A new dimension for digital logic

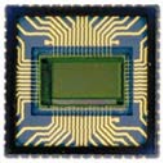
Image Sensor Test

(CMOS and CCD-Technology)

The difference between image sensors and electronic components is substantial and calls for a new dimension of test and measurement solution; electrical and optical parameters have to be measured.

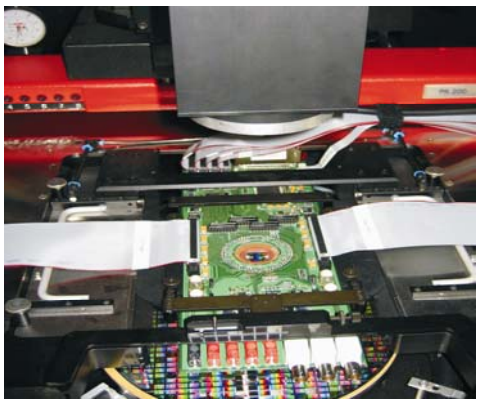
Dark = Zero, Light = Fullscale?
Yet, it is not that simple. Between dark and light, thousands of digital gradings are available to identify detailed image information.

Captured images can often be incorrect. Damaged pixels (blind spots), hot pixels and non-linearities are often detected – some of them are intended, while some of them are not. A few of these failures will later be compensated in the system. Unfortunately, while the sole use of error-free sensors would be ideal, it would also be quite expensive.



** CMOS image sensor EMPHIS-300*

New principles in testing
The borderline between acceptable and unacceptable results impacts the required measurement techniques. For example, a logic module and a memory module with a single error are problematic, while an image sensor with a few damaged pixels is satisfactory.



***Test of an image sensor wafer*

New technologies call for new methods
The test system needs to consider the whole optical pixel field, in reference to the amount and position of the damaged pixels.

Being illuminated with the exact same lighting, two adjacent pixels might not necessarily deliver the same digital result. So it is difficult to state which conclusion might be correct and which deviation is acceptable.

Besides accurate test hardware and software, image sensor wafers require exact and consistent illumination of the sensor surface as well as clean room conditions.

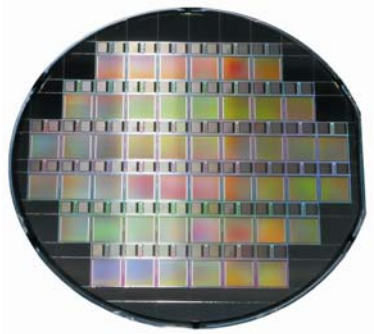


**Image sensor wafer, highly sensitive*

Testing the electrical parameters
Increasingly, image sensors include complex logical blocks, from address decoders to memory arrays to complete micro controllers. The test system needs the capability to test these digital, functional blocks to their full extend. Embedded SCAN-chains or BIDTF functions facilitate these tests, but do not reduce the required performance of the test system. In addition, the SCAN-chains often require very long digital test patterns due to their serial characteristics. Sensors featuring analog output have to be digitized first by the test environment.

Image Sensor Interfaces
Digital sensor interfaces are either wide parallel busses such as the camera link or very fast serial ports. The test system must be able to verify both types. Therefore, besides testing low and high conditions, the voltage level (starting level under maximum pressure, entry level parameters) and the switch behavior (i.e. delay, slewrate, channel) also must be verified by the test system. Finally, the functionality of the

module at minimum and maximum voltage as well as supply and leakage currents must be measured.

Test equipment for image sensors
The test lab *microtec* in Stuttgart has several Mixed-Signal VLSI test systems (VLSI = very large scale integration, high-integrated circuits) best suited for electrical screenings in operation.

These systems can be upgraded by adding an optical test module which collects a vast number of image data, calculates measurement values and controls the illuminating device.

Conventional digital test systems and mixed signal test systems are not adequate since they can only record a small amount of data and do not offer the necessary image-editing algorithms. The communication between the VLSI test system and the image sensor test module is driven through a standard interface. The module acts as an external measurement device. The VLSI test system controls the operation of the test, including application queries, handler and waferprobes control, as well as reporting and storing of measurement results and data.

Test and evaluation of optical parameters
The complexity of the image sensor parameters test depends on the use of the end-product, i.e. consumer or high-end applications.

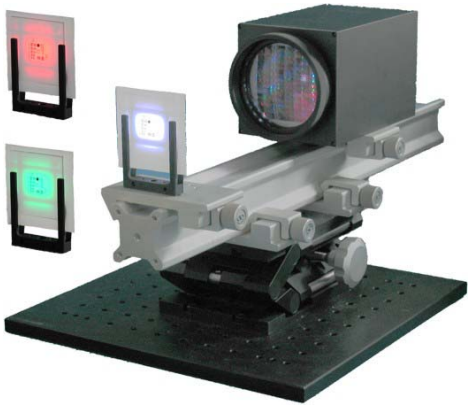
According to the specifications, the number of “allowed“ failure pixels in different areas of the wafer (i.e. in the middle or on the edge) is classified. The evaluation-software identifies the pixels that deviate too far from average of the image content.

However, slow interferences (i.e. grey scales) are eliminated in advance. The damaged pixels are then rated according to their position. For connected failure-pixels, the cluster defects, small tolerances, so-called wound pixels, are defined and sorted by size. Adjacent defects are divided into small cluster, large cluster, damaged rows or columns. Especially for high-end products, noise parameters, such as FPN (Fixed Pattern Noise), DSNU (Dark Signal Non Uniformity), PRNU (Photo Response Non Uniformity) and Read Noise, are relevant characteristics and need to be measured.

The test lab *microtec* offers packaged image sensor test for temperatures from -55°C to +175°C as well as wafer test temperatures from +25°C to +150°C.

Exact illumination is a must
The most important part of the test module is the illumination source. This module specifically stimulates the sensor surface. Inadequate illumination (i.e. failures in color temperature, intensity and regularity) would falsify the test results.

microtec invested in a LED Illuminator with replaceable LED-Arrays as a high-performance solution for consistent illumination. LED-lights quickly react to control signals. LED-arrays are also capable of sequentially accessing the red, green or blue LEDs, depending on the required color temperature.



*** LED-Illuminator*

Security relevant applications
Unlike the mass products for consumer electronics from Far East, the European market for security relevant applications emphasizes the higher quality of the sensors. A complete manufacturing test, qualification and characterization are basic requirements for this quality.

Author: Fritz Schlicher, Test Engineer
microtec GmbH
testlab for opto+microelectronics
70499 Stuttgart / Germany
Tel.: +49 (0)711 86709-0
www.microtec.de

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