Introduction

In the last few years display market growth has been significantly influenced by the vast penetration of touch screen panels (TSP). As the TSP market expands the production tools must also advance to meet the more demanding requirements of next generation TSPs. Touch screen producers today are enhancing their product portfolios with larger, lighter and more reliable TSPs demonstrating improved electrical and optical performance originating from better transmittance, patterning invisibility, sunlight readability, color fastness and anti-fingerprint surfaces. Applied Materials offers continuously improved manufacturing platforms to meet this demand by serving essentially all major TSP technologies including resistive and projected capacitive. The SMARTWEB® has been optimized for producing high quality TSPs on flexible substrates using an advanced modular roll-to-roll production architecture. The processes developed range from single layers serving as passivation, metal leads and transparent conductive oxides (TCO) to optical enhancement films and whole stack solutions to meet the requirements for fully integrated, invisible and reliable TSPs. Additionally, solutions have been developed to serve the need for highly conductive TCO deposited at thermal budget constraints. Together, such advanced processes and machine capabilities are rapidly enabling next generation TSPs.

SmartWeb Architecture

Roll-to-Roll (R2R) production of thin film based electronic devices (e.g. touch screens) combine the advantages of the use of inexpensive, lightweight & flexible substrates with high throughput production. Significant cost reduction opportunities can also be found in terms of processing tool capital cost, utilized substrate area and process gas flow when compared with batch processing systems. Nevertheless, material handling, patterning and yield issues have limited widespread utilization of R2R manufacturing within the electronics industry.

Significant challenges also exist in terms of the deposition technologies used in R2R manufacture of these devices. Unlike traditional semiconductor or display based cluster tool platforms, R2R systems require to process substrates in a continuous fashion with rolls up to several kilometers in length. Depending upon the process itself, this imposes a limitation in terms of the mean time before cleaning (MTBC) and in some cases the particle management strategy. This has led to the implementation of “sputter up” configurations in PVD tool designs (Fig. 1).

Figure 1: Principle Design of SmartWeb®

Applied Materials has developed web handling & coating technologies/platforms to enable high volume R2R manufacture of thin film based flexible Touch Panels. Current advances in Touch Panel manufacture include the enhancement of the active layer stack electrical, optical and environmental performance necessary to enable the next generation of film based projective capacitive Touch Panel devices.

The SmartWeb modular PVD production platform is shown schematically in Figure 1. In its simplest form it consists of an unwinder module (inclusive degas unit), a process module and a rewinder module. For more complex layer stacks with increased number of layers and for higher line speed, a second identical process module can be added, thus doubling the number of process zones.

Each process module can be equipped with either high rate planar or rotatable cathodes in separately pumped process compartments. Planar cathodes are available as DC powered single cathodes and as AC powered TwinMag cathodes. Both cathode types are optimized for high deposition rates without compromising layer uniformity over a substrate width up to 1350 mm (Figure 2).
The standard SmartWeb platform employs a tempered coating drum to accurately control the substrate temperature and planarity within the coating zone. This configuration also has the advantage of permitting the use of a very small gap between the coating drum/substrate and the chamber separation walls resulting in pressure separation between individual process compartments in each process module. Indeed, pressure separation factors greater than 200:1 have been achieved between process compartments enabling high conductivity, highly transparent indium tin oxide (ITO) layers to be deposited in neighboring process compartments to reactively sputtered SiO$_2$ and other oxide based high/low refractive index based materials. Consequently, low cost single process module systems can be configured for the 4 layer optoelectronic systems typically used in film based Projective Capacitive Touch Panel devices (Figure 3).

**In-Situ Quality Control**

R2R systems require to process substrates in a continuous fashion with rolls up to several kilometers in length. Consequently, accurate process monitoring and control systems are required for quality control and yield optimization. Sheet resistance measurements are therefore performed through the use of either two contact-rollers or alternatively through the use of an eddy current measurement (for contact-less measurement). The measurement principle for the contact based method is shown in Figure 4 below. A voltage is applied between two parallel contact rollers and the resulting current is measured. Sheet resistances in the range 30 mΩ/□ to 100 kΩ/□ can therefore be detected.

**Figure 2:** Typical Layer Thickness Distribution across Web Width

**Figure 3:** Typical Film Based Projective Capacitive Layer Stack Structure.

**Figure 4:** Contact based inline resistance.
Optical monitoring of the layer quality typically involves measurement of the layer reflectance, or where appropriate the layer transmission. The SmartWeb is equipped with an optical measurement system co-developed by Zeiss from Jena in Germany (Optoplex®). This measurement system is installed within the tool downstream of the coating drum as shown in Figure 5. For flexible Touch Panel applications spectral transmission and reflection measurements are commonly used with layer thicknesses typically determined by monitoring the reflection maximum wavelength.

![Optical inline measurement system.](image)

**Figure 5**: Optical inline measurement system.

**SUMMARY**

A modular PVD system has been developed for the high productivity deposition of ITO based layer systems for the film based resistive and projective capacitive Touch Panel devices. The system is intelligently controlled and employs inline optical and electrical layer property and thickness measurement systems to ensure through-roll layer quality confirmation. Processes have been developed for both simple two layer analog resistive touch panel devices in addition to the more complex four layer projective capacitive device architecture.