Challenges for large size TV manufacturing: Process and Test Equipment

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Abstract

As the manufacturing capacity needs for large size LCD TV shifts very fast into next generation, processing and test equipment makers face more difficult challenges in accommodating productivity, reliability and lead time of panel makers as well as the prerequisite of high process quality. In this paper, AKT will discuss its new innovative productivity solutions in PECVD (Plasma Enhanced Chemical Vapor Deposition), as the key thin film process system, and EBT (Electron Beam Test), as the key array test system, for the huge glass size with surface dimension larger than 2 meter by 2 meter.

1. Objectives and Background

Market demand of TFT LCD TV has grown fast since 2003, and it is forecasted LCD TV CAGR will be about 88% [1] from 2003-2008. The most popular size of LCD TV will shift from 30-inch to 40-inch and even larger. In order to meet the fast market demand growth and size expansion, equipment makers has to take the challenges for higher generation system development with relatively better system performance but critical target manufacture cost .

PECVD, which forms the most critical amorphous silicon layer and dielectric layers for thin film transistor that drives the LCD, is a vacuum chemical vapor deposition system with capacitive coupled RF (radio frequency) power. In order to deposit high quality and uniformity thin films, reactive gas flow, substrate temperature, RF power, etc. are the key process control parameters need to be fine tuned. From system development point of view, such process control roots in the system engineering design.

With the fast glass substrate expansion and higher productivity expectations, the key challenges for PECVD system development is summarized as following:

- Gas delivery uniformity within huge chamber
- RF power distribution uniformity without standing wave effect for huge capacitor dimension
- Faster Load/Unload design for high throughput
- Safety Glass handling design for critical glass thermal expansion and bending compensation
- Easy operation and maintenance for huge weight part

AKT has been successfully taken the key challenges in Gen.8 PECVD development. System performance will be discussed in the results section.

TFT array test has been more critical for larger generation mass production by detecting process problems for fast factory ramp up and enabling repair of array defects to save more yield lost from next manufacturing process steps. With the generation evolution, TFT array tester makers has to take the challenge of upgrade the high throughput testability for larger array substrate, but also testability for more complicated pixel designs like IPS, MVA structures.

AKT has developed several generations of array test systems and the test technology itself was continuously improved to keep pace with the evolution of the display technology.

AKT's EBT (Electron Beam Test) technology [4] uses a simple shorting bar contact method to drive the display and this way avoids the requirement for expensive probers. It measures pixel voltages by an electron beam using the robust beam control concept of the CRT tube with a large area beam deflection as shown in Fig.1. During the test the focused electron beam generates secondary electrons at the pixel surface that is addressed. The pixel voltage accelerates or decelerates these emitted secondary

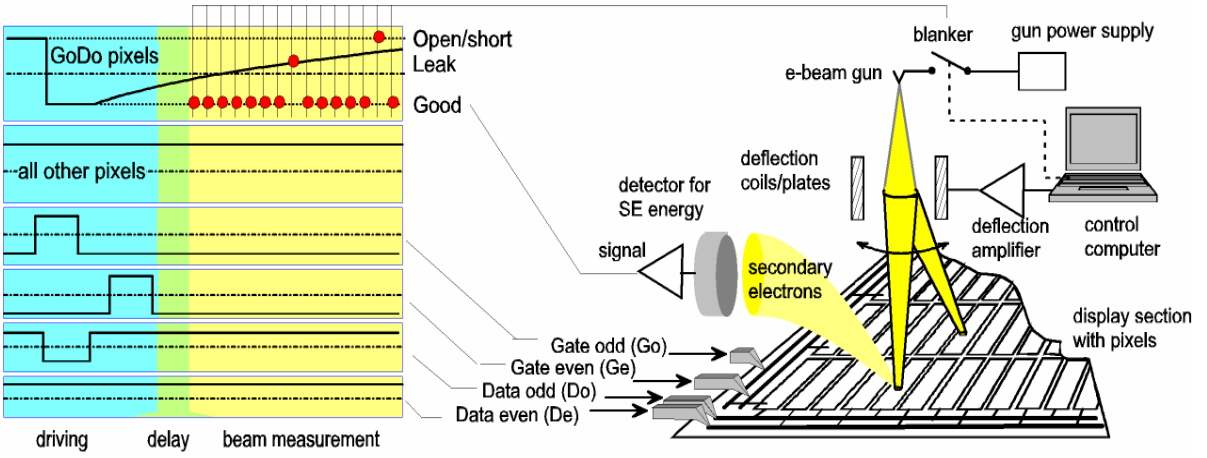

Fig. 1 Principle of e-beam TFT array test

electrons so that their energy can be evaluated as a measure for the pixel voltage.

