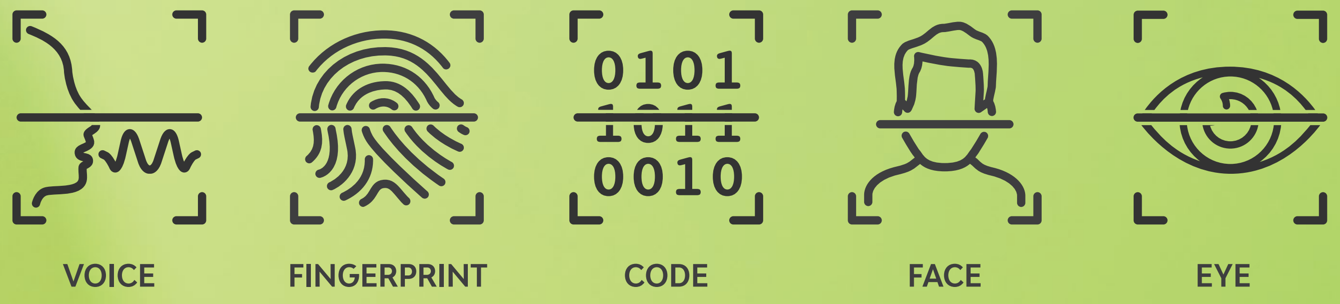
HOW DOES MY SMARTPHONE RECOGNIZE ME?

Biometrics is the science of measuring and analyzing biological characteristics and biometric methods are in common use today to authenticate our identity. In particular, fingerprint or face recognition are chracteristics that are used to secure access to personal devices like our mobile phones and Evatec's production tools are already in use for exactly this type of application around the world today. Evatec Product Marketing Manager **Silvio Nigg** gives us an introduction into biometrics and the kinds of optical coatings required.



Biometric identification

Biometric identification is achieved using specific traits, which can be split into 3 categories – "morphological", "biological" and "behavioural". Behavioural traits, as the word implies, are traits that detect the unique behaviour of subjects. For example, a person's signature is a behavioural trait, whilst biological traits include DNA and blood markers. Morphological traits can be the features of a face, a finger print, the color and pattern in the iris and the human voice.

However, not all human characteristics are equally suitable for biometric identification processes. We need to identify characteristics which are:

- ✓ **Unique:** Individual to each and every person
- ✓ **Measurable:** Easily and reliably measurable by sensors
- ✓ **Constant:** Does not change with the age of the person over time
- ✓ **Universal:** As many people as possible have the attribute

Based on these properties a number of different features have successfully been used for biometric process in a whole range of applications – from hand geometry and the structure of the hand lines and veins, to the structure of the rainbow skin of the eye (iris), the voice (tone color), the shape of the ears, the fundus of the eye (retina), the typing behaviour on keyboards, the signature and even characteristic body movements.

In this article we shall focus on two morphological traits – face recognition and fingerprint detection for use in mobile phone applications, and some of the thin film coatings essential for their effective performance.

Face recognition

How do we know if what we see is a real person or a painting?

In addition to a 2 dimensional image we require depth information to clearly determine a 3 dimensional object in general and a person by his or her facial features. A computer with access to a camera module will have the same 2D-information about the face we see in a picture. Even with a pair of eyes and stereo sight, the information at hand remains a 2D-Picture. Surprisingly, we humans have the “experience” to determine that this face is a picture. Our brain can “recognize” a face from this 2D information. The human mind can access the special algorithm and operates on a non-physical plane that can solve problems by comparing information with experience whereas a smartphone with its computing power will rely on the depth information and for each pixel on the image. The distance to the observer must be known. This is paramount.

Methods to determine depth information

As already explained. we need to measure the distance from the object to the camera for EACH pixel to provide the required depth information.

There are three current technological solutions:

- Two cameras for stereo vision just like in humans and animals.
- Projection of a laser beam in a predefined structured light pattern over a 3 dimensional object which creates a line pattern on this 3D-Surface. This pattern appears distorted to an observer when they are not in the same observing position as the projector emitting the light pattern. This “distorted” image can now be used for an exact geometric reconstruction of the surface shape.
- Time of flight which works as its name indicates. A light pulse is sent out and hits the target. The reflected light will return to the pixel on a camera module. The time the emitted light requires to return to the pixel on the camera module provides the required distance information.

Each technology has its advantages and challenges. In particular however, both structured light and time of flight methods using light sources to illuminate the target have been applied successfully in handheld devices in recent years.

