Photonic Curing: Expanding the Processing Window

Stan Farnsworth
Photonic Curing Tools, NovaCentrix, Austin, TX 78728, U.S.A
Tel.:512-491-9500 ext.210, E-mail: stan.farnsworth@novacentrix.com

Photonic Curing is the high-temperature thermal processing of a thin film using pulsed light from a flash lamp. When this transient processing is performed on substrates that have relatively low thermal damage threshold, such as plastic or paper, it is possible to attain significantly higher temperatures in the thin film than accessible in an ordinary oven. This ability enables drying, sintering, reacting or annealing of the thin film on substrates that are commonly not possible for the stated application. Additionally, as many of these transformations follow an Arrhenius relationship, i.e. the higher temperature processing enables much faster processing and in many cases. Thus, the transformation can proceed further than possible than with a conventional oven.

Photonic curing was first developed by NovaCentrix (then Nanotechnologies, Inc.) and is incorporated into the PulseForge® set of tools. It has become a transformative process used in the manufacture of printed electronics as it allows inexpensive and flexible substrate materials to be substituted for traditional glass or ceramic substrates. The ability to process materials on a sub-millisecond time scale fits naturally in with roll-to-roll (R2R) or sheet to sheet processing. The PulseForge tools have been engineered with numerous technologies to enable a faster and more seamless adoption of continuous printing and processing modes. Processing rates above 1 m^2/sec are common in a wide web format and speeds beyond 100 m/min are easily achieved. Such speeds, make photonic curing compatible with conventional industrial printing processes.

Photonic curing is a very energy efficient process. The lamps convert nearly 50% of input electricity to light, and in practice, about 40% of the wall energy is converted to useful light. Although much more energy efficient than an oven, the process introduces significant thermal load into the system as the hardware is comparatively compact. The small size of a photonic curing system allows it to be retrofitted onto existing lines and saves money when integrated into cleanroom environments. Consequently, in order to keep up with high speed industrial printing processes, all components of an industrial PulseForge system are water cooled to eliminate buildup of heat in the system. Water cooling increases the processing rate by 6 – 10X over an air cooled system.

Processing in a continuous format requires subsequent pulses to be "stitched" together as the material is conveyed underneath the flash head. To form a continuous cure that is void of over- or under-cured regions, a very uniform exposure area is needed. This process is called "overlap" on the PulseForge systems. To enable overlap, the PulseForge system delivers ±2% exposure uniformity over the processing window. In contrast, a traditional flashlamp system has a beam uniformity of about ±10% which renders it ineffective as a processing tool for many materials. Unlike most other processing equipment, the uniformity of the PulseForge system improves as the processing width increases.

The maturing complexity of modern displays for customer applications demands high throughput manufacturing and improved device function. The functionality of the displays is critically important as customers demand more out of each device. In that order, multiple layers are designed into each display, requiring ever more versatile processing techniques. Photonic curing is uniquely suited to complement the processing needs in the manufacture of modern displays. The photonic curing process can provide a fast, reliable and transformative processing step to meet the most demanding production designs. Photonic curing enables lower thermal processing budget with current materials, and it can provide a path to incorporate more advanced materials and functionality into future displays.