

Laser Welding for Medical Device Industry. Advantages of the 2 micron Laser for Medical Applications

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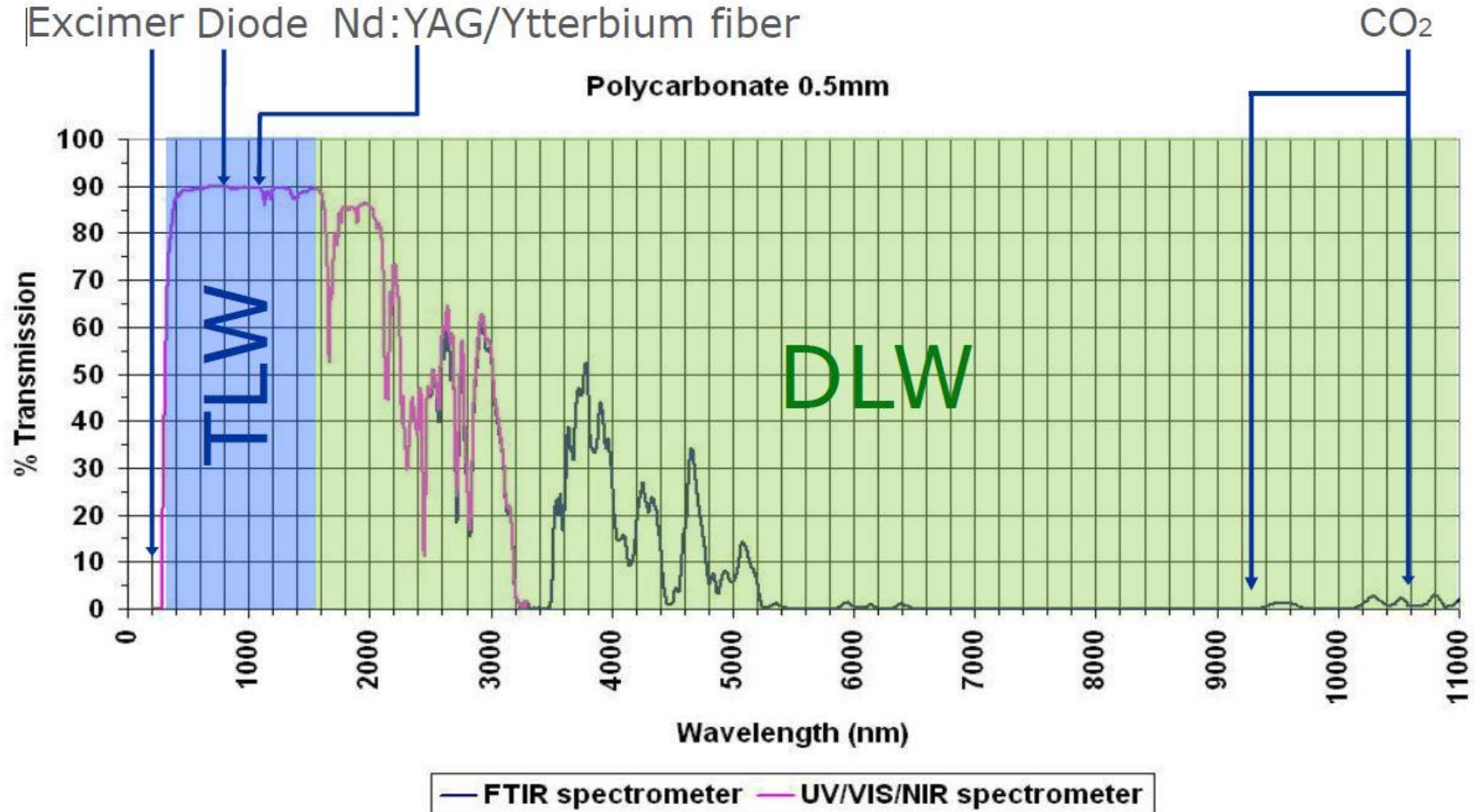


Content

- Laser Welding Process Fundamentals
- Advantages of Laser Welding Process
- 2 Micron laser and its unique applicability to Pharmaceutical and MD industries
- Some Considerations in Selecting Applications for Laser Welding

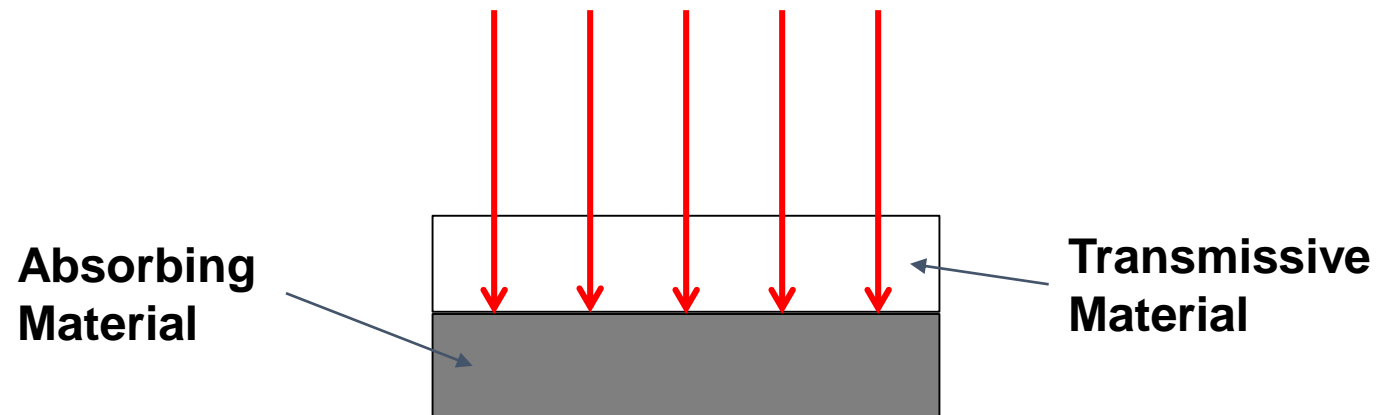


Transmission of Light in Polymers



Transmission Laser Welding

Laser Source With Wavelength λ about $1\mu\text{m}$.
Typically 808, 960, 980, 1050 nm



