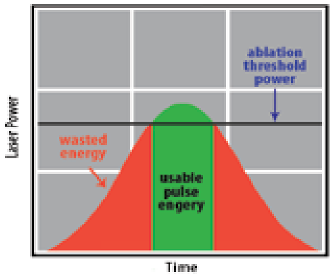
Fabric Processing

Pulsed vs. Continuous Wave CO_2 Lasers

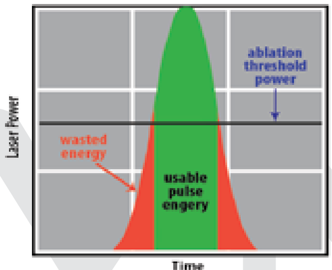
Innovation drives the apparel market—especially in the booming activewear segment, where performance and unique design drive sales. Materials like polyester and spandex (commonly used for their quick drying or shape-retention qualities) do not breathe, so manufacturers look to perforation or mesh to increase garment airflow and user comfort. While this can be accomplished mechanically or by altering the weave itself, the fabric's durability or opacity can be negatively impacted. Using lasers, holes can be strategically placed in the garment for ventilation or aesthetic embellishments. Lasers can also seal the fabric, preventing fraying caused by mechanical processing and preserving the fabric's integrity for demanding use. Further, these designs and settings can be altered with software for on-the-fly design changes.

The best processing speeds and quality are achieved when the laser energy is efficiently absorbed by the material. While synthetic fabrics absorb the long wavelength produced by CO2 lasers well, using a pulsed laser can further improve throughput. Pulsed lasers are so named because they deliver shorter pulses of energy with higher peak power compared to a continuous wave (CW) laser. In fabrics, this translates to reduced Heat Affected Zone (HAZ), preventing the fabric from feeling rough or scratchy along the cut edge. The Figures below show the difference in the power profile of these two lasers: above the ablation threshold, energy is used to penetrate or remove material. Energy below that threshold is essentially wasted, often as excess heat absorbed by the garment. Notice that the pulsed laser spends a much higher percentage of its pulse time above the ablation threshold—this is why we see such efficient, quality processing when perforating fabrics.

Figure 1: Pule profiles of laser beams.



Long Pulse or Continuous Wave (CW) Laser



Pulsed Laser

Example Test Case Setup

For this example, two Synrad lasers were compared: an i401 CW laser and a p250 pulsed laser. Both were combined with a Flyer 3D scan head, which uses high-speed galvo mirrors to direct the laser beam across the material surface. Scan heads are generally required for production-level throughput due to their high beam delivery speeds, especially compared to slower X-Y plotters. This specific scan head is a three-axis model, used because it creates a smaller focused spot size over a larger field of view—necessary for fine detail processing over a large area. Flyer 3D was configured with a field size of 269 mm x 227 mm (10.6" x 8.9"), with a 181 μm focused spot size.

Results

Three fabrics commonly used in the industry were chosen for this example:

1. 0.35 mm thick 100% Polyester (used in hats and athletic shorts)
2. 0.58 mm thick 80% Polyester/20% Spandex® (used in hats, shorts, leggings, and dresses)
3. 0.5 mm thick 82% Nylon/18% Spandex® (used in leggings)

Figure 2: p250 perforations at 5,715 mm/s (225 ips) in Polyester

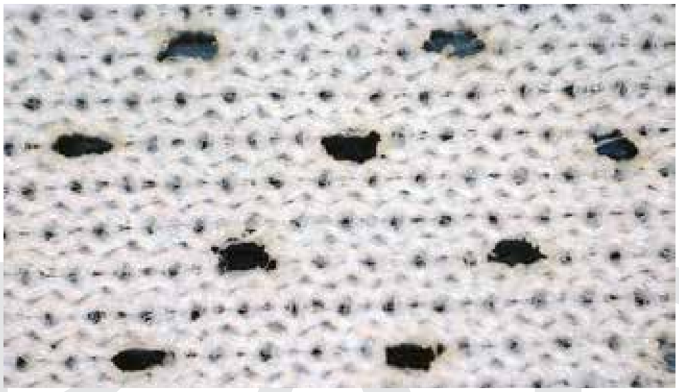


Figure 3: i401 perforations at 3,302 mm/s (130 ips) in Polyester

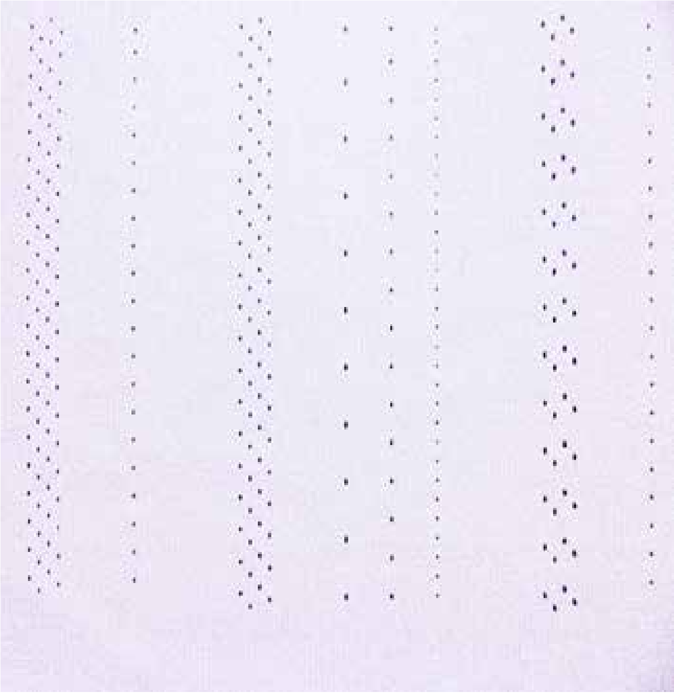


Figure 4: iPerforations at various frequencies in Polyester/Spandex

Perforations were created by pulsing each laser at low frequency while directing the beam across the fabric at constant speed. Laser settings were chosen to maintain the same pulse energy (allowing us to test how much of that energy is useful), while determining the maximum achievable scan speed. Maximum speed was defined as the highest speed still capable of penetrating the material.

The settings for each round of testing are summarized in the table below. A few highlights:

1. 100% Polyester: the higher peak power of the p250 resulted in a 1.7X speed increase over the i401.
2. 80% Polyester / 20% Spandex®: here we see a 1.4X speed increase using the p250.
3. 82% Nylon / 18% Spandex®: the p250 achieved a 1.5X speed improvement over its CW equivalent.

While there are slight changes in throughput depending on each material's unique absorption characteristics, an improvement of roughly 1.5X makes a compelling case for the efficiency of pulsed lasers for perforating. Note also that there is typically reduced heat effect surrounding holes processed by pulsed lasers, increasing the appearance and quality of the final product.

Fabric	Laser	Duty	Frequency	Peak Power	Scan Speed	Speed Increase	Example
100% Polyester	p250	13%	1.15 kHz	~619 W	5715 mm/s (225 ips)	**1.7 X**	Figure 2
	i401	13%	0.80 kHz	~431 W	3302 mm/s (130 ips)		Figure 3
80% Polyester/20% Spandex®	p250	10%	0.66 kHz	~580 W	2540 mm/s (100 ips)	**1.4 X**	
	i401	10%	0.50 kHz	~440 W	1778 mm/s (70 ips)		
82% Nylon/18% Spandex®	p250	8%	0.41 kHz	~607 W	1524mm/s (60 ips)	**1.5 X**	
	i401	8%	0.30 kHz	~443 W	1016 mm/s (40 ips)		

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