# Organic Optical Sensors Enabling Fingerprint and Vein Recognition Modules

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Keywords: Organic Image Sensor, Fingerprint on Display, OLED Display, Vein Imaging.

## ABSTRACT

*With semiconductor materials sensitive in both visible and NIR (Near-Infrared) regions, organic optical sensors have been developed for fingerprint recognition integration within smartphones, as well as for vein imaging modules.*

## 1 Introduction

Nowadays, higher level security is required for all kind of portable devices. Within smartphones, for which the creation and development of new features depend upon the protection of biometric data of the users, manufacturers are keen to integrate safer authentication solutions. Even if facial-based identification systems have been developed by some mobile phone companies, fingerprint recognition is still the most widely used biometry system. Most of the currently available fingerprint solutions are based on Complementary Metal Oxide Semi-Conductor (CMOS) backplanes coupled with optical, capacitive or ultrasonic technologies, which present considerable limitations. CMOS devices can efficiently operate in visible range but has lower sensitivity in near infrared (NIR) range and due to expensive processes, their capture area is limited to a few mm². In contrast, organic-based fingerprint solutions are fabricated with cost-effective processes, which enable the integration of larger capture area sensors within smartphones, leading to multiple finger authentication and thus higher security level [1]. In addition, the absorption of organic materials can be engineered to be sensitive to the visible light, finding applications in Fingerprint on Display (FOD) devices based on Organic Light-Emitting Diode (OLED) displays or to the NIR (850 & 940 nm) light opening applications for vein imaging or for FOD devices based on Liquid Crystal Display (LCD) displays [2-3].

In this paper, we will present some of the multiple applications enabled by organic photodetectors. While taking advantage of the visible and NIR sensitivity of organic semiconductors, we will introduce the FOD technology integrated within smartphones with OLED displays, as well as a vein imaging module (Fig. 1). Both modules include Thin-Film Transistor (TFT) backplanes, our proprietary OPD technology and optical collimator. The sensors are driven by our own Read-Out IC (ROIC) integrating Gate-on-Array (GOA) signals control. A dedicated image processing pipeline has been developed to achieve the high matching performances required by the market. All these key components have been precisely detailed during SID Display Week 2021 [1] for FoD modules. Here, we will show how the same technology can be used for vein imaging in NIR range.

Thanks to the higher security level brought by this new technology, we expect a commercialization of both fingerprint and vein recognition modules in a near future.

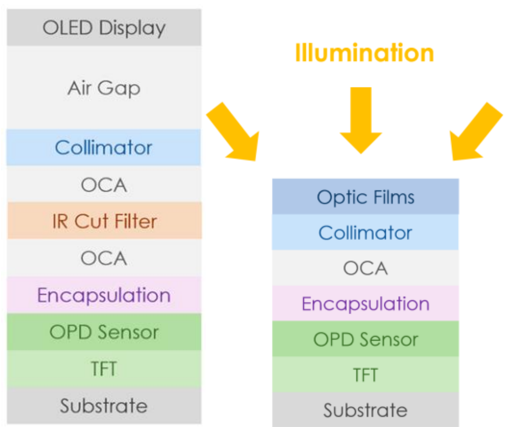


**Fig. 1 (left) FOD Module and (right) Vein Imaging Module using Isorg OPD technology**

## 2 Organic Photodiode

Our own proprietary image sensor technology has been developed and industrialized within our GEN3.5 (650x780 mm² backplanes) factory line. The image sensor architecture is displayed in the Fig. 2. More details about the OPD technology, such as process information, performances and reliable data, have been detailed during SID Display Week 2021 [1]. The organic layers are coated on top of TFT, and such devices display resolution between 300 and 500 DPI (Dots Per Inch).

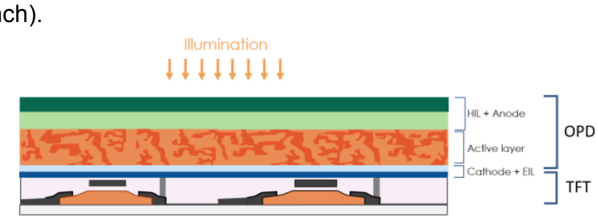


**Fig. 2 Architecture of Image Sensors**

Several organic materials have been designed and synthesized to enable applications at different wavelengths. Sensitivity in the visible (540 nm) and NIR (850 & 940 nm) regions have been achieved with quantum efficiency above 50% (Fig. 3), enabling both fingerprint and vein imaging. In both cases, the high-quality image is obtained on the sensor thanks to our own proprietary collimator film (or angular filter), that allows only perpendicular light rays to reach the sensor, rejecting diffuse light that would otherwise blur the image [1].

