



***DUKANE***

***BEST PRACTICES FOR LASER  
WELDING***

**FROM DESIGN TO PRODUCTION**

# HOST



## Josh Brown

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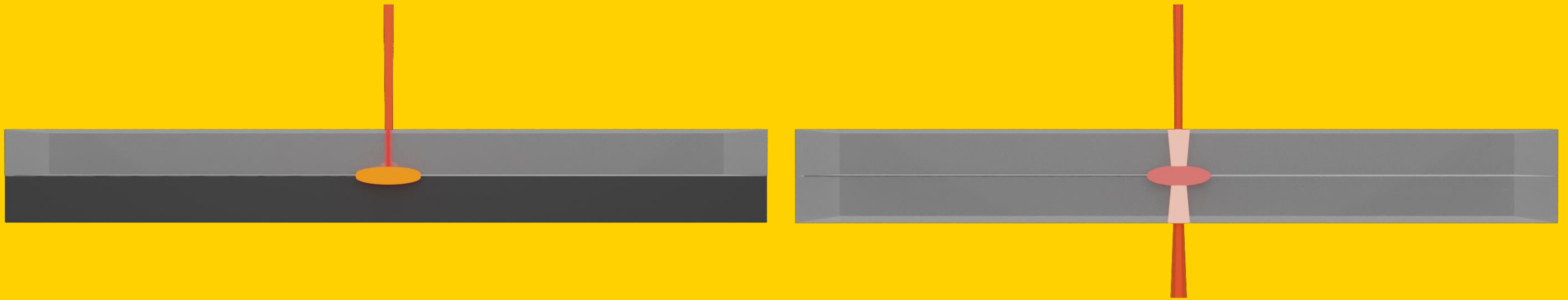
(503) 930-4519

### Online

[www.dukane.com](http://www.dukane.com)

# Agenda

- 1 $\mu$ m v. 2 $\mu$ m Laser Welding
- 1 $\mu$ m Critical Material & Design Concepts: 4 Pillars
- 2 $\mu$ m Critical Material & Design Concepts
- Project Roadmap



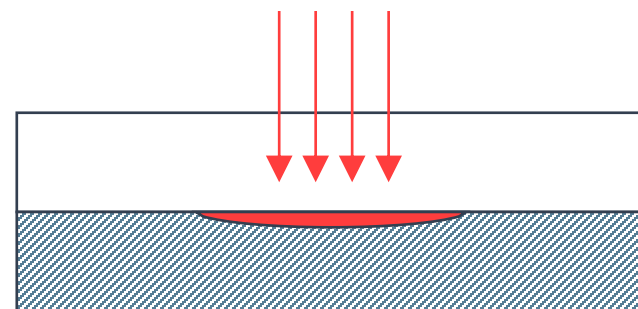
# *1 $\mu$ m v. 2 $\mu$ m*

## Laser Wavelengths and Process Types

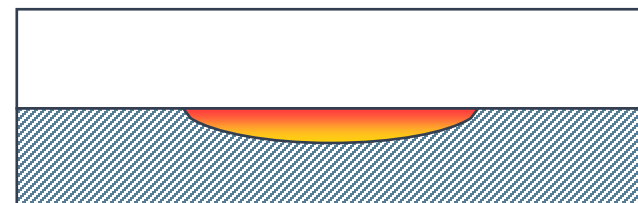
# 1 MICRON VS 2 MICRON LASER WELDING

## LASER WAVELENGTHS AND PROCESS TYPES

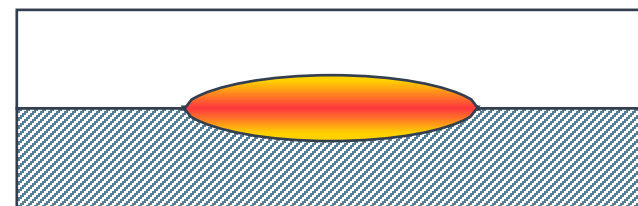
### 1 Micron Laser



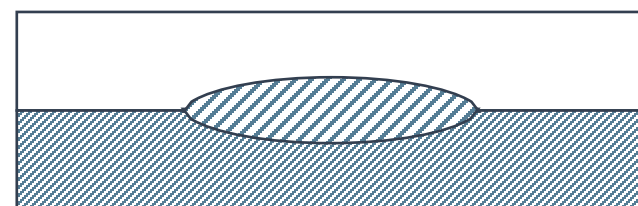
Laser transmits through transparent layer



