

THE NEXT GENERATION

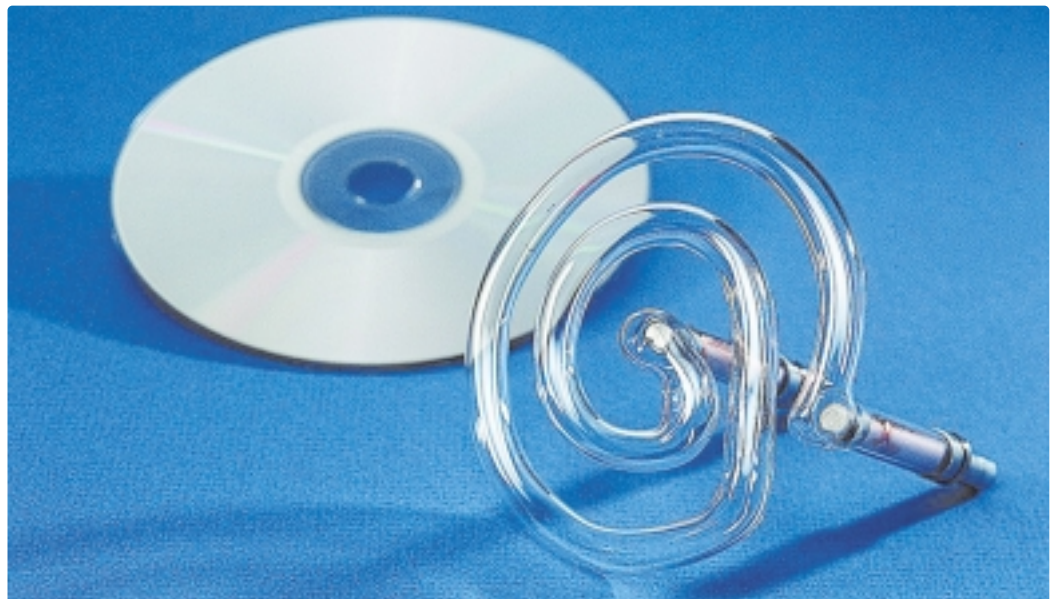
FUTURE FORMATS IN MEDIA MANUFACTURING

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Pulsed UV curing for blue laser media

Among the many new challenges for manufacturers of third generation media are the issues of bonding and curing; pulsed UV curing may be an effective solution

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Next-generation media offer clear benefits over previous formats, but their production is more arduous. In particular, bonding and curing for Blu-ray Disc (BD) and HD DVD (HD) formats become more difficult. The processing method must provide low temperature curing with high surface uniformity. The curing technology must be capable of penetrating thick and multi-layer substrates, as well as curing a variety of substrate materials.

Manufacturing high-definition discs is markedly more difficult than DVDs and CDs. The increase in content on each disc results in tightened manufacturing tolerances while market forces limit increases in cost. The moulding process becomes more critical, disc handling time decreases, and yet heat-related effects are less acceptable in these new formats. Pulsed UV solves a variety of prob-

lems facing BD and HD disc manufacturers, by offering a rapid curing technology for adhesive bonding and hard coat curing.

The UV pulses avoid heat-induced damage to the disc, penetrating deep into materials for 'chemically complete' cure bonding at high production speeds. Pulsed UV curing systems are also an effective and proven tool for cost reduction, already used by many integrators including M2, Alpha Sweden, Origin, Anwell, ADM, Katano, and replicators such as Cinram and CMC.

Pulsed UV curing lends itself to BD and HD production: the high-intensity short-duration pulses provide manufacturers with a technology that balances the need for fast curing and thermal management. In addition, the systems in general and output pulses in particular are flexible enough to be tailored to specific applications: the systems are

modular, and the timing and spectrum of pulses can be precisely controlled to match the substrate's shape and chemistry. Even the lamp shape can be tailored to the application.

Because the new high definition formats have smaller pits, smaller track pitch, and tighter tolerances on tilt and jitter, the effect of substrate temperature is much more pronounced. Heated substrates tend to develop negative tilts – in particular, curing the outer edges of the substrate becomes a challenge. Also, Blu-ray disc has an even greater need for a scratch-resistant hard coat. Pulsed UV curing provides excellent penetration and can deliver sufficient energy to affect a complete cure at a low substrate temperature, at high speed.