Principle of Laser Welding of Polymers

Transmission Laser Welding

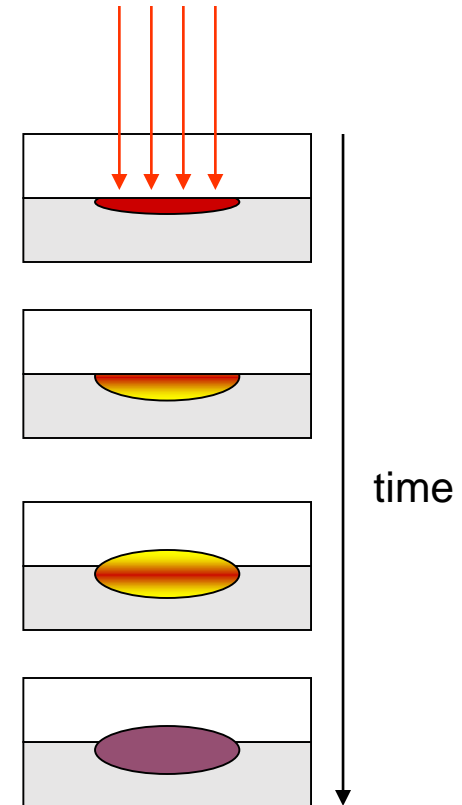
1. **Heating of the parts by laser light until the parts are sufficiently softened:**

1a: Absorption of electromagnetic radiation (light) by the sample

1b: Transformation of the absorbed energy into heat

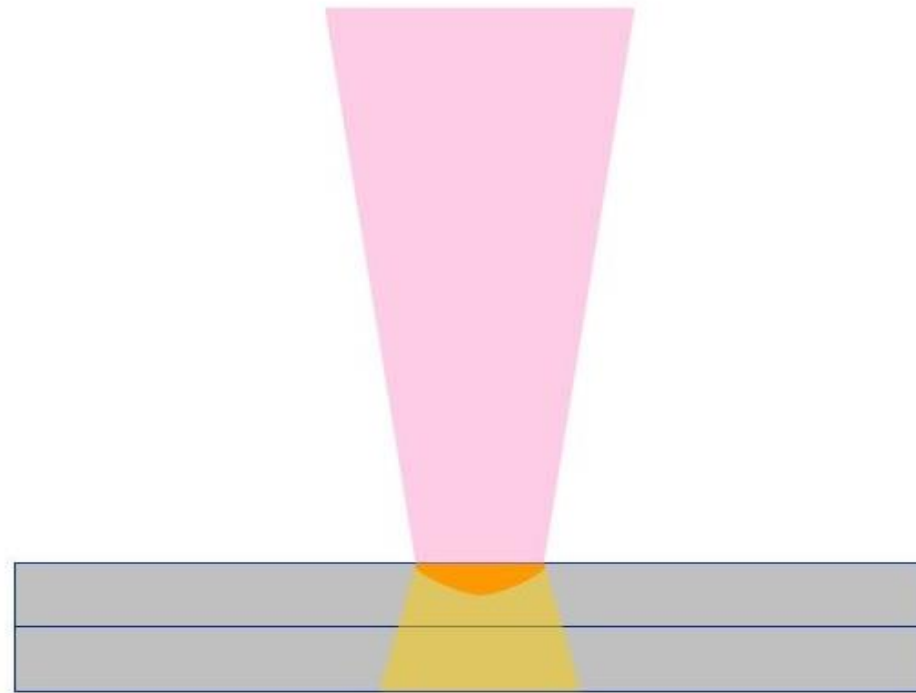
2. **Melting of transparent part via heat conduction**

3. **Solidification and Joint formation**



Principle of Laser Welding of Polymers

- Direct laser welding



Unique Advantages of Laser Welding

Joint Characteristics:

- Excellent Bond Strength and Long-Term Stability
- Hermetic seals are achievable
- Minimal or no flash. Clean and aesthetically pleasing appearance
- No particulate matter, residue, or other debris generation

Unique Advantages of Laser Welding

Joint Characteristics:

- Highly applicable to welding housings containing sensitive electronics and delicate parts.
 - Localized heat input with highly controlled melting produces assemblies with no flash.
 - Non-contact process with no vibration or other damaging mechanical forces during the weld and minimal mechanical stress level on inner components.
 - *Reduced residual stress* – mechanical stress from ultrasonic welding can damage parts and affect long-term performance. Light energy from laser welding is precisely controlled and creates very low residual stress on the joint

Unique Advantages of Laser Welding *Assembly Process*

- Clean and Flexible, Easy for automation non-contact process
- Process Adjustability and Precision
- Welding of complex shapes is possible
- Process Repeatability – highly controlled and consistent heat input, precision clamping with no relative motion of parts during the welding cycle assures a highly repeatable welding process and consistent joint quality. **Result - Reduced scrap and QC cost**
- Non-contact, minimized tool wear and retooling cost
- No consumables

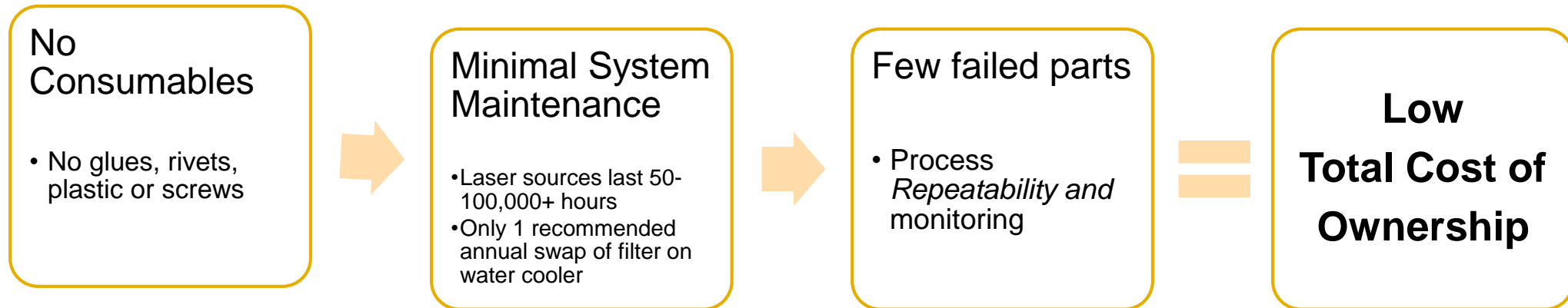
Benefits of Fiber Lasers in Manufacturing Operations

