Advances in LED Technology Aid Adhesive Curing

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Light Emitting Diode (LED) light sources offer many potential benefits over traditional light cure equipment, specifically longer life, lower operating costs and more flexible configurations. Until recently, LED light sources have not offered sufficient power to properly cure adhesives used in manufacturing operations. New developments in LED technology make it possible to produce devices with the output needed to meet this challenge.

How It Works

Typical light sources use electrical energy to heat a filament or excite materials into a plasma state, thereby generating light. With LED technology, light generation occurs when electrical current runs through a semiconductor. LED based light sources eliminate bulky, expensive bulbs , improve efficiency, require less energy to produce equivalent amounts of light, and generate less heat than traditional light sources. And whereas traditional light sources costs thousands of dollars plus associated bulb replacement costs, LEDs are now available for less than $1,000, with no bulb replacement required.

LED output is focused in a very narrow range of wavelengths when compared with other light sources (Figures 1 and 2). While the dental industry has used LED technology for years to cure composites, these light sources typically emit in the 450 to 470 nm range, too high for typical industrial assembly adhesives. The latest LEDs are available with output around 405 nm, a wavelength appropriate for a wide range of industrial adhesives.

The narrow spectral distribution range of LED light sources essentially eliminates output in the IR range, so the potential for damage to heat sensitive substrates is minimized. Since LEDs do not require a warm-up or cool down period, they can be turned on only when they are needed, further increasing their efficiency. Their low power consumption allows them to be designed as small hand held units with irradiance levels of 1 Watt/cm^2 or more. And the operating lifetime of an LED is measured in tens of thousands of hours, much longer than the lifespan of alternative light sources.

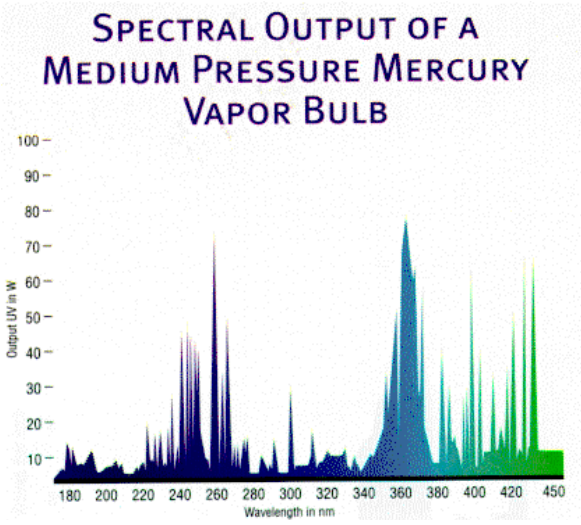

Figure 1 - Spectral output for a medium pressure mercury vapor-based light source

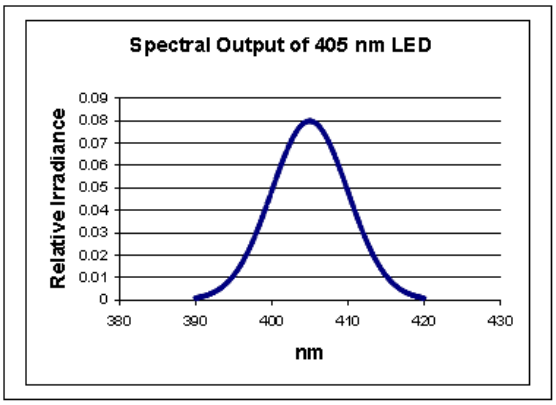

Figure 2 - Spectral output distribution for a 405 nm based LED light source

Adhesive Technology

LED light sources with output in the 405 nm range deliver excellent performance with adhesives that cure above 400 nm, in the visible light cure range. Visible light cure adhesives offer two key benefits to end-users: 1) they may be used on UV blocking substrates including many plastics and glass, and 2) they tend to have better depth of cure than UV adhesives.

Unfortunately, the farther light absorbance extends into the visible region (450 nm and beyond), the more likely the adhesive will have an undesirable color. Adhesives

that absorb light in the lower visible light range allow the user to reap all the benefits of a visible light curing in water clear formulations. The performance and processing advantages of these types of adhesives could not be fully exploited until LEDs became available with output as low as 405 nm.

New Developments in LED Technology

In addition to spectral output, irradiance of the LED source is critical to device performance. Irradiance measures the rate at which the LED delivers light energy to an area, and is typically expressed in units such as Watts/cm^2. Irradiance of a light source has a dramatic effect on adhesive curing properties such as depth of cure and the speed of tack free surface cure. While proper adhesive formulation can mitigate some cure concerns, high irradiance or output is required to ensure a complete, tack-free cure.

LEDs always generate heat as they operate. With typical LEDs, as heat increases, light output drops, making it difficult to achieve the high output levels required for many industrial adhesive curing processes. To solve this problem, the newest LED light source on the market features a patented internal cooling technology that allows it to operate at power levels far higher than other LEDs without a drop in output. The device is hand held, battery operated, and highly portable. This portability permits easy positioning of the light source in confined areas and expands its viability beyond typical applications (Figure 3). The device cures adhesives in seconds to yield hard, tack free adhesives that bond tenaciously to a wide variety of materials.

Figure 3 - Handheld high irradiance 405 nm LED based light source

Future Developments

LED light cure systems that offer high irradiance from 405 nm have opened the door to widespread use of LED technology in industrial assembly processes. By lowering the initial investment required and the operating costs associated with the use of light cure technology, these systems are allowing more manufacturers to take advantage of visible light cure adhesives.

The economic advantages of LED technology will continue to drive innovation in this area as light curing equipment suppliers find ways to satisfy industrial needs. On the horizon are LED systems that can cure larger areas, expanding the number of appropriate bonding processes. Increased irradiance may also allow LED systems to cure a broader range of adhesives faster. While adhesive formulators have already made great strides in producing adhesives that cure rapidly with LED systems, the range of adhesives that are available to satisfy LED criteria will continue to expand.

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