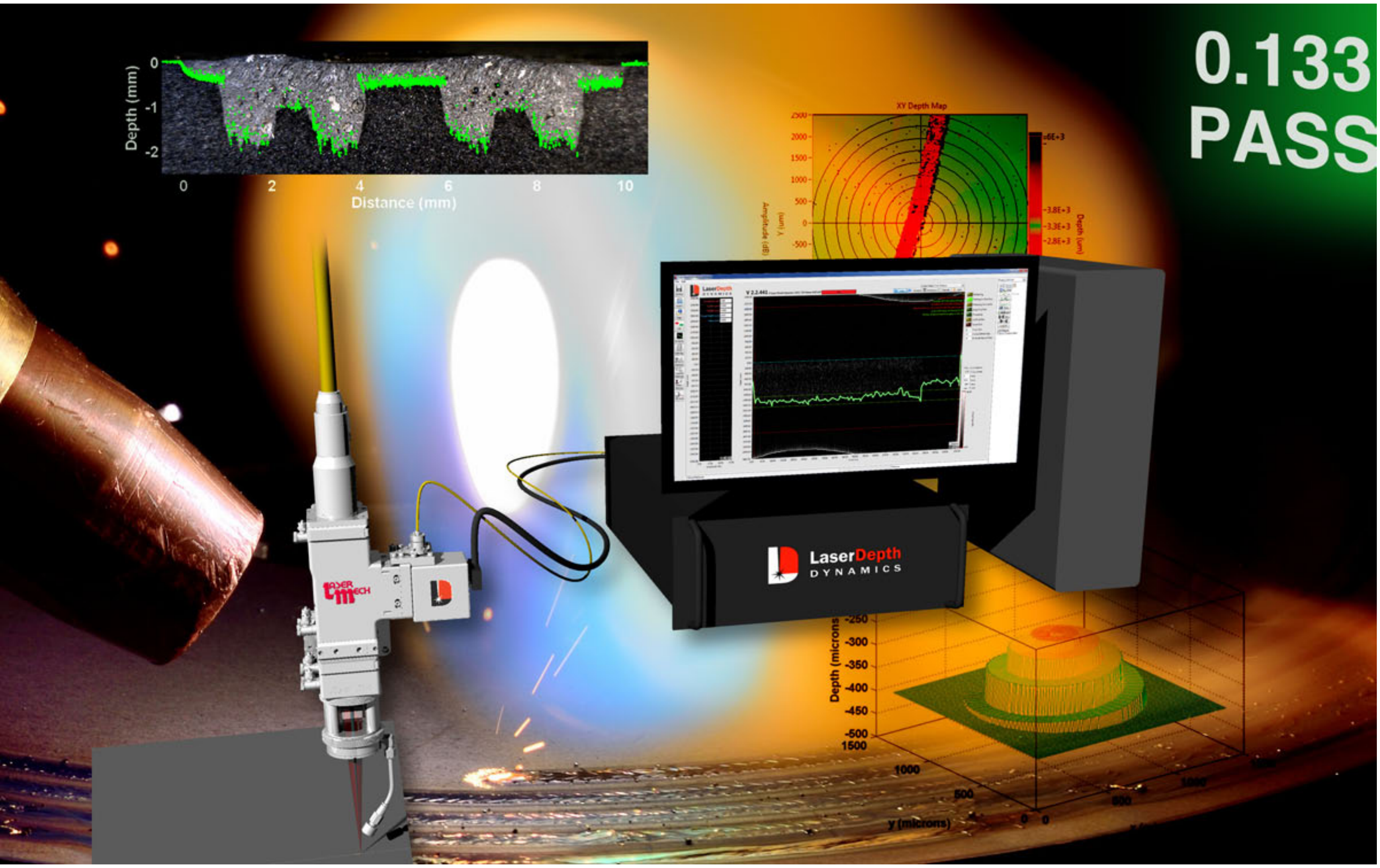
LD-600

Real-Time Direct Penetration Monitoring
For Advanced Laser Applications



Based on patented inline coherent imaging (ICI) technology, Laser Depth Dynamics' LD-600 allows for precise depth measurement of industrial laser processes. Connecting to the head assembly through a camera port, a measurement beam with a unique wavelength is coaxially combined with the primary laser beam. The measurement beam is reflected off the surface being worked, back to the LD-600 unit where it is processed to determine the depth of penetration. Readings are accurate even while the laser is operating, allowing for real-time measurement and quality control. Output can be fed back into the control system for remediation and full closed-loop operation.