Absorbed by the non-transmissive or additive layer

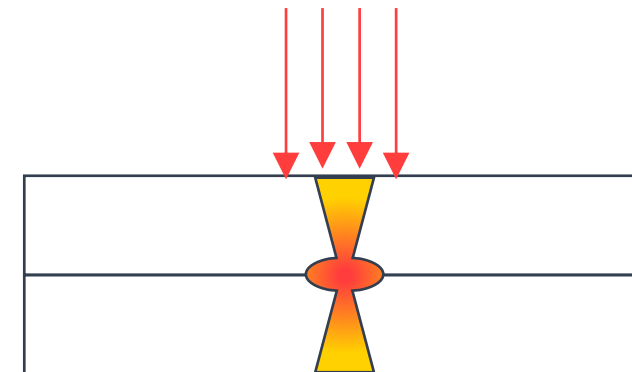


Plastic Heats and Melts

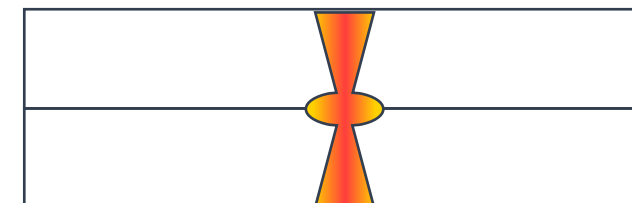


Parts cool down and bond

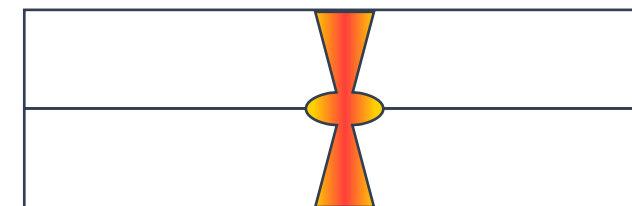
### 2 Micron Laser



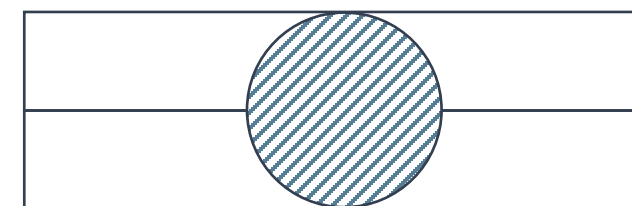
Absorbed by both Transparent Layers



Heats both Layers



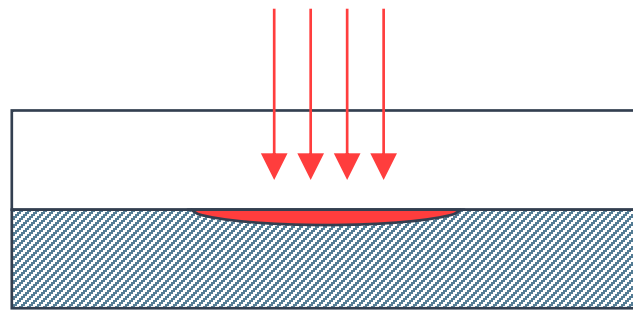
Melts both Layers



Parts cool down and bond

# COMPARISON

## 1 Micron Laser



Laser transmits through transparent layer



Collapse control



Larger parts, working fields

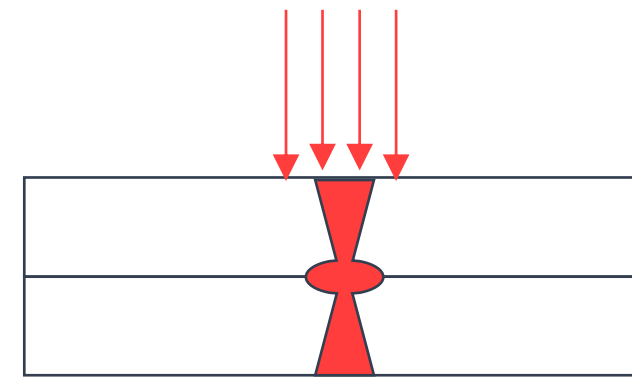


More complex joint designs



Metal tools possible

## 2 Micron Laser



Absorbed by both Transparent Layers



Both parts can be natural/clear



No additive required for absorption



Multilayer joints possible

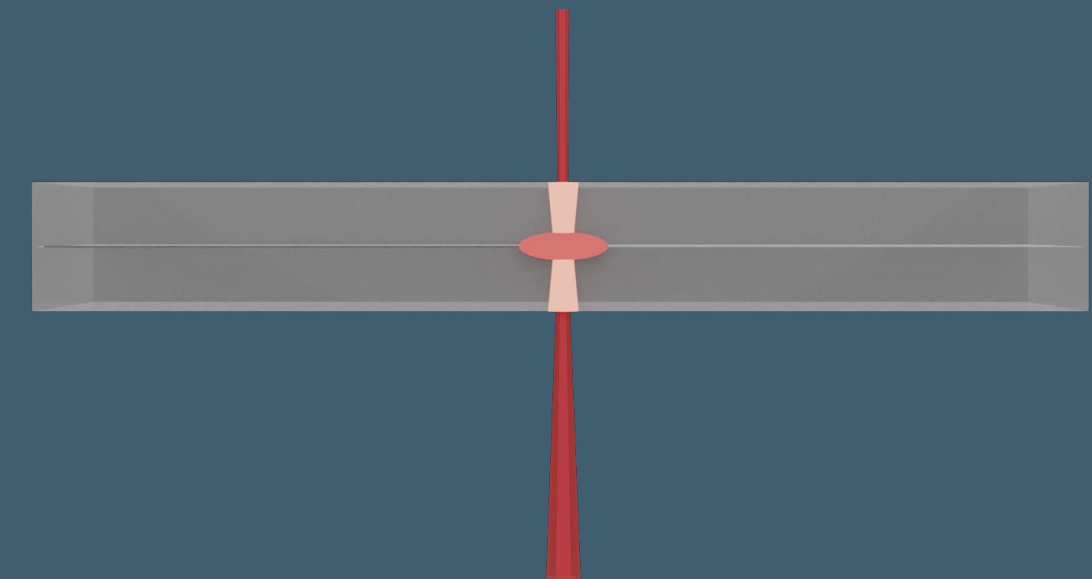
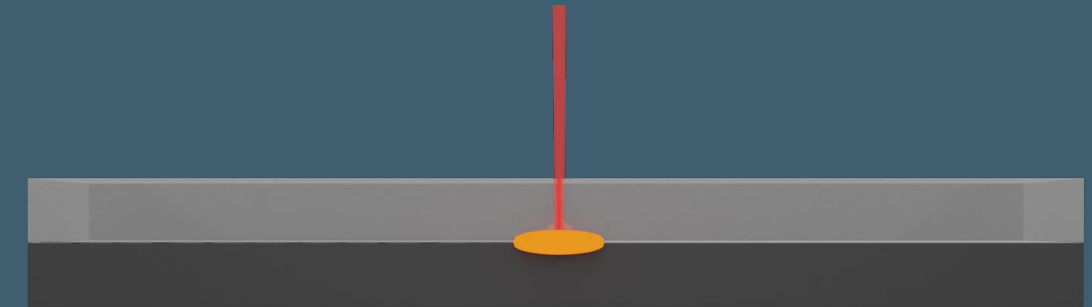
# SO WHICH IS BETTER, 1 $\mu$ M OR 2 $\mu$ M?

This is a bad question, neither is better!

It all depends on the application and requirements

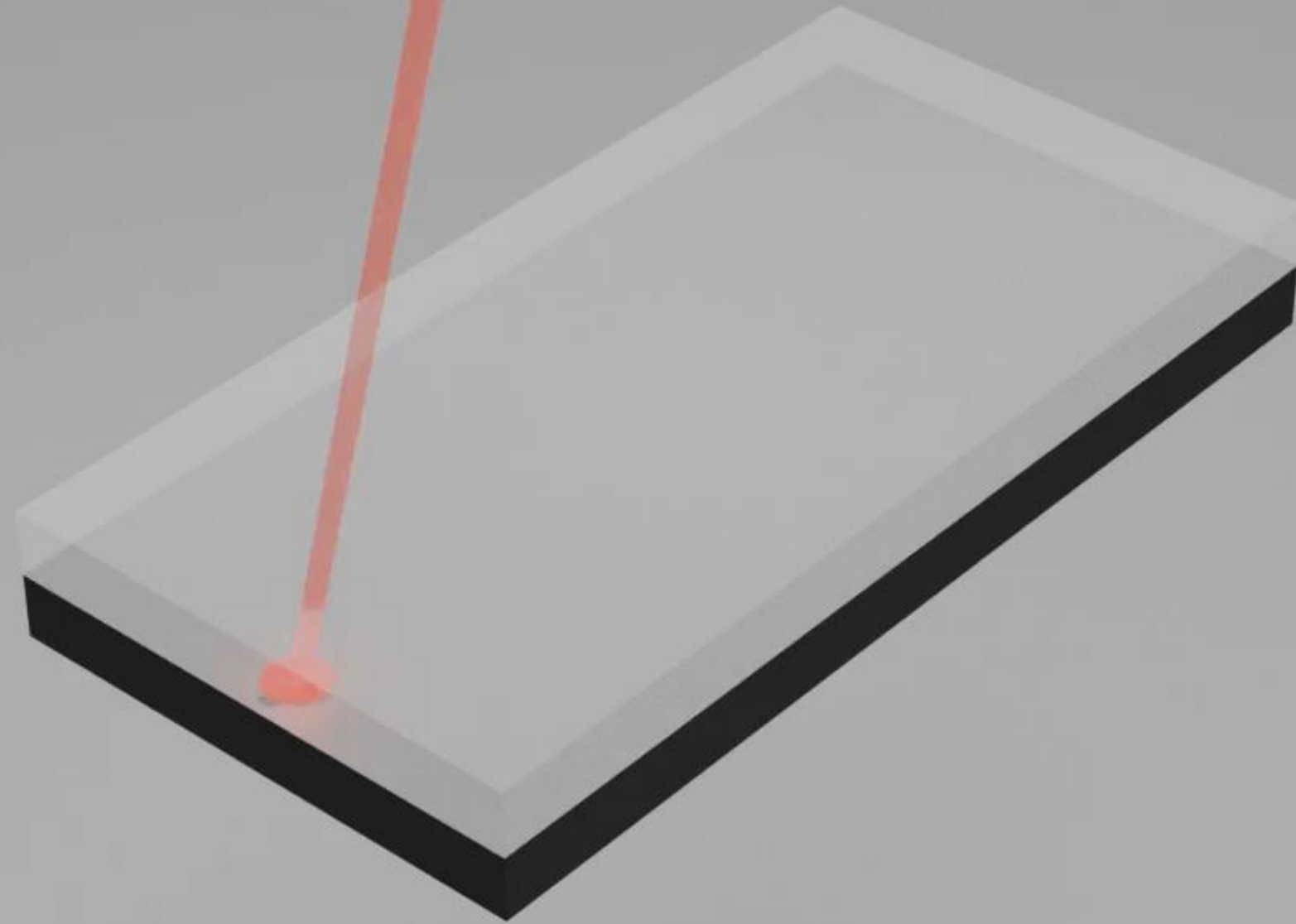
The main point is...

**We can do both!**



# ***1 $\mu$ M TECHNICAL OVERVIEW***

## **Through-Transmission Laser Welding**





# ***THE 4 PILLARS***

**IR  
TRANSPARENT  
UPPER**

**IR ABSORBING  
LOWER LAYER**

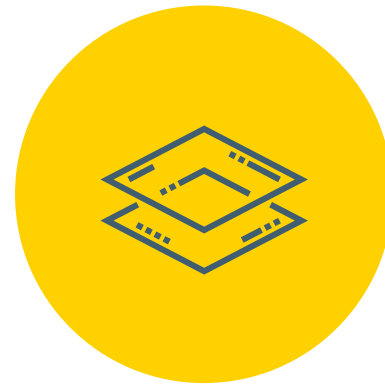
**TIGHT  
MECHANICAL  
CONTACT**

**COMPATIBLE  
MATERIALS**

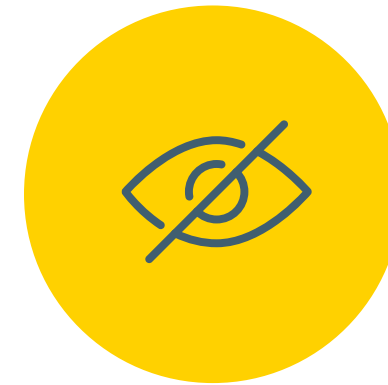
# #1. IR TRANSMISSIVE UPPER LAYER



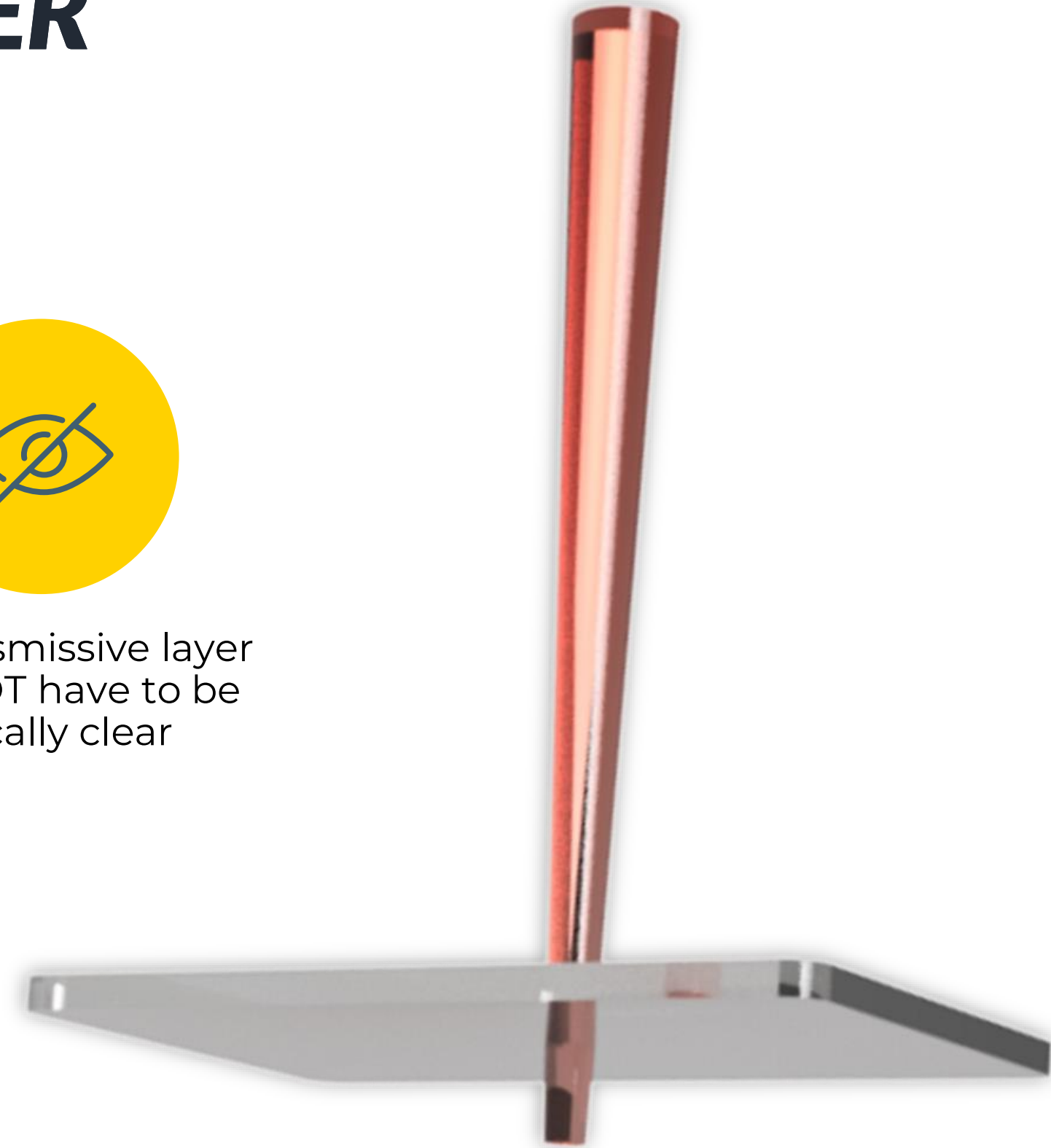
The laser “passes” through the upper layer



