Technical Disclosure Commons

Defensive Publications Series

June 2020

Under-Display Fingerprint Sensor System

David Lim

Joe Allore

Michael J. Lombardi

Reggie Weece

Recommended Citation

Lim, David; Allore, Joe; Lombardi, Michael J.; and Weece, Reggie, "Under-Display Fingerprint Sensor System", Technical Disclosure Commons, (June 10, 2020)
https://www.tdcommons.org/dpubs_series/3309

Under-Display Fingerprint Sensor System

Abstract:

This publication describes techniques for embedding an under-display fingerprint sensor (UDFPS) system, without increasing the thickness of an electronic device (*e.g.*, smartphone) and/or decreasing the storage capacity of a battery of the smartphone. The described techniques allow a manufacturer to embed the UDFPS system outside the planar footprint of the battery of the smartphone. Also, these techniques enhance user experience by assembling the UDFPS system closer to the bottom edge of the smartphone, may enable the removal of a display flex support (backer), and may decrease the shear stress of a display bend of a display screen of the smartphone, increasing the mechanical strength the display screen.

Keywords:

Under-display fingerprint sensor, UDFPS, UDFPS system, fingerprint sensor, FPS, display flex, smartphone, battery size, display, organic light-emitting diode, OLED, liquid crystal display, LCD.

Background:

Mobile electronic devices (*e.g.*, smartphones) are frequently powered by at least one rechargeable battery when the device is not plugged into a power source. The smartphone utilizes the reachable battery to power various components of the smartphone. There is a positive correlation between battery size and the amount of charge capable of being stored in the battery. Also, there is a positive correlation between the amount of charge in the battery and the time a user can use the smartphone without recharging the battery. Thus, there is a positive correlation between the battery size and the time the user can use the smartphone without recharging the battery.

The manufacturer of the smartphone often embeds an under-display fingerprint sensor (UDFPS) system between the battery and a display screen (display) of the smartphone, as is illustrated in Figure 1.