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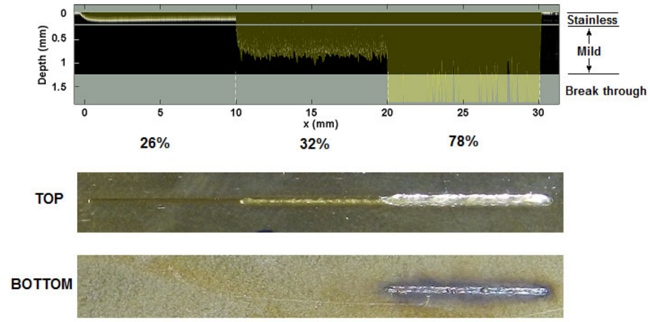
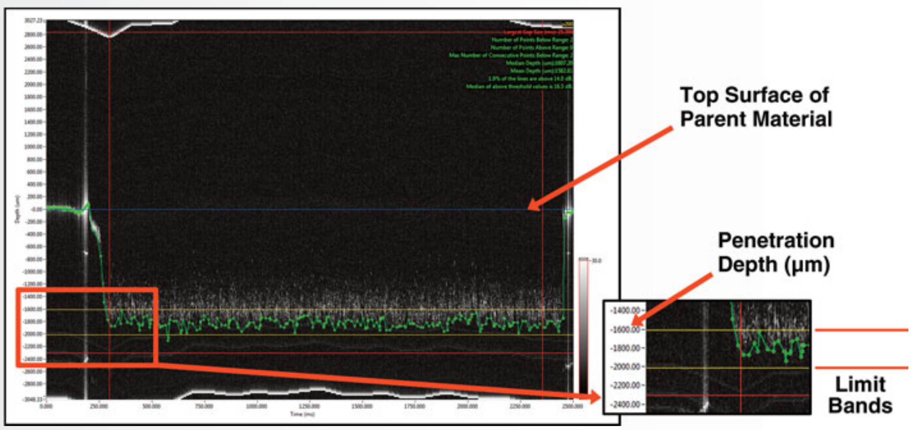
Weld Depth Penetration

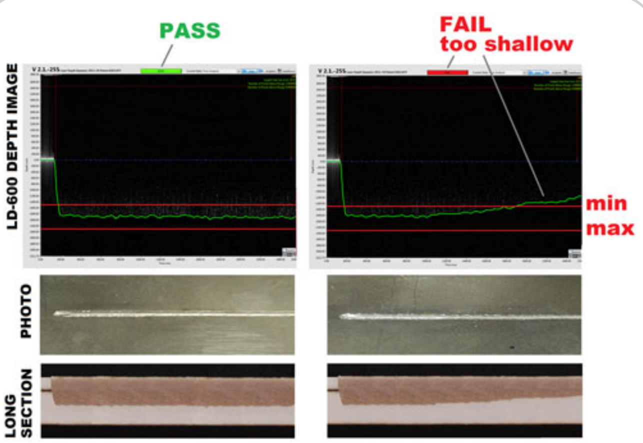
In the figure at right, a 1 kW IPG Fiber Laser was configured to demonstrate measurement of weld depth penetration. A 0.38mm stainless steel shim is welded onto a 1mm thick mild steel plate. In the initial 10mm portion, 26 percent power is used and the primarily conduction weld is unsuccessful as it does not penetrate through the shim. In the 10mm middle portion at 32 percent power, the weld is successful and contained within the plate. In the final 10mm portion using 78 percent power, full penetration is achieved and the laser breaks through the plate.



ICI Penetration Measurement

Weld penetration data is shown in the Y-axis at micron-level resolution all referenced to the top surface of the part being welded. This is regardless of the focus head path and part height variations during welding. A time base in milliseconds is used as the X-axis for monitoring weld time. Minimum and maximum penetration level boundaries are also shown as input by the end user.



