Support continuing cost reduction for large area TFT-LCD manufacturers by unique PVD array solution

Erkan Koparal[1], Marcus Bender[2]
[1]Global Product Management, Sputter Products, AKT Display Group
Applied Materials, 63755 Alzenau, Germany
Tel.:+49 6023 92 6361, E-mail: erkan_koparal@amat.com
[2]R+D New Technology, Sputter Products, AKT Display Group
Applied Materials, 63755 Alzenau, Germany
Tel.:+49 6023 92 6246, E-mail: marcus_bender@amat.com

Abstract

The ubiquitous nature of large area TFT-LCD televisions are truly one of the major success stories of consumer electronic products for the 21st century.
It is the industry's ability to lower prices over the years that have made TFT-LCD television an affordable option for the majority of consumers. TFT-LCD equipment manufacturers have played a major role these cost reduction efforts.
Increasing requirements for high process quality like for eg UHD panels need to be met simultaneously with the demand of an highly productive and reliable equipment.
AKT provides an excellent PVD product by improving performance and cost of ownership (CoO) for Gen8.5 and beyond.

1. Introduction

The focus of this article is a new concept TFT Array sputtering system to support TFT manufacturers; developed to further reduce CoO (Cost of ownership) of the large size TV panel manufacturing as well as material costs of production. The new design supports large size substrates beyond Generation 8 and is used for Gate and Source Drain conductive layers and pixel ITO deposition.

Major portion of operating PVD tools are target costs. A fab with a size of 100k/month has typically annual target cost of approx. $40M. This can be significantly reduced by high target utilization > 75% applying rotary targets. High sputtering rates and the reduction of re-deposition areas on the target surfaces with reduced particle generation are well received side effects of this cathode technology.

The target vendor landscape adapted to rotary targets already by offering all TFT related materials (see Fig. 1). Depending on the material, the targets can be either monolithic or bonding type (see Figs. 2 and 3).

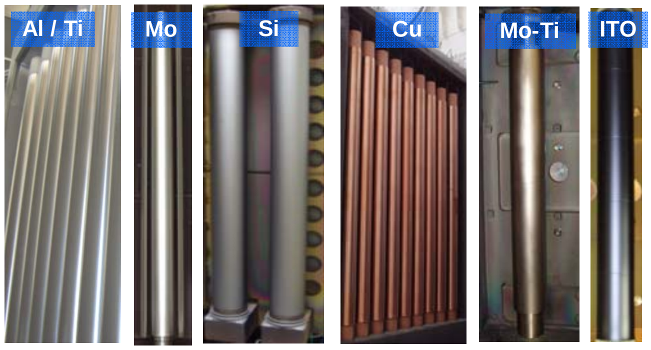

Fig. 1. Various rotary targets

Lowering the operating expenses by reducing the number of dummy substrates for target conditioning and reduced cleaning costs of substrate carriers will be discussed as well.

2. Experimental

2.1 Cathode array setup

An array of 12 rotary targets not stringed in a straight line are required to coat a Gen8.5 substrate in a static manner. Each target is equipped with a magnetron and water cooling designed for achieving a deposition rate of up to 140Å/sec for Cu.

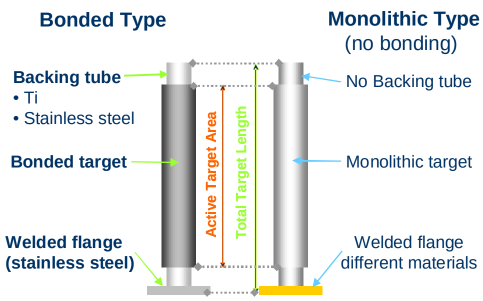

Fig. 2. Rotary target types

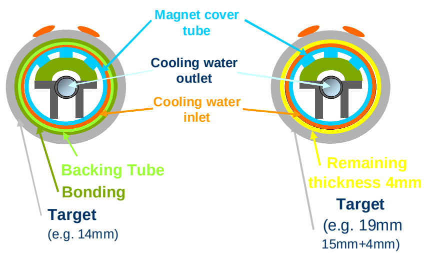

Fig. 3. Rotary cathode cross section

Each cathode within this target array can be individually controlled regarding rotation speed and direction to further optimize thickness uniformity.

DC power is used for metal and TCO materials.

2.2 Magnet setup

Due to the cylindrical design of the sputter magnetron two new helpful features have been introduced:

1. A new target can be conditioned by pre-sputtering with minimum pollution of the substrate surrounding mask area and a clear reduction of dummy substrates. This improves the overall particle situation and reduces the cost of ownership of the entire system. For pre-sputtering the magnet yoke inside the target is turned 180° to the backside of the chamber (see Fig. 4). The commonly used quantity of up to 100 dummy sheets can be significantly reduced.
2. The circular geometry of the cathode arrangement provides an inherent advantage for improving uniformities. In particular for static deposition better layer thickness distribution can be achieved by oscillation of the magnet yokes, the so called wobble. The best wobble angle and speed profile can be adjusted in a wide range and thus can be optimized for different target materials having a variety of specific sputtering characteristics. Results will be discussed at chapter 3 of this paper.