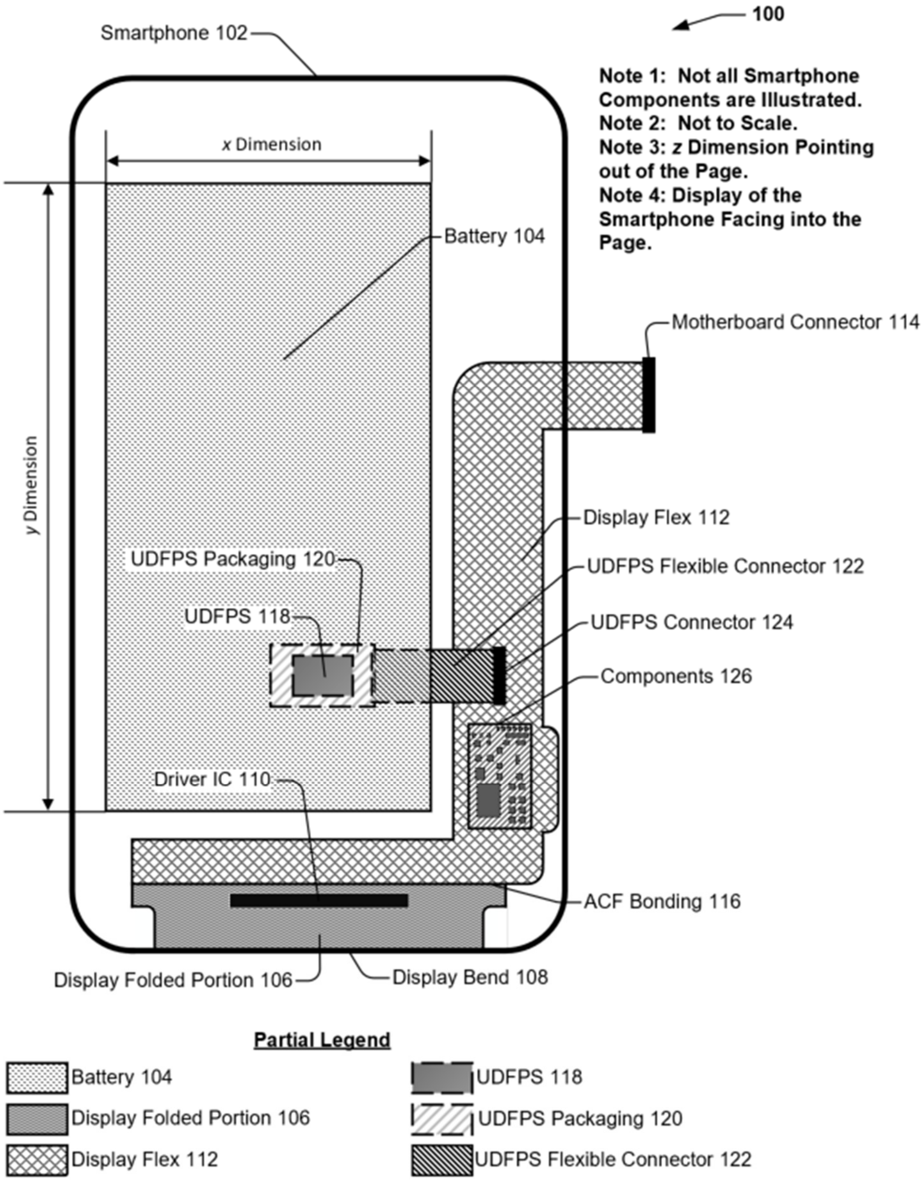

Figure 1

Figure 1 illustrates a top view 100 of a smartphone 102. The display of the smartphone 102 is facing into the page (Note 4 in Figure 1). Thus, the display and a back cover of the smartphone 102 are not illustrated. The smartphone 102 includes a battery 104 with *x*, *y*, and *z* dimensions, as is illustrated, and noted (Note 3) in Figure 1. The smartphone 102 includes a display folded portion 106. The display folded portion 106 is an extension of the display of the smartphone 102 utilizing a display bend 108. Hence, the display of the smartphone 102, the display bend 108, and the display folded portion 106 are a continuous composite(s) material. Note that the manufacturer may utilize various display technologies, for example, organic light-emitting diode (OLED) technology, glass-OLED technology, plastic-OLED technology, and liquid crystal display (LCD) technology. In the display folded portion 106, the manufacturer may embed a driver integrated circuit (IC) 110, which acts as an interface between microprocessors and the display of the smartphone. The smartphone 102 routes image information to and from the display and a motherboard (not illustrated) via a display flex 112 and a motherboard connector 114. The manufacturer may utilize anisotropic conductive film (ACF) bonding 116 to connect the display folded portion 106 to the display flex 112.

As is illustrated in Figure 1, the smartphone 102 includes a UDFPS 118 and an associated UDFPS packaging 120 (jointly "UDFPS system"), which is embedded underneath the battery 104, enabling a user to present their thumb, finger, or palm (hereinafter "thumb") on the display of the smartphone for authentication. Depending on the imaging technology that the smartphone 102 utilizes to capture a fingerprint image, the UDFPS 118 may be a complementary metal-oxide-semiconductor (CMOS) image sensor, a charge-coupled device (CCD) image sensor, a capacitive image sensor, an ultrasonic image sensor, a thin film transistor (TFT) image sensor, and a quanta image sensor (QIS). The smartphone 102 transfers a fingerprint image captured by the UDFPS system via a UDFPS flexible connector 122 to the display flex 112 using a UDFPS connector 124. Note that the display flex 112 may include other passive and active components (illustrated "components 126"), for example, resistors, capacitors, inductors, and various ICs. Thus, the smartphone 102 utilizes the display flex 112 for multiple functions, including to transfer image information from the display and from the UDFPS system to the motherboard of the smartphone 102, while reducing signal integrity issues.

Embedding the UDFPS system between the display and the battery 104 increases the thickness of the smartphone 102 by approximately 0.2 millimeters (mm) to 0.4 mm, depending on the type of the UDFPS technology. Users, however, do not prefer to carry a thick smartphone. The manufacturers, to keep the smartphone 102 thin, may reduce the thickness (z dimension) of the battery 104, resulting in a reduced time the user can use the smartphone without recharging, adversely affecting user experience. Therefore, it is desirable to have a technological solution to embed a UDFPS system without sacrificing the size (x, y, and z dimensions) of the battery 104 and without increasing the thickness of the smartphone 102.

