# Ultra-fast laser processing

Rainer Pätzel, director of marketing at Coherent Inc., discusses the field of laser ablation for organic and printed electronics

Lasers provide established solutions at several points in the production of OLED devices on traditional (rigid) substrates. Standout examples include excimer lasers used for polysilicon annealing of display backplanes, and for laser lift-off to separate flexible display films from glass substrates. Other important applications are the use of ultra-short pulse (USP) lasers for circuit repair, both $CO_2$ and USP lasers for film and foil ablation and glass cutting, and a variety of marking applications employing both fibre and diode-pumped solid-state lasers.

Significantly, many of these processes are directly applicable to OPE fabrication. In particular, laser ablation utilising USP lasers offer substantial benefits for both device


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structuring and singulation over other methods. This article reviews the mechanism and benefits of laser ablation and provides an overview of the tradeoffs involved in choosing a USP laser for a particular task.


Ultra-short pulse laser from Coherent

## Laser Ablation Mechanics

There are two basic means by which a laser can ablate or process a material. Continuous output lasers and pulsed lasers with pulsewidths in the tens of nanoseconds range remove material through a photothermal interaction. Here, the focused laser beam acts as a spatially confined, intense heat source which vaporises (essentially boils away) material. This allows relatively high material removal rates; however, for the most demanding tasks, peripheral heat affected zone (HAZ) damage can be a significant problem. This undesirable damage can include delamination of surface coatings, microcracking, changes in the bulk material properties, and/or the presence of some recast material.

The second mechanism for laser material removal is based on photoablation, typically accomplished using USP lasers whose short pulsewidths lead to very high peak powers. This power is sufficient to directly break the molecular or atomic bonds which hold the material together, rather than simply heating it, resulting in "cold" material removal. Plus, the material is exposed to the laser light for such a short time that the energy isn't carried beyond the area of impact. This minimises the heat affected zone. Additionally, this is a very clean process, leaving no recast material that could require post-processing.

For OPE applications, a major advantage of ultrafast processing is that it works on virtually any material, even ones that are normally transparent at the laser wavelength. This, coupled with the ability to very precisely control ablation depth, makes it ideal for either cutting partially or completely through substrates comprising layers of disparate materials.

The typical tradeoff of USP lasers is a higher capital cost than longer pulse length lasers. As a result, ultrafast processing provides the best rate of return for applications that demand the greatest possible precision, quality and smallest HAZ.

## USP laser process parameters

Commercial USP lasers are currently available with output in either the infrared, visible or ultraviolet, and over a range of pulse repetition rates and output powers. Choosing the optimum source for a specific application typically represents a compromise between quality, processing speed and cost.

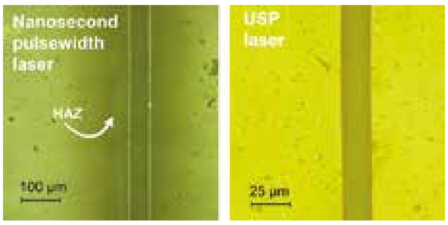
For example, process quality (specifically kerf width) improves in virtually all materials as wavelength decreases. But, shorter wavelength lasers have lower material removal rates than longer wavelength sources (all other factors being equal), so processing speed also decreases with wavelength.

Similarly, process speed can often be increased by using higher laser power or pulse repetition rates. However, laser cost is usually tied directly to these parameters, so increasing them raises cost. Determining the optimum laser characteristics for a given process typically requires some practical testing, and is often best done in cooperation with an experienced laser supplier that offers applications development services utilizing a wide range of products.

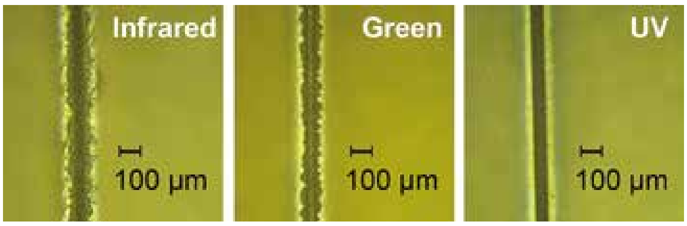
In conclusion, many laser processes already established in display and semiconductor fabrication are directly applicable to roll-to-roll OPE production. USP lasers are useful to cut inhomogeneous layers, either partially or completely, in a single process. They produce a minimal HAZ and kerf, and deliver better finish quality than virtually any other technique. Furthermore, for many applications, USP laser processing delivers a highly desirable combination of superior finish quality with and higher process utilization, resulting in a lower cost-of-operation.

## Information

Founded in 1966, Coherent, Inc. is one of the world's leading providers of lasers and laser-based technology for scientific, commercial and industrial customers. Its common stock is listed on the Nasdaq Global Select Market and is part of the Russell 2000 and Standard & Poor's MidCap 400 Index.




**"Dark Yellow," 30µm thick polyimide sheets scribed with a nanosecond and USP laser. The nanosecond laser processed at 66mm/sec, while the USP laser cut at 193mm/sec. The nanosecond laser produced a substantial HAZ – seen as a darkening in this image – while the USP laser produced none, and also delivered a substantially smaller cut width**




**A 220µm thick simulated display layer on glass scribed with a Coherent HyperRapid NX laser with output in the infrared, green and ultraviolet. This clearly demonstrates the improvement in cut quality with decreasing wavelength**