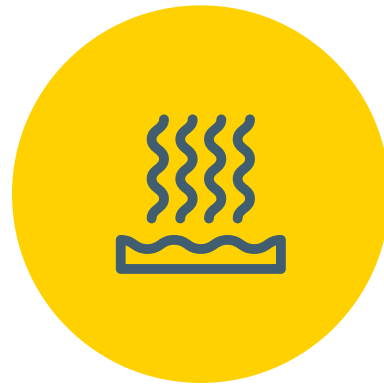
In most cases thermoplastics are transmissive to IR radiation between 800nm – 1064nm in their natural, uncolored states



The transmissive layer does NOT have to be optically clear



## #2. IR ABSORBING LOWER LAYER



The IR “light” energy from the laser is converted to thermal energy at the joint interface

because the beam interacts with the colors / additives in the plastic

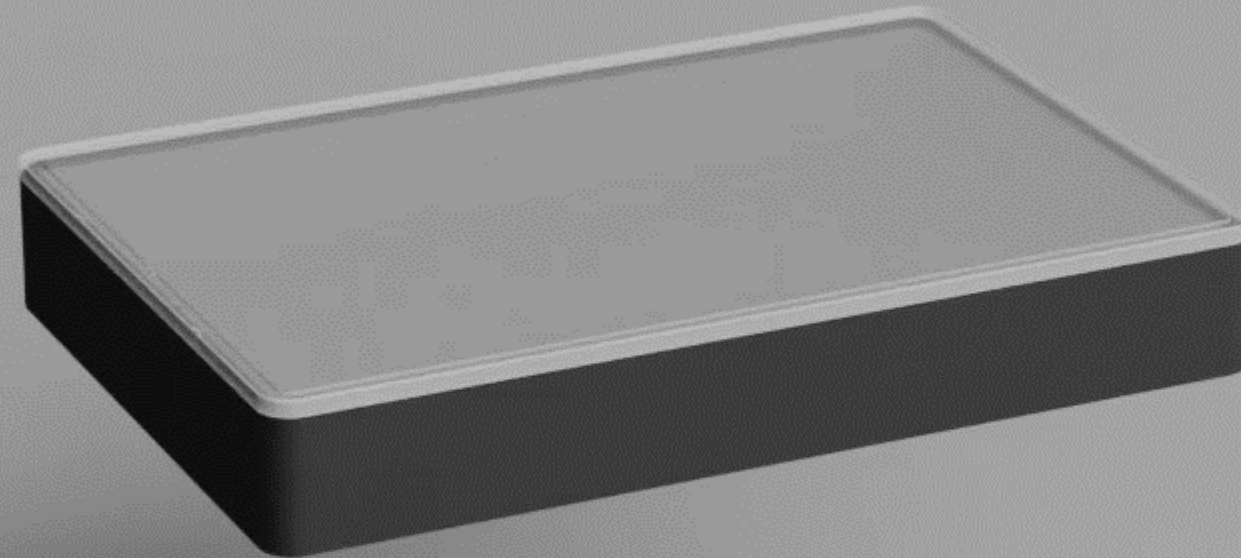


The most common color for a lower layer is black

carbon is cheap and an excellent absorber



# #3. TIGHT MECHANICAL CONTACT

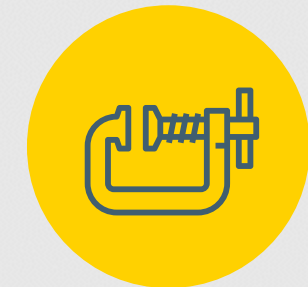


The thermal energy created in the lower, absorbing layer must be efficiently transferred to the upper layer

This creates melt

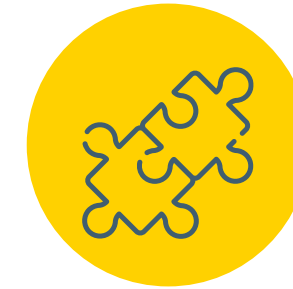


This is achieved through conduction  
Parts are required to be in excellent contact throughout the joint



This is, in most cases, achieved with controlled clamping

# #4. MATERIAL COMPATIBILITY

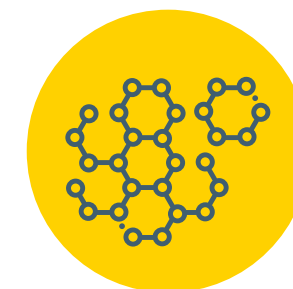


Finally, the joining materials must be compatible, this requires:

Similar surface energies

Chemical compatibility

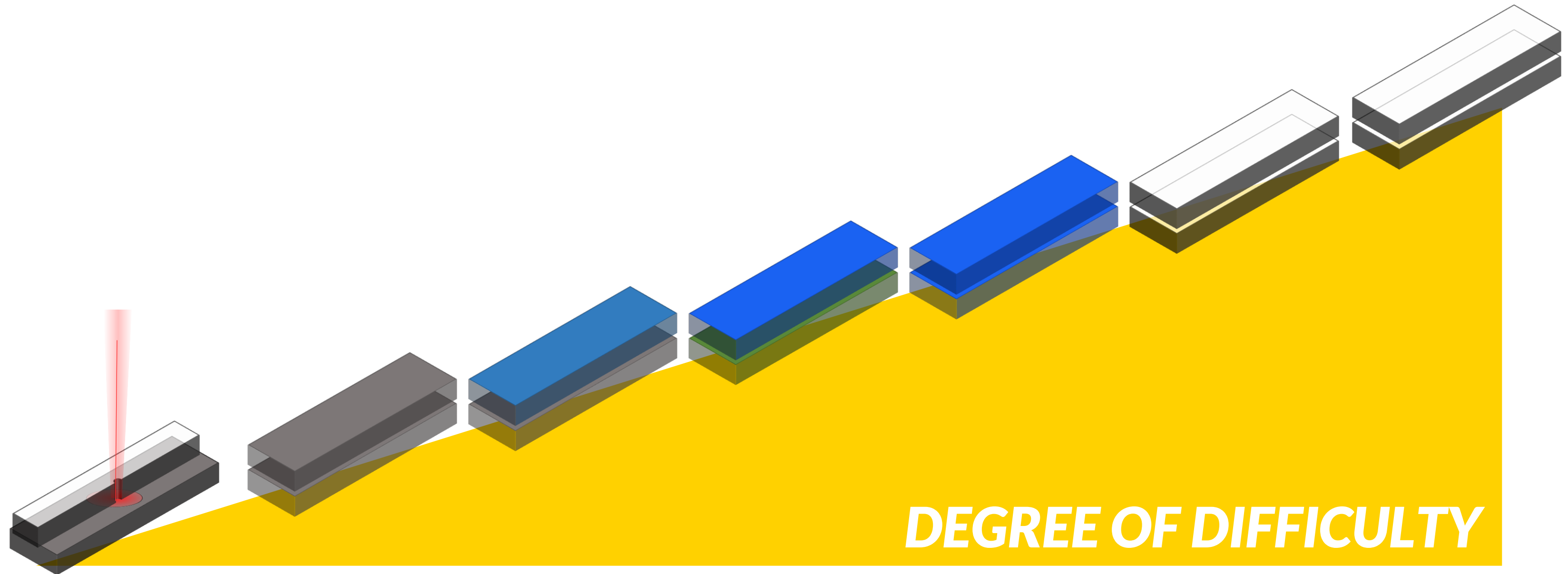
Overlapping melt ranges



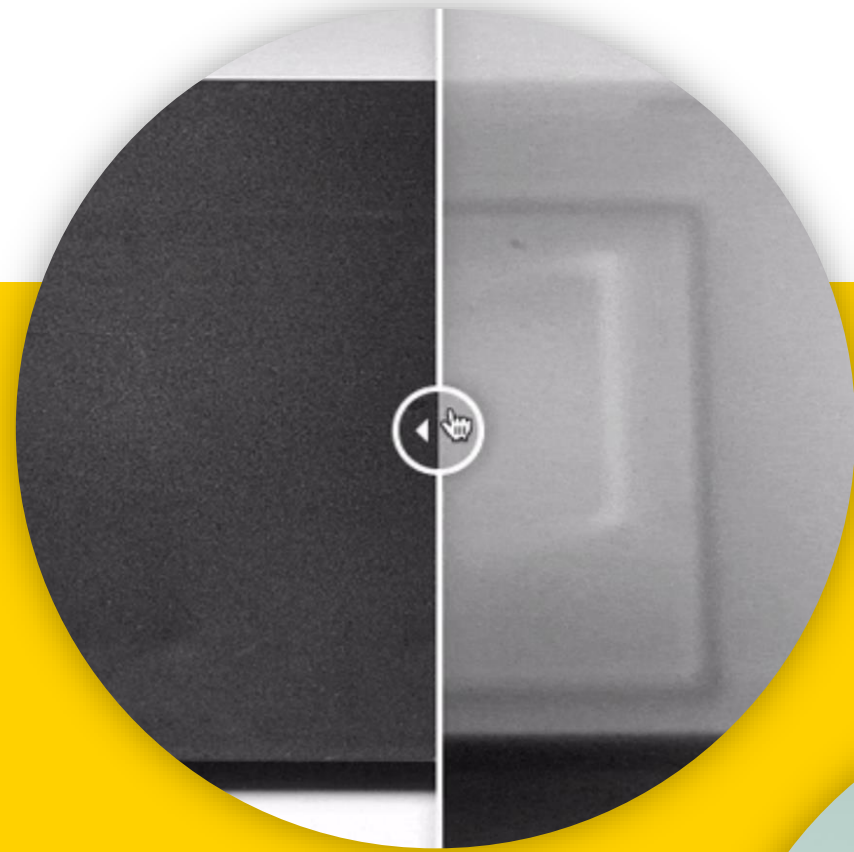
Laser can weld some dissimilar polymers

	ABS	ASA	COC	EVA	LCP	MABS	PA 11	PA 12	PA 6	PA 66	PBT	PBT/ ASA	PC	PC/ ABS	PE-HD	PE-LD	PEEK	PEI	PES	PET	PI	PMMA	POM	PP	PPS	PPSU	PS	PSU	PTFE	PUR	PVC	SAN	SB	TPE			
ABS	Green	Green				Green					Green	Yellow	Green	Green					Yellow	Green		Green				Yellow	Yellow			Green	Green			Green			
ASA	Green	Green									Green	Green	Green	Green								Green									Green	Green					
COC			Green																																		
EVA				Green																																	
LCP					Green																																
MABS	Green					Green																															
PA 11							Green																														
PA 12								Green																													
PA 6									Green	Green																											
PA 66									Green	Green																										Yellow	
PBT	Green	Green									Green	Green	Green							Yellow	Green		Yellow					Yellow			Green						
PBT/ ASA	Yellow	Green									Green	Green	Green							Yellow	Green		Yellow					Yellow									
PC		Green									Green	Green	Green	Green						Green	Green		Green							Green	Green						
PC/ ABS		Green									Green	Green	Green										Yellow														
PE-HD											Green	Green			Green	Green																					
PE-LD											Green	Green																									
PEEK																	Green																				
PEI																		Green																			
PES											Yellow	Yellow	Green	Green						Green									Yellow								
PET	Green										Green		Green	Green							Green										Green						
PI																						Green															
PMMA	Green	Green									Yellow	Yellow	Green	Green								Green									Green	Green					
POM																							Green														
PP																								Green													Green
PPS																									Green												
PPSU																										Green											
PS	Yellow																										Green										
PSU	Yellow										Yellow	Yellow								Yellow							Green										
PTFE																													Green								
PUR																														Green							
PVC	Green	Green											Green	Green									Green							Green	Yellow						
SAN	Green	Green									Yellow		Yellow	Yellow							Green						Green			Yellow	Green						
SB																																			Green		
TPE	Green										Yellow		Yellow	Yellow										Green												Green	