Description:

This publication describes techniques for embedding a UDFPS system in a smartphone, without increasing the size of the smartphone or decreasing the storage capacity of the battery. Dimensions throughout this disclosure are examples and do not limit the described techniques for embedding the UDFPS system in the smartphone 102. Figures 2A and 2B help illustrate one aspect of how the manufacturer may integrate the UDFPS system, without decreasing the x, y, and z dimensions of the battery 104.

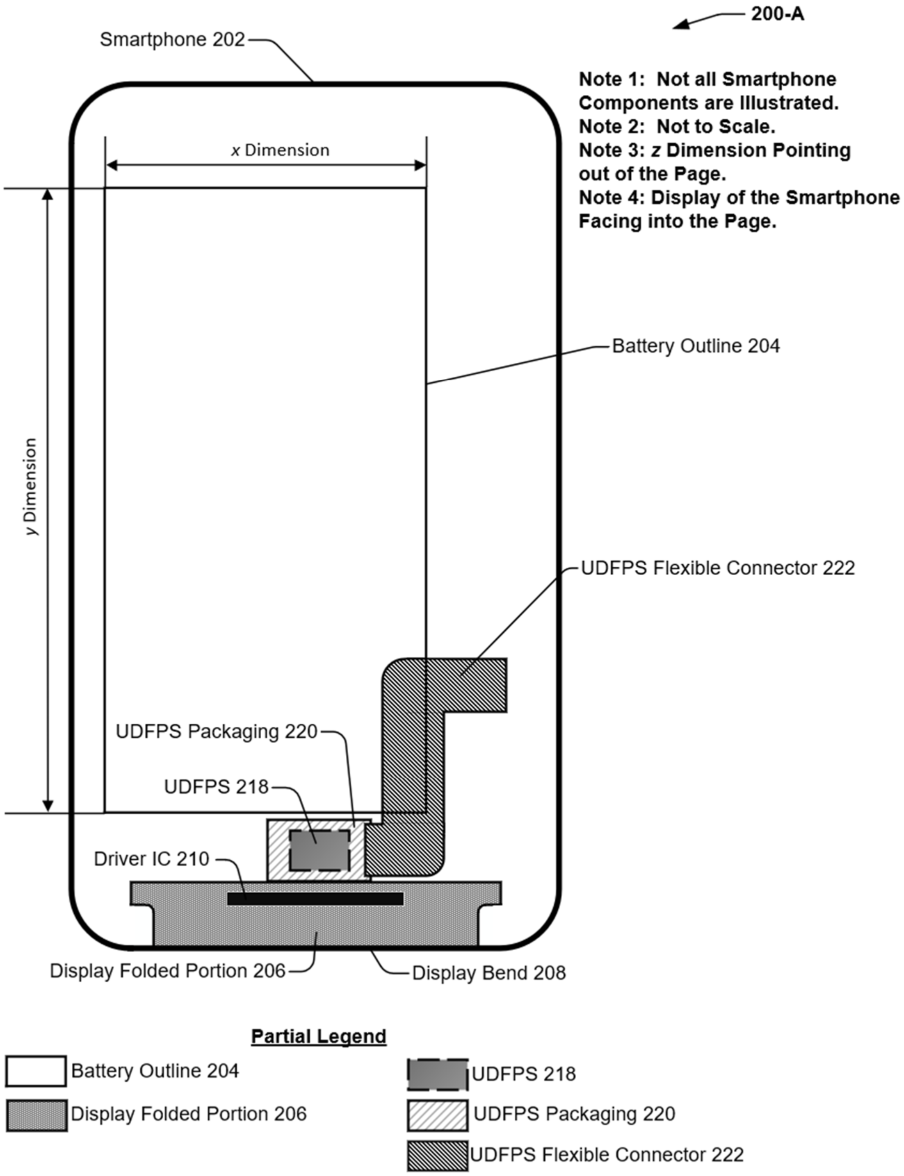
200-A
Smartphone 202
Note 1: Not all Smartphone Components are Illustrated.
Note 2: Not to Scale.
Note 3: z Dimension Pointing out of the Page.
Note 4: Display of the Smartphone Facing into the Page.
x Dimension
y Dimension
Battery Outline 204
UDFPS Flexible Connector 222
UDFPS Packaging 220
UDFPS 218
Driver IC 210
Display Folded Portion 206
Display Bend 208
Partial Legend
Battery Outline 204
Display Folded Portion 206
UDFPS 218
UDFPS Packaging 220
UDFPS Flexible Connector 222

