Maintaining Coater Gap Uniformity in multi-layer applications such as Large Flat Panel Displays and Solar Panels

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Extended Abstract

There has been a significant increase in capital investments into streamlining the process of manufacturing flat panel displays and, more recently solar panels, in an effort to reduce cost and boost efficiencies. Manufacturing and Process R&D engineers at these companies are benchmarking semiconductor manufacturing coating methods for new ideas. Since Capacitec has 20 years experience supplying electronic set up tools for coating processes at semiconductor and film manufacturing equipment suppliers they are in an ideal position to transfer these skills to the manufacture of both flat panels and flexible solar cell laminates. These tools are used to reduce material and labor cost, boost yields and improve quality.

Flat Panel Displays

Flat panel display manufacturers continue to increase the overall panel size (currently at 6 m^2) in an on-going effort to drive down costs. Before the manufacturing process begins the producer must certify that the parallelism is <15 microns between the large CVD head and the platform that holds the large glass substrate panels in place. Nominal gap measurements must also be taken in various locations to assure that the gap between the coater head and the glass is uniform. Control of these variables is critical as there is a direct correlation to the subsequent coating thickness and uniformity across the large glass panels.

Capacitec has been approved for this application with the development of a system which places several "gap discs" between the coater head and the base platform to measure the gaps in key locations. This allows the calculation of overall parallelism of the surface prior to the start of coating. The gap discs are used in sets of 5 for smaller panels and up to 16 for the largest panels. Here's how the system works.

The system starts with the placement of non-contact displacement sensors inside metal "gap discs" (see Figure 1) that are manufactured with extremely flat surfaces. The discs are positioned between the large CVD coater head and the platform. When the assembly closes, the spring loaded discs are compressed. The displacement sensor picks up this

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movement and the nominal gap is calculated. The results are then sent via an RF transmitter to the RF receivers located at the laptop data acquisition station (See Figure 2). The advantage of this gap sensing system is the excellent repeatability and extremely low hysteresis due to the use of capacitive non-contact displacement sensors inside the disc.

Figure 1: *Pressure applied to the spring-loaded enclosure is transferred to a non-contact displacement sensor, which calculates the nominal gap.*

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At the laptop data acquisition station, the electronics collects all the gap values and feeds them into the system's Bargrafx™ software for parallelism analysis.

Figure 2: *Sixteen-channel system showing gap discs, RF signal receivers (in white) and individual gap results shown on custom software*

The software output allows the operator to make precise adjustments of the gap in the locations between the CVD head and the platform that are out of specification. The better the parallelism of the CVD head and platform prior to coating, the better the uniformity of the very thin coatings over the surface of the total display.

The large flat panel display manufacturers are also competing in the Solar panel market. Here they are using CVD to apply thin film coating of amorphous silicon (a-Si) onto similar sized large glass plates. The same Capacitec sensor system is used to control parallelism in these applications. Flat display manufacturers believe that their long-term competitive advantage in the Solar market is the fact that glass substrates offer one of the best trade offs between higher efficiency levels and low cost.

Solar Panel Applications

According to the European Photovoltaic Industry Association (EPIA), the driving forces in the photovoltaic industry are the reduction of cost per kilowatt hour and module efficiency. Currently the costs are \$0.60 to \$0.75/kWh and 5 to 15% efficiency while companies are promoting medium term goals of a 50% cost reductions and a doubling of efficiency.

For decades solar cell production was based on crystalline silicon. Today thin-film alternatives are challenging these techniques by offering greater versatility and comparable efficiency at lower costs. Four types of thin film modules (depending on the active material used) are commercially available at the moment:

- Amorphous silicon (a-Si)
- Cadmium telluride (CdTe).
- Copper Indium/gallium Diselenide/ disulphide (CIS, CIGS)
- Multi junction cells (a-Si/m-Si)

In this field, CIGS (copper, indium, gallium and selenide) technologies are rapidly becoming the preferred choice for large-scale manufacturing. Use of these materials frees producers from dependency on world silicon markets. Figure 3 shows a typical CIGS cross-section courtesy of MOTSolar thin-film technologies.