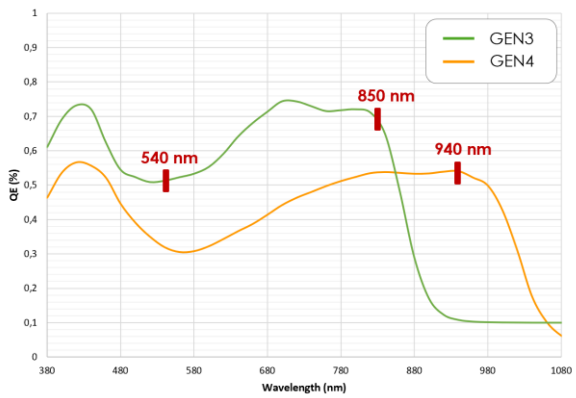


**Fig. 3 QE vs Wavelength of Organic Semiconductors.**

## 3 FOD Application with OLED Display

Thanks to 25 µm Optical Clear Adhesive (OCA) films, our proprietary collimator together with an IR cut filter is laminated on our sensor (TFT backplane, OPD material sensitive in the visible light and encapsulation film) and subsequently assembled behind an OLED smartphone screen to produce the FOD module (see Fig. 1 and 4). The module is not attached to the OLED to enable display repair if necessary. The module is then put in a casing box and connected to a smartphone where a dedicated app is used to acquire fingerprint images.

**Fig. 4 FOD Module with OLED Display**

As OLED displays light transmittance is low (~4 % at 540 nm), and as the display itself is patterned, the fingerprint signal level is mixed with electronic noises (touch panel, metal grid) which have to be removed. Specific image processing has thus been developed to clean up the images with the reduction of temporal and spatial fixed noises, defect correction as well as background removal [1] before converting the image in 8 bits. Subsequently, a binarization is performed prior to the extraction of minutiae used for image comparison.

**Fig. 5 Fingerprint Image Acquired with FOD Module and After Binarization Treatment**

## 4 Vein Imaging Application

Vein can be easily imaged using IR light that is absorbed strongly by the blood, resulting in darker region in the image. In order to demonstrate the ability of the OPD technology for vein imaging, we have prepared a vein module based on the same technology developed for FOD applications. The two main differences being the nature of the active OPD material (using materials sensitive in the NIR area instead of in the visible region) and the absence of IR cut filter that would otherwise cut out the image signal. The full architecture of the module is detailed in Fig. 1.

The finger is applied on top of the module, under IR illumination. As it is seen in Fig 6, vein imaging can be achieved, enabling new security and recognition applications brought by OPD technology.

Such solution can be currently used as a stand-alone module to control a person identity. In the future, we plan to couple vein and fingerprint recognitions in an unique module, to increase security level and confirm that the subject is alive (anti-spoofing feature).

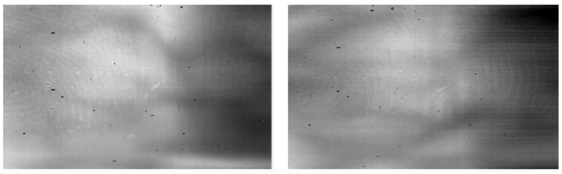

**Fig. 6 Vein Images Achieved with our Module**

## 5 Conclusion

In this paper, we demonstrated a complete OPD-based FoD solution designed for next smartphone generation. Thanks to optimized fabrication processes, cost-effective solutions with capture area being adjustable from 1-finger capture area (20 x 30 mm² for instance) to 4-fingers recognition module (so called full-display sensor) are now available. We also show that the same OPD technology can be used for vein imaging using sensitivity to IR light. Both solutions include TFT backplane, OPD image sensor, collimator filter and read-out integrated circuit, and are ready to be produced for mass production and commercialization.

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