NIR Laser technology as the emitter

Near infrared (NIR) lasers are safer for the human eye than visible laser at similar output power and are therefore a popular choice for optical sensing. Potentially we can operate a NIR laser at higher power and extend the object detection range for remote sensing applications. Visible laser diodes on the other hand can be used if operated at low-power or limited to low risk environments.

Vertical-cavity surface-emitting lasers (VCSELs) have become an important technology trend for 3D sensing. With integrated optical elements, the light from the laser can be shaped into a pattern (structured light). Measuring the “shape” of the reflected light provides depth information.

VCSELs have a superior beam quality and wavelength stability then edge emitting lasers and therefore produce more accurate data. Apple (USA) adopted VCSEL for their face recognition technology. Measuring the facial structure with a depth sensor makes VCSEL-based 3D facial recognition more reliable and ideal for differentiating between a living head and a 2D picture.

How to overcome the signal to noise challenge in the camera module

Despite technological advanced in LASER technology, the problem remains that sensor pixels in the camera modules are not ideally matched with best conversion for the visible light range and are still sensitive to IR radiation. Although the human eye cannot detect the NIR-Laser beam, the camera module can, and this creates unwanted signals. For the depth sensor the opposite challenge needs to be mastered. The sensor needs as much information from the NIR-laser signal without being overwhelmed with the stray light from the visible range which is where thin film technology plays an essential part in delivering reliable operation.

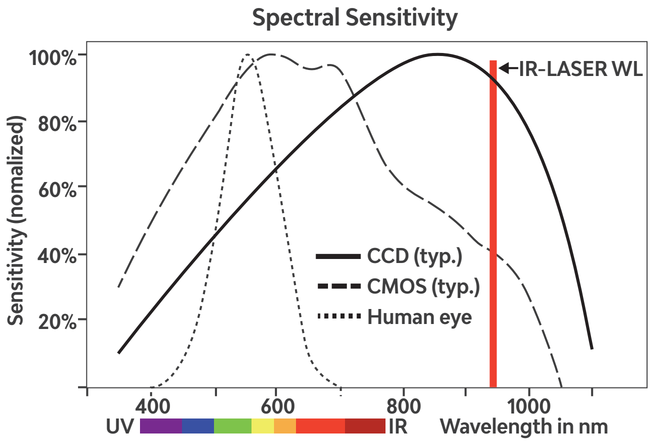


Figure 1: Comparison of spectral sensitivities.

High end NIR bandpass filters are key

The filter requirements for the imager sensor are quite straight forward. The filter that blocks the UV and IR light is already a commodity in the camera model market, but the requirements for the depth sensor are much more demanding. This is because the wavelength range of interest is still in the range where camera modules are sensitive and we therefore require a narrow bandwidth in combination with high transmittance.

For cost effective mass production the requirements are:

- To pass as much light at nominal wavelength of the NIR-Laser diode
- To block of all other wavelength. We only want to detect the “interesting light”
- A very steep filter characteristic with pronounced corner.
- The bandpass at 50% with a very narrow width
- A center wavelength uniformity <± 0.25 % on a 200mm Wafer (WiW)
- A coating system that supports high throughput in mass production, achieving high yield and lowest operating costs consistent with production of mass market consumer devices.

CLUSTERLINE® provides a production solution

Automated tools have many benefits including low particles and excellent process repeatabilities. The excellent optical performance of typical bandpass filters deposited on a fully automated CLUSTERLINE® 200 BPM tool shown in figure 2 are illustrated in figure 3.

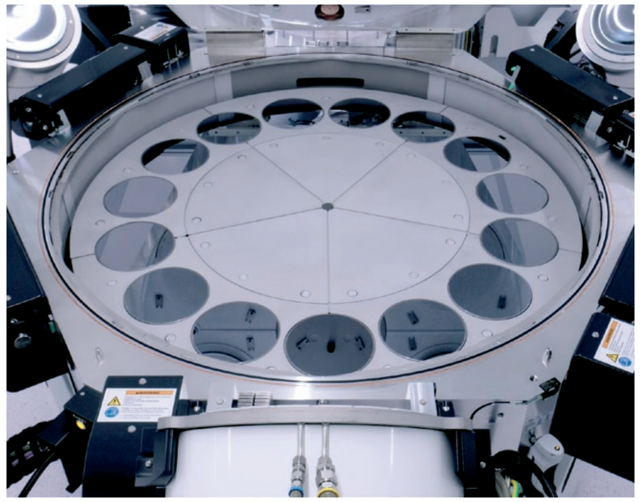


Figure 2: Cassette to cassette CLUSTERLINE® 200 solution integrating batch module processing technology for 200mm wafers.

