

Flat panel display (FPD) photoresist (PR) stripping process optimization using a multi-channel online FT-NIR wet process analyzer (WPA)



This white paper presents an overview of the flat panel display (FPD) production process and the challenges process engineers face during the photoresist (PR) stripping step.

Abstract

All components in a stripper chemical, and stripped PR, must be precisely monitored throughout the PR stripping process to reduce the probability of panel damage and increase process yield through better process control. The document underlines the importance of process control using precise and efficient analysis tools. An outline of pre-existing technologies brings into focus the usefulness of real-time, high-precision analysis of this process. It also demonstrates the relevance and advantages of ABB's Wet Process Analyzer (WPA) as a real-time multi-stream analytical method for FPD PR stripping process optimization.

Introduction

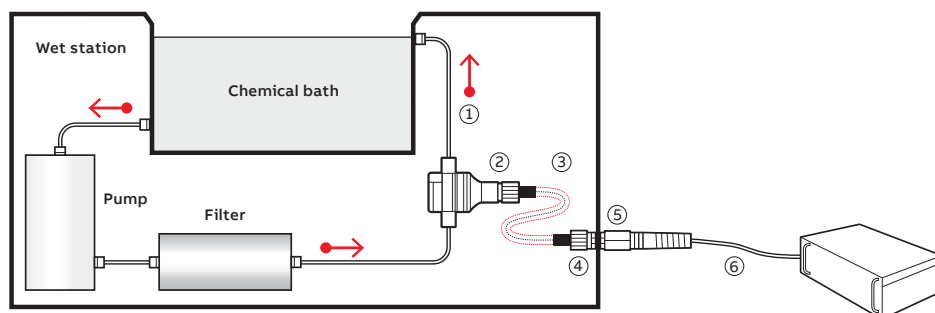
The liquid crystal display panel consists of two sheets of glass separated by a 5 μm gap containing liquid crystals. The image is created by applying an electric current to the liquid crystals to control the passage of light. The technology exploits the properties of liquid crystals to both maintain the same orientation with respect to each other and change orientation when a voltage value is applied.

The production of a liquid crystal display (LCD), which is the most common type of flat panel display (FPD), requires a process quite similar to the semiconductor

manufacturing process, except that the transistors are fabricated on a glass substrate instead of a silicon wafer. One of the crucial steps in producing a liquid crystal display panel is the creation of the circuits that form the required array on the glass substrate. To achieve this, a photoresist coating is applied on the array. The assembly is exposed and then etched. It's basically a lithography process. Afterwards, the photo resist (PR) film must be stripped from the panel. The PR stripping process guarantees that the layer of unwanted photoresist material is removed from the panel as quickly as possible. Process control procedures must ensure that no surface material under the photoresist material is attacked by the stripping chemicals used.

A tight and continuous process control is therefore essential, and the technologies must offer precise and reliable results in real time, without affecting the process itself. It is crucial to rapidly and accurately measure PR stripping chemical concentrations to have a better process control that leads to a process yield increase by reducing probability of panel damage. The results of the measurement can also be used to determine the endpoint of stripper bath life and enable chemical auto-spiking to increase the lifetime of the bath.

— 01 Bath monitoring process
 — 02 WPA with patented ClippIR+
 — 03 The patented ClippIR/R



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- ① The ClippIR+ is designed to be clipped directly around the recirculating line and is self-supporting. However, an optional bracket can be provided.
- ② 15.2 cm (5.98 in) minimum clearance around the ClippIR+
- ③ Teflon tubing protecting fibre optics: 1.5 m (4.92 ft) long
- ④ 2.5 cm (0.98 in) access hole required
- ⑤ Standard bulkhead fitting
- ⑥ Standard 10 to 100 m (32.80 to 328.08 ft) optical cables housed in PVC tubing

Background technological horizon

Several technologies have been introduced over the years to measure the concentrations of stripping chemicals. The composition of the stripping chemical formulations has also evolved considerably, reducing toxicity while preserving stripping efficiency. Traditional analysis methods are often invasive, require process circulation tubing modifications and produce chemical waste. This can lead to contamination of the stripping solution and affect the integrity of the process. Another problem: real-time analysis of the stripping chemical remains an issue with most technologies.

There are four (4) main technologies: filter photometry, titration, UV-based solutions and Fourier transform-near-infrared (FT-NIR) spectrometry. The first three technologies have less versatility in identifying a wide array of chemical components and often require direct interaction with the process circulation tubing and chemicals.

