COHERENT BEAM COMBINING OF HIGH POWER LASERS FOR MATERIALS PROCESSING

www.civan.co.il
Civan Advanced Technologies develops and manufactures single-mode, high-power laser systems with a dynamic beam based on its Coherent Beam Combining (CBC) technology. The dynamic beam relies on Civan’s propriety Optical Phased Array (OPA) technology. OPA technology enables ultra-fast electro optical beam shaping, positioning and focusing.

CBC OPA laser systems enable the digitalization of materials processing. Laser beams can be tailored for different processes at the touch of a keyboard, without any hardware modification required. The versatile laser systems are controllable at MHz speed and enable disruptive opportunities in materials processing applications such as Cutting, Welding and Additive Manufacturing.

The OPA technology enables electro-optical beam steering, beam shaping and beam focusing. The outcome is ultra-fast beam oscillation that improves process efficiencies both in terms of processing time and quality. Civan’s portfolio includes high-power lasers at different wavelengths. The CBC technology makes manufacturing of high-power, single mode lasers in 532nm and other wavelengths possible. This provides our customers the ability to Ideally match between material and wavelength.
COHERENT BEAM COMBINING TECHNOLOGY

Coherent Beam Combining (CBC) is the technology for combining multiple high-power laser channels into one. CBC enables reaching:

• Very high laser power in single mode beam
• Dynamic control over the beam parameters
• High-power laser at a variety of wavelengths.

CBC is modular, scalable and relies on relatively inexpensive components.

Fig. 1: Single Mode High Power Optical Phased Array Coherent Beam Combining Laser systems

VERTICAL INTEGRATION

Civan is a vertically integrated laser manufacturer with the most advanced manufacturing technologies. Vertical integration together with automation in manufacturing allows utilizing CBC in an affordable, robust and efficient way. Civan’s unique ability to apply its proprietary CBC technology into robust high-power laser systems is the result of nearly 20 years of R&D.
Civan offers Optical Phased Array (OPA) CBC Lasers. Our OPA technology enables ultra-fast, electro optical beam shaping, positioning, focusing and modulation. All dynamic features are achieved without any mechanical movement and can be done mid-process and at MHz speed.

Unique features & abilities of Civan’s OPA Lasers for Materials Processing:

1. **Variable Beam Parameter Product (VBPP)**
   The inherent ability to change spot size and BPP in MHz speeds, dynamically and mid-process, without any mechanical changes.

2. **Dynamic beam focusing**
   The focusing distance of the beam can be changed electro-optically in MHz speeds, dynamically and mid-process.

3. **Dynamic beam shaping in MHz speeds**
   Unique beam shapes can be created electro optically to improve the process speed and quality. These shapes are digitally generated and can be dynamically changed mid-process at MHz speed.

4. **Ultra-Fast beam movement of the beam**
   The ability to "steer" the beam at MHz rates, dynamically and mid-process in a variety of shapes and pattern, to optimize application efficiency. i.e circular beam movement, back and forth (wobble).

5. **Fast Power Modulation (temporal Modulation)**
   The ability to modulate laser power mid-process at MHz rates.
CUTTING: ADVANTAGES OF SINGLE MODE

In remote operation with a high power single mode CBC laser, fast ablation cutting can be achieved and cutting speeds can increase x10! Single Mode Remote cutting of thin metals is faster, cheaper and more versatile.

CUTTING: ADVANTAGES OF DYNAMIC BEAM

<table>
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<tr>
<th>Beam Shaping</th>
<th>Fast Beam Movement</th>
<th>Fast Power Modulation</th>
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<tbody>
<tr>
<td>• One optics enables thin &amp; thick plate cutting</td>
<td>• Increase of cutting speed</td>
<td>• Reduction of surface roughness and dross, dross, debris and recast</td>
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<tr>
<td>• Optimized piercing process</td>
<td>• Reduction of surface roughness and dross</td>
<td>• Cutting of filigree contours</td>
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<tr>
<td>• Adjustable kerf width</td>
<td>• Improvement of process quality</td>
<td>• Reduced use of process gas</td>
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Fig. 3: Civan’s Optical Phased Array Coherent Beam Combining Beam Shaping Simulation
WELDING: ADVANTAGES OF SINGLE MODE

Civan’s CBC Single Mode fiber laser offers versatility and speed in the production of deep welds or shallow conduction welds. The single-mode, high-power beam quality enables a unique process that can be done successfully with the laser located at a large distance from the work surface.