Figure 2A

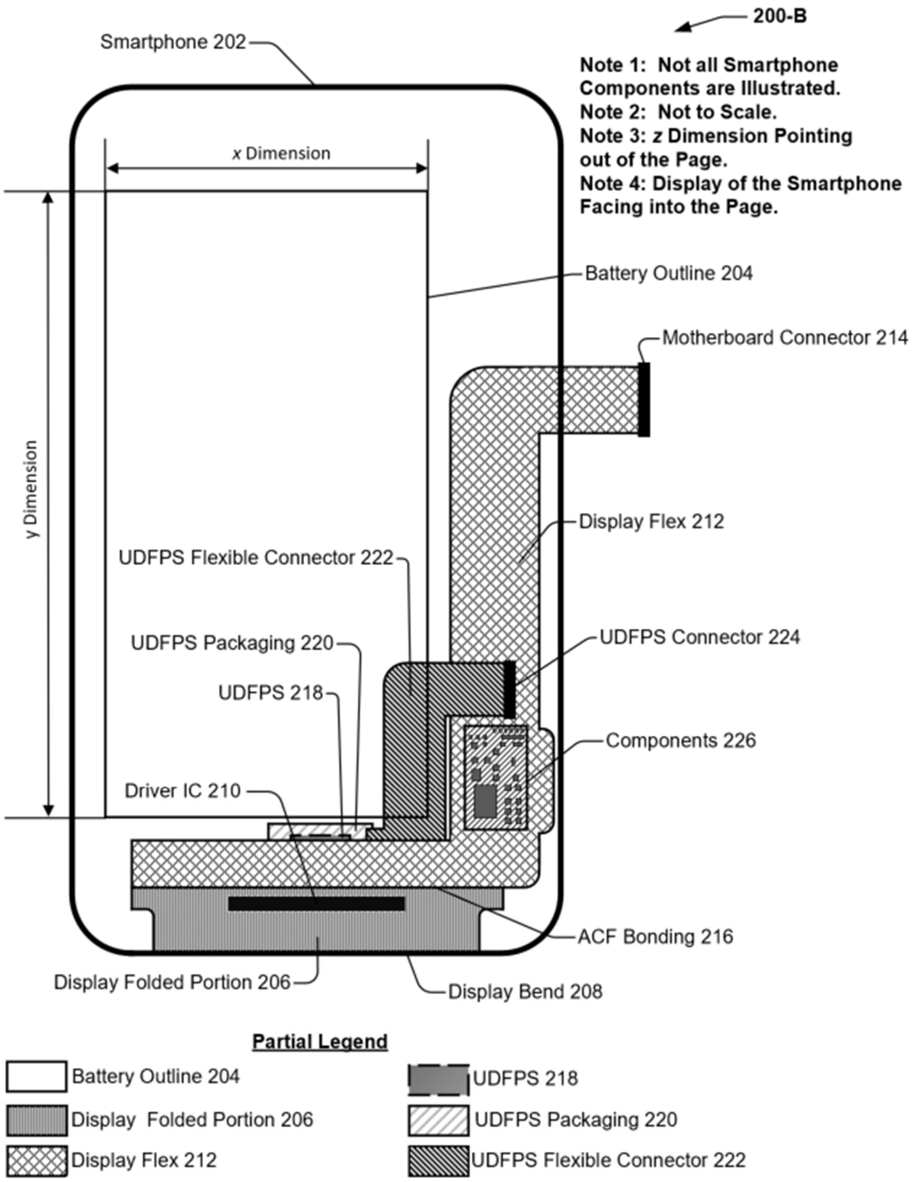

Figure 2B

Figures 2A and 2B illustrate a plan view 200-A and a plan view 200-B of the smartphone 202. Like Figure 1, a display and a back cover of the smartphone 202 are not illustrated. Figures 2A and 2B illustrate the same aspect of the smartphone 202. For ease of description, Figure 2A illustrates components of the smartphone 202 without a display flex 212, and Figure 2B illustrates the components of the smartphone 202 with the display flex 212. Figures 2A and 2B illustrate a battery outline 204 of the smartphone 202, where a battery can be installed. Note that the battery outline 204 in Figures 2A and 2B has the same *x* and *y* dimensions as the battery illustrated in Figure 1. Like Figure 1, the smartphone 202 includes the display folded portion 206, the display bend 208, and the UDFPS system (UDFPS 218 and UDFPS Packaging 220) with the same dimensions as the UDFPS system in Figure 1. The manufacturer may assemble the UDFPS system prior to bending the display of the smartphone (display bend 208) when the manufacturer utilizes a plastic-OLED technology. Also, the manufacturer may assemble the UDFPS system under the display flex 212 (illustrated in Figure 2B), when the manufacturer uses other display technologies, for example, glass-OLED technology or LCD technology. Regardless of which display technology the smartphone 202 utilizes, the manufacturer assembles the UDFPS system outside the battery outline 204, enabling the manufacturer to maintain the desired thickness (*z* dimension) of the battery without increasing the thickness of the smartphone 202.

