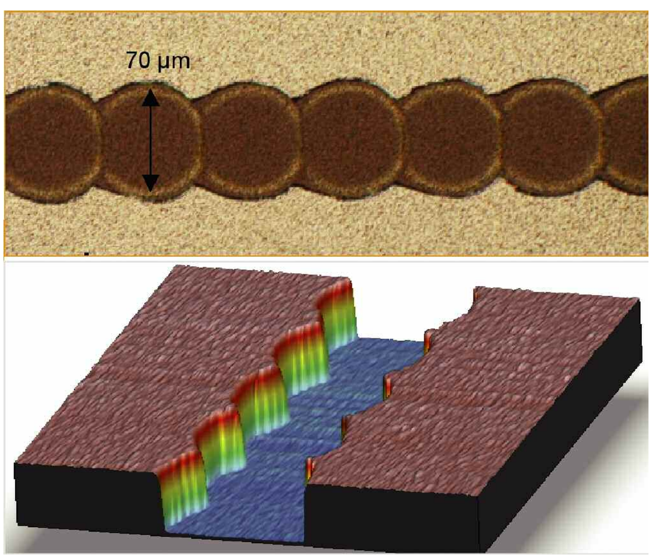
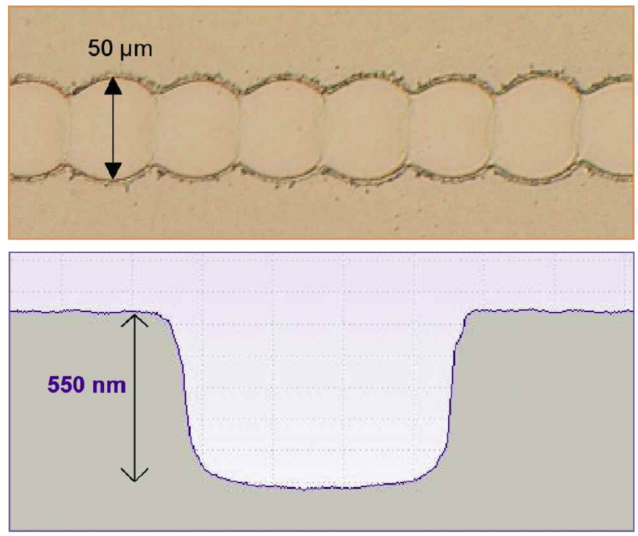
Amorphous Silicon Thin Film Solar Cell Scribing

Photovoltaic device technology is a large beneficiary of increasing investment in alternative energy solutions. With manufacturing advantages such as scalability and cross-compatibility with the flat panel display industry, and with considerations for potential scarcity of silicon, the amorphous silicon (a-Si) thin film photovoltaic device (TFPD) is often the technology of choice for high-volume solar cell manufacturers.

Diode-pumped solid state (DPSS) lasers have proven their worth in the manufacture of a-Si thin film devices. Q-switched lasers are used for the three principle scribe processes – known as the P1, P2, and P3 scribes – which separate the large planar device into an array of series-interconnected photovoltaic cells. The scribe processes involve the removal of various thin film (0.2 – 3.0 μm typical) materials with minimal collateral damage to the glass substrate or other films.



Microscope (top) and 3D depth profile (bottom) images of tandem-junction a-Si P2 scribe generated at 12 m/sec speed



Microscope image (top) and 2D depth profile trace of P1 (SnO_2) scribe generated at 8 m/sec scan speed

For P1 scribing, a thin film of TCO (transparent conducting oxide) material – typically SnO_2 – is removed from the glass substrate, and is typically achieved with 1064 nm Q-switched lasers. This process requires relatively high laser fluences due to the optical transparency and mechanical hardness of the TCO film. With the Spectra-Physics HIPPO™ 1064-27, 50 μm wide P1 scribes are achieved at industry-leading speeds. The laser's short pulse width and exceptional pulse-to-pulse energy stability allow for processing at 200 kHz PRF (pulse repetition frequency), which translates to scribe speeds of 8 m/sec.