# COLOR COMBINATIONS

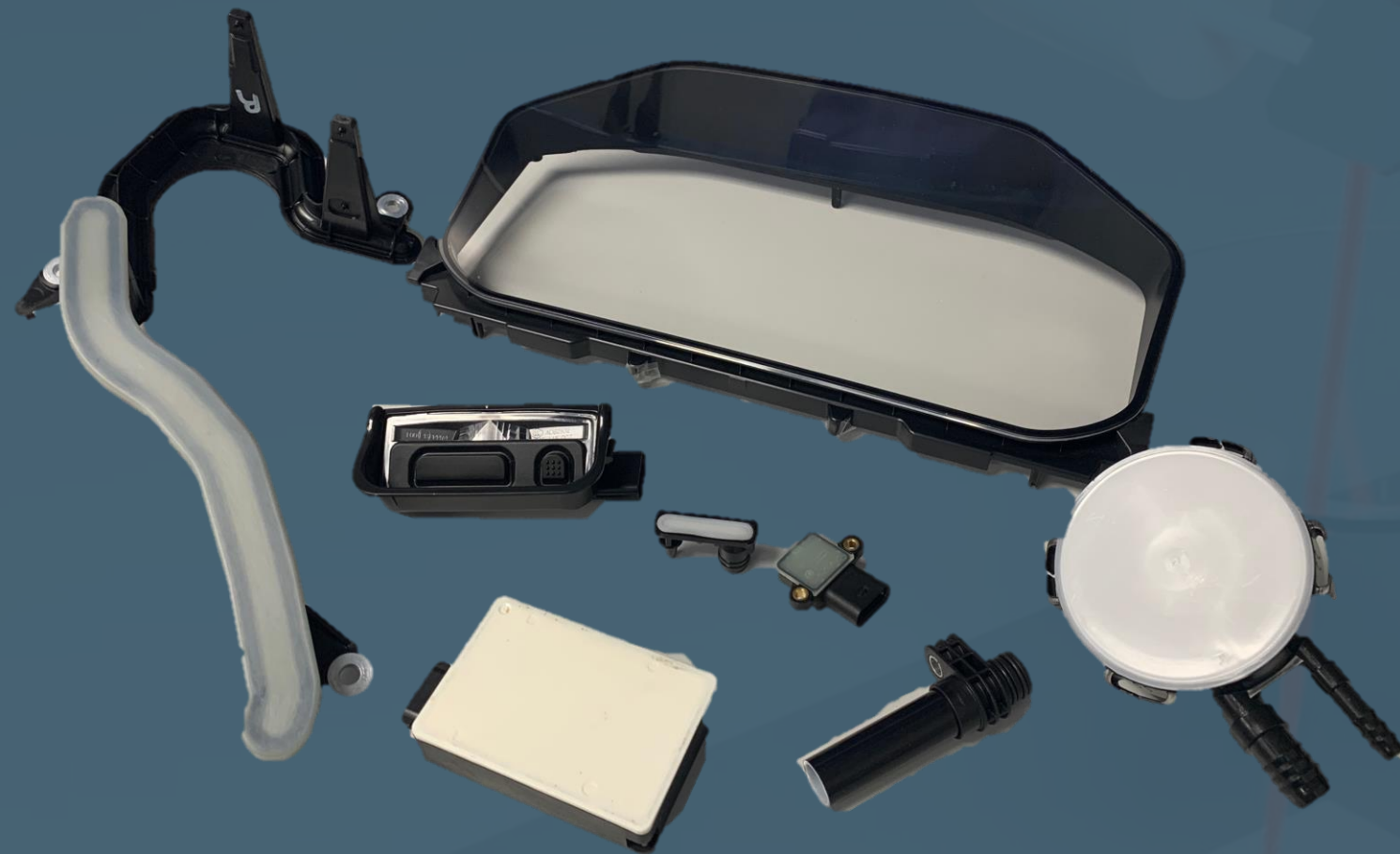


# EXAMPLE APPLICATIONS





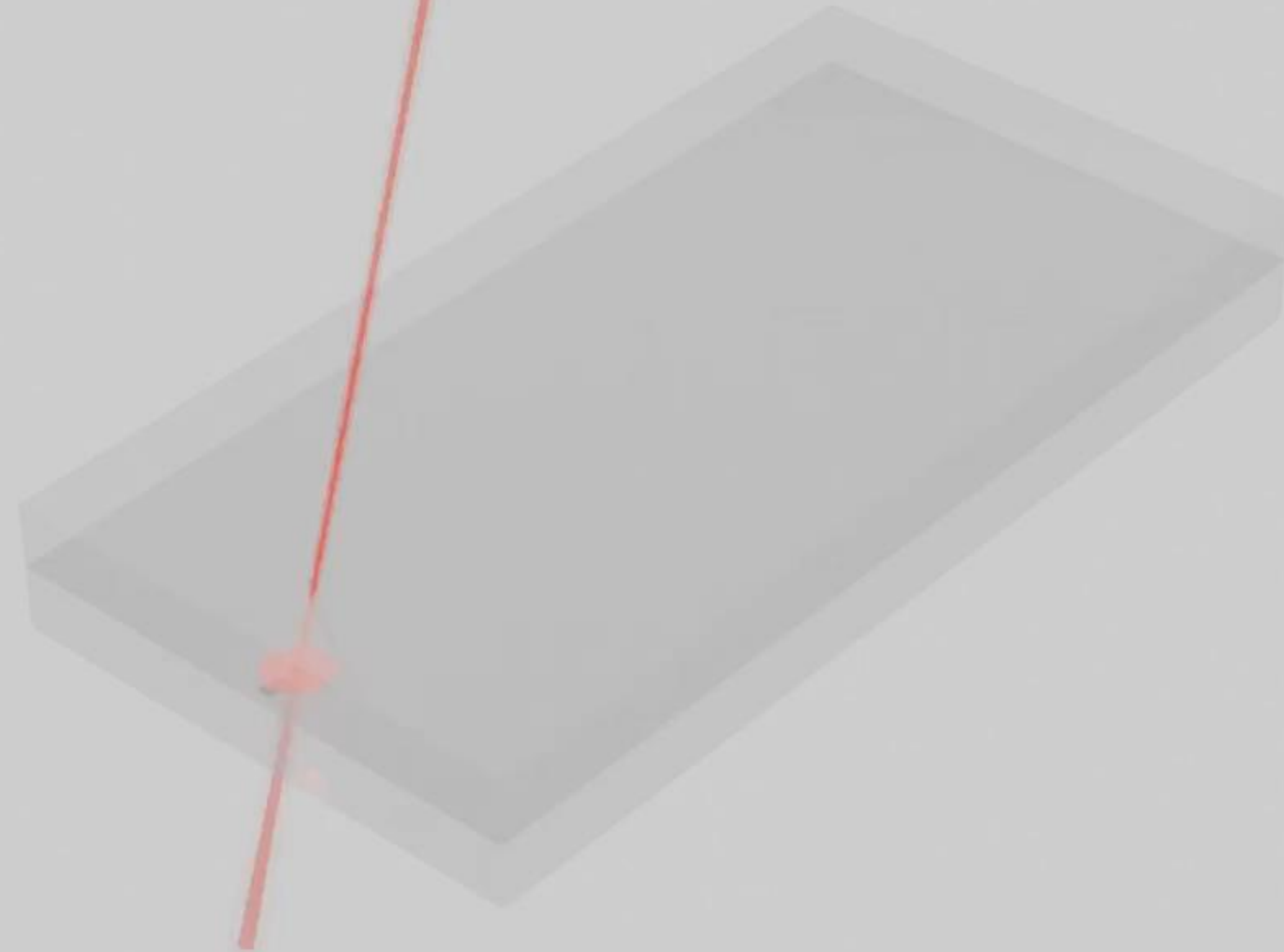
# COMMON LASER WELDING APPLICATIONS



Application	Interior	Exterior	Under Hood
Air Intake Manifold			X
Tail Lamps		X	
Side Marker Lamps		X	
CHMSL		X	
Side Impact Sensor			X
Power Steering Reservoir			X
Brake Fluid Reservoir			X
Lighted Emblems		X	
Instrument Cluster	X		
Camera Lenses		X	
Electronics Enclosures			X
Mechatronic Components			X

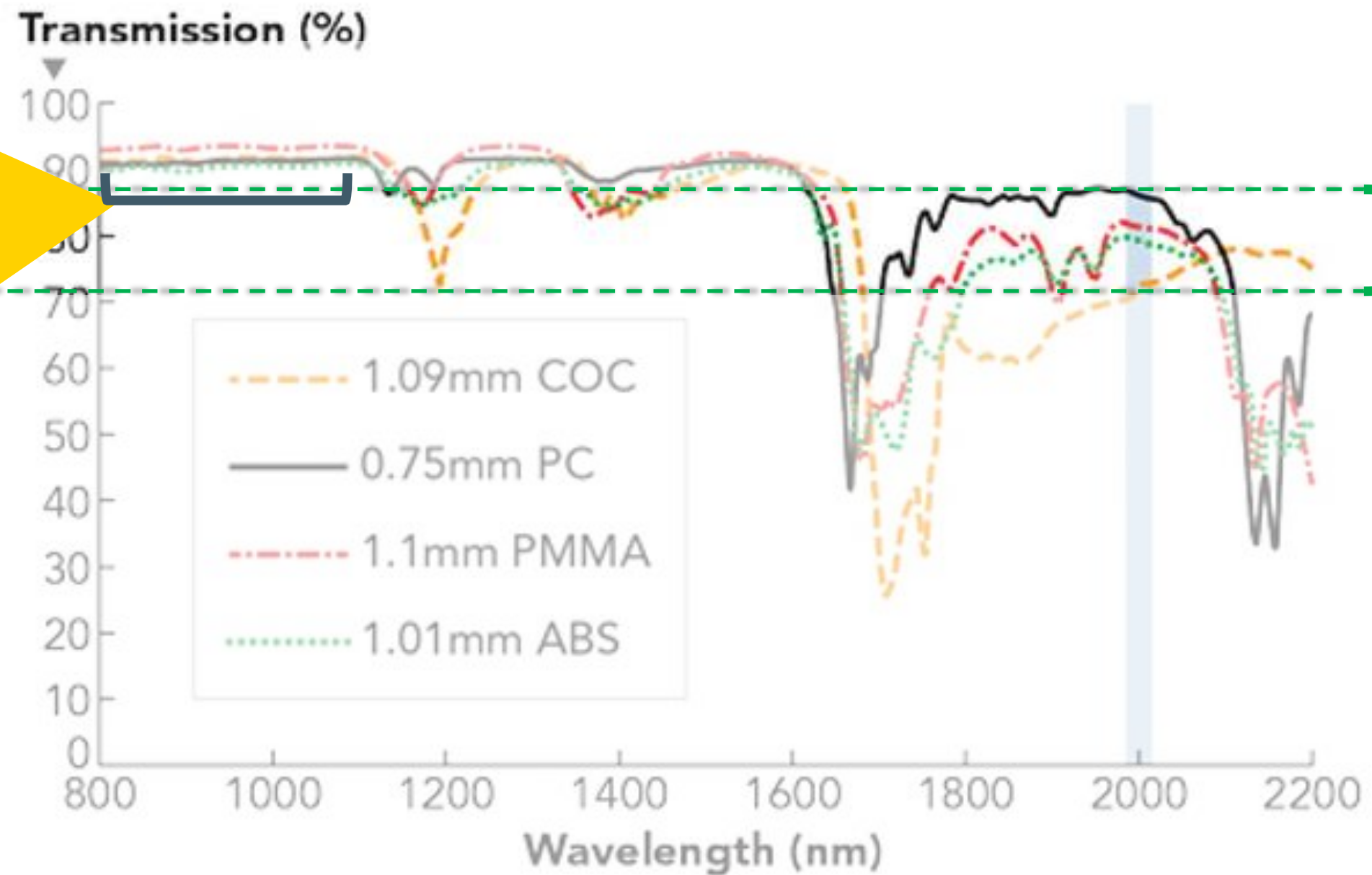
# ***2 $\mu$ M TECHNICAL OVERVIEW***

## **Clear-to-Clear Plastic Welding**



# LASER TRANSMISSION BY WAVELENGTH

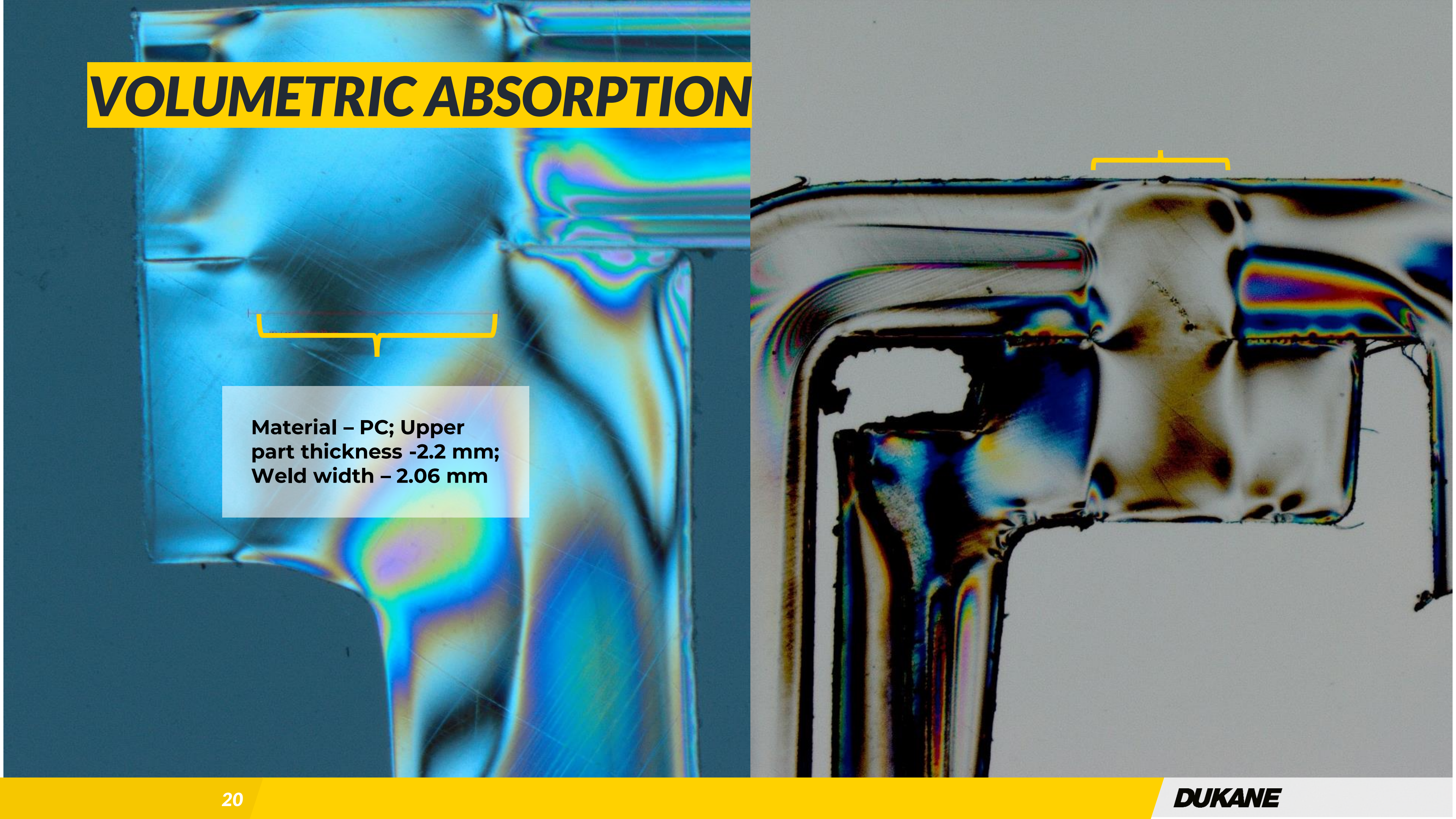
Transmission spectra of COC, PC, PMMA, and clear ABS