The fourth technology, based on the FT-NIR spectrometer, which is a powerful analytical tool for precise quantitative analysis of multiple components, is the industry leading wet process analyzer (WPA) developed by ABB. The WPA is non-destructive, does not require chemical reagents, and makes highly repeatable analysis faster and more reliable.



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ABB's Wet Process Analyzer (WPA): a complete multi-stream online monitoring solution

The ABB Wet Process Analyzer (WPA) is a non-contact chemical measurement technology. It offers real-time analysis of PR, amine, and solvent concentrations from the PR stripping process. Through near infrared spectrometry, using the revolutionary and patented ClippIR+, it eliminates the risk of chemical bath contamination. The patented sampling system, designed to be directly clipped onto the existing circulation tubing, allows easy and rapid installation without process interruptions (tube modification/cutting), and eliminates the need for sample extraction/conditioning.



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The fully Teflon™ made ClippIR+ also offers maximum chemical resistance. The Teflon™ design ensures that the ClippIR+ is protected from the chemical vapours emanating from the tool. Furthermore, with the WPA, there is no need for impractical bypass lines: optical fibre brings infrared light to the measurement point, allowing direct measurement through the PFA process tubing. Since there is no chemical contact or interference with the stripping system, the measures can be taken at operational bath temperatures, allowing real-time process control without delay from sample conditioning process. There is no need for reagents or cooling units.

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01 ABB's ClippiR+
non-contact sampling
accessory

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02 Table showing
amine vs PR trends

The WPA also supports multiple FPD stripper chemical calibrations giving the end user the flexibility of changing calibrations to meet evolving process changes. Different applications or chemistry can be measured using one WPA on multiple tools.

The WPA has proven capabilities of measuring all major stripper chemicals used for the FPD industry which include: **N-300**: PR, MEA, H₂O; **TOK-106**: PR, MEA, DMSO, H₂O; **ETS-100**: PR, DMAC, AEE, MMF, NMP, H₂O; **LGS-200-DIZ**: PR, amine, H₂O; **DPS-3300-XC**: PR, amine, NMF, H₂O. This versatility makes it easily adaptable to practically any FPD PR stripping process monitoring.



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The trend chart below shows concentration changes of PR and amine for PR stripping process with continuous fresh stripper chemical dosing controlled by the concentration level of PR.

