UV LED Curing for Touch Screen Manufacturing

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Introduction

This paper provides an introduction to UV LED curing and its many benefits for bonding and coating applications in the touch screen manufacturing segment. UV LED curing technology provides a more consistent and reliable process without damaging or discoloring heat-sensitive components. Product manufacturers, machine builders, and chemistry formulators will gain an understanding of the benefits and how to apply UV LED curing in manufacturing processes.

Background

Ultraviolet (UV) curing is a photopolymerization process that uses UV energy to change a liquid to a solid. Upon absorption of the UV energy, as shown in Figure 1, the photoinitiator (PI) produces free radicals which initiate cross-linking with binders (monomers and oligomers) in a polymerization reaction to cure or solidify the ink, coating or adhesive, usually in a few seconds.

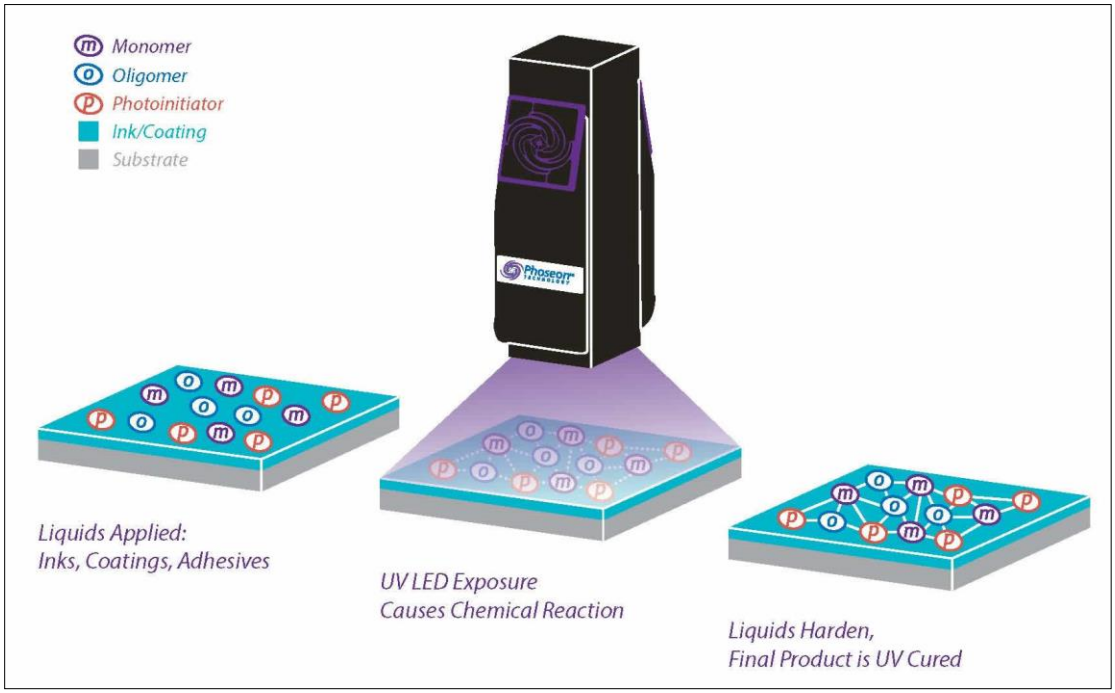

Figure 1: UV Curing Photopolymerization Process

Originally introduced in the 1960s, manufacturers today use UV curing for a wide variety of applications from graphic arts printing to automotive headlamp coating, and more. In fact, the UV curing market continues to grow as it displaces water and solvent-based thermal drying processes due to increased productivity, higher quality and performance, and environmental benefits.

