Is UVC LED technology ready for real-world UV curing?

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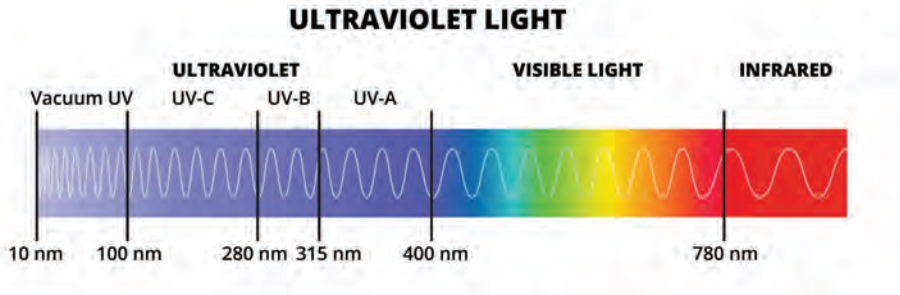
Over the past decade, UVC LED technology has experienced significant advancements in efficiency, operational lifetime, production yields and manufacturing costs. These improvements have enabled new applications and significantly reduced costs, making UVC LEDs increasingly viable for widespread use. UVC, when paired with UVA, delivers superior curing results for demanding UV curing applications.



ULTRAVIOLET LIGHT'S DEPTH OF PENETRATION BY BANDWIDTH

Regardless of how UV output is generated, longer UVA (315 – 400 nm) and UVV (400 – 445 nm) wavelengths penetrate deep into inks, coatings and adhesives while shorter UVC (200 – 280 nm) wavelengths are absorbed at the surface. In terms of curing, UVA and UVV produce through-cure while UVC is responsible for activating the layer of chemistry exposed to atmosphere. A lack of through cure can leave formulations soft and can contribute to inadequate adhesion at the bottom film or construction while insufficient UVC can leave formulations feeling greasy or tacky to the touch.

A common method for improving the surface cure of free radical formulations is to provide sufficient energy in the UVC wavelength range (200 to 280nm) to cure the top surface of the formulation. The short wavelength UVC energy does not penetrate the formulation, rather it provides curing energy targeting the surface of the formulation to overcome oxygen inhibition from taking place. Conventional mercury lamps are broadband sources (UVC, UVB, UVA, UVV, visible and infrared) while UV LEDs are monochromatic with specific wavelengths UVA (385 and 395 nm) and UVV (405 nm) and UVC (275 nm).

ADVANCEMENTS IN UVC LED TECHNOLOGY

Typical optical performance from ten years ago, UVC LEDs (between 260 nm and 280 nm) suffered from low wall-plug efficiencies of less than one per cent with a large portion of electrical input power lost as heat, thus requiring significant thermal management (heat sinks and cooling fans). However, more recent improvements in epitaxial growth techniques, substrate materials and chip architecture have led to substantial boosts in efficiency and commercial UVC LEDs can now achieve wall-plug efficiencies of four to five per cent. Early-generation UVC LEDs typically experienced short operational lifetimes of less than 1,000 hours of continuous use due in part to material degradation, poor thermal stability and inefficient die packaging. These issues limited their suitability in many applications where short life coupled with high replacement costs became barriers to adoption. More recent improvements in LED technology, including manufacturing processes to employ AlN substrates, chip designs that optimise epitaxial layer structures, and more robust packaging solutions, have led to significantly increased lifetimes.

Currently, a typical UVC LED offers lifetimes of greater than 10,000 hours with 70 per cent of the initial optical output (L70). This tenfold improvement allows for cost-effective adoption for applications requiring sustained use, in applications such as automotive, medical devices, fibre coloring as well as sterilisation systems.

Although UVC LEDs produce less power than UVA LEDs, some applications require UVC as a supplemental energy source to UVA for an optimal surface cure. Testing in our materials laboratory has demonstrated that a ratio of 12:1 of UVA and UVC energy provides ideal total cure properties with excellent surface cure results. Using a cure rating scale of 0-5, UVC + UVA produced a tack-free surface rating of 5, while UVA curing alone resulted in a very tacky surface with a rating of 0.

SUMMARY

It has been shown that with the enhancements in UVC LED technology, surface cure challenges are being overcome. When paired with a UVA LED system, providing just a little UVC exposure for post cure not only provides a tack-free surface, but also reduces the total dose requirements. When UVC + UVA combinations are implemented modifications to legacy formulations can be avoided.

Discover the key developments driving UVC adoption—and what they mean for your production process.