

UV Light-Curing Adhesives for Increased Productivity

By Dr. John Herold and Dr. Martin Kluge

Fast processes are preferred in nearly every industrial production process. Single production steps must mesh together in a smooth and reliable way in order to achieve high production volumes with optimum yield. A high degree of automation and short cycle times have become fundamental preconditions to fulfill these requirements.

If it comes to joining components on a large scale, UV- and light-curing adhesives offer significant advantages. These adhesives are usually solvent-free and one-component, allowing an easy and safe integration into stationary and continuous production processes. The products polymerize quickly in just seconds by exposure to UV or visible light, enabling the short cycle times required, the corresponding dispensing and curing times and a high degree of automation. UV-light curing is not only fast, it also protects the components

thanks to the possibility of “cold” joining. Thermal sources (such as ovens or welding systems) are not required for curing. As a result, energy consumption is considerably reduced. The adhesives’ special features also include curing “on demand,” which allows trouble-free and precise positioning, and fixing of the components to be bonded as curing is only achieved after exposing the adhesive to light of a certain wavelength.

In terms of UV- and light-curing adhesives, two major product families can be distinguished—radically initiated adhesives are usually based on an acrylate matrix, while cationically initiated adhesives are based on epoxy resins. In addition, dual-curing adhesives on the basis of both product families are also available and can offer the possibility to cure shadowed areas with a second mechanism (i.e., with heat or humidity).

TABLE 1

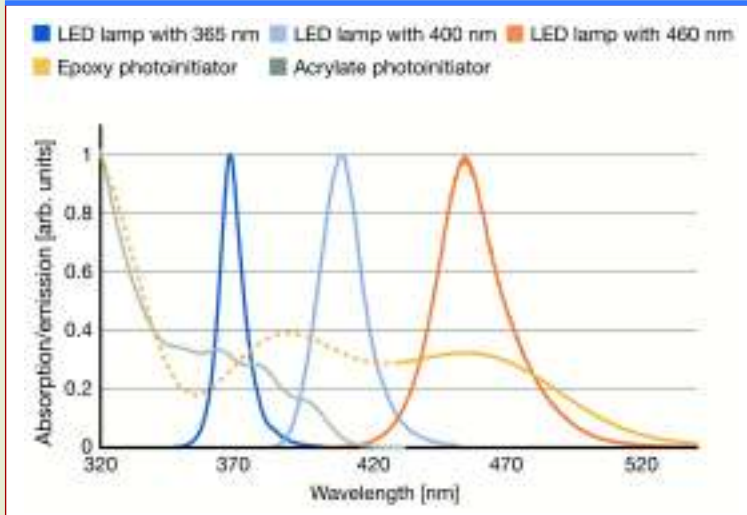
Advantages of acrylate and epoxy products

Basic Resin	Acrylate-based	Epoxy-based
Strong Points	Extremely fast curing	Thermal resistance
	High peel resistance	Chemical resistance
	Optically clear	Low outgassing
	UV-stable	Optically clear
	Universally good adhesion	Yellowing-resistant
	High equalization of tensions	Dry surface
		Preactivation possible

The strong points show where the product types are particularly efficient. Depending on the product, these strong points are subject to variations.

FIGURE 1

Match between LED lamp spectra and photoinitiator spectra of acrylate- and epoxy-based adhesives



Both families offer certain advantages depending on the application. Some strong points are summarized in Table 1.

For both chemistries, it is essential to adapt the wavelength of the

photoinitiator with the wavelength of the UV-light source to ensure an effective curing reaction. Effective does not necessarily mean that the maximum absorption of the photoinitiator has to match the

maximum emission of the lamp. Last but not least, this depends on the application where the adhesive is supposed to be used.

It is recommended to use light sources based on LED technology. Thanks to their distinct “peak” emission spectrum, the photoinitiator of the adhesive is activated at the perfect level. Depending on the type of adhesive/photoinitiator, LED lamps are available with different wavelengths (see Figure 1).

In the following, some application examples illustrate the versatile application areas of the UV-light curing acrylate- and epoxy-based adhesives.