Also, placing the UDFPS system closer or adjacent to the display folded portion 206 may offer a better user experience, because it may be more comfortable and more natural for the user to present their thumb for authentication. To adjust for the placement of the UDFPS system closer or adjacent to the display folded portion 206, the manufacturer may utilize an extended UDFPS flexible connector 222, as is illustrated by the difference of the UDFPS flexible connector 122 in Figure 1 in comparison to the UDFPS flexible connector 222 in Figures 2A and 2B. Like Figure 1, the smartphone 202 transfers the fingerprint image via the UDFPS flexible connector 222 to the display flex 210 using the UDFPS connector 224. The manufacturer may install part of the UDFPS flexible connector 222 underneath the display flex 212 and part of the UDFPS flexible connector 222 and the UDFPS connector 224 above the display flex 212, as is illustrated in Figure 2B.

The installation of the UDFPS system underneath the display flex 212 enables the UDFPS system to function as support (backer) of the display flex 212. Alternatively or additionally, the manufacturer may assemble the smartphone 202 by integrating the UDFPS system into the display flex 212 or the display of the smartphone (not illustrated as such) before bending (display bend 208) the display of the smartphone 202. As is illustrated in Figures 2A and 2B, the display folded portion 206 and the display flex 212 are not overlapped and are connected via the ACF bonding 216. This enables the manufacturer to reduce the thickness of the smartphone 202 further.

Figure 3A illustrates a cross-sectional view 300-A, and Figure 3B illustrates a cross-sectional view 300-B of various components of the smartphone 202 outside of the battery outline 204. Thus, Figures 3A and 3B illustrate the cross-sectional views of the smartphone 202 in Figures 2A and 2B.