P2 and P3 scribes typically use 532 nm lasers, primarily because the light is strongly absorbed by the silicon solar absorber layer. The P2 scribe removes the silicon layer only, while the P3 scribe removes the additional back contact metal/TCO films as well. A short pulse width is essential for achieving best-efficiency scribe results. When combined with excellent pulse energy stability at high PRF, scribe speeds of 12 m/sec are achieved with the Spectra-Physics HIPPO 532-15 laser system operating at 160 kHz PRF.

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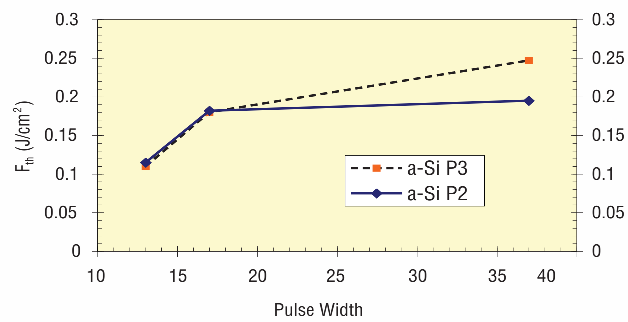
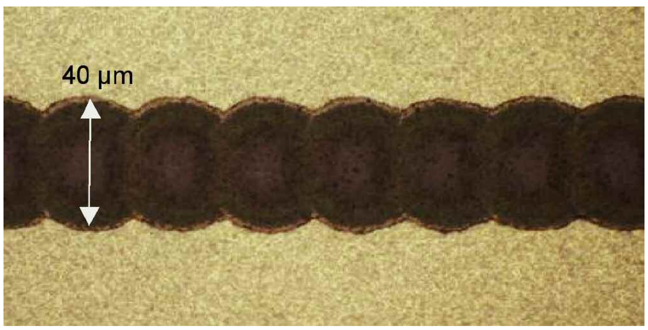
Several Spectra-Physics' lasers meet the demands of a-Si PV scribing. Depending on the final scribe tool design, the Explorer® 532 nm family of lasers also provides strong advantages. Whereas the very high powers of the HIPPO platform allow for beam-splitting or high-speed galvo scanning techniques to be applied, the Explorer laser offers a rugged and compact design that is the perfect choice for a multi-module, distributed tool design. Excellent pulse energy stability and short pulse width combine for first rate results as seen in the a-Si P3 scribe image below.





Microscope image of a-Si P3 scribe generated with Explorer 532-2 laser system at 1.5 m/sec speed

Laser scribing is a delicate process and the demands of removing sub-micron films with minimal "collateral damage" are best addressed with short-pulse lasers. A shorter pulse width means less time for heat to travel to sensitive areas. Furthermore, our research has proven that there is also a distinct efficiency advantage with short pulses. As illustrated in the above data plot, using a 12-ns versus 37-ns pulse width laser results in a 50% reduction in the film removal threshold. This suggests that for the same laser power, a factor of 2X processing speed is achieved, simply by "going short".

Product: HIPPO Laser

Spectra-Physics' latest HIPPO 1064 nm and 532 nm lasers are optimized at 100 kHz pulse repetition frequency, making them ideal for PV scribing with high-speed beam scanning. Their high power output (27 W IR, 15 W green) allows for various degrees of beam-splitting to achieve higher system throughput. These advantages combined with short pulse width, excellent beam quality, and good pulse-to-pulse energy stability, make the HIPPO 1064-27 and HIPPO 532-15 ideal engines for thin film PV scribe tools.

Product: Explorer Laser

The Spectra-Physics Explorer 532 nm laser is also an option for a-Si TFPV P2 and P3 scribing. Up to 2 W of 532 nm output power is available for processing speeds of 2-3 m/sec. And with the laser's rugged and compact design, the Explorer offers a versatile platform if a modular approach to scribe tool design is desired. In addition, with the system's ultra-light weight and undersized footprint, the benefits of a tool based on a motion-mounted laser can now be most fully achieved.

Model	Wavelength	Peak Power	Average Power	Pulse Width	Repetition Rate (nominal)
HIPPO 1064-27	1064 nm	>9 kW	>27 W	<30 ns at 100 kHz	100 kHz
HIPPO 532-15	532 nm	>6 kW	>15 W	<25 ns at 100 kHz	100 kHz
Explorer 532-2	532 nm	>17 kW	>2 W	<12 ns at 10 kHz	10 kHz

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DS-031004 (06/11)