- *Laser systems are very robust and designed for high-volume production with little or no down time.*
 - For many applications seen as the next step in achieving a more consistent and reliable manufacturing process for joining operations
 - Ease of automation
 - Easy to retool when changing products. Low retooling cost
 - Low operating cost: laser and chiller run for about \$0.30/hour
- Ongoing maintenance costs are minimal in comparison to other welding or bonding methods.
 - **Fiber lasers are maintenance free. There are no user-serviceable parts in the laser**
- Lasers may have relatively higher initial cost, but the long term costs proved to be insignificant when the cost of required maintenance and high durability of equipment are factored in

Equipment Reliability

- **Laser.** The expected life of a fiber laser is typically in the 50,000 – 100,000 hour life range.
- The MTBF (Mean Time Between Failure) of the pump diodes exceeds a calculated life of 340,000 hours
- **Note.** Laser is made of many parts and things like power supplies and circuit boards, etc., which can fail as in any electronic device
- IPG warrants the laser for one year.
- If the laser is “mission critical”, it can be considered to keep a spare laser in inventory.
- **Scan Head’s** lifetime can be somewhat shorter than laser source.
 - The coatings on the optics might wear over time. But even then these are expected to last 20,000 hours or more

Low Joining Costs

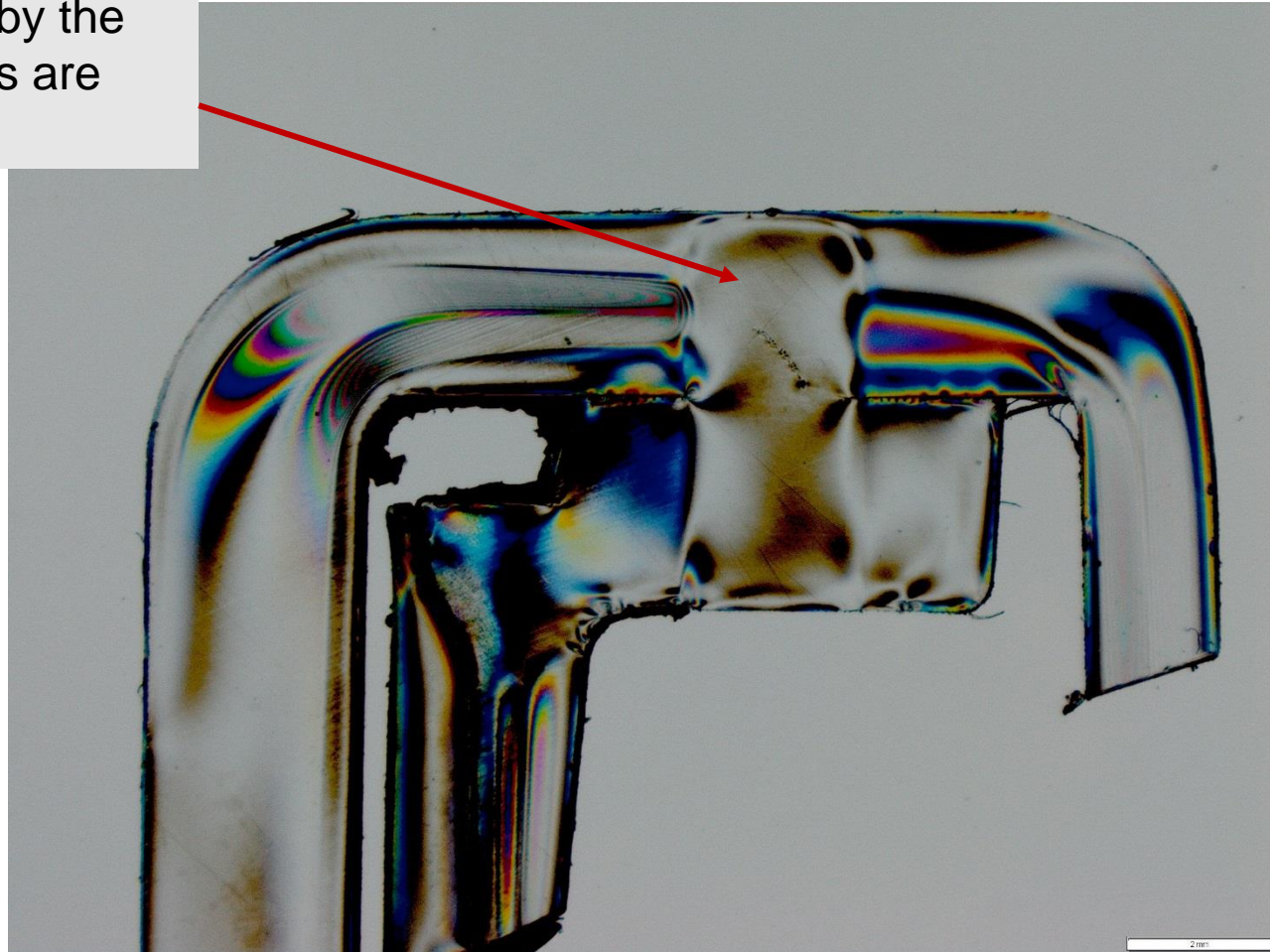


Advantages of 2-Micron Laser

- **No special absorbers required**
- Both joint components can be clear
 - Or the bottom part can be pigmented. Clear to white is possible
 - Multi-layer joining possible

Laser Welding with a 2-micron Laser

Laser radiation is absorbed by the polymer itself, and both parts are melting simultaneously.



Selecting Applications for Laser Welding

Materials

- For more efficient process upper part preferably to be *unfilled polymer to maximize transmission*
- Upper part thickness up to 3.5 mm
- Bottom part – clear, white, pigmented, black...
- Limited application for glass filled materials
- Tubular and Cylindrical components welding (*tube-to-tube, tube-to-port, tube-to-cap assemblies*)

Materials (Cont.)

