High Speed Processing of Plastics with a 100 W Femtosecond Laser

Plastics are used increasingly in various industrial sectors such as medical device and organic electronics manufacturing. Medical device applications include manufacturing of implantable devices like stents, catheters and wires, which need to be structured and cut using lasers at the highest possible quality with minimum heat damage. As the flat panel display market moves from LCD to organic LED (OLED) display technology which utilize plastic materials, laser structuring and cutting of plastics with high qulity is needed.

Femtosecond lasers are capable of machining plastic materials with minimum heat affected zone (HAZ) and very precise control of the material removal. Although the processing quality achieved meets industrial demands, processing speeds need to be improved to satisfy an industrial user. To process parts quickly and cost-effectively a femtosecond laser system with average power of >100 W is required. Additionally, the laser system has to be robust and stable to sustain the demands of the production floor. The Spirit® 1030-100-SHG laser from Spectra-Physics® (Figure 1) sets new standards for femtosecond lasers in high-precision industrial manufacturing. This laser offers impressive versatility and performance, enabling a variety of applications. High average power (>100 W) and high pulse energy (>100 µJ) at a wavelength of 1030 nm combined with high repetition rates (up to 10 MHz) and short pulse duration (<400 fs) pushes femtosecond micromachining applications to highest levels of throughput at lowest cost-of-ownership. The user-configurable burst mode enables processing with increased ablation efficiency, and thus increased throughput and quality for certain materials. Additionally, the integrated second harmonic generation (SHG) offers an output power of >50 W at a wavelength of 515 nm.

Figure 1. Spectra-Physics' Spirit 1030-100-SHG high power industrial femtosecond laser.

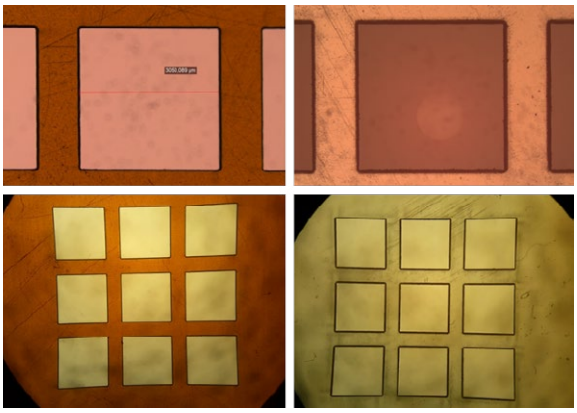

Figure 2. Microscope images of Polyimide (left) and Polyethylene Terephthalate (right) plastics cut using Spirit 1030-100-SHG laser from Spectra-Physics. Application of a femtosecond laser with average power of 100 W at 1030 nm results in cutting speed above 1 m/s for 75 µm thick plastics and very high quality (HAZ <50 µm).

The Spirit 1030-100-SHG laser system at the wavelengths of 515 and 1030 nm has been used for cutting of 75 µm thick ribbons of Polyimide (PI) and Polyethylene Terephthalate (PET) plastics. We have studied the maximum possible cutting speed in a high quality machining regime (heat affected zone or HAZ <100 µm) as a function of applied average power and wavelength.

Figure 2 shows the microscope images of PI and PET plastics machined using Spirit 1030-100-SHG laser. Application of this femtosecond laser at 100 W average power at 1030 nm resulted in cutting speeds over 1 m/s for the both plastics. Additionally, high quality of machining with very minimal thermal damage (HAZ <50 µm) was achieved. The demonstrated cutting speed and quality meets the requirements of the medical device and OLED display manufacturers .

The machining quality of plastics can be further improved by using femtosecond lasers at shorter wavelengths. In this case laser energy can be used more efficiently for ablation of transparent plastics, so that plastics can be machined with higher spatial resolution and with smaller thermal damage. Figure 3 shows features cut in PET using a Spirit laser with an average power of 50 W at 515 nm. As it can be seen from Figure 3, the shorter wavelength resulted in significantly reduced HAZ. A HAZ of less than 10 µm and a cutting speed over 400 mm/s were demonstrated.

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High Speed Processing of Plastics with a 100 W Femtosecond Laser

Our results show that a high power industrial femtosecond laser, Spirit 1030-100-SHG laser from Spectra-Physics is an ideal choice for machining of plastic materials at high cutting speed and quality. The ultrashort laser pulses (<400 fs) result in precise and clean cutting of plastics at wavelengths of 515 and 1030 nm.

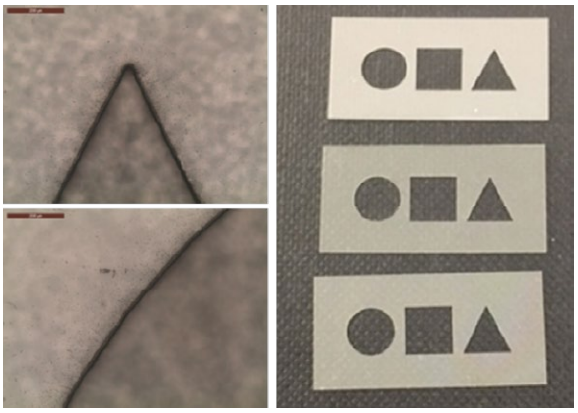

Figure 3. Microscope images of Polyethylene Terephthalate (PET) plastic ribbon cut using a femtosecond Spirit 1030-100-SHG laser at 515 nm. The average power of 50 W at 515 nm results in cutting speeds over 0.4 m/s for 75 µm thick PET with superior quality (HAZ <10 µm).

PRODUCTS: *SPIRIT 1030-100, SPIRIT 1030-70 & SPIRIT 1030-100-SHG*

The Spirit 1030-100 and 1030-70 lasers set new standards for femtosecond lasers in high-precision industrial manufacturing. These lasers deliver high average power, high pulse energy, and high repetition rates for increased throughput. Customers benefit from the shortest industrially available pulse duration and superior beam quality that in turn enable machining complex and challenging parts with highest precision and quality with no heat affected zone (HAZ) at the highest throughput. Spirit 1030-100 and 1030-70 are designed for industrial use and offer reliable and robust 24/7 operation with lowest cost of ownership.

	Spirit 1030-100	Spirit 1030-70	Spirit 1030-100-SHG
Wavelength	1030 nm ±5 nm		515 nm ±3 nm
Output Power	>100 W	>70 W	>50 W
Pulse Energy	>100 µJ	>70 µJ	>50 µJ
Repetition Rate	Single shot to 10 MHz		
Pulse Width	<400 fs		
Pulse-to-Pulse Energy Stability	<2% rms		
Power Stability	<1% rms over 100 hours		
Spatial Mode	TEM_{00} (M^2 <1.2)		

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