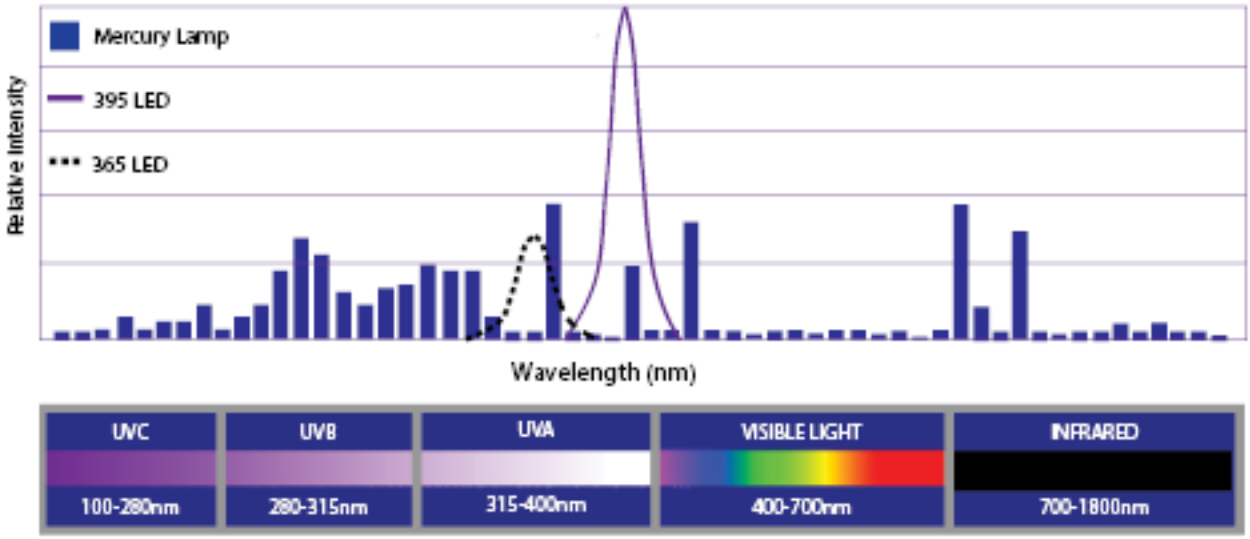

Figure 2: Wavelength Output Comparison of Mercury Arc and UV LED Lamps

UV LED curing basics

Light-emitting diodes for ultraviolet curing applications, UV LED, generate UV energy in an entirely different way. As an electric current, or electrons, move through a semiconductor device called a diode, it emits energy in the form of photons. The specific materials in the diode determine the wavelengths of these photons. In the case of UV LEDs, the output is typically in a very narrow band +/- 10nm. Figure 2 compares the output of a 395nm UV LED lamp with a typical mercury arc lamp. It is important to note the difference in intensity and wavelength of the output, both are important to understanding a UV curing process.

UV LEDs have been commercially available for over ten years now. However, their unique output characteristics require newly formulated UV chemistries in order to take advantage of UV LED's many benefits. For efficient and effective UV curing of an ink, coating or adhesive, the formulator seeks to overlap the UV lamp output with the spectral absorption of the photoinitiator. A very efficient cure is possible with a formulation designed specifically for UV LED curing using a photoinitiator with concentrated absorption in the UV-A range.

Chemistry

UV chemistries for electronics applications are typically acrylates, silicones, or epoxy formulations, with acrylates being the primary choice because they generally cure faster. Many formulations are one-part, which makes handling and application easy. Most UV formulations are 100% solids with no solvent emissions and available in a range of viscosities depending on application needs. Shelf life varies from six months to several years. Some UV formulations, especially those for bonding or encapsulating, where the UV energy cannot reach everywhere due to shadow areas, use dual-cure mechanisms such as UV with heat or moisture curing. UV adhesives can adhere dissimilar materials such as metal, glass and plastics with precision dispensing via syringe.

Touch screens

The touch screen market continues to grow with uses in smart phones, tablets, eBook readers, mobile game consoles, and in-car navigation systems. Asia-Pacific is the largest and fastest growing regional market for touch screen manufacturing.

Figure 1: Touch Screen Displays

A touch screen display is an assembly of many different layers such as the liquid crystal display (LCD) or organic light emitting diode (OLED), glass, conductive and non-conductive layers, and a protective flexible layer. Each of these layers needs a liquid optically clear adhesive (LOCA) to provide a strong bond, a protective seal from moisture, and desirable optical properties while withstanding sunlight.