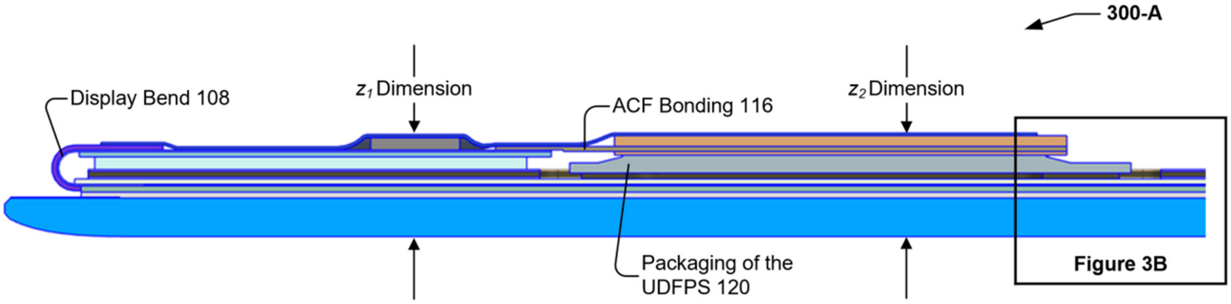

Figure 3A

The cross-sectional view 300-A of Figure 3A illustrates changes in the thickness of a stack of some components of the smartphone. Assuming the thickness of the UDFPS system is approximately 0.300 mm, an illustrated z_1 dimension may increase by approximately 0.046 mm (*e.g.*, from 1.676 mm to 1.722 mm), and an illustrated z_2 dimension may increase by approximately 0.138 mm (*e.g.*, from 1.609 mm to 1.747 mm). Nevertheless, increases in the z_1 and z_2 dimensions in Figure 3A do not translate to an increase in the thickness of the smartphone. Note that the z_1 and z_2 dimensions in Figure 3A are considerably smaller than the thickness (z dimension in Figure 1) of the battery. In this example, by placing the UDFPS system closer or adjacent to the display bend 308, increases the radius of the display bend 308 by approximately 0.023 mm (*e.g.*, from

0.250 mm to 0.273 mm), which decreases the shear stress of the display bend 308, resulting in a more mechanically robust display. The cross-sectional view 300-B of Figure 3B illustrates additional details of the stack of some components of the smartphone.

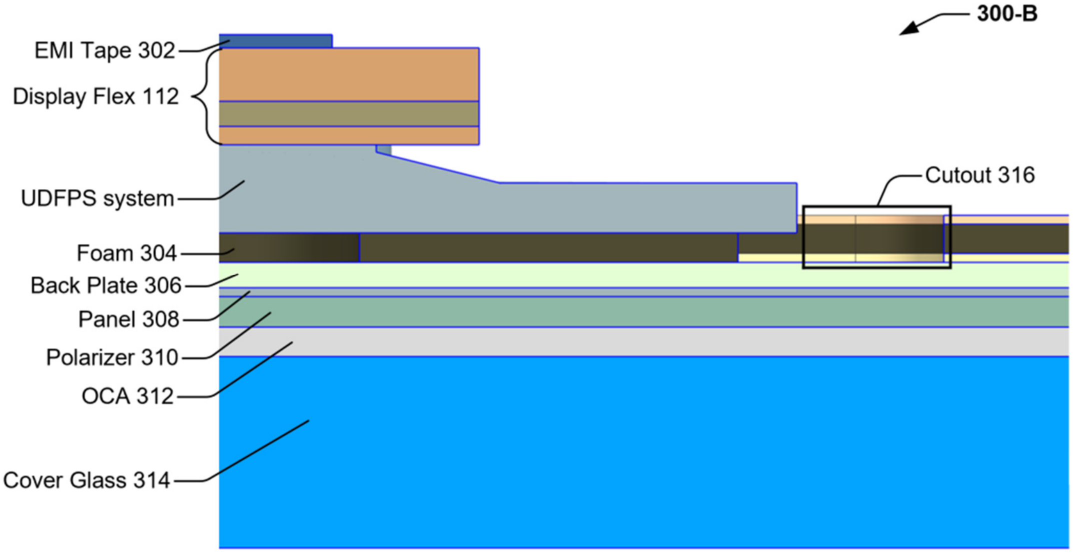

Figure 3B

The cross-sectional view 300-B of Figure 3B details the z_2 dimension in Figure 3A, including an electromagnetic interference (EMI) tape 332 (*e.g.*, 0.045 mm), layers of the display flex 312 (*e.g.*, 0.330 mm), the UDFPS system (*e.g.*, 0.300 mm), and a foam layer 334 (*e.g.*, 0.100 mm), installed above the display of the smartphone. The display of the smartphone includes a backplate 336 (*e.g.*, 0.088 mm), a display panel 338 (*e.g.*, 0.030 mm), a polarizer 340 (*e.g.*, 0.104 mm), an optically clear adhesive (OCA) 342 (*e.g.*, 0.100 mm), and a cover glass 344 (*e.g.*, 0.650 mm). Figure 3B also illustrates part of a cutout 346, which enables the UDFPS system to be utilized by the user for authentication.

Conclusion

The described integration method of a UDFPS system in an electronic device decreases the overall thickness of the electronic device, allows for a thicker battery, enhances user experience, may enable the removal of a display flex backer, and may decrease the shear stress of the display bend, increasing the mechanical strength of the display of the electronic device.