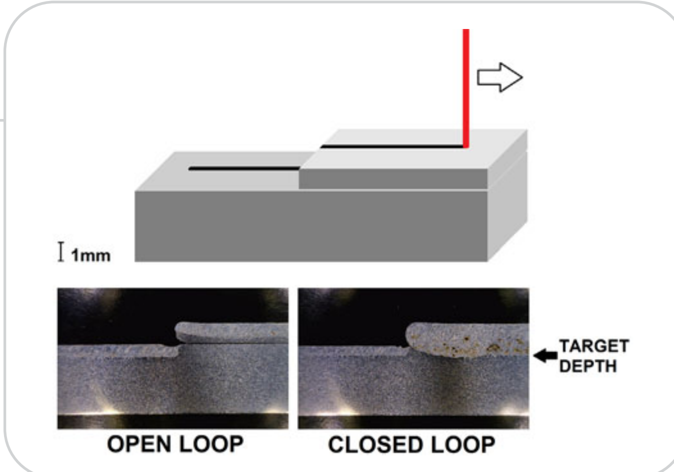


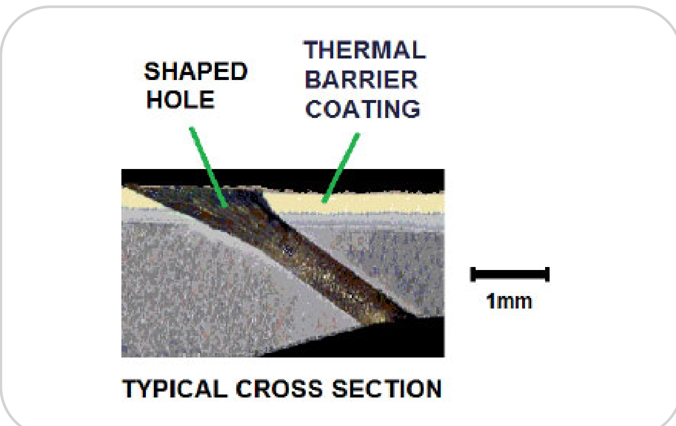
Welding Quality Control

In the stainless steel lap welding example at left, a 1.0mm top sheet is joined to a 2.5mm thick bottom sheet using partial penetration CW laser welding. The two sheets must be mechanically joined but it is also critical that there is no penetration of the back side of the bottom sheet. A target depth of 2.0mm (i.e. 1.0mm into the bottom sheet) is set and QC min. - max. tolerances of 1.5mm to 2.3mm are established. The LD-600 unit measures penetration during the welding process and when complete, displays the weld depth profile on screen (note that the vertical axis of the screen image is magnified approximately 2X). The measured depth profile is then compared against the established min. - max. tolerances to determine a PASS/FAIL result that is displayed on screen and also output as a digital signal that can be connected to a PLC in an automated production environment. The depth profile record can also be stored on the PC for a traceable record of every weld.

Closed Loop Welding Control

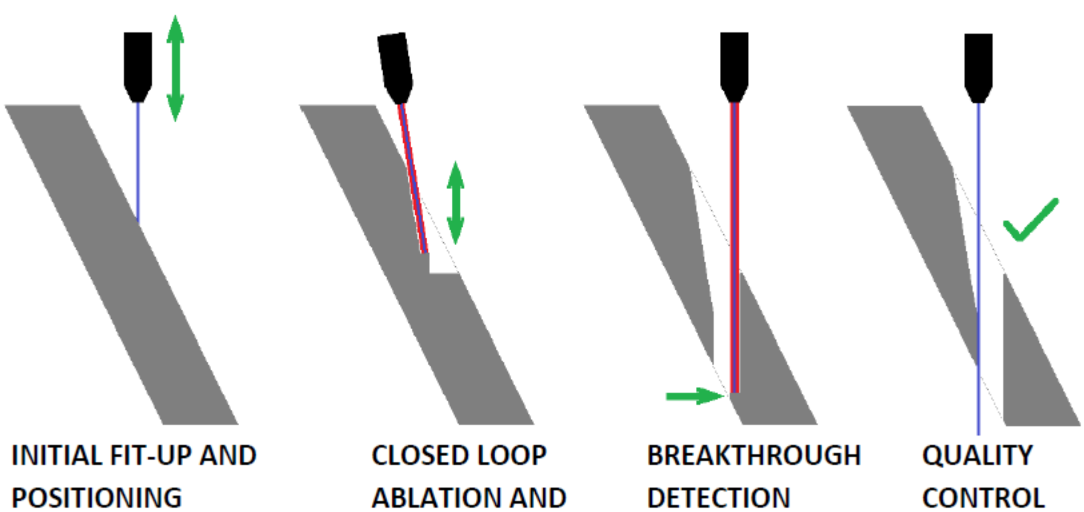
In the configuration at right, laser welding begins on a steel base plate and then moves onto a 1.0mm thick steel top plate. The initial test (left cross section) is performed without control (i.e. open loop) at a fixed power level. The second test (right cross section) is performed using the LD-600 to control the laser power in real-time (i.e. closed loop) to achieve a specified target depth of 0.7mm into the base plate. An analog output from the LD-600 proportional to weld depth is connected to the laser power control input. When crossing onto the top plate in closed loop mode, the LD-600 quickly increases the laser power to maintain the target depth.