Wavelength:  
800nm-1064nm

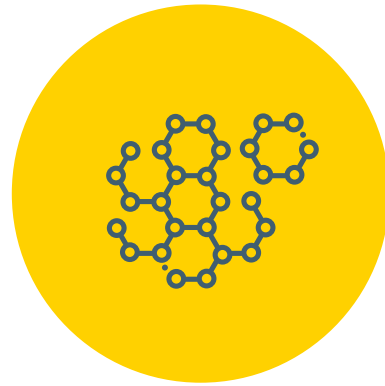
Wavelength:  
2000nm  
"Goldilocks Zone"

# VOLUMETRIC ABSORPTION



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

# GENERAL GUIDELINES



For more efficient process upper part preferably to be unfilled polymer to maximize transmission



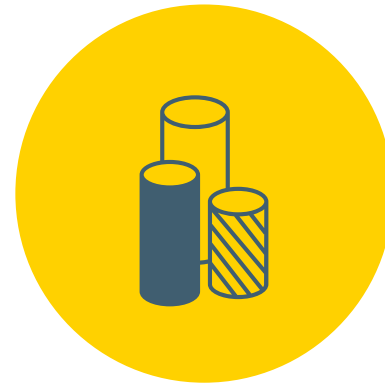
Upper part thickness up to 3.5 mm



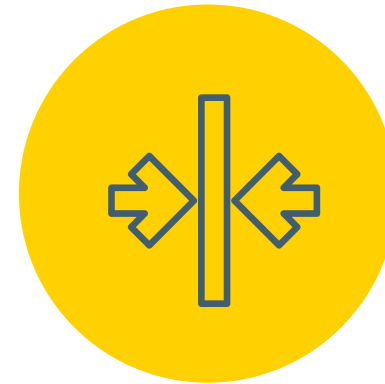
Bottom part – clear, white, pigmented, black...



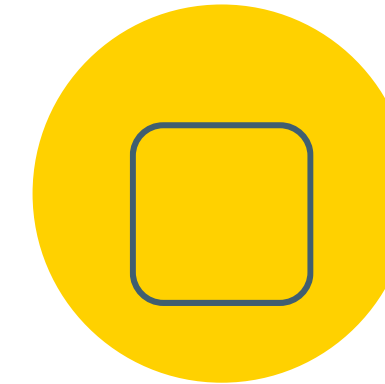
Limited application for glass filled materials



Tubular and Cylindrical components welding (tube-to-tube, tube-to-port, tube-to-cap assemblies)