Pulsed UV is a fast, safe, environmentally benign and extremely flexible technology, capable of delivering

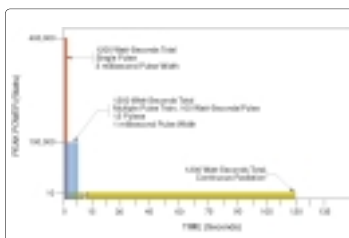


Figure 1: A comparison of pulsed vs continuous mercury UV

complete cures. It is unlike continuous mercury lamp UV systems (which are used to cure lacquer coatings on CDs). Pulsed UV light provides high-intensity pulses, with better penetration ability, while maintaining a low average power.

The pulsed UV source does not include any hazardous materials, which increases system safety. Pulsed UV systems also offer process flexibility to tailor key parameters to the application, including changing the peak power, pulse repetition rate, pulse sequencing, curing duration, and output spectrum.

This process flexibility is important because it helps process developers and system designers find the optimal balance between high energy, low heat, and short cure times. Pulsed UV helps to avoid depositing heat on the substrate in a number of ways. This technology provides:

- high peak power pulses that penetrate much more effectively than continuous illumination, with complete cures, thus eliminating the need for high average power sources that produce high levels of heat
- short duration pulses; fast enough to avoid heat build-up on the substrate
- cooling zone between pulses
- lamps that run cooler than mercury UV lamps (which must operate at a temperature high enough to vaporize the mercury), resulting in less heat build-up on the substrate and the bonding apparatus
- significantly less IR radiation

The instantaneous peak power of pulsed UV can exceed 100,000 times that of the sun. Consider two ways of expending the same amount of 100 Joules of energy: one can either power a 10 watt continuous lamp for 10 seconds or power a 1,000,000 watt pulsed lamp for 100 microseconds. This is analogous to penetrating a block of wood with a nail: one could press a nail into the wood with a finger for 10 seconds without effect, or exert the same amount of

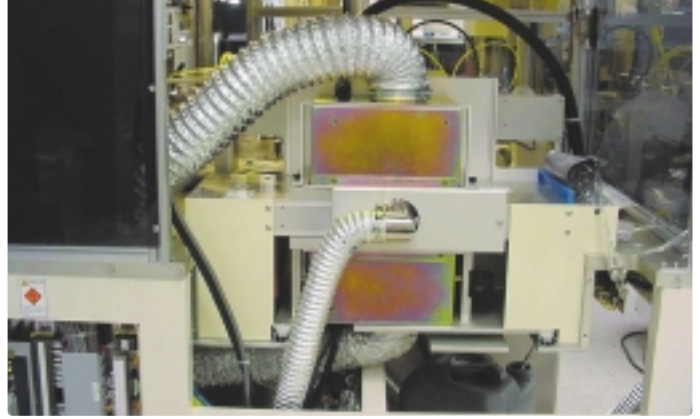
energy and drive the nail instantaneously into the wood with a single strike of a hammer. Pulsed UV, like the hammer, delivers light at high peak power for deep penetration.

The high peak power UV pulses penetrate thick and/or low transmissibility substrates much more effectively than continuous mercury UV. Pulses can deliver the energy necessary to cure an adhesive or coating in short, microsecond pulses. This essentially eliminates the possibility of substrate changes from exposure to unwanted energy.

The efficiency of pulsed UV curing also results in higher overall energy efficiency. Depending on the operating conditions, about 50% to 60% of the input electrical energy is converted to optical energy. The lamp is only on during the cure time. In some cases, users can decrease curing time by increasing the delivery rate of high-energy UV pulses. In others, the quantity of photoinitiators in the chemical mix can be reduced. At a major DVD replicator, use of pulsed UV systems reduced the average power requirement for inline DVD manufacturing from 6,000 watts (using mercury vapour lamps) to less than 1,000 watts.

The spiral lamp shown earlier in this article illustrates the flexibility inherent in being able to choose the shape of a lamp. The spiral lamp design was specifically developed for the DVD disc. Traditionally, mercury UV lamps have been limited to short arc or linear designs, but other shapes may fit the application better. The spiral lamp design can provide better uniformity and enhanced matching of the UV light with the substrate. The spiral shaped pulsed UV lamp meets the tough bonding and hard coating requirements of BD and HD disc formats.