Seal-Bonding in Seconds

Electromechanical devices (such as snap-action switches) are used in a variety of applications, all which have a high demand for accuracy and reliability. Hermetical sealing against environmental influences is essential to fulfill these demands. Therefore, one key step in the production of snap-

FIGURE 2

Dispensing and curing process of an automated production line for snap-action switch sealing

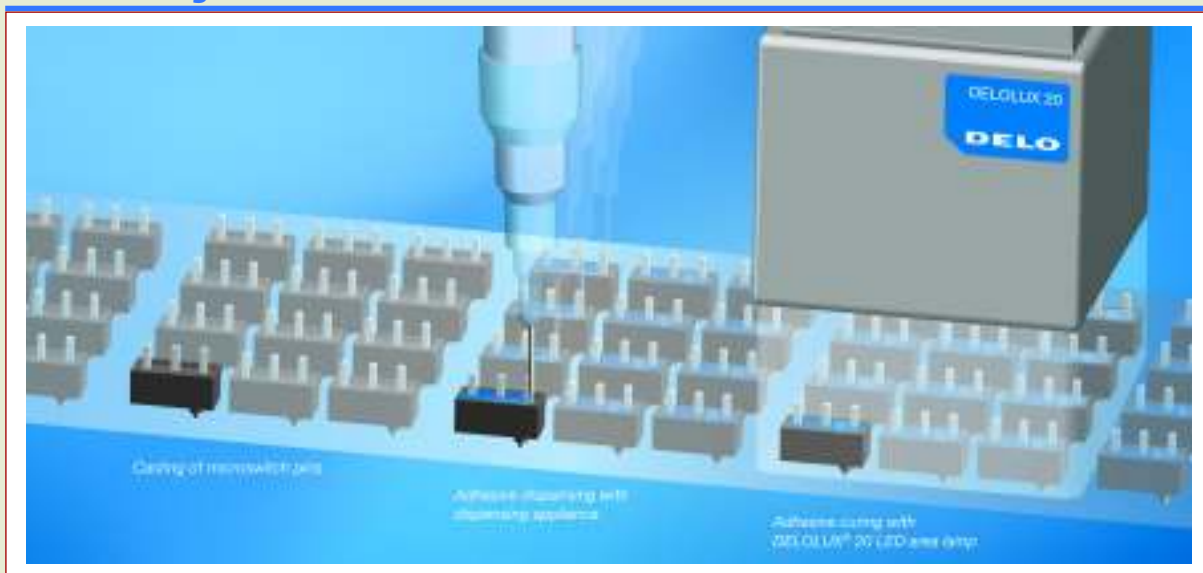
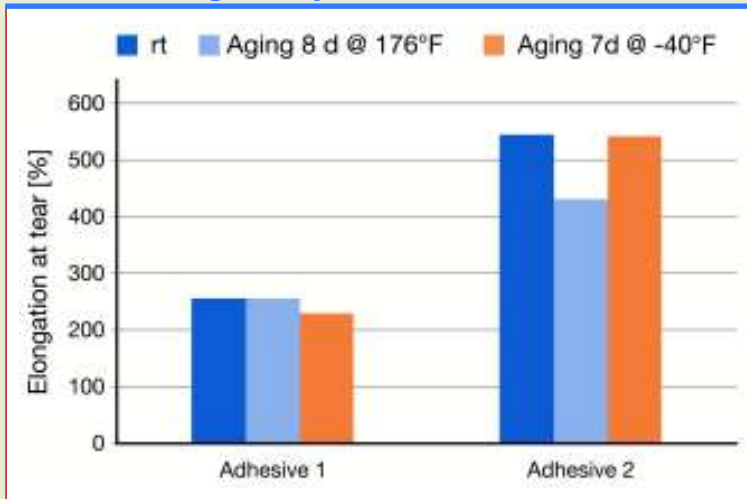


FIGURE 3

Climate testing of acrylate-based adhesives



action switches is the reliable sealing of the switch housings and connectors. In this field, it is often necessary to bond the housing and seal the connector pins in one step (seal-bonding). The production volumes are in the upper millions so that means it is essential that the components are bonded in an automated and reliable process. Two-component or heat-curing adhesives and encapsulants cannot sufficiently fulfill these requirements. The complex and high-maintenance processing systems for two-component adhesives are only conditionally suitable, especially for small adhesive amounts (< 100 mg). Heat-curing adhesives involve high investment for curing ovens and cause high operating costs.

