ITO & Ag Patterning Using the VGEN-ISP Fiber Laser

In the fabrication of touch panel modules, a number of complex process steps are required, of which thin-film patterning is the most important and expensive step in the production. While the conventional fabrication of Indium Tin Oxide (ITO) and silver (Ag) pattern is based on a complex and expensive photolithographic process, laser scribing offers a dry, chemical waste free, high throughput process that is widely used today in flat panel and touch panel display device manufacturing. Moreover, laser technology enables economic and market viability by meeting the need for continuous decrease in weight and size of the flat and touch panel devices. To some extent, the touch display's size is governed by the touch panel because the signal traces for the capacitive touch sensor occupy a significant portion of the border, resulting in additional weight and cost for the system. Therefore, there is an ongoing trend to reduce the width of the scribing lines toward sub-20 µm to create consumer devices that are lighter and thinner.

The VGEN-ISP-20 fiber laser produces pulses with peak power up to 15 kW, up to 500 kHz pulse repetition frequency (PRF), excellent beam quality with M^2 <1.2, and fast switching ON/OFF times, which makes it a versatile tool for high throughput ITO and Ag patterning with uniform narrow scribing line widths capabilities. While shorter wavelengths enable better resolution, the VGEN-IPS-20 laser's basic wavelength of 1064 nm provides good performance in regard to laser material interaction and highly effective solution compared to frequency-doubled (green) or frequency-tripled (UV) lasers.

KEY FIBER LASER FEATURES AND ITO PATTERNING

Pulsed fiber lasers are widely used for micromachining applications because of their various merits, such as excellent beam quality, compactness, and high wall-plug efficiency. In particular, the Master Oscillator Power Amplifier (MOPA) type pulsed fiber lasers feature excellent control over the pulse duration, shape and PRF. The effect of several key parameters of the VGEV-ISP-20 on the ITO and Ag patterning processing capabilities, including beam quality, pulse width, peak power, and PRF are described below.

Beam Quality/Spot and Scribing Linewidth

The VGEN-ISP-20 has near diffraction-limited beam quality with M^2 <1.2 and can produce a focused optical spot size down to less than 20 µm using standard scanner optics, making it particularly suited for advanced Ag and ITO patterning. In addition, the beam roundness is better than 90%, resulting in symmetrical grid pattern scribing capability.

Laser Pulse Width and Peak Power Combination

The VGEN-ISP-20 produces short pulses while maintaining high peak power levels. It offers the ability to create more effective ablation since more energy above the threshold required to perform material ablation is transferred to the material quickly. In contrast, for longer pulses, in general it takes longer to reach energy levels above the threshold so a lot of energy simply goes into heating. In ITO removal, the pulse duration and peak power affect the quality of the scribe edge produced. Shorter pulses with high peak power capabilities offer accurate and precise scribing patterns.

Rise Time Effect

Most laser direct patterning/ablation applications require various lines and shapes scribing according to the designs. The shapes and lines scribed must perfectly match the design. The biggest challenge is the ability to meet the start/end position of a given pattern. In order to meet those requirements, the VGEN-ISP-20 has instant rise and fall times, as well as uniform energy per pulses. A slower rise time, even of a few pulses will result in a tapered line with increased width. Non-uniform energy per pulses will result in a different linewidth for each pulse. Specifically, if the first pulse is stronger than the rest of the pulses, a wide spot would appear at the beginning of the line, which may also damage the material. The control of the first pulse for obtaining uniform pulses with instant rise and fall times is done in the VGEN-ISP-20 automatically for any pulse parameters.

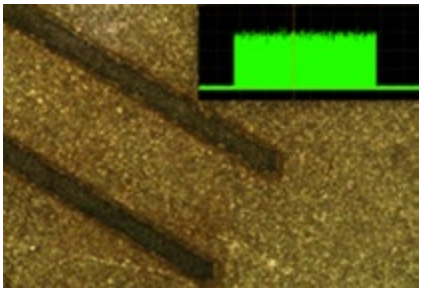

FIGURE 1.
Fast rise time illustrated by patterning of Ag paste on PET substrate and a temporal trace of the fiber laser for 5 ns pulse width, 200 kHz (inset).

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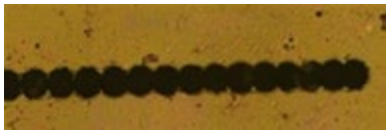
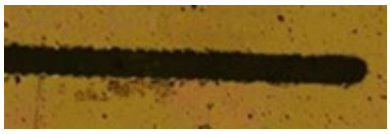
Laser Pulse Repetition Frequency

The range of laser pulse repetition frequencies in scribing applications is directly related to the processing speed or the scan speed that the laser can support. Higher repetition rates contribute to higher processing speeds or to high percentage of overlap between pulses for a specific speed. For example, in ITO scribing applications, the scanning speed of 2-2.5 m/sec is generally being used at 200–250 kHz, which corresponds to an overlap of 25–33% for 40 µm and 30 µm spot diameters using standard scanner optics. The process speed can be increased by 200% while maintaining the same pitch/overlap for lasers that can support PRF levels of ~400 kHz and scanners that can support speeds of 4 m/sec. In some other cases, high PRF lasers can be used to increase the pitch/overlap for a defined scanner speed and therefore improve the scribing line quality.

By using the V-Gen-ISP-20 operating at 200 kHz, 10–30 ns pulse duration, and a beam expander that can produce 14 mm beam diameter in conjunction with a standard f-theta lens of 163 mm focal length, we have successfully demonstrated typical Ag and ITO scribing with 19 µm linewidth with good quality of the edges at 2 m/sec scanning speed.



(a)



(b)

FIGURE 2.
Pulse PRF effect with f-theta lens of 163 mm focal length at 2 m/sec scanning speed with (a) 100 kHz, and (b) 200 kHz PRF.

(a)

(b)

FIGURE 3.
~19 µm-width scribing lines on (a) Ag, and (b) ITO using the VGEN-ISP-20.

PRODUCTS: *VGEN-ISP-20*

The Spectra-Physics VGEN-ISP-20 Ytterbium fiber laser incorporates leading edge technology in a MOPA configuration with top performance in a wide range of precision-intensive micromachining applications in a 24/7 manufacturing environment where system uptime is critical.

	VGEN-ISP-20
Wavelength	1064 nm
Average Power	20 W
Pulse Width	5–100 ns
Max Peak Power	15 kW
PRF	30–500 kHz
Switching ON/OFF Times	<10 µs
M^2	<1.2
Beam Diameter	4–14 mm
Beam Roundness	>90%

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