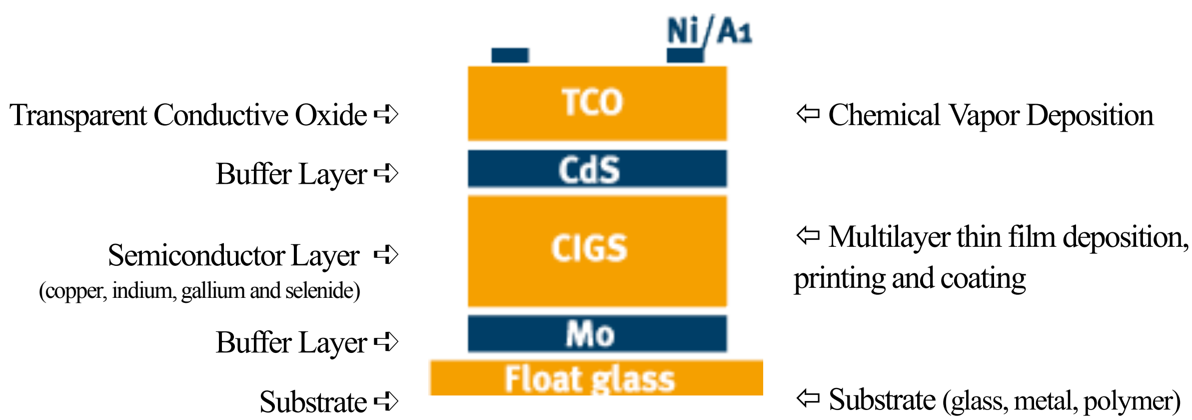

Figure 3 Cross section of layers in a thin film CIGS solar panel

Currently Capacitec is providing non contact capacitive gap sensing systems to help maintain coating thicknesses of the top and bottom layers of the figure above. We provide high temperature gap measurement systems for both the Chemical Vapor Deposition of the top TCO layer and gap control of the CVD coating onto the bottom glass plate panels or float glass layer.

The semiconductor layer made up of multilayer thin films are applied through deposition, printing and coating.

Chemical Vapor Deposition of TCO layer

Capacitec is supplying high temperature gap sensors to a European producer of Flexible Solar Cell Laminates. These foot wide laminates are lightweight, unbreakable, very pliable and well suited for integration in to other products such as roofing materials. (see Figure 4)

A roll-to-roll production process is used in the deposition of various active and non active ultra thin layers onto the solar cell metal foil. This process offers important cost saving advantages in large scale production. There are a number of roll-to-roll steps from the deposition of the transparent top layer and the amorphous silicon layers to the final reflective metal backing.

Figure 4: Flexible Solar Cell Laminate Production

The top transparent conductive oxide layer (TCO) is deposited by chemical vapor deposition under atmospheric pressure (APCVD) onto a temporary carrier foil. According to the producer, the advantage of this approach is that high deposition temperatures (500°C) for the transparent conductive oxide and silicon layers facilitates deposition of high quality material at high deposition rates.

In this CVD process it is very important to set and maintain the gap between the coater head and the roll positioning the carrier foil. The coater head must also be parallel relative to the roll. If the gap is too big the coating will be too thin, too small a gap would produce TCOs that are too thick. An unparallel head would distribute the coating unevenly across the width of the substrate. The challenge in this application is that the producer cannot set the gap at ambient temperature before the start of the process. This is due to the fact that, once heated to over 500°C during production, the roll diameter thermally expands by 5 to 8 mm.

To control the position of the coater head, Capacitec supplies four high temperature sensors that are positioned next to the coater head on a custom fixture that measure both the gap and parallelism between the coater head and the metal roller at production temperatures. This constant measurement ensures that the gap and parallelism are maintained during long production runs.