The outer ring of the spiral lamp proved itself in 24/7 DVD manufacturing equipment over five years ago when it was first installed in



Pulsed UV lamp housings sandwich the DVD for tilt management in the Cinram bonder

systems at the Cinram (formally WAMO) facility in Pennsylvania. The pulsed UV systems using the spiral lamp eliminated problems the facility had with excessive heat and 'tacky' edge cures. Other lamp shapes are also available.

The same installation demonstrated a cost-saving arrangement in which two lamps were operated from a single programmable-logic-controller-run power source. The lamps were located above and below the disc, to manage tilt during high-speed batch processing.

In addition to general spectral shifts, the spectrum of each individual pulse can be 'tuned' to critically match the tilt management and/or absorption requirements of chemical formulations. At the beginning of the pulse, the output is primarily delivered at shorter wavelengths. As the pulse progresses, the output moves toward longer wavelengths. The amount of UV, visible, and IR delivered can be adjusted for the specific applications.

Pulsed UV systems do not require lamp warm-up time, disc rotation,

"The production of next generation formats is more arduous"

The dual lamp capability also allows for multiple format capability on the same production line.

Newly developed formulations for DVDs often require both UV and visible light for curing. Pulsed UV lamps provide a wide range of wavelength selection that offers an advantage to processing developers and DVD manufacturers: the output from these lamps allows users to control the spectra of the overall output and of specific pulses to best match adhesive chemistry.

Conversely, more formulators are developing chemistry for pulsed UV, which results in higher performance and lower cost production. Chemistry tuned to pulsed UV will simplify new format process development.

Pulsed lamps typically emit a broad spectrum with wavelengths ranging from 200 nm (in the UV) through the visible spectrum to 1,000 nanometres. The spectrum of the pulsed lamp is 'tuned' by appropriate design of the pulse configurator, which delivers the electrical energy to the lamp. Pulsed UV is the only technology whereby the spectrum can be changed without changing the lamp for optimum energy delivery to the substrate. The IR can be 'tuned out' and UV 'tuned in', preventing the need for heroic thermal management.

mechanical shutter controls, or water cooling. The compact power supply can be located a distance from the lamp. Additionally, pulsed UV lamps can turn on and off instantly, which makes them ideal for start-stop-start operation. This translates into significant savings in time and lamp maintenance on high volume manufacturing lines. The lamp is only on during the cure cycle. It is also safer for the operators if the lamp is completely off when not curing.

Pulsed UV technology provides compelling advantages for curing BD, HD and other new-format discs. The high-power pulses penetrate easily, and cure efficiently and completely with low average power and relatively low heating. Pulsed UV offers the opportunity for photoinitiator reduction, thus reducing costs. Pulsed UV systems also offer process flexibility to tailor key parameters to the application, including changing the peak power, pulse repetition rate, pulse sequencing, curing duration, and output spectrum, and the ability to instantly turn on and off the lamp without incurring warm-up or cool-down-time penalties. Cure time can be reduced by simply increasing the number of pulses/second. The lamps do not need water cooling, disc rotation, or mechanical shutters.

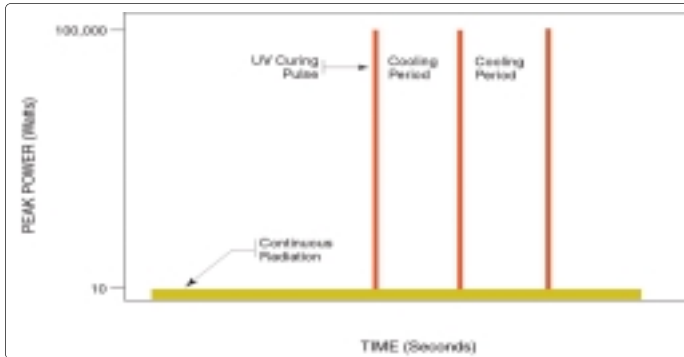


Figure 2: Instead of continuously warming the substrate, as does continuous UV curing, pulsed UV provides cooling zones between pulses