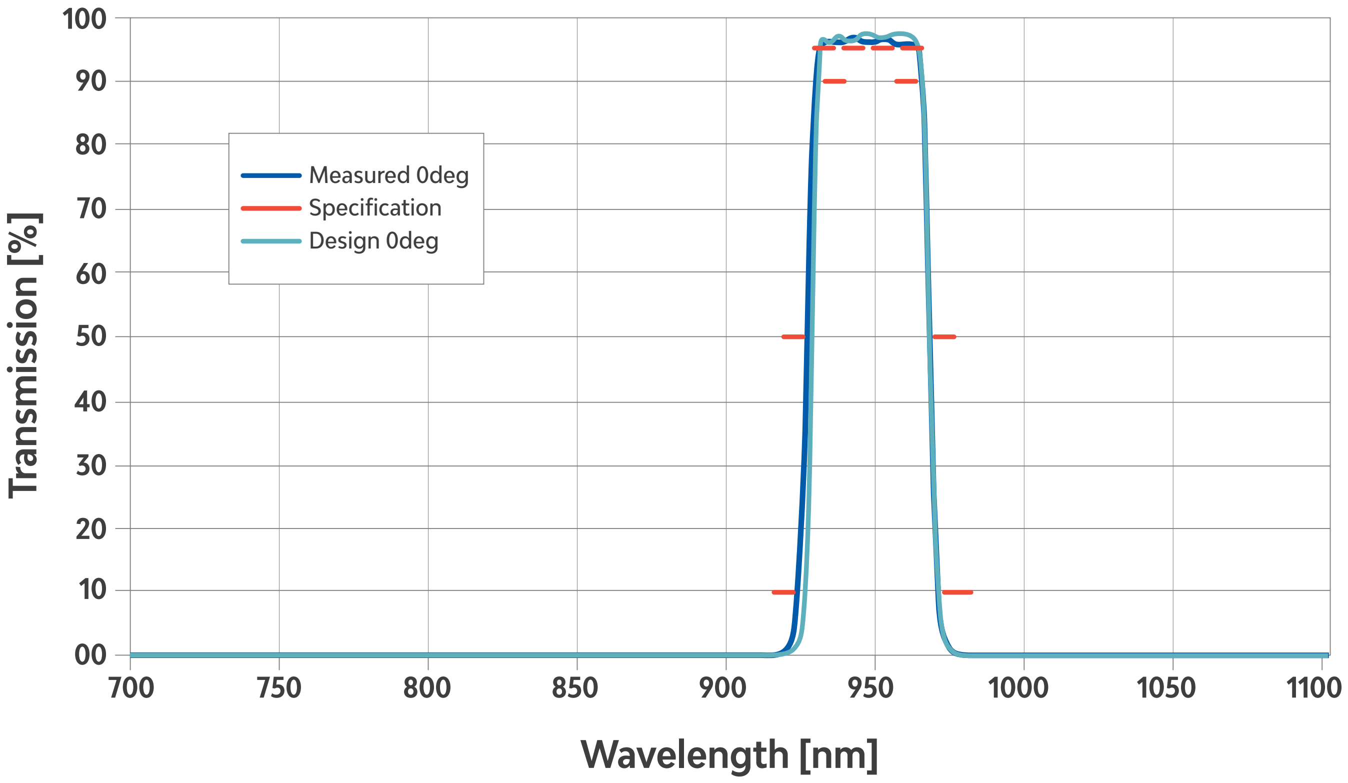


Figure 3: Typical 947nm bandpass filter performance.

In-display Fingerprint Detection

The past decade of smartphone development saw a continuing evolution of how we unlock our devices, from typing in passcodes, to fingerprint scanners, and then facial recognition as already discussed earlier. In recent times however, we have seen a move towards "in-screen fingerprint" detection or scanning, so let's take a closer look at the technique and how two coatings prepared by thin film technology also play a key role in this biometric sensing technology.

How does your phone scan your finger?

As the name suggests, in display detection involves a fingerprint scanner that sits underneath the screen. The race is ongoing to make screens as large as possible so hiding an unlocking mechanism under the display is paramount to saving that extra space. The two main approaches are ultrasonic and optical.

The ultrasonic approach

The first method uses ultrasonic waves. When you place your finger on the phone, an ultrasonic wave is produced, interacting with the finger's skin and bouncing back. A 3D map of a digit is created and the technique works best when the interface between finger and display is pronounced such as when your fingers are wet or dirty. An ultrasonic in-screen scanner is hard to deceive, so even a 3D model of a finger is unlikely to fool more sophisticated sensors.