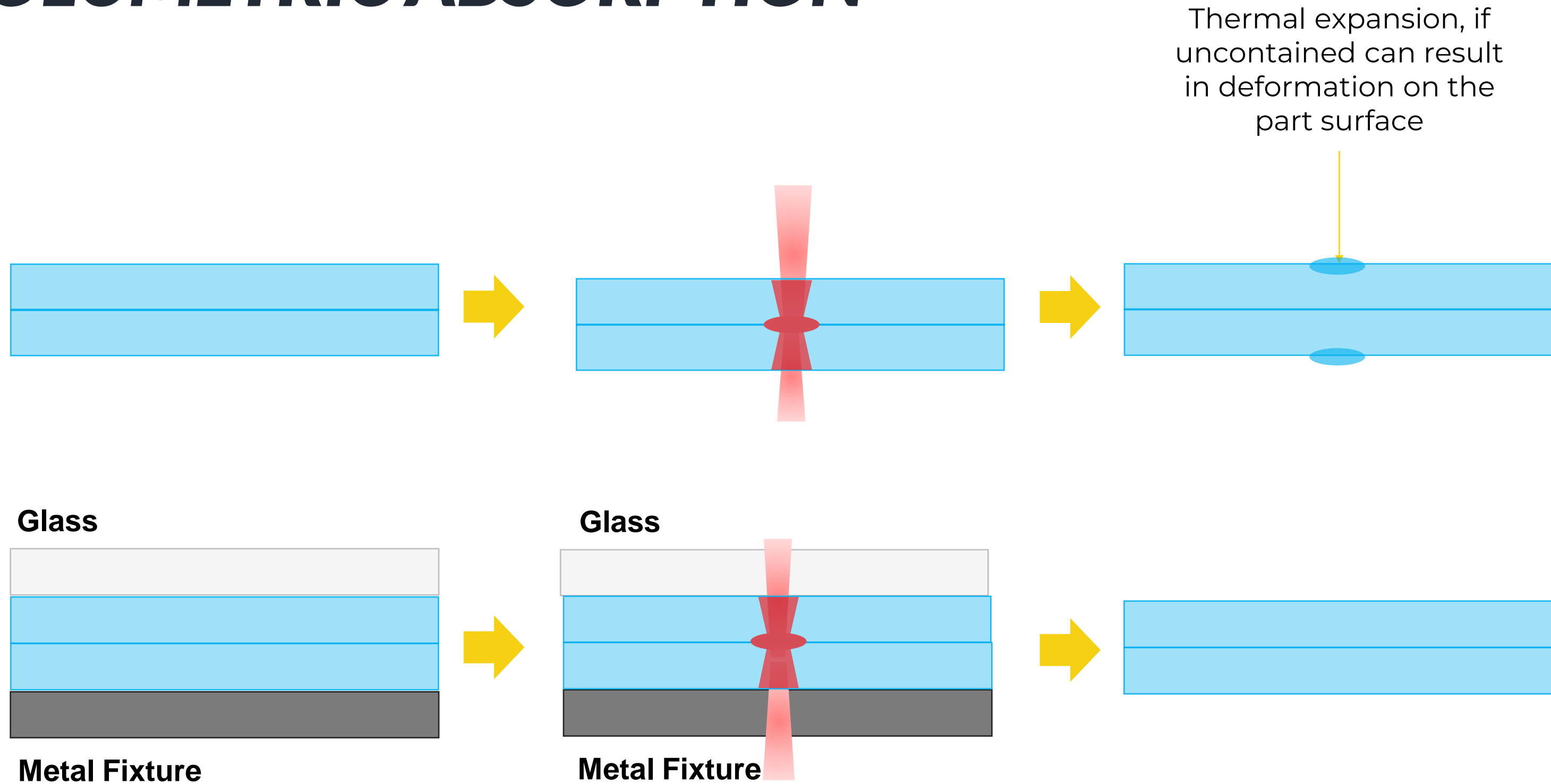


Tight contact during welding



Parts should be flat or only moderately curved

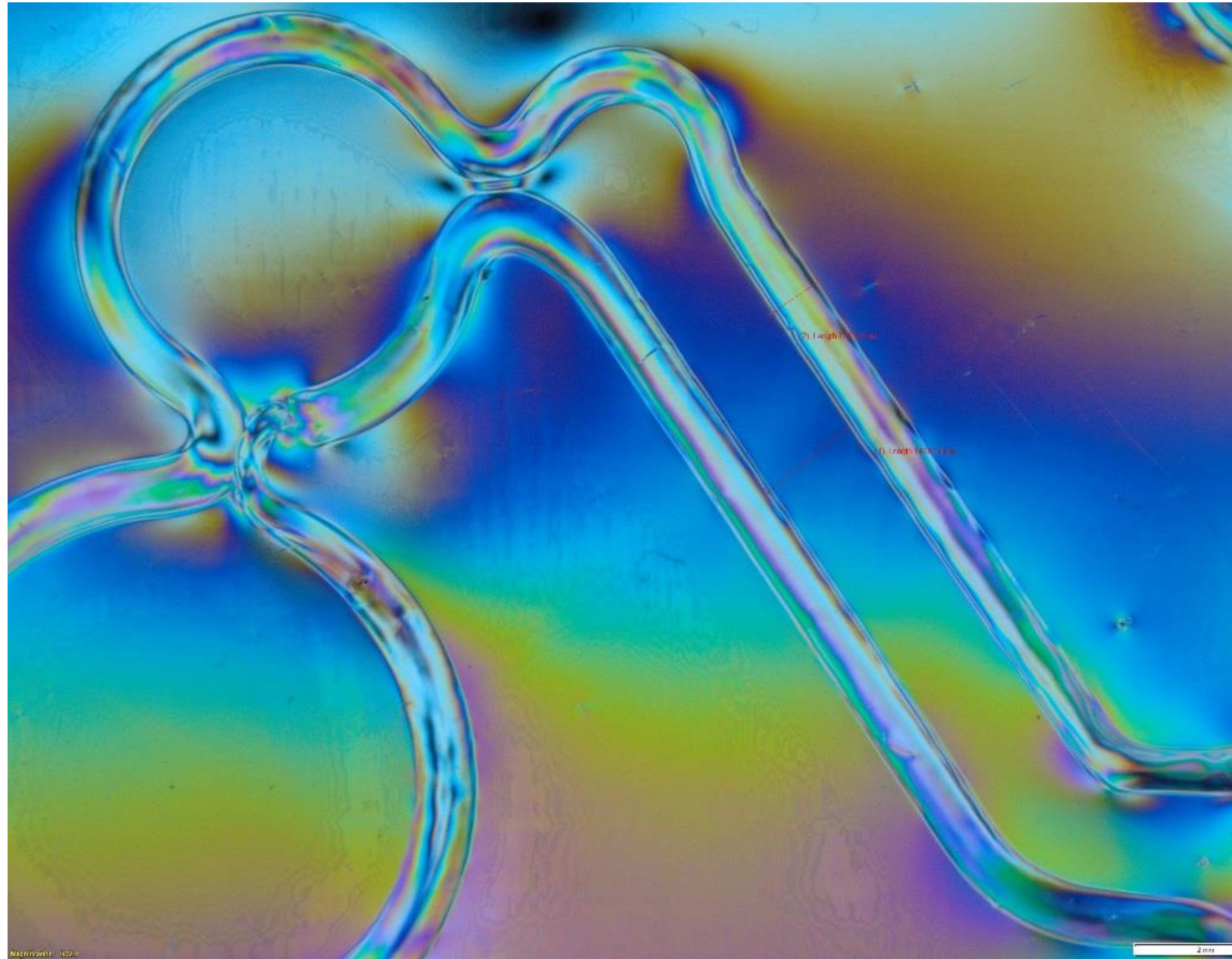
# VOLUMETRIC ABSORPTION



# APPLICATIONS IMAGES



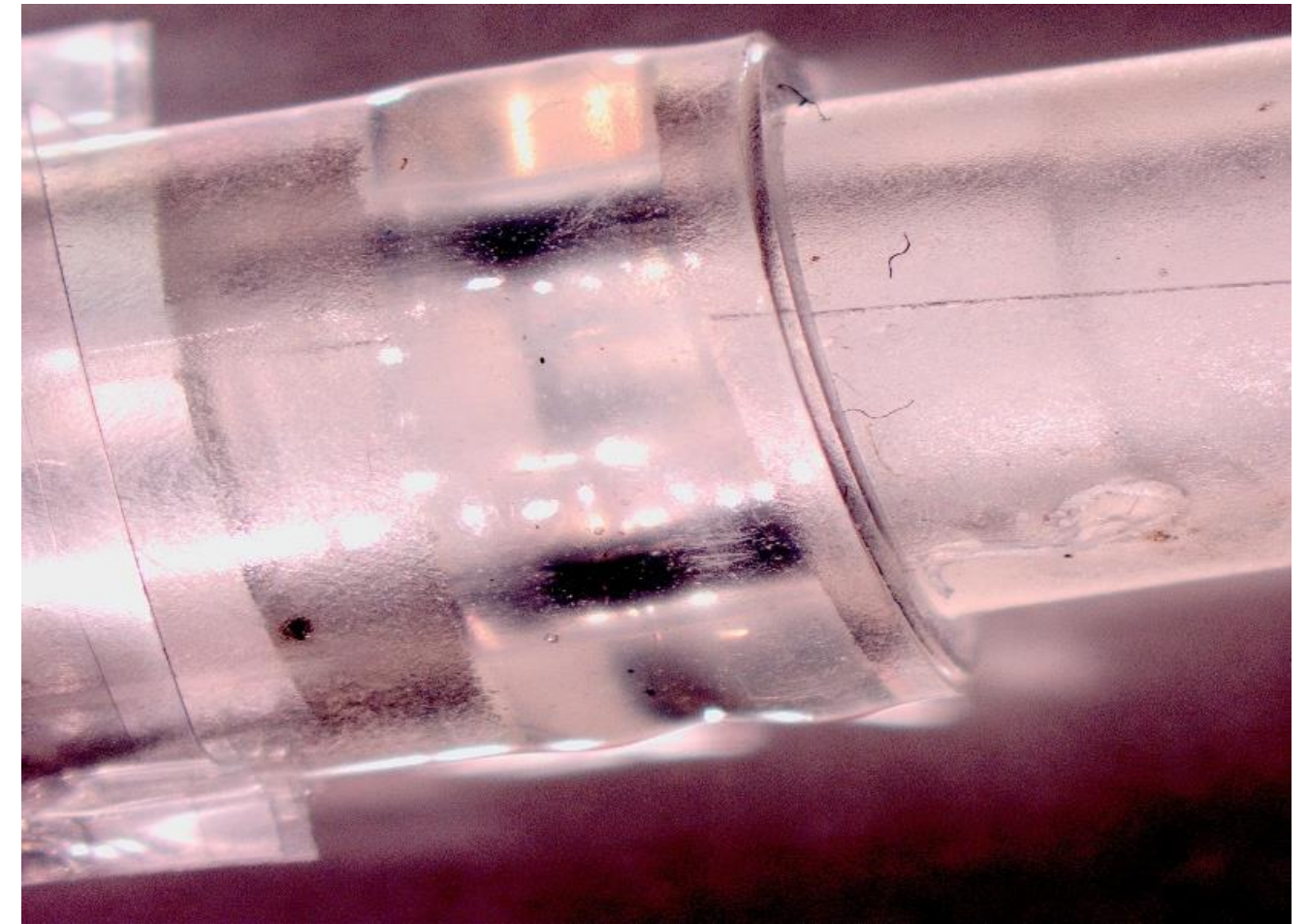
# APPLICATIONS IMAGES



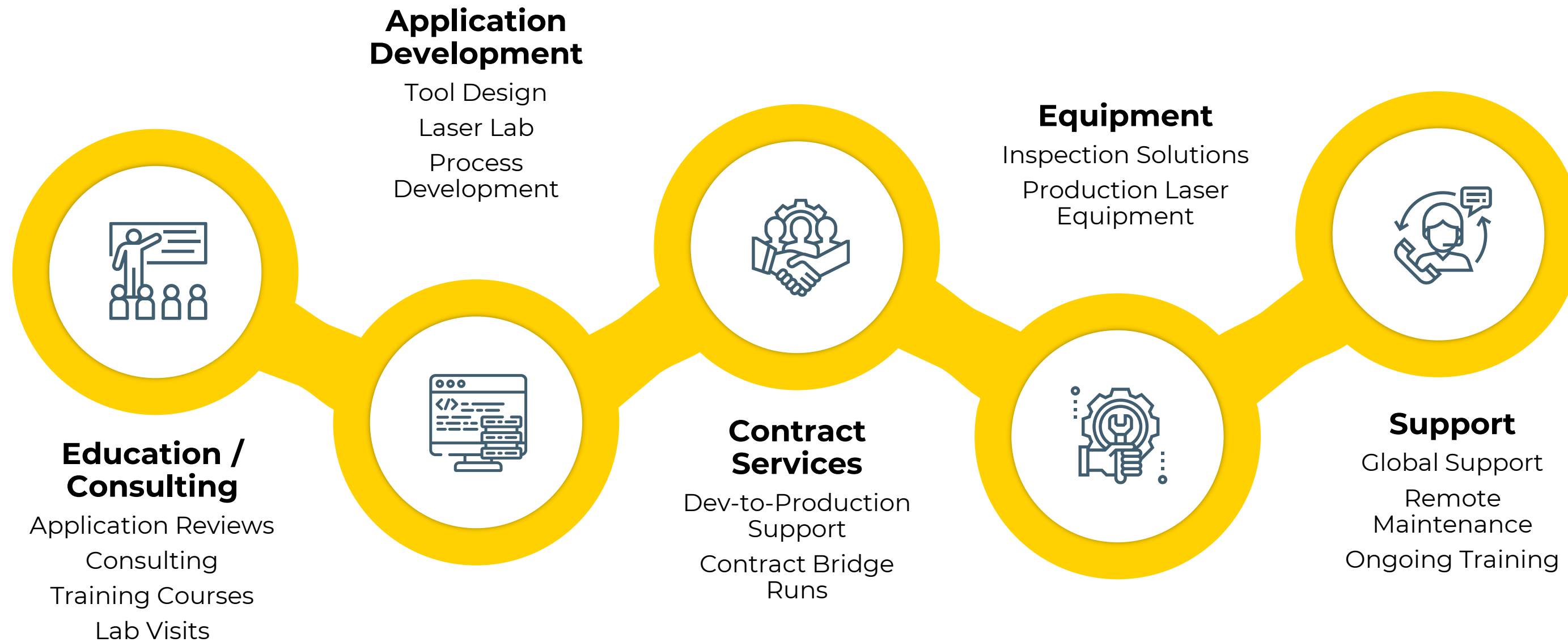
Material – COC; Upper part thickness -0.38 mm; Weld width – 0.2 mm



# APPLICATION IMAGES



# YOUR PATH TO SUCCESS



# PROJECT ROADMAP

Dukane

Customer

Both

Critical Milestones

DISCOVERY

1 day

1-3 days

1-2 days

1-2 days

Discovery Call

NDA Executed

Send CAD + Info

Design Review Done

Feasibility / Review Call

Quote Prototype Work

R&D

1-2 weeks

1-2 weeks

1-2 days

PO Placed / Kickoff Tools

Proto Tools Finished

Process Development Finished

Welded Parts Needed for Eval.