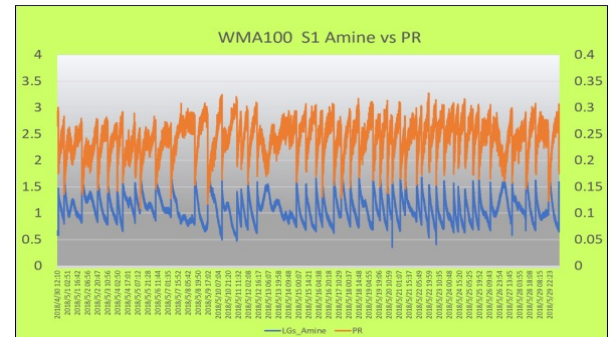
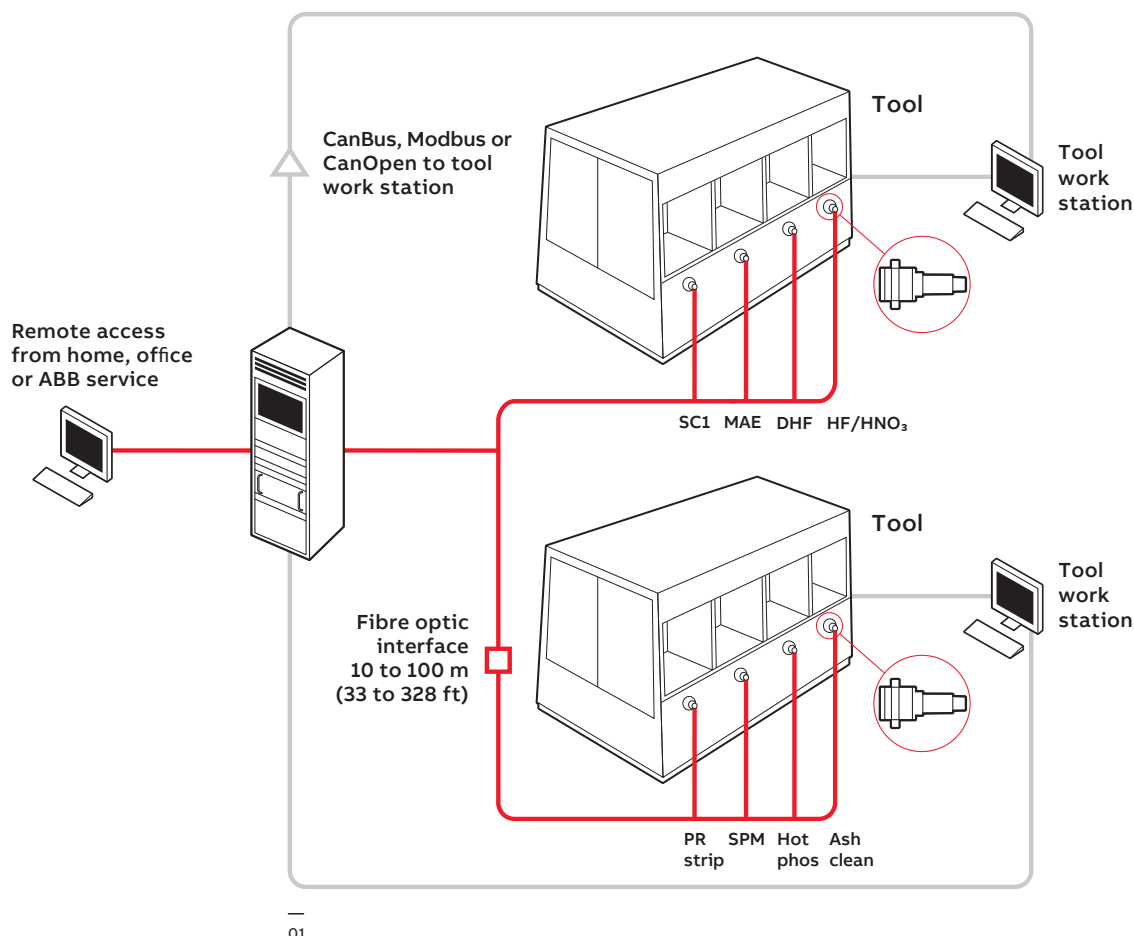


Figure: PR stripping process trend chart
Legend: Red: amine, Blue: PR
Title: Amine vs PR
x-scale: in days
y-scales: Left (wt% for amine), Right (abs for PR)

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With its multi-stream analysis function, one WPA can monitor up to 8 different chemical baths, thus offering a very cost-effective solution when compared to setups with multiple analyzers per tool. Precise end-of-bath alert and bath life extension, through chemical auto spiking, can be achieved by the real-time monitoring capability with measurement time in less than 30 seconds.

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01 Only one wet process analyzer (WPA) for multiple tools and 8 baths per WPA



In the end, the WPA generates savings by promoting increased bath lifetimes and reducing chemical consumption, while offering precise multi-stream chemical analysis. Moreover, no downtime is required for installation (with the patented non-contact sampling accessory ClippIR+) and off-line laboratory analysis, making the WPA a complete process control tool.

Conclusion

As flat panel displays (FPD) become ever more sophisticated and expensive to produce, cost-effective production solutions need to be implemented with the most reliable and efficient technologies. A good real-time process control plays a fundamental part in attaining performance landmarks and every process optimization contributes to profit growth. To achieve this, engineers must rely on state-of-the-art analytical tools to guarantee perfect quality control leading to an optimized process yield. The PR stripping process is a key step in maintaining high-quality production standards in the FPD manufacturing. Implementing

the proven ABB Wet Process Analyzer (WPA) system to the existing stripping process tool significantly reduces panel damage risk through an enhanced process control by rapidly and precisely monitoring stripping chemical concentrations.

ABB's Wet Process Analyzer (WPA), with its online multi-stream analysis capability, is the market leader for PR stripping process monitoring in the FPD industry with large install bases in Taiwan, China, and Korea. It offers a fast, efficient, and reliable real-time analysis solution for FPD makers. The non-invasive approach allows precise data driven process control without interacting with the process itself.

With its large installed base in Northern Asia, where the majority of FPDs are produced, ABB is recognized as the leading supplier for PR removers in display manufacturing in Asia since 2003. Simply said, the ABB Wet Process Analyzer (WPA) is a must have analytical tool for any FDP manufacturer.

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