UV-light curing adhesives are an ideal solution as they are easy to dispense and cure within seconds without adding heat. Their constant viscosity and unchanging flow properties allow complete wetting and reliable sealing. Fully automated inspection of the adhesive application process by cameras is enabled by colorants and/or fluorescence agents. This ensures that a lack of adhesive

or possible contaminations at the connector pins can be detected. If necessary, the system can be stopped and faulty production is avoided.

In addition, a direct 100% in-line control of the tightness is possible as acrylate-based, UV-light curing adhesives achieve final strength directly after irradiation.

Figure 2 shows the dispensing and curing process of an automated production line.

The adhesives for this kind of application are particularly characterized by their high flexibility over a wide temperature range (-40° to +176°F), which is essential for reliable sealing. Figure 3 shows two dissimilar acrylate adhesives which were optimized regarding low- and high-temperature flexibility. The microswitches are reliably sealed thanks to the tension-equalizing behavior of the adhesives. The good flow behavior ensures sufficient wetting and flowing on the components.

Even if adhesive flows through the cavities at the pins into the housing and cannot be light-cured in these shadowed areas, solutions on the basis of innovative dual-curing adhesives are at hand.

The light-curing acrylates were combined with new moisture crosslinking polymers in order to enable reliable curing in shadowed areas. Similar to UV/VIS-curing acrylates, these dual-curing adhesives

FIGURE 4

Touch-to-lens assembly



can be fixed by light in seconds and reliably cured in shadowed areas by the surrounding moisture. This ensures that no uncured adhesive residues are left if adhesive capillates into the housing. The risk of corrosive processes is also clearly minimized.

Optical Transparency and Tension-Free Joining

The rapid development of smartphones went along with an increased demand for fast and easily automatable joining methods in the production of the associated displays used. UV-light curing, acrylate-based adhesives allow fast joining of the display components in seconds. Tension-free, direct bonding to the liquid crystal display (display bonding) is possible, as is bonding the cover glass to the touch panel (touch-to-lens bonding), enabling the high optical transparency required in this type of application. (See Figure 4.)

In order to minimize tensions which cause display failures, the adhesives need to be very flexible and “soft.” Figure 5 shows the flexibility expressed by the shear modulus which ranges in a 30 times lower modulus for

a low-stress adhesive compared to a “standard” flexible acrylate.

Dual-curing adhesives for displays with shadowed areas (i.e., black print edges) are also available. (See Figure 6.) They cure by exposure to light and have a secondary moisture-curing mechanism for reliable curing in shadowed areas.

Exceptional Reliability and High Output

Chip cards are found in credit and bank cards, just as in SIM cards for

mobiles phones. The number of items range into double-digit billions all over the world. Due to the high output, card production and the encapsulation of the microchips on them require fast and extremely reliable encapsulation processes. Epoxy-based adhesives offer the solution—a high-viscous “dam” compound is quickly dispensed around the chip. Afterward, the chip is encapsulated by a lower viscous “fill” compound. Curing also proceeds within seconds. The adapted flow properties of both encapsulants are

