley becomes minimal. In other words, it is tough to differentiate a

ridge and a valley. Therefore, the layer over the sensing layer should be thinner than for the conventional type, because capacitance possesses an inverse proportionality to the distance between the anode and the cathode plates.
The specifications of an image-based fingerprint sensor can be applied for capacitive fingerprint sensors as well because a capacitive sensor can be modelled into capacitors per inch (CPI). Each capacitor in a capacitive sensor is considered as a dot in the optical fingerprint sensor because sensed data is obtained from the capacitor; hence, a capacitive sensor with more than 250 CPI can detect a fingerprint.

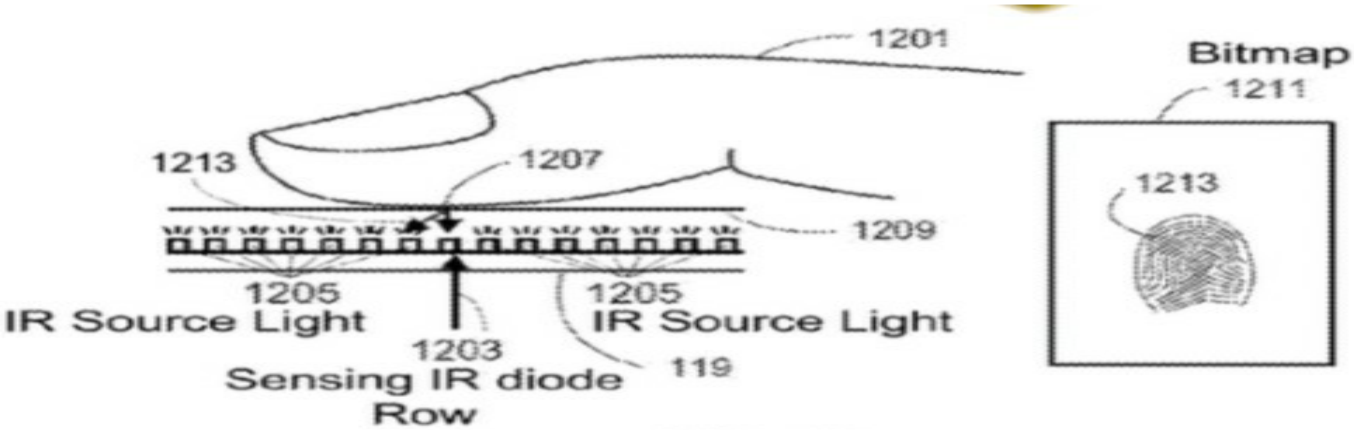


Fig. 4. Finger scanning and bitmap creation

Therefore, a mutual capacitive type touch screen with high resolution can be employed as a fingerprint sensor to recognize ridges and valleys.
To satisfy over 250 DPI with a vertical pattern, the electrodes have to be narrower and closer. A thin wire increases the parasitic resistance leading to an increase of the time constant. In that case, the driving ability of a sensor becomes very low. To scan more than 250 CPI at the same time as a conventional touch screen, the parasitic resistance of the electrode should be small. Therefore, new material is needed, with a minor sheet resistance compared to ITO, and which will allow a high narrower, the overlapped areas become smaller than before. It means the mutual capacitance will get smaller as

The electrodes become narrower. A general capacitance- sensing block is formed from an inverting operational amplifier with capacitors. By utilizing the ratio of the
are the parasitic capacitances, offsets from fabrication mismatch, noise from transistors, and so on. Furthermore, the environment of the sensor also creates a substantial amount of noise. Therefore, for the capacitive fingerprint sensor to work as a simple sensing mechanism, the sensing capacitance must be large enough to detect accurately regardless of errors and noise.

At present, the proportion of the active matrix organic light emitter diode (AMOLED) used for a mobile display is higher than that of the liquid crystal display (LCD). The advantages of the AMOLED are its fast response time, wide viewing angle, low power consumption, natural color expression, and paper-like thickness. However, an RGB pattern cannot be used in a mobile display, because of the limitation of the life expectancy of the blue LED in the AMOLED. Therefore, instead of an RGB pattern, a penTile design is used for an AMOLED display. Moreover, to realize a high-resolution display of over400DPI, a diamond-shaped penTile design is used. Within the diamond penTile patterned AMOLED display, the sensing and driving lines in a conventional perpendicular linear patterned touch screen affects the LED pixels negatively. Even though a regular touch screen uses transparent ITO, it reduces the visibility of the display. As a result, new patterns for a fingerprint sensor compatible with the diamond penTile are required to increase the mutual capacitance and enhance visibility.

## IV. Future Scope

The New suite of features when compared to the previous generation, which supports more design flexibility for operators and original equipment manufacturers by making it easier to differentiate products with unique form factors and advanced features and designs. The experience to satisfy customers demanding design specifications and other sensing capacitance to the feedback capacitance, the capacitance variation can be measured. However, there are undesired errors and noise within the sensing block. These requirements with numerous benefits, including the following:

- More ease of system integration.
- Reduce its product development cost.
- Shorter product time to market.
- Compact and more efficient platforms
- Improved product functionality and utility.
- Product differentiation.

## V. Conclusion

Nowadays, every mobile manufacturer is going in for bezel-less displays because of which the demand for the fingerprint sensors has also increased. For all the full-screen devices, the under-display fingerprint sensor is the most practical method to unlock the device.

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