MBRAUN Whitepaper: UV Curing

GUIDELINE TO UV-CURING

Developing a successful light curing process requires knowledge about the following key concepts.

Higher Intensity means Faster Cures

Intensity is the light energy reaching a surface per time and is usually measured in mW/cm². Higher intensity light will generally provide faster cures. A well designed UV light-curing process incorporates a UV-source with excess intensity as it provides both a safety margin and a long bulb life. Lamp intensity should be regularly monitored with a radiometer. Bulb replacement shall be conducted when intensity drops under a pre-determined minimum value.

Curability

Light-curable materials will remain uncured unless exposed to light of appropriate wavelength, intensity and duration. Some materials might require thermal post-curing in order to complete the cure.

Short-wave vs long -wave bulbs

UV-Curing systems can be outfitted with either short-wave bulbs which emit primarily at UVB /UVC or long-wave bulbs which emphasize UVA and visible light. It is of crucial importance to match the spectral output of the lamp to the materials and application. Long-wave bulbs are recommended for curing most of the commercially available OLED sealants as these epoxies usually cure at wavelengths between 320-400 nm. In general long-wave bulbs provide superior depth of cure whereas short-wave bulbs are the component of choice for surface cure of coatings and inks. The chart below describes the portion of the electromagnetic spectrum which is emitted by standard long-wave and short-wave bulbs.

Distance and Substrates

Distance from a UV-bulb always effects intensity. Intensity decreases with increasing distance from both spot curing and flood curing systems. A further drop in intensity is observed when the light passes through substrates which transmit less than 100% of the incoming UV-light. However advances in light-curable adhesive technology allow curing through most translucent substrates, even those that block UV completely.

Curing Area

The size of the area to be cured dictates which lamp configuration is appropriate. Spot lamps are typically used to cure areas of up to 10 mm in diameter. They are widely used in OLED manufacturing processes when localized pre-bonding of the cover glass to the EL glass is required. In R&D systems flood or focused beam lamps usually equipped with a shutter and a reflector system are used. These units can effectively cure areas of up to 200 x 200 mm. For larger curing areas lamp fields combined of multiple flood lamps are utilized. However sophisticated reflector and heat management systems are required to achieve good uniformities across the entire curing area and remove the excess heat respectively.

Depth of Cure

Since light-curable materials absorb light themselves in order to cure, each has a maximum depth of cure. Layers thicknesses in OLED applications typically range between 50 µm up to 1.5 mm which is well below the curing depth limits of the average light-curable material (range between 4 mm up to 10 mm).

Definition of Total Cure

Changing from liquid to solid state is a simple but technically insufficient characterization of a finished curing process. A more complete definition is that curing is completed when further light exposure no longer improves product qualities. In terms of OLED applications it is directly related to tightness of the seal against moisture as well as mechanical strength of the bonding. Quantitative testing of cured specimens has to be done to determine the minimum exposure time and/or minimum intensity required for a complete cure.

Oxygen Inhibition

In some cases UV-adhesive beads exposed to oxygen during curing may remain tacky after cure. This phenomenon is caused by oxygen inhibition. Ambient oxygen actually slows down the curing process at the top-most layer of an air-exposed adhesive surface. The tackiness does not necessarily indicate incomplete cure and can be observed in a variety of materials. However it allows moisture to penetrate the seal more easily resulting in a reduced life time of the OLED. Generally there are three methods to eliminate tackiness associated with oxygen inhibition. Firstly a longer or higher intensity cure will minimize a tacky surface. Secondly a short-wave bulb instead of a long-wave bulb may help to achieve better curing results. Thirdly ï and this is the favored method in OLED applications ï is the curing in absence of oxygen. As OLED processes are primarily performed under inert environments an integration of the curing process into gloveboxes together with the rest of the encapsulation tools is the most efficient way to avoid tackiness due to oxygen inhibition.

Time Bottleneck vs. process flow

Ideally the UV light-curing process is designed to be faster than the limiting step in the overall manufacturing process. Coating substrates, cleaning of cover glasses, mounting of desiccants and dispensing of the adhesive will maximize efficiency. In automated lines with designated tact times where the required curing time exceeds the cycle time multiple cure stations or pre-curing with spot-lamps followed by final curing in a separate module can be used as brief interruptions during cure are acceptable.