Most common Materials successfully welded with 2 micron laser:

- PC, different suppliers and grades
- Eastman Tritan, different grades
- Acrylic
- COC
- ABS
- PP and PE blends

Welding Clear to Clear Parts

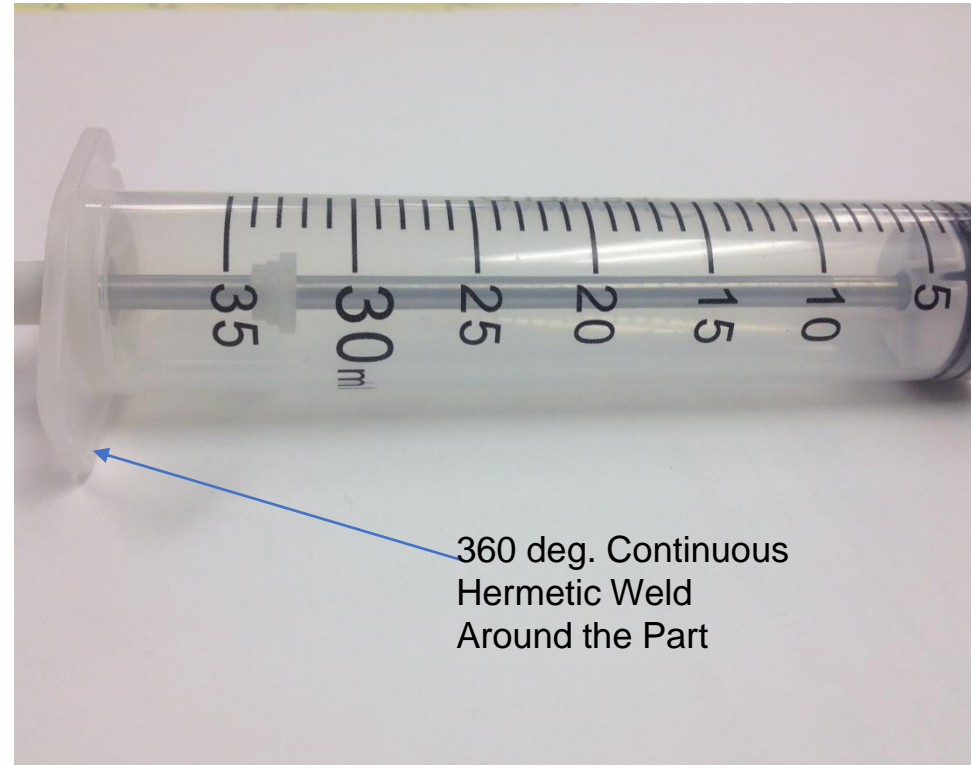


Parts

- **Main requirements:**
 - Good fit between mating surfaces
 - Good surface quality
- **Parts size:** Our preference is smaller parts, but we welded components over 700 mm in diameter
- **Curvature:**
 - Moderate part curvature.
 - Operates in the XY plane, but process the parts which have a curvature in Z axis

Parts (Cont.)

- Tubular components welding – *tube-to-tube, tube-to-port, tube-to-cup* assemblies
- Outer part – natural unfilled plastic.
- Inner part – less critical
- **Special technique** to weld small tubular assemblies without spinning them under the beam
- Process automation



Welding Tubes & Connectors with Solvent Free Laser Technology



Collaboration between IPG Photonics and Eastman Chemical Tritan Materials

Medical Applications Samples

- *Most Common assemblies in MD manufacturing:*
 - *Tube-to-Port*
 - *Tube-to-Tube*

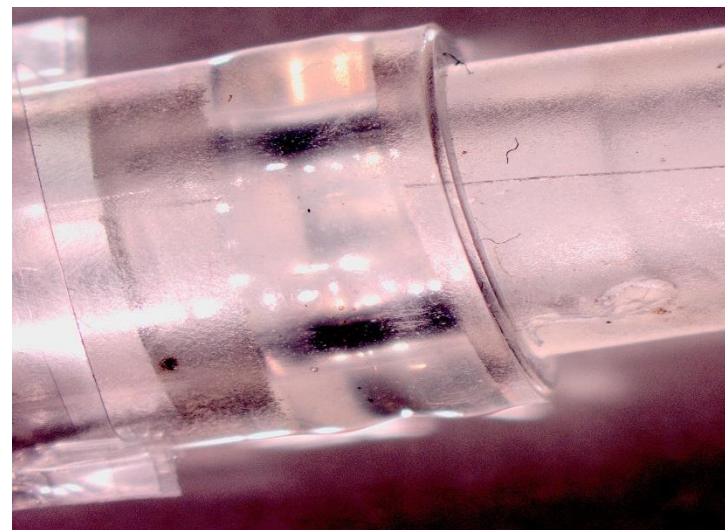
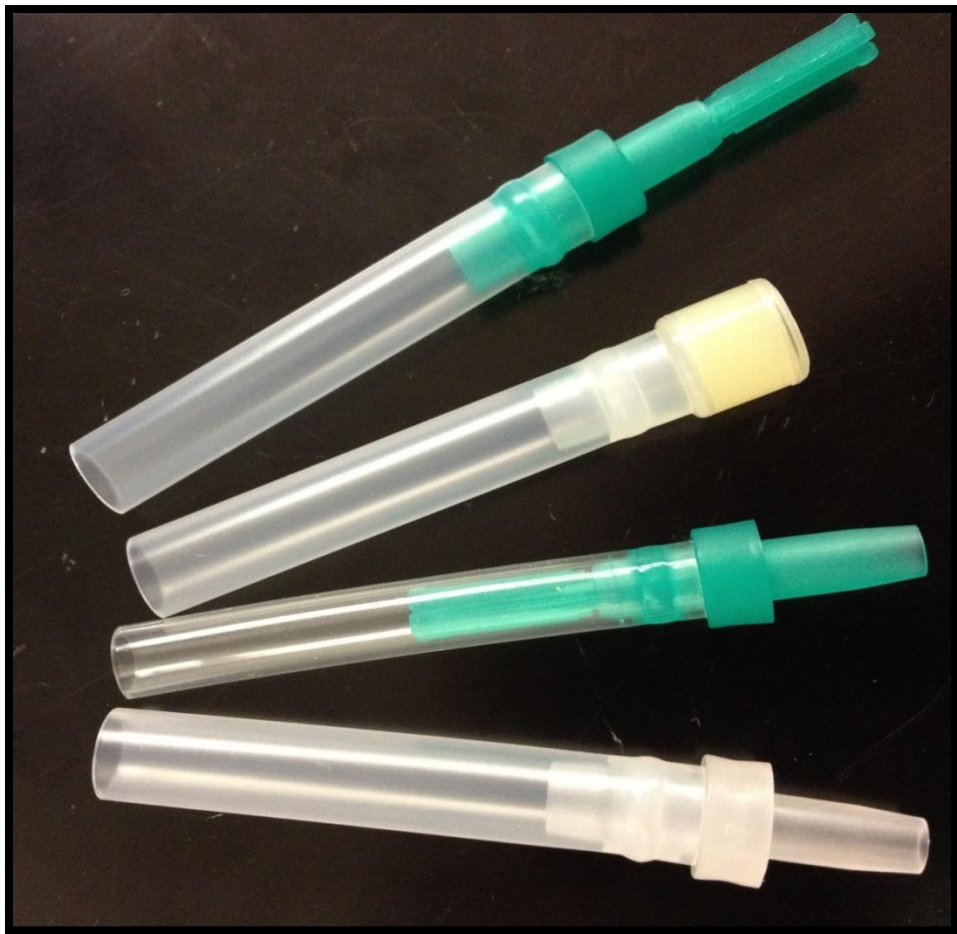