The optical approach

Optical in-screen fingerprint sensors operate by projecting light. The functional area of the sensor illuminates the finger. A sensor or camera underneath the screen detects an image which is then compared with the information stored in the phone. If it matches, it unlocks the phone. In other words; "In-display fingerprint optical sensors work by capturing an image of your fingerprint based on the light reflected from the gaps between the pixels on your phone's display." When it comes to "security" its reported that Goodix's optical in-display fingerprint sensor has a 0.002% false acceptance rate and a false rejection rate of less than 2%.

In-screen fingerprint concepts and filter requirements

There are many different in-display sensors, but two examples are the optical collimator shown in figure 4 and the pinhole array illustrated in figure 5.

Whatever technology is chosen, all have a common requirement for 2 key coatings:

- Coating 1: An optical filter that suppresses undesired background light; blocks NIR from the sun and parts of red spectrum above 580nm (the human finger absorbs most light < 580nm).
- Coating 2: A black coating, which is an optically absorbing material between the optical collimators to absorb light and avoid crosstalk of light between collimators.

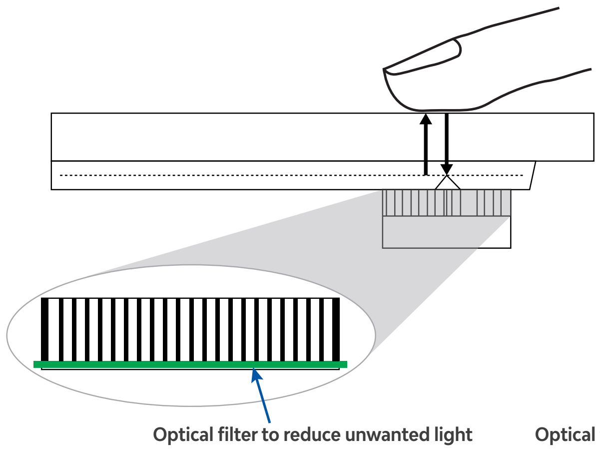
Coating 1: Bandpass filter (green line)

The wavelength range may be different, but just like in face recognition applications process repeatability and manufacturing automation are key considerations for achieving cost effective mass production at the high optical specs and low particle levels required. Typical performance for filters which could be produced on Evatec's CLUSTERLINE® 200 BPM is illustrated in figure 6.

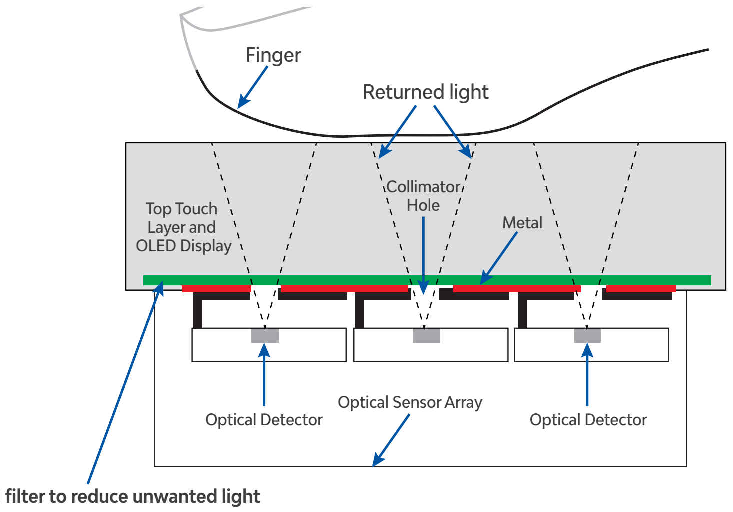
Coating 2: Black AR (red line)

An optical absorption coating between optical collimators is used to absorb any unwanted reflection from the detectors and reduces cross talk between the different optical collimator holes.

Optical Collimator (Figure 4)



Pinhole Array (Figure 5)