WELDING: ADVANTAGES OF DYNAMIC BEAM

<table>
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<tr>
<td>• One optics - deep penetration welding &amp; optimization of outer weld geometry</td>
<td>• Increase of welding speed</td>
<td>• In combination with fast beam movement new process features for improved process stability</td>
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<td>• Adjustable beam width for overlap joints</td>
<td>• Improved weld quality for hard-to-weld materials like Aluminium die casting, AA5xxx with high Mg-content</td>
<td>• Adjustable penetration depth for 3D-welding / change of beam incidence angle</td>
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<td>• Optimized gap bridging</td>
<td>• Adjustable weld seam width</td>
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Dynamic and Rapid Beam Oscillation advantages:
- Extension of melt pool life time
- Increase of degassing time for bubbles
- Slow solidification

Welding Without Beam Oscillation

Welding with Beam Oscillation

Source: Fraunhofer IWS

OPPORTUNITIES BY FAST BEAM OSCILLATION

Source: Fraunhofer IWS
Additive Manufacturing: Advantages of Dynamic Beam

1. Fast beam movement
   - Increases metal sintering rates >X10, achieved by dynamic MHz rate Electro – Optic scanning from OPA CBC in combination with platform’s scanning head.
   - Enables accurate edge forming with unique beam shapes
   - Reduces processing time per part and cost per part

2. Fast power modulation
   - Optimizes process quality by fast power modulation at high rates as required.
HIGH POWER PROCESSING AT DIFFERENT WAVELENGTHS UNLOCKED BY CBC:

Successful and efficient laser-based processing is based on good interaction between the laser light and the material. The main high power industrial lasers existing today at wavelengths of 795 – 976nm (diode), 1070nm (Ytterbium fiber laser) or 10.6μm (CO2 lasers) are absorbed poorly and do not interact well with some materials, making it difficult and non-efficient to use lasers to process such materials.

In many wavelengths there are no available laser solutions that provide sufficient high-power outputs. Achieving high power in unique wavelengths through CBC by coherently combining many lower power lasers unlocks possibilities for new applications with new materials and improved performance in existing ones.

One Material for example is copper, vastly used in the electronics and automotive industries for its good thermal and electrical conductivity. The best laser for copper processing is a high brightness (single mode) 532nm (green) fiber laser, achieved by using a doubling (Second Harmonic Generation) crystal with a 1064nm fiber laser. This method is limited in achievable power due to the crystal’s damage threshold. Using CBC Civan can offer high power lasers at 532nm. Green single mode laser modules of 50W can be combined coherently to achieve much higher powers (>500W) needed in the industry to improve laser processing in various materials. CBC is applicable for other wavelengths as well.
The Fourth Industrial Revolution is taking shape and Civan’s CBC technology enables ambitious fourth revolution factories to adapt to the ever-rising processing demands.

Civan’s Single Mode High Power Laser technology enables manufacturers a versatile manufacturing process with greater accuracy and speed than currently possible.

Civan’s Dynamic Beam based on the CBC OPA technology disrupts materials processing. Dynamic Beam High Power Laser in single mode beam quality enables electro-optical control over materials processing. Civan has recently won funding from the prestigious European Union Horizon 2020 SME Instrument for this innovative project.

Civan currently employs over 100 talented physicists, engineers and manufacturing personnel. The company leverages its proprietary CBC technology and knowhow, combined with its in-house manufacturing infrastructure and expertise, to offer a range of high power, off-the-shelf and custom-made lasers.
CIVAN’S SINGLE MODE HIGH POWER LASER UNLOCKS NEW POSSIBILITIES IN MATERIALS PROCESSING. CIVAN’S DYNAMIC BEAM HIGH POWER FIBER LASER ENABLES DISRUPTIVE AND VERSATILE PERFORMANCE IN A WIDE RANGE OF APPLICATIONS.