Weld Joints



Samples of tubular "**Clear-to-Pigmented**" and "**Natural-to-Natural**" assemblies welded with laser

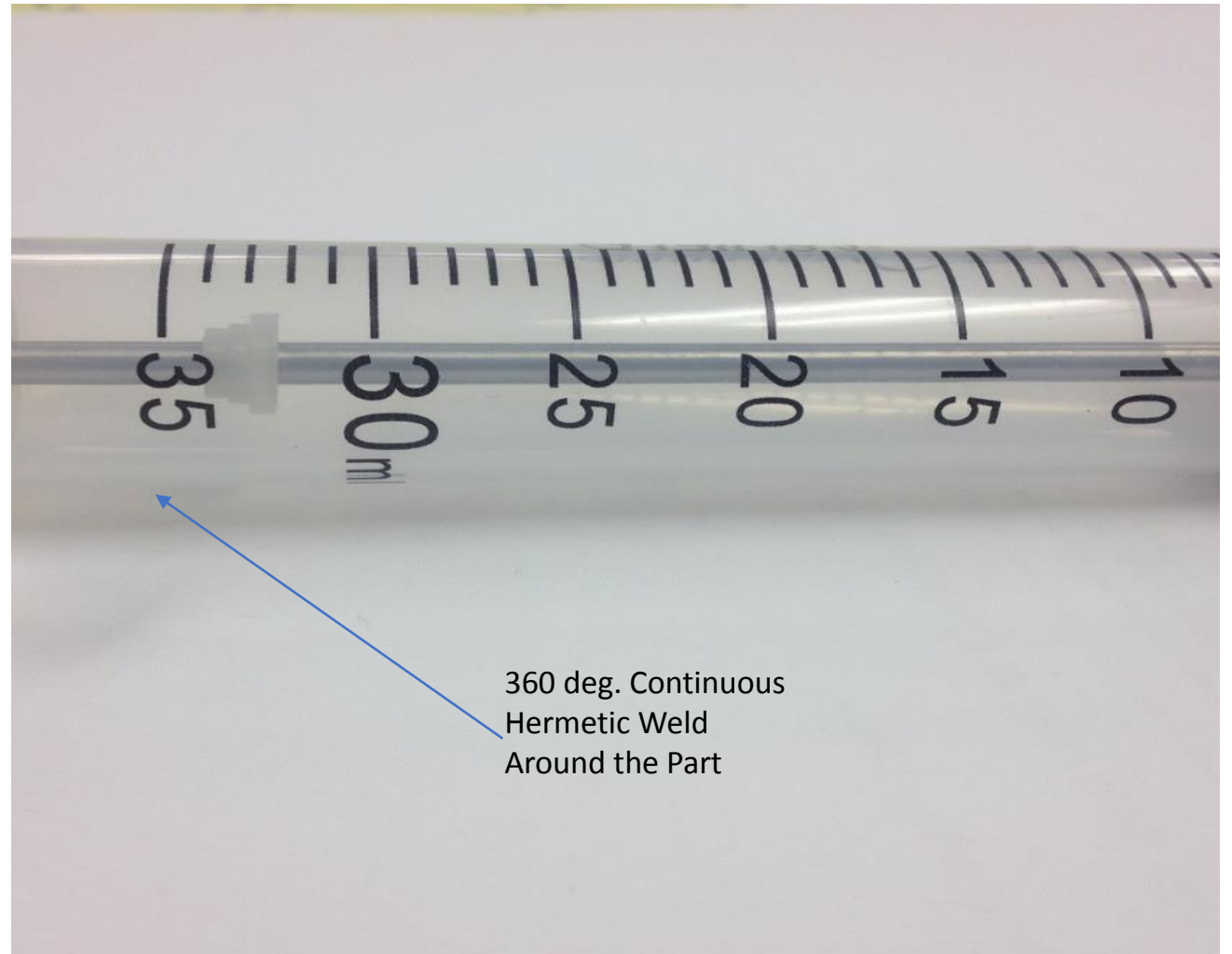
More Medical Applications Samples



Parts (Cont.)

