Advanced Array Test Sensor

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Abstract

This paper will discuss the latest results from an advanced array test system, using newly developed sensor technology. A comparison of detection results between old and new generation products will be shown along with a discussion of the advantages of the new, higher signal to noise ratio detector.

1. Introduction

Array test is important to any LCD fab yield management as it allows accurate location of actual electrical defects for subsequent repair. To detect properly, the system should have adequate dynamic range. To be economical, the system throughput (TACT) should be as fast as possible. These two requirements are often conflicting suggesting that optimized tradeoffs can be made. In the past, array test was used to identify shorted or open transistors. The dynamic range required was approximately 5-6 bits since the signal was strong for a defective site. Recent requirements are getting more stringent as marginal performance transistors are desired to be detected.

In addition, new panels are becoming much larger in area, placing new requirements for faster TACT. A generation 8 (2160mm x 2460mm) has almost four times the area to test of a generation 5 plate. This area must be tested in approximately the same time as the Generation 5 plate so TACT improvements are critical.

The most popular array test sensor is the Voltage Imaging Optical System (VIOS) which has been described before[1] and is shown in figure 1. Its principal components are an illumination system, optics, a liquid crystal sensor, and image capture/processing. The above referenced paper

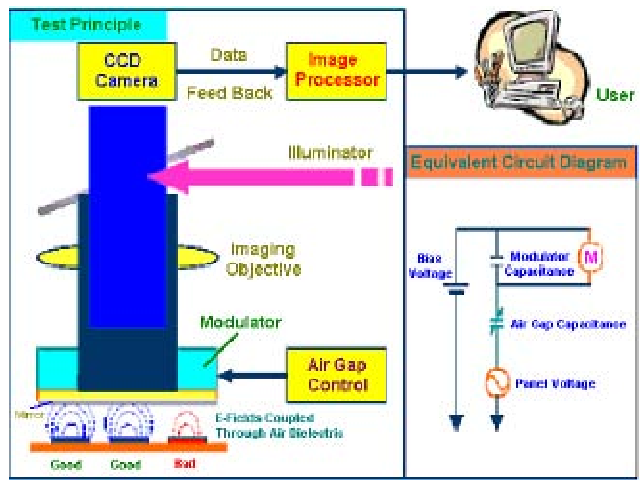

Figure 1- VIOS System

describes optimization of the liquid crystal portion of the sensor and showed approximately 40% improvement in sensitivity. This work will describe further performance increases by optimizing the optics and illumination. Future papers will discuss image processing improvements.

2. Experimental

A complete characterization of the sensor subsystem identified several areas for improvement. First, the illumination uniformity could be optimized for the liquid crystal sensitivity profile. This allowed extension of the dynamic range by increasing the maximum output of the sensor. Second, internal stray light sources could be minimized in the optical system. This lowered the noise floor of the system. When these improvements were coupled with the improved sensitivity of the liquid crystal material, the dynamic range was at least doubled.

Exact pixel histogram results are shown in figure 2. The improvement in the signal to noise ratio is apparent.

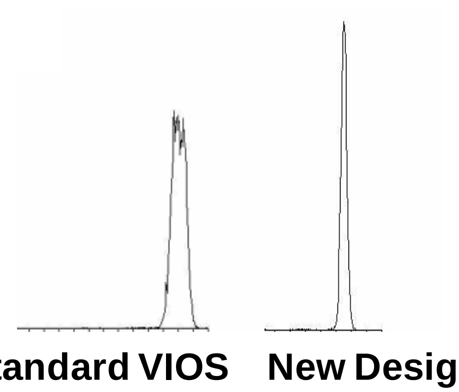

Figure 2 -- Pixel Histogram Comparison

3. Results and discussion

The lower noise floor allowed an experiment to see how much lower recipe thresholds could be set before false defects were found. Figure 3 shows these results on a test TN monitor plate. The standard VIOS recipe was set to eliminate false defects (a production recipe) The figure has the thresholds shown as a percentage of the nominal value.

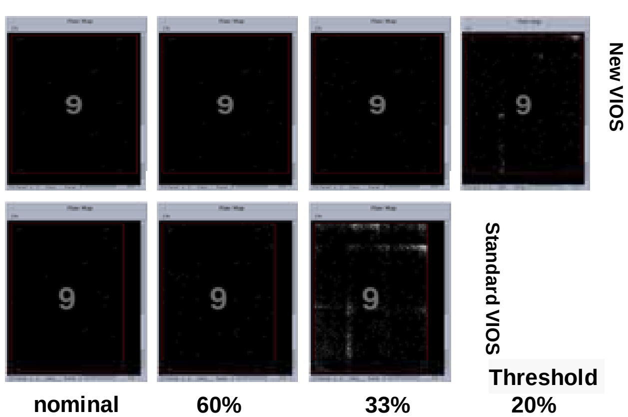

Figure 3 -- Threshold Experimental Results

The new VIOS could have the threshold reduced by two thirds and still have negligible false rates. This allows production recipes to be much more sensitive without paying a penalty in false defect rate. To verify the false rate improvements, tests were run in production fab environments. The least amount of false rate improvement was by 20% without any recipe optimization at multiple customer sites. Figure 4 shows results at one customer. The bottom of the scale is zero and, in this case, the false rate was improved by a factor of close to 3:1.