Aero Hole Drilling

In this set up cooling holes are drilled in specialized, thermally coated materials for jet turbine blades. An ultrafast YAG or Fiber Laser is used in conjunction with a 5-axis motion control system to drill precision shaped holes. The LD-600 uses a co-axial measurement beam to determine penetration depth between laser pulses. Closed loop process control first determines initial head position and focus, then controls ablation depth while maintaining optimal focus, followed by concise breakthrough detection and final 3D QC hole profile. Rapid process development, and instant validation for every hole is achieved without the need for post process destructive or non-destructive testing.



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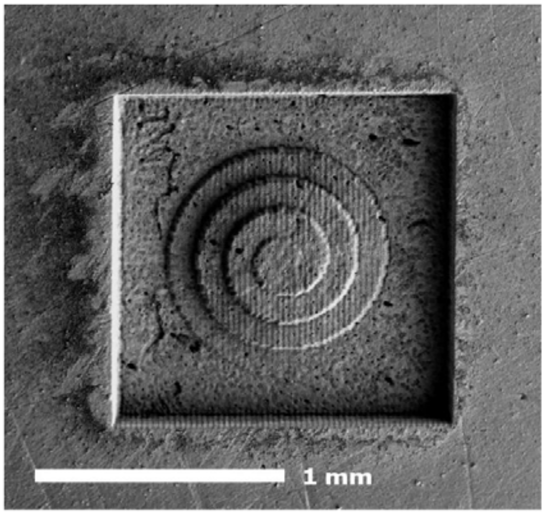
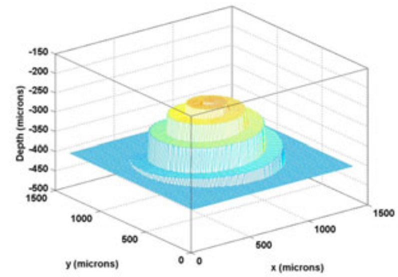


Micromachining

In this configuration, the LD-600 is used to provide closed-loop depth feedback to the laser control system so that precise laser machining can be performed despite the varying density and voids in the material. The motion control system manipulates the material in an x/y multi-pass process while the laser is pulsed as required to remove material to the specified depth at each point on the grid. Programmable 3D geometries can be created with minimal process development even in complex materials.



Technical Data

Measurement Technique	Inline Coherent Imaging
Measurement Wavelength	840 nm (alternate configurations available)
Laser Head Attachment	Fiber to Standard Camera Port
Measurement Range	MICRO 1mm / MACRO 6mm (instantaneous)
Resolution	± 10μm MICRO
Response Time	2 ms
Peak Measurement Frequency	300 kHz
Depth Outputs	Image, 0-10 V Analog, TTL Threshold, PASS/FAIL
Computing Platform	Windows PC
System Configuration	4U Rack Mount, PC, 20" Display
Rack Unit Dimensions	19" x 7" x 29" / 49 x 18 x 74 cm
Weight	55 lbs. / 30 kg
Power Requirements	120/240 VAC, 250W

WELD QUALITY CONTROL – measures the progression and maximum keyhole depth achieved. Results including PASS/FAIL are displayed and analog or digital feedback signals can be sent to the control system.

PRECISION DRILLING / MACHINING / SURFACE TREATMENT – real-time measurements of penetration allows instant adjustment for variations in materials, output power or environmental factors.

BREAK THROUGH DETECTION – identifies when the laser breaks through the material and signals the control system to turn off the laser, proceed with cutting or advance to the next work point.

ABLATION / COATINGS – depth information along with the ability to detect variations in the reflection signature of materials give a new dimension of control in ablation and coating application.

AUTOFOCUS / ALIGNMENT – by measuring the distance from the laser head to the work surface before, during and after processing, precise focus and position can be maintained even under unstable conditions.

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