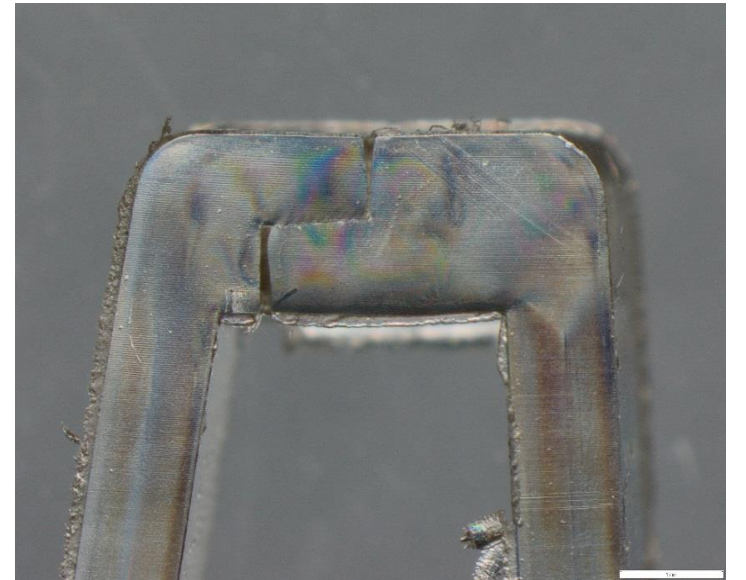
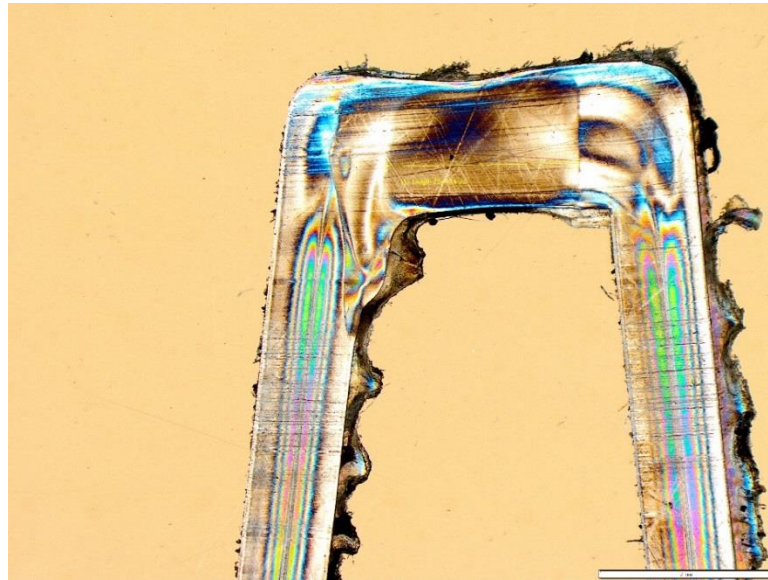
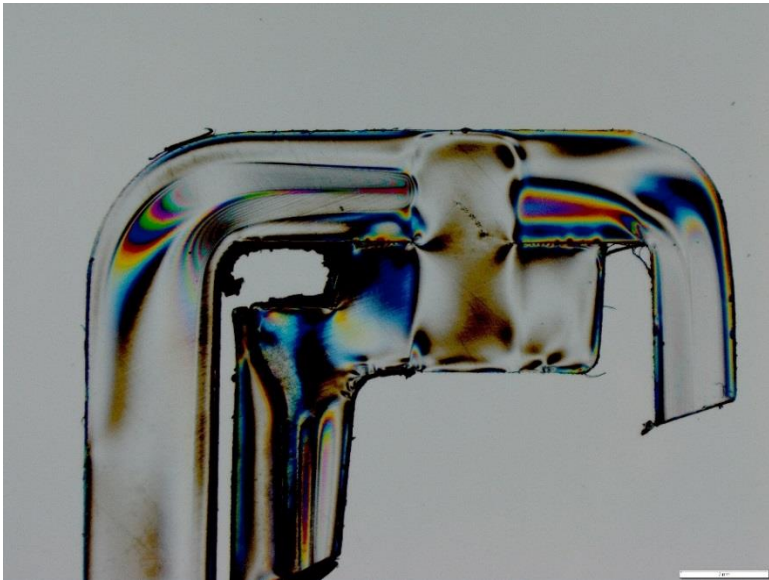
Tubular components welding – *tube-to-tube, tube-to-port, tube-to-cup* assemblies. The Outer part – natural unfilled plastic. Inner part – less critical.

We have a unique way to weld small tubular assemblies without spinning them under the beam. It is an important advantage for process automation