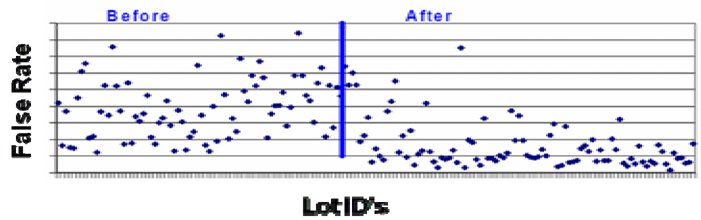

Figure 4 -- False Rate Improvement

The next experiment was to see if detection sensitivity could be improved in actual fab production. This would be useful for "weak" or close in defects with signals very similar to normal pixels. These defects are typically partial open or shorts in both lines and points and are important as they can degrade after aging. They then might not be caught until final module inspection or worse, at the customer's home. Other classes of weak defects include residues and partial finger defects. Usually, if a recipe is tuned to improve detection of weak defects, the false rate degrades more quickly than the detection improves. This is a consequence of the larger standard deviation of the defect signals compared to the good pixels. If the standard deviation of the good pixels can be improved enough, the opposite will occur as the threshold is further out on the good pixel "tail". As figure 5 shows, the detection could be improved and still have acceptable false levels. The thresholds, detection, and false rates have been separately normalized to allow plotting together. The false rate is plotted in a log scale to keep it on the graph so the actual false rate falloff is much steeper than shown.

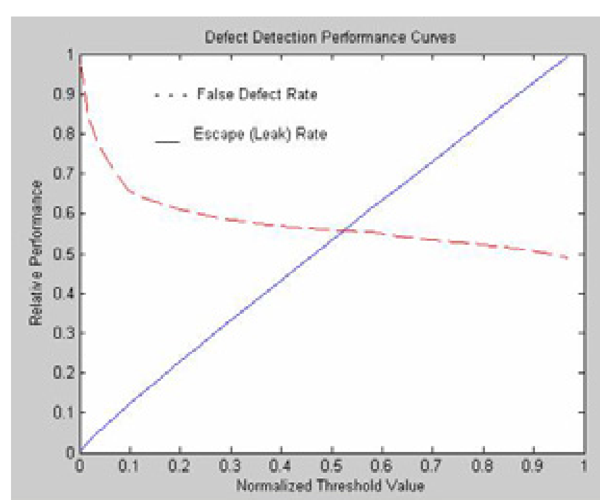

Figure 5 -- Weak Defect Detection vs. False rate

A 10% normalized threshold is very aggressive and would normally cause the false rate to degrade unacceptably. The new sensor performance allows thresholds in a production setting to find marginal defects without false rate penalties.

To see if the dynamic range could be used to improve TACT instead of simply increasing sensitivity, an experiment was done comparing the detection rate at the standard "fly height" of the modulator air gap above the substrate and with the air gap doubled. This larger gap would allow the system to have faster transitions and settling times, and the greater sensitivity allows shorter acquisition times as it is scanned from location to location across the plate, significantly improving TACT. The results are shown in figure 6 for several different recipes. Although the doubled fly height reduces the sensor sensitivity by approximately 50% the new VIOS can double the fly height and still have significantly better sensitivity than the old version. The lab results were then verified in production fabs. Even larger improvements in detection at the new fly height were obtained in these fabs. Thus, TACT can be increased with no tradeoff in sensitivity compared to the current systems.

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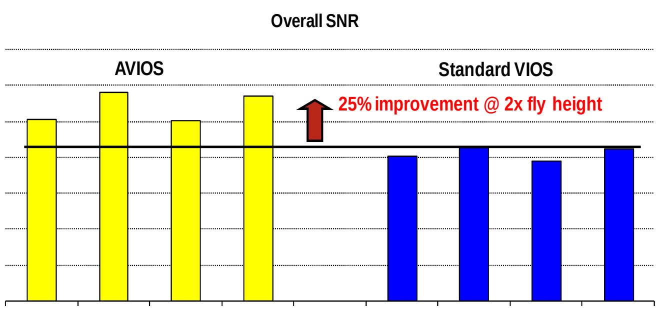

Figure 6 -- Increased Fly Height Experiment

4. Summary

Higher dynamic range detectors will allow improved TACT and increased detection ability. This will allow systems to choose a fast mode of normal production testing but to have the flexibility of using very high sensitivity measurements for process diagnostics or to find marginal defects.

5. Acknowledgements

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6. References

1. X. Chen, *New-Generation Electro-Optic Modulator for TFT Array Testing*, SID Symposium Transactions, page 1792, (2005)