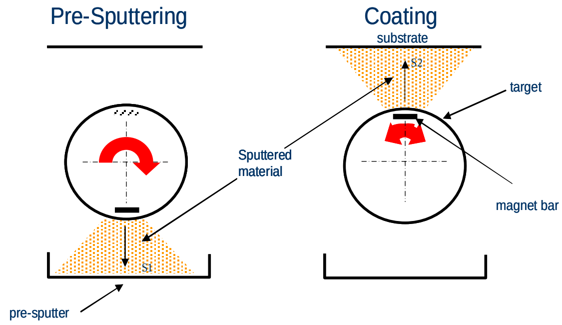

Fig. 4. Pre-sputter unit

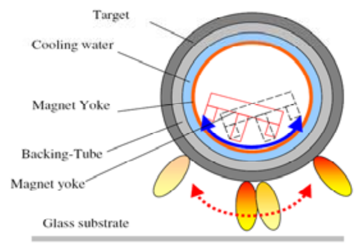

Fig. 5. Oscillating Magnets

3. Results and discussion

The improvement of target utilization compared to planar cathodes is tremendous using rotary cathodes. Values of 75% are even exceeded for metal and TCO materials. Fig 6 shows a vertical erosion profile of a Gen 8.5 Al target at different target lifetimes. Total usable target thickness is in this case 15 mm.

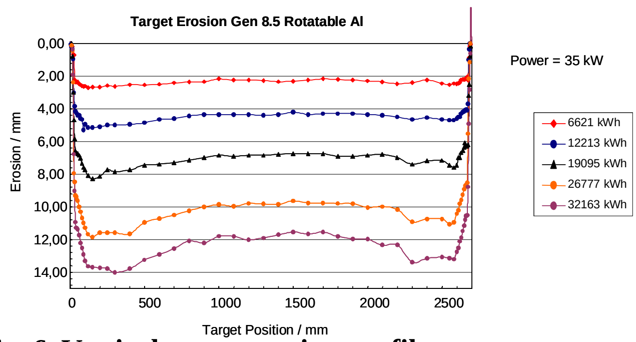

Fig. 6. Vertical target erosion profile

The rotary target design due to its geometry provides the opportunity to store more target material for an extended target life time. The reason is that the surface area of a rotary target, which is defined by

$$A = l \times d \times \Pi$$

Is much larger than that of a planar target of comparable size.

The larger amount of target material and higher target utilization extend the period between target replacements by a factor of up to 5 compared to planar targets (see Tab. 1).

	Rotary	Planar
Target utilization	75%	35%
Coated substrates coated per Al target (300nm layer)	64,000	13,000

Tab. 1. Target utilization planar vs rotary

The PVD coating of a TFT takes place in a static mode. The target position in front of the glass is reflected by a higher layer thickness in this area as can be seen in the top chart of fig 7. This so called local uniformity varies depending on material.

One measure to address faster switching time by RC delay reduction is lowering the bus resistance by using Cu. However especially Cu shows a worse local uniformity compare to other materials with the same process setup.

By oscillating the magnets during coating this effect can be almost eliminated. Rs uniformity can be improved from 12% down to 5%.

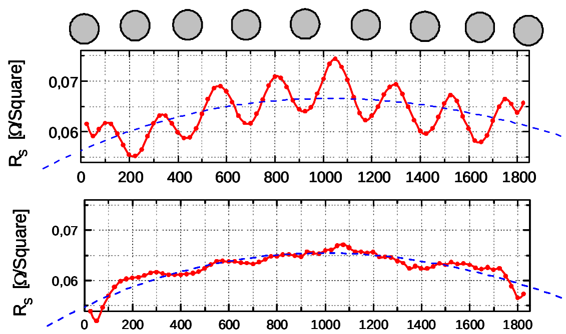

Fig. 7. Thickness distribution without and with oscillating magnet

In addition also the film structure is homogenized by this coating technique of oscillating magnets. The XRD analysis shown in Fig. 8 has been measured for two specific points on the substrate (i) exactly opposite the target pos 5 and (ii) between 2 targets pos4/5. Beside the homogenous thickness also grain size and lattice constants are uniform regardless of the substrate position relative to the cathode.

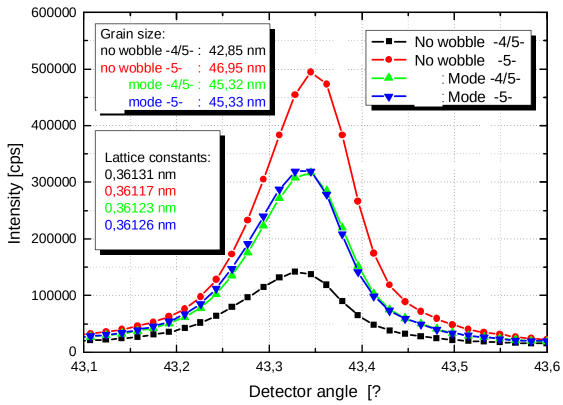

Fig. 8. XRD film analysis opposite and between rotary targets

4. Summary

The rotary target technology contributes in many ways to the needs of the TFT-LCD industry to lower the operating costs. Longer target life and higher system availability are well recognized as well as lower layer costs. This trend is even more accelerated as more rotary target suppliers are producing in volume.

Beside the commercial aspect the rotary cathode holds the technology capability to follow the path of TFT-LCD manufacturer roadmap regarding better film uniformities or even set the pace for new developments.