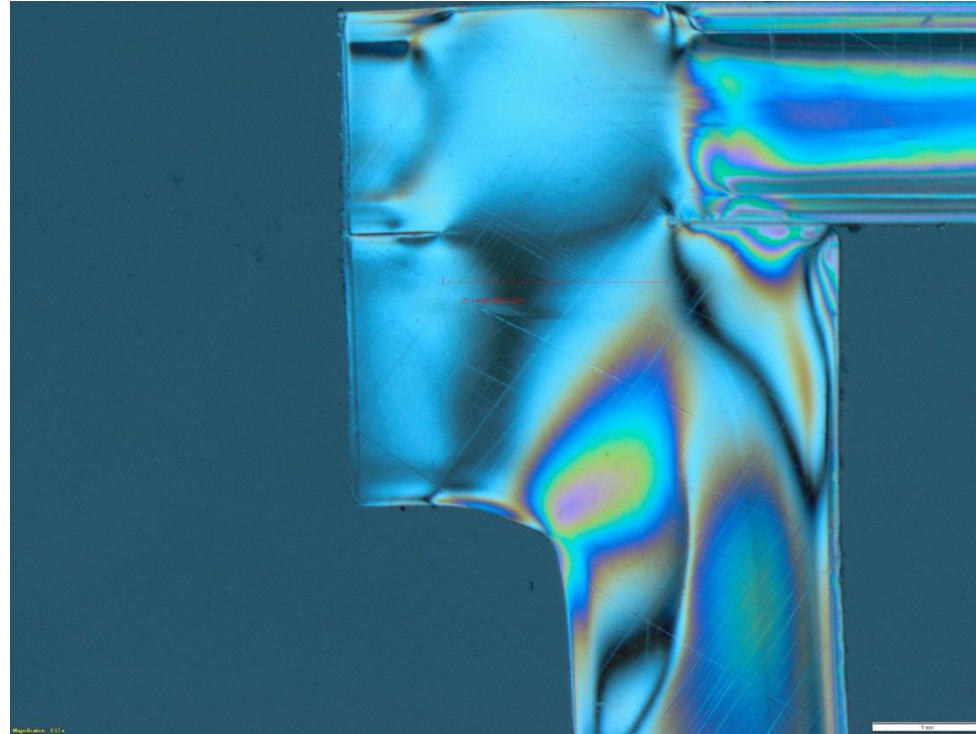


More Medical Applications Samples

Selected samples of clear-to-clear joints in medical devices

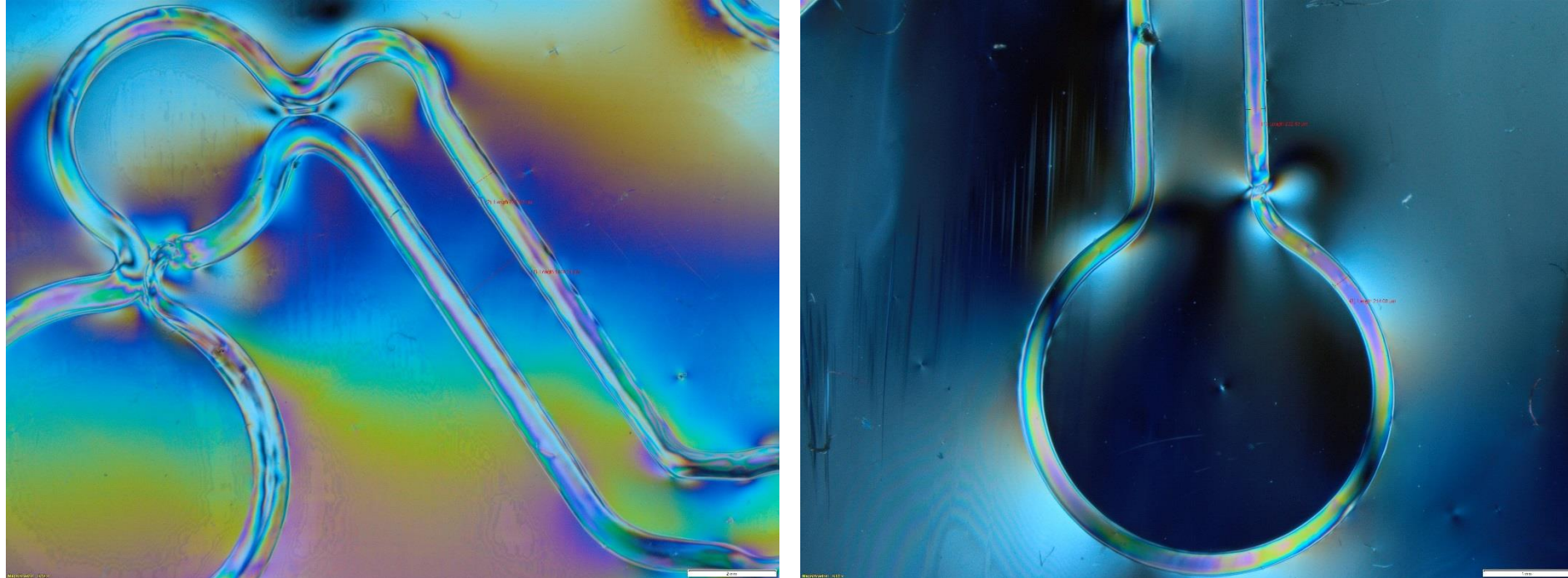


More Medical Applications Samples



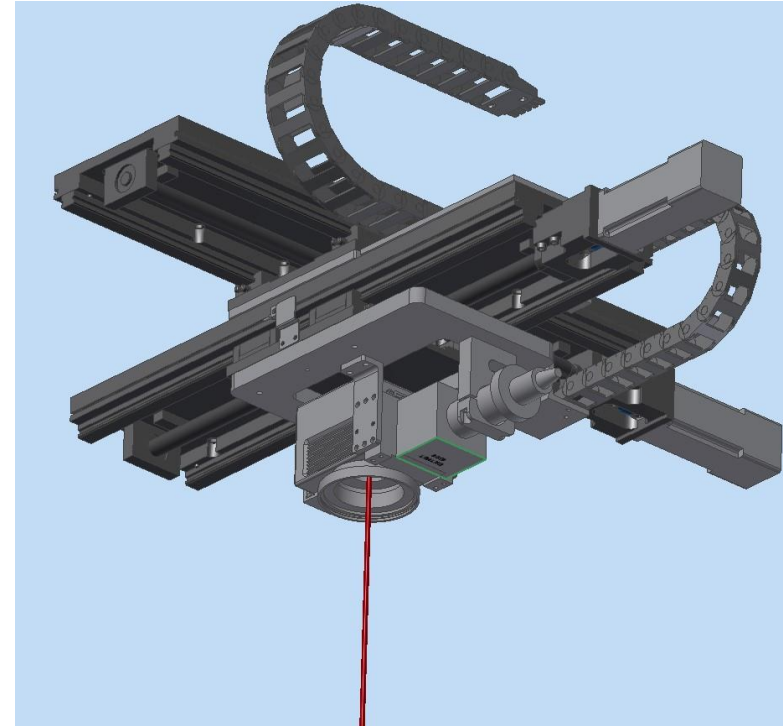
Material – PC; Upper part thickness -2.2 mm; Weld width – 2.06 mm