FIGURE 5

Shear modulus of a low-stress adhesive for display bonding

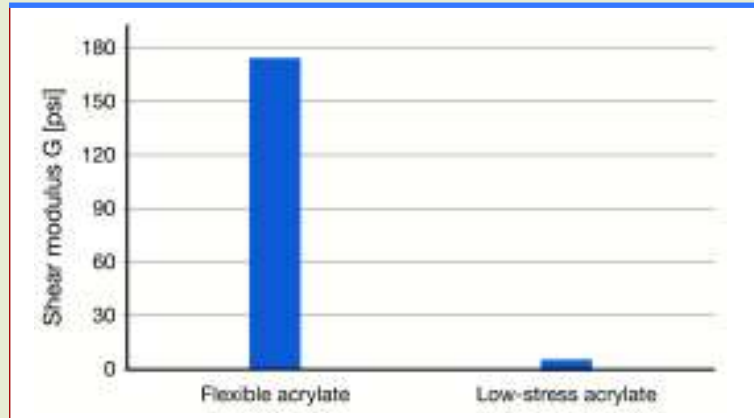


FIGURE 6

Display bonding with dual-curing adhesives

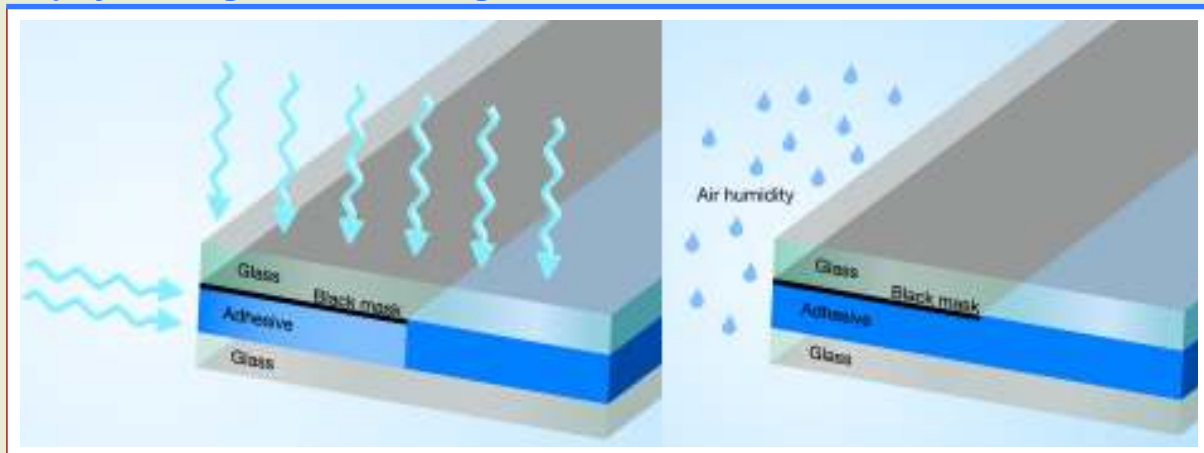
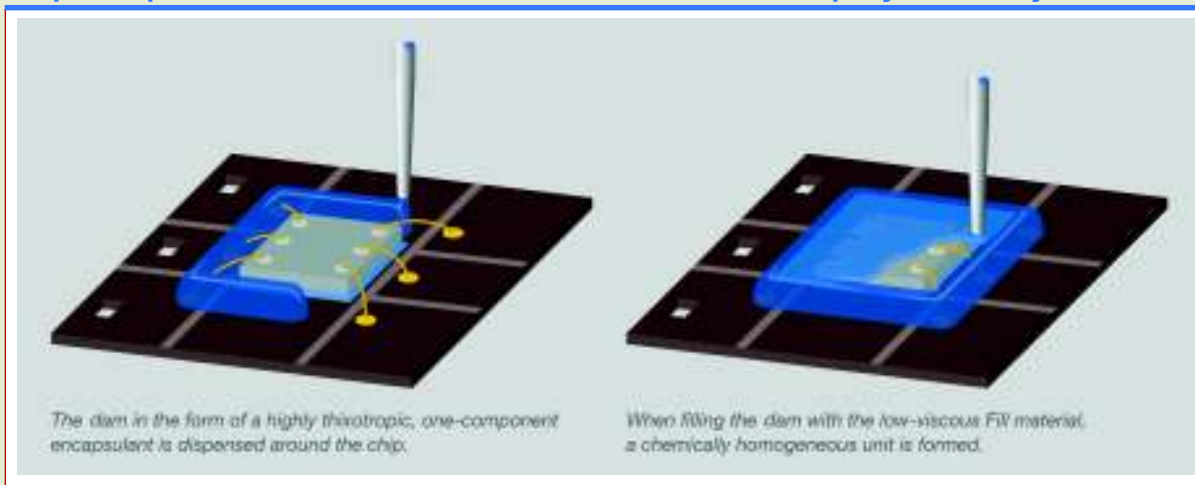


FIGURE 7

Chip encapsulation with dam and fill material based on epoxy chemistry



of particular importance as the chip is placed in a cavity and a maximum cover height must not be exceeded. Both adhesives maintain this tolerance very well. (See Figure 7.)

Conclusion

Both UV-light curing adhesive families provide the customer with

major advantages in terms of quality, safety and reliability. Short cycle times achieved through the short curing times of acrylates and epoxies boost productivity and reproducibility. Dual-curing adhesives offer the possibility to bond components with shadowed areas not accessible by light. ▶

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