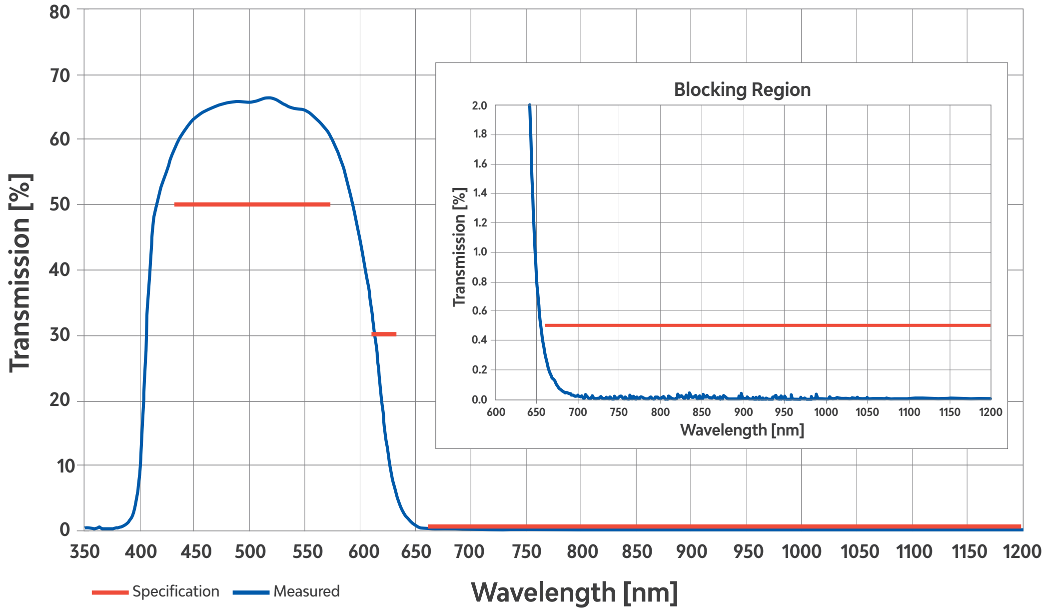


Figure 6: Typical bandpass filter with IR blocking which would be suitable for in-display fingerprint detection.

Effective black AR coatings could be produced for large display areas and in large volume on Evatec's SOLARIS® "inline" production platforms (Figure 8). The smaller SOLARIS® S151 handles substrates up to 8 inch diagonal while the larger S380 handles up to 15 diagonal. Carrier handling capability is available in both tools for simple handling and conversion in production between a whole variety of display sizes without any compromise in coating uniformity and performance.

Evatec process specialists are ready to work with individual device manufacturers to optimize stack design according to their device architecture. However, figure 7, shows the basic stack design of a typical 6 layer film which could be achieved on a SOLARIS® S380 (Figure 8). The optical performance in figure 9 would show reflectance levels well below the 1.5% specification required in this example design right out to 150mm radius across a large 300mm working diameter.

A little bit of Evatec in every household

Next time you unlock your phone it may well be thanks to Evatec's thin film technology, so If you would like to know more about our biometric sensing production solutions why not pick up your mobile phone now and give your local Evatec office a call. Our process specialists are here to help you put together the best production solution for your own particular needs.

Figure 7: Typical Black AR film stack.

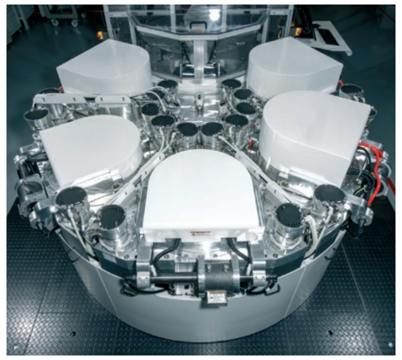


Figure 8: SOLARIS® S380.

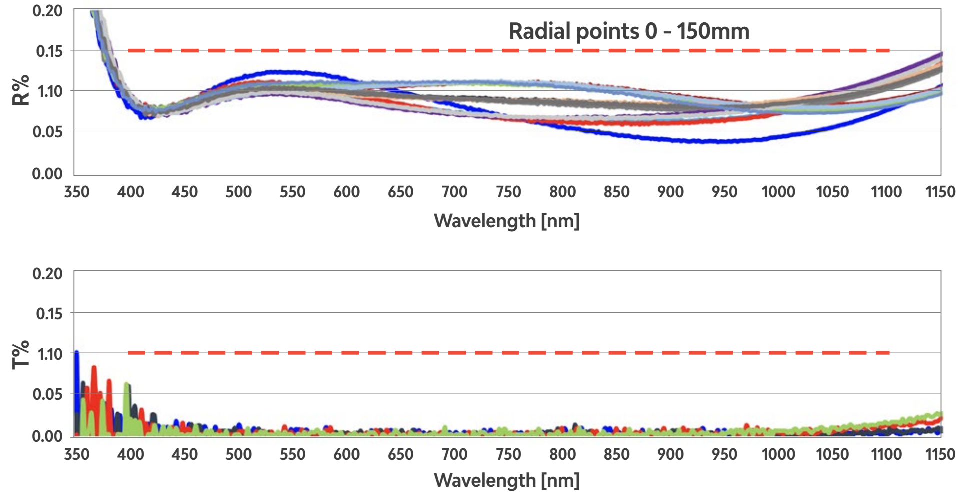


Figure 9: Evatec's SOLARIS® is capable of depositing black AR coatings with reflection and transmission performance within the typically required specification.