More Medical Applications Samples



Material – COC; Upper part thickness -0.38 mm; Weld width – 0.2 mm

Equipment



Proprietary LaserLinQ™ Software

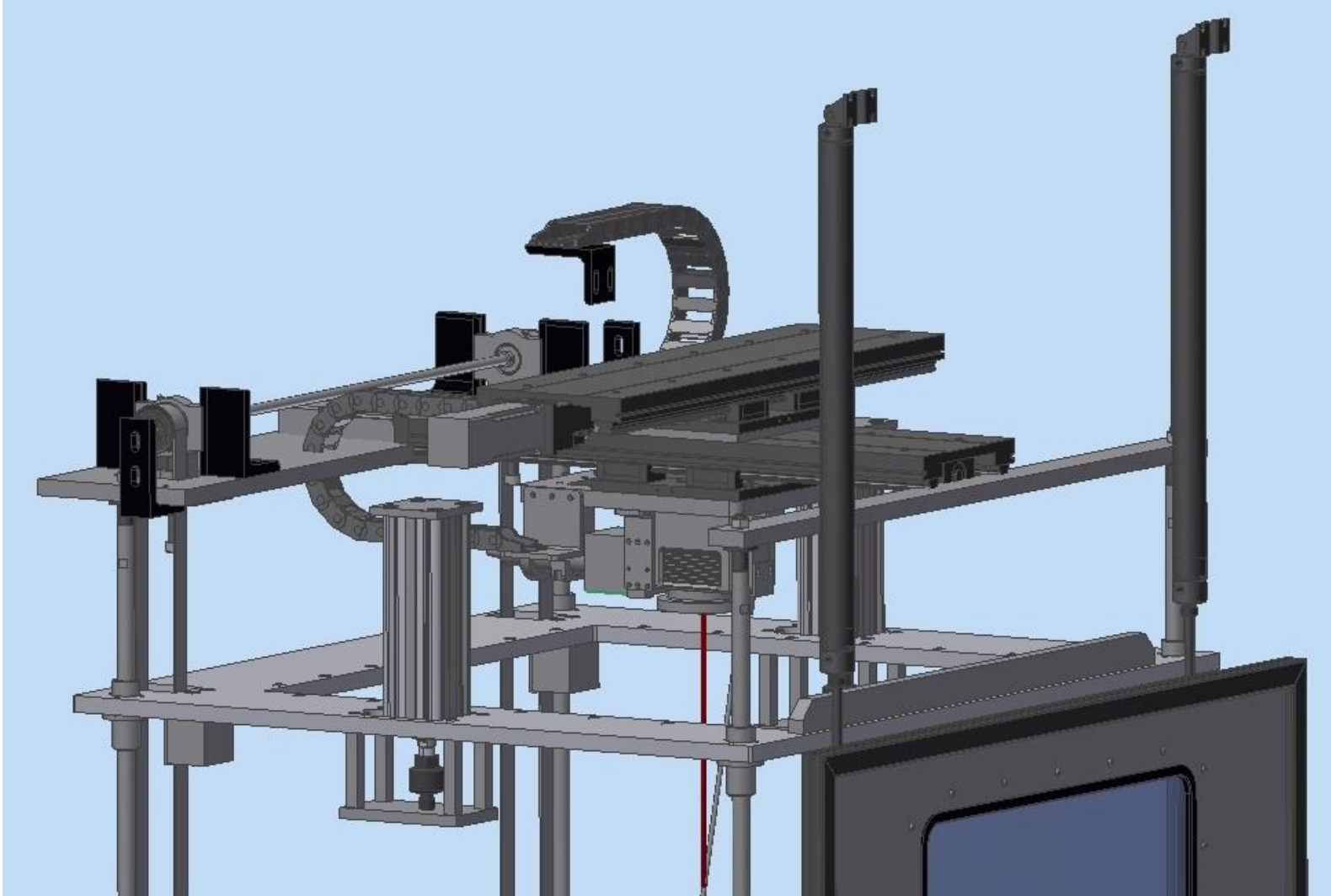
The screenshot displays the LaserLinQ™ software interface for configuring a weld pattern. The window title is "LaserLinQ™ - [WeldTOP-ClampBoth]". The menu bar includes "File", "Tools", "Window", and "Help". The toolbar contains icons for file operations, settings, a "Guide" button, a video camera, a red stop button, a refresh button, a keyboard icon, a numeric keypad icon, a help icon, a printer icon, and a power icon.

The main interface has tabs for "Status", "Process Settings", "Weld Preview", "Diagnose", and "Cycle Data". The "Weld Preview" tab is active, showing a "Primary" section with a "Weld Pattern" sub-tab. A list of weld pattern elements is shown on the left, each with a checked checkbox and a small icon:

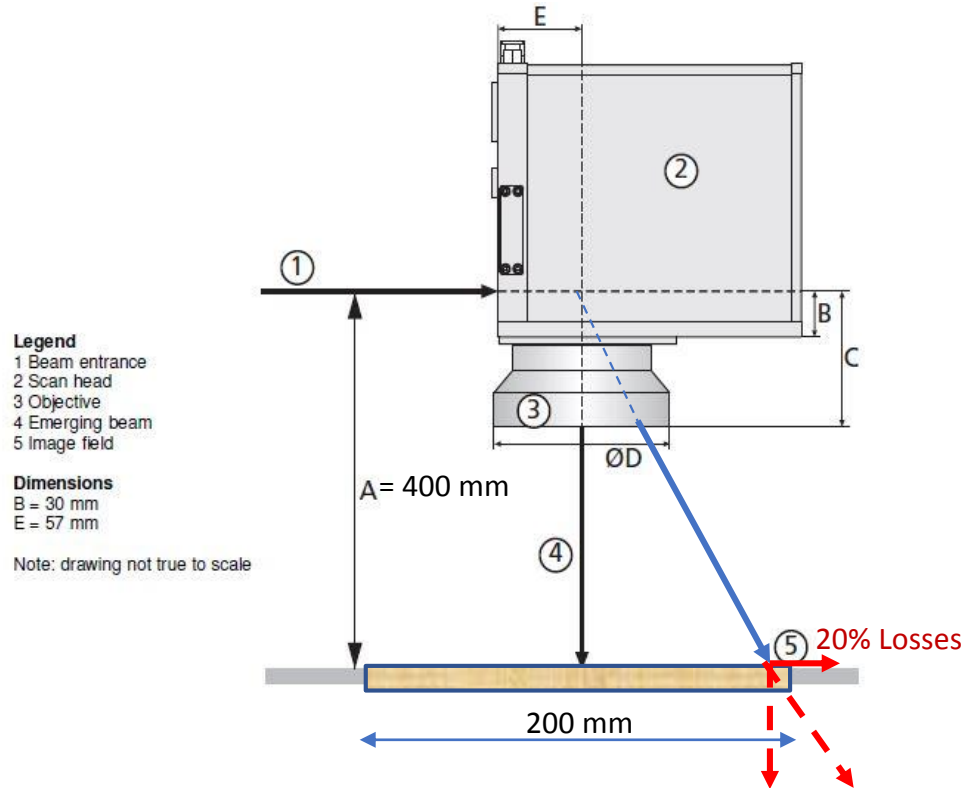
- Line BOTTOM
- Arc BL
- Line LEFT
- Arc TL
- Line TOP
- Arc TR
- Line RIGHT
- Arc BR

An "Edit" button is located to the right of this list. Below the list are "Check All" and "Uncheck All" buttons. To the right of the list is a graph with "Axis X" and "Axis Y" labels, both ranging from -200 to 200. The graph shows a dashed rectangular weld pattern with rounded corners and a red asterisk at the bottom center. Below the graph is a checkbox labeled "Enable ability to pan graph by touch and drag" which is currently unchecked. At the bottom right of the graph area, the "Graph Field Size" is set to "450.0000 mm".

The status bar at the bottom of the window shows several indicators: "Offline" (yellow), "Guide On" (green), "E-STOP" (yellow), "Homed" (green), and "Initialized" (green). The date and time are displayed as "Tuesday, September 22, 2015 2:16:03 PM".



Even in the case when the part size will be 200 mm, using a conventional stationary scan head for beam delivery would result in about 20% energy losses. This loss will only increase with the parts size approaching 250 mm and is directly related to process efficiency and a throughput.



Dukane's beam delivery system integrates both, XY servo gantry and a scan head, supported by a proprietary software which harmonizes the action of both components moving the beam.

The system assures that the beam is always perpendicular to the part surface (assuming flat parts) which maximizes beam utilization.

