OLED Materials Processing with High Power UV Picosecond Lasers

Manufacturing of flexible organic light-emitting diode (OLED) displays is critical for next-generation consumer electronic devices, including foldable phones. OLED displays are comprised of multiple layers of polymer materials, including polyimide, polyethylene terephthalate (PET) and cyclo olefin polymer (COP). These materials are transparent to infrared and visible wavelengths and are prone to thermal damage, making them difficult to machine with conventional laser sources. Increasingly, ultraviolet (UV) picosecond (ps) lasers are becoming a promising solution for processing such materials. Both the ultrashort pulse width and the UV wavelength help to create small, high quality features at high processing rates.

Recently, a high-power ps UV laser source was tested for cutting of OLED polymer materials in MKS Spectra-Physics® industrial applications lab. Using a 50 W UV IceFyre® 355-50 picosecond laser system, processes were developed for cutting both PET and COP polymer sheets. Laser parameters were tuned to generate optimal speed and quality.

PET is commonly used as a substrate throughout OLED manufacturing and is typically part of a layered stack that needs to be cut. Because of its high transparency, it is also one of the more difficult to cut of the constituent materials. Using an IceFyre 355-50 laser, 75 µm thick PET film was cut and a range of laser output pulse energies and pulse frequencies. Figure 1 shows how the resultant quality was improved by optimizing the laser's pulse repetition frequency (PRF) while maintaining the same cutting speed of 628 mm/s.

With the increased laser PRF, the output pulse energy is somewhat lower and closer to what is required to create optimal fluence conditions within the material. Since the laser maintains a high average power output even at the higher PRF, the effective cutting speed is unchanged while the quality is improved with less debris generated and heat-affected zone (HAZ) reduced from ~8 to ~6 µm.

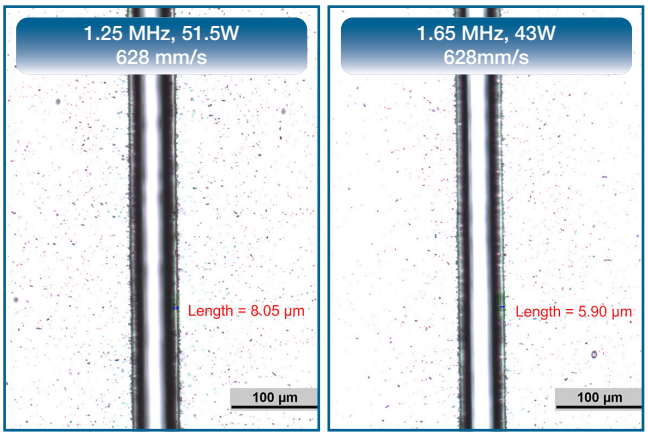

Figure 1
PET film cut with lower (left) and higher (right) laser pulse frequencies.

COP is a more advanced OLED polymer that, in addition to application as a highly transparent protective cover, is also used in layered anti-reflection stacks for manipulating optical polarization. In a series of experiments, the trade-off of throughput

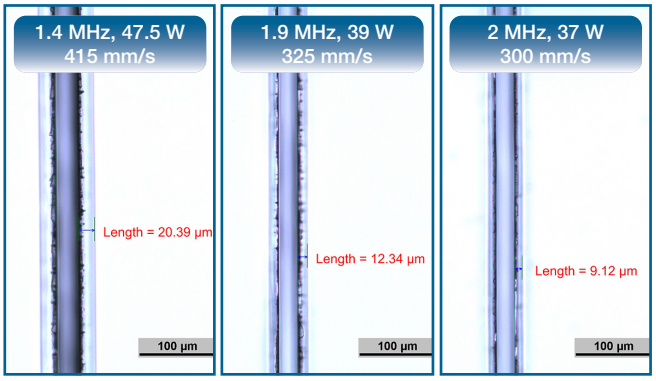

Figure 2
COP film cut with lower (left) and higher (right) laser pulse frequencies.

and quality for cutting 100 µm thick COP was explored in detail. Microscope photos in Figure 2 show a summary of the results.

The highest speed was achieved with a PRF of 1.4 MHz, at which point the laser output power is still markedly close to its maximum 50 W at the lower nominal PRF of 1.25 MHz. At this maximum speed, the cutting quality is quite good with a HAZ of ~20 µm. By increasing the PRF, the corresponding reduced pulse energy forms a gentler process—with a >50% reduction in HAZ—while still maintaining a high cutting speed (>72% of maximum). In some cases, the larger HAZ at the higher speed may be acceptable; for those more demanding applications, however, significant HAZ reduction with minimal throughput reduction is possible due to the laser's ability to generate high average powers at higher output pulse frequencies.

OLED manufacturing often has demanding requirements on quality and throughput. The materials are challenging for conventional laser technologies, and newer industrial ps UV laser sources are proving valuable. With the IceFyre ps UV platform, excellent throughput and quality can be achieved, and the flexibility of the laser's output allows for application specific process tuning for optimal quality and throughput.

PRODUCT: *ICEFYRE®*

The new IceFyre 355-50 is the highest performing UV ps laser on the market, providing >50 W of UV output power at 1.25 MHz (>40 µJ) with 100's µJ pulse energies in burst mode, and pulsewidths of 10 ps. The IceFyre 355-50 sets new standards in power and repetition rates from single shot to 10 MHz. The IceFyre 355-30 offers >30 W of typical UV output power with pulse energy >60 µJ (greater pulse energies in burst mode) and delivers exceptional performance from single shot to 10 MHz. The IceFyre 1064-50 provides >50 W of IR output power at 400 kHz single pulse and delivers exceptional performance from single shot to 10 MHz.

IceFyre laser's TimeShift™ unique design exploits fiber laser flexibility and Spectra-Physics' exclusive power amplifier capability to enable TimeShift ps programmable burst-mode technology for the highest versatility and widest range in the industry. A standard set of waveforms is provided with each laser; an optional TimeShift ps GUI is available for creating custom waveforms. The laser design enables true pulse-on-demand (POD) and position synchronized output (PSO) triggering with the lowest timing jitter in its class for high quality processing at high scan speeds, e.g. when using a polygon scanner.

	IceFyre 1064-50	IceFyre 355-30	IceFyre 355-50
Wavelength	1064 nm	355 nm	
Power	>50 W @ 400 kHz	>30 W typical @ 500 kHz >25 W @ 800 kHz >20 W typical @ 1 MHz	>50 W @ 1250 kHz
Maximum Pulse Energy, typical (greater pulse energy per burst possible with TimeShift ps)	>200 µJ single pulse @ 200 kHz	>60 µJ typical @ 500 kHz >31 µJ @ 800 kHz >20 µJ typical @ 1 MHz	>40 µJ @ 1250 kHz
Repetition Rate Range	Single shot to 10 MHz		
Pulse Width, FWHM	<20 ps (15 ps typical)		<12 ps (10 ps typical)
TimeShift ps	yes		
Pulse-to-Pulse Energy Stability	<1.5% rms, 1 σ	<2.0% rms, 1 σ	
Power Stability (after warm-up)	<1%, 1 σ, over 8 hours		

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