Besides purely detecting the pixel defect, AKT's EBT offers an additional unique capability to clarify the root causes from TFT structures for different defects, which helps a lot for panel makers to precisely trace back to the corresponding TFT manufacture steps.

2. Results

AKT has successfully developed Gen. 8 system and delivered the worldwide 1st Gen.8 PECVD system to the market in Jan., 2006.

Fig.2 AKT-50K Gen. 8 PECVD

Fig. 2 is the Gen.8 system picture, as named AKT-50K PECVD. The Gen.8 PECVD system keeps cluster configuration as the previous generation designs. With a multi angle transfer chamber in the center, other functional chambers are attached around as load-lock, process chamber, heating chamber etc. refer to customer requirement.

With AKT-APX$_L$™ patented process chamber design, less than 8.0% deposition uniformity with 20mm edge exclusion has been achieved for 2460 mm x 2160 mm substrate size. Fig.3 is the AKT-50K process result presented as the thickness uniformity along glass diagonal directions. From Gen.5, Gen.6 and Gen.7 processes, the thickness uniformity has been successfully upgraded to Gen.8 as shown in Fig.3.

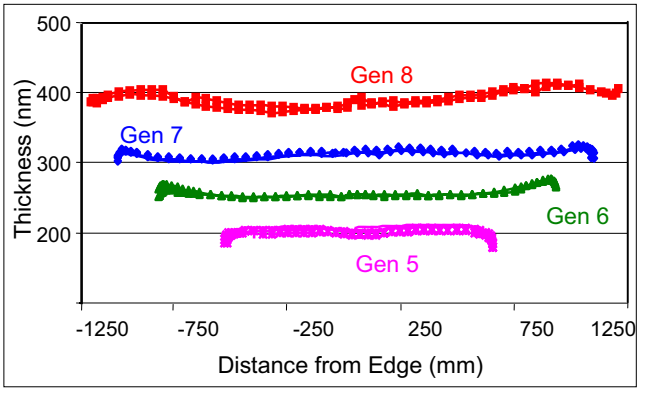

Fig. 3 AKT-50K PECVD process result

AKT's vector E-Beam array test EBT has been upgraded from Gen.4 to Gen.7 and even higher generation will be mass production ready. As shown in Fig.4 is AKT 40K EBT for Gen.7 application.

Development focused strongly on throughput improvement by optimizing system configuration and process control. Fig. 5 shows the progress of

test speed (pure test time) that was made via a series development activities.

Fig. 4 AKT-40K EBT Four column system

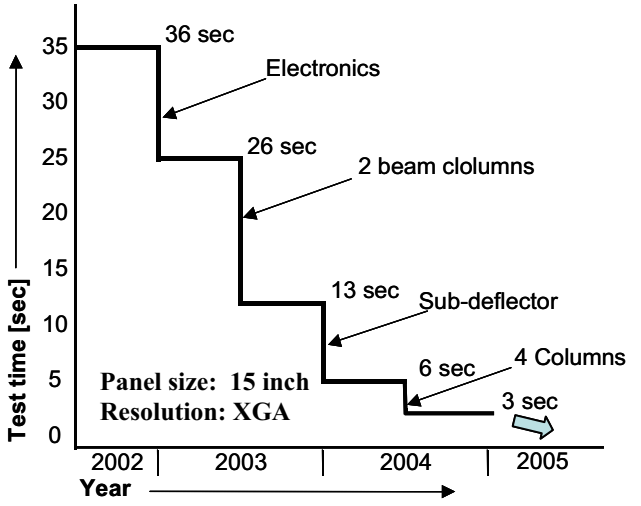

Fig. 5 EBT Throughput Progress

For IPS, MVA mode pixel designs, which has more substructures than traditional TN mode design within one pixel, EBT extended its testability via electron beam focus adjustment and upgraded calculation method from software.

Comparing with other array testing approaches with much expensive prober design, the prober replacement cost will be saved quite a lot via EBT approach. With continuously effort from AKT, the prober lifetime has been extended from 6 to 9 and finally to 12 months, several times longer lifetime than other probers.

3. Impact

In brief, expertise technology are required to meet the practical challenges of making very large-size vacuum processing equipment and array tester to satisfy the industry's high expectations for capital productivity improvement. With over ten years professional system development experience, AKT has successfully developed the key film process and array test systems and will keep leading in the next generation system revolution.

4. Acknowledgements

5. References

[1] ADT, Displaysearch, Applied Material Marketing Data.

[4] M. Brunner, R. Schmitt, D. Winkler, R. Schmid. Electron Beam AM LCD Testing. Proc. Of the 13th Int. Disp. Research Conf. Eurodisplay (1993), pp. 387-390