UV LED curable adhesive formulations are typically acrylic or epoxy cured at 365nm, and deliver excellent optical properties such as light transmission, reduced reflections, anti-fogging and impact and scratch resistance. They are easy to dispense and provide high flexibility without shrinkage or tension between layers, which could cause image distortion.

The manufacture of LCD and OLED displays also use UV LED curing prior to assembly into a touch screen. The low heat and on-demand curing using UV LED lamps is especially advantageous for preventing damage to sensitive components and delivering a consistent, high-speed process. One specific application is edge sealing of OLEDs, which uses an epoxy resin and spot curing UV LED system to deliver a precise and efficient cure that effectively seals out moisture.

UV LED curing offers many benefits to electronics manufacturing. We will examine the following three benefits to touch screen manufacturing: improved yield, process stability and better adhesion.

Figure 2: UV Light Source

The first benefit is increased yield. Yield (defined as the number of salable, good units as a percentage of total units produced) is critical in high-volume manufacturing. Assuming a vendor can product 5,000 displays per hour, a 24x7 operation for 50 weeks could produce 42M displays on a line. A 0.1% yield increase from 98% to 98.1% would be worth 42K displays annually. At the competitive prices displays are offered, these extra 42K displays could provide significant profit margin to the vendor or allow them to gain market share from their competition.

Yield is improved with UV LED curing systems by providing consistent UV output over long periods of time. The image shows output from a UV LED lamp covering an area the size of a display screen. As shown, the display material receives a homogenous dose of UV energy consistently across the surface with no “hot” spots or “dead” spots which would lead to a rejects.

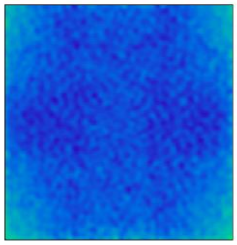

Figure 3: Consistent UV Output

The second benefit is process stability. UV LED systems provide stable output over long periods of time, typically greater than 20,000 hours. At the low power levels needed for display manufacturing, it is conceivable that the UV LED systems would last beyond 40,000 hours with the only maintenance being monthly checks of air filtration and ensuring the emitting window is clean. And as a reminder, this would be 40,000 hours of ‘on-time’. Being semiconductor devices, UV LED systems can be turned on and off instantly with no damage to the light source. No warm-up or cool-down period is required.

The consistent output and long life lead to process stability, a key requirement for high-volume manufacturing. Knowing the equipment is producing the same UV output yesterday, today, and in the future allows the vendor to focus their resources on other parts of the manufacturing process. Process stability is further aided by the fact UV LED systems only produce output in the UV-A range, typically 365nm to match with the acrylic adhesive being used. Since no UV-C or infrared is being produced, the adhesive and surrounding transport are only receiving the amount of dose in the wavelength required. This UV LED 'cold cure' again improves process stability by not damaging the electronic components while the UV adhesive is being cured.

The third benefit is improved adhesion of the adhesive. Since UV LEDs provide energy in a narrow band, a wavelength-optimized adhesive can be formulated to ensure deep-through curing and attachment to display surfaces. The adhesive manufacturer can depend on UV LED's consistent output at a specific wavelength to develop a formulation which is highly reactive to the UV energy and thus shorten the curing time. Future developments of UV adhesives may also mean less adhesive is use for each display screen leading to an additional cost savings to the manufacturer.

Conclusion

UV LED curing offers electronics manufacturers higher yield rates and productivity due to a consistent and stable process with less damage to heat sensitive components. UV LEDs require very little space making them easy to integrate into small spaces. Since UV LEDs produce no ozone emissions or hazardous waste concerns, they are the most environmentally friendly and safe UV curing technology available. Electronics adhesive and coating suppliers have formulations available for use with UV LED curing which are easy to handle and apply in precision, high-speed processes so common in electronics manufacturing. Many electronic product manufacturers are already reaping the benefits of using UV LED curing to improve their manufacturing processes. Electronics manufacturer's who needs to improve their yield rates should consider UV LED curing technology.