Design Locked

PRODUCTION

1-5 days

12-18 weeks

1-2 weeks

Mold Tools Purchased

Equipment RFQ

Eq. Quote Submitted

Equipment PO Placed

Equipment Build Done / FAT

Install / SAT

STOP

# QUESTIONS TO BE READY FOR

**DUKANE**

## Project Data Sheet | Laser Plastic Welding

Please email this sheet along with your assembled CAD files to your Dukane rep, STEP files preferred

Yellow Fields = Required

### Overview Information

Company		Date Opened	
Address		Sales Rep	
Customer Project Name		Territory No.	
Market Code		Laser Rep	
Project Number		CAD Received?	

# Q&A



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### Online

[www.dukane.com](http://www.dukane.com)

# COMMON PITFALLS

Pitfall	Solution
<b>Material Selection: Non-compatible or non-weldable materials</b>	Refer to Material Compatibility Chart as starting point, consult an expert at beginning of project, and have samples tested
<b>Poorly transmissive upper layer – fills (glass, TiO2) or dyes, etc.</b>	Keep glass fills below 50%, work with vendors familiar with laser weldable materials
<b>Bad injection molded components – loose tolerances</b>	Tight tolerances are critical, select molding vendors that can meet specified tolerances, and work with an expert to help design your joints
<b>Parts deform under clamping pressure</b>	Ensure solid support under joint, anticipate 2-3 Newtons of force per square millimeter of joint surface
<b>Internal part features obstructing welding collapse</b>	Prototype tests should include populated parts, avoid hard stops if joint collapse is required
<b>Internal/external features refracting beam</b>	Keep channels, occlusions, molding gates, ejector and slide marks out of joint area if possible



# ***ADVANTAGES***

## **And Disadvantages of Laser Plastic Welding**

# ADVANTAGES OVERVIEW

Particulate-Free



Bond Strength Virtually That of Parent Material



Minimal Thermal or Mechanical Part Stress



Micron-Level Precision and Control of HAZ



No Damage to Surrounding Material or Internal Components



Smaller Parts



Highly Repeatable, Excellent for High Volumes and Automation



Aesthetically Pleasing Welds



Quality Control



Hold Tight Tolerances



3D Joints and Radial Welds



No Consumables + Low Failure Rate = Low Total Cost of Ownership



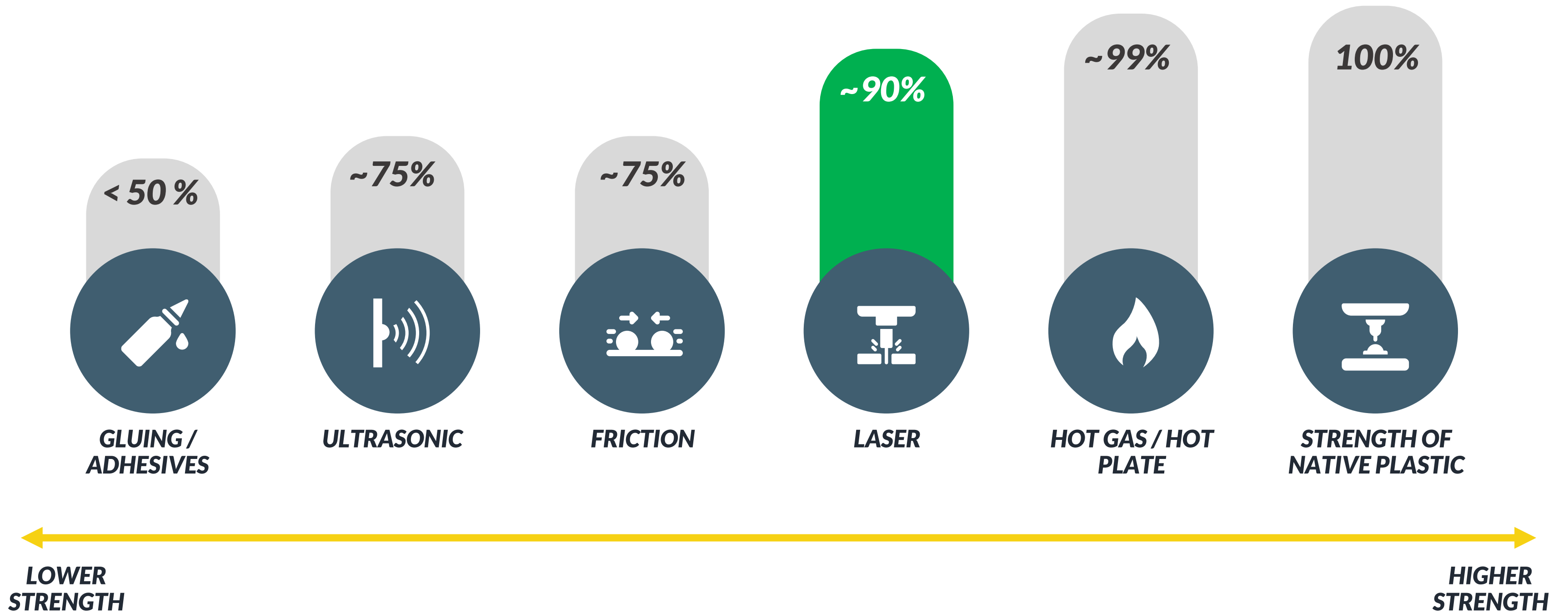


# ***PARTICULATE-FREE***

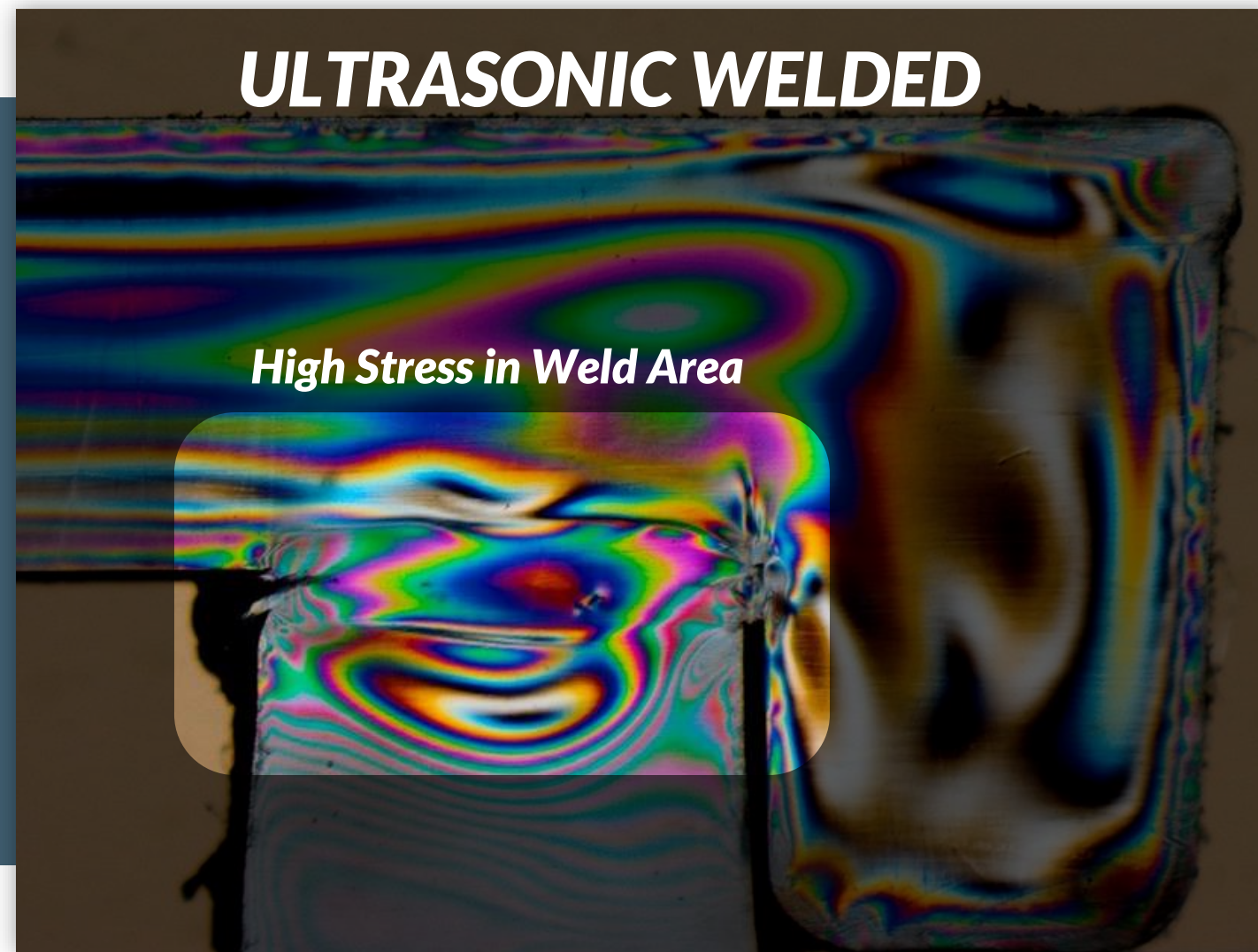
**With no relative motion or friction between the joining partners, laser plastic welding delivers beautiful, particulate-free joints every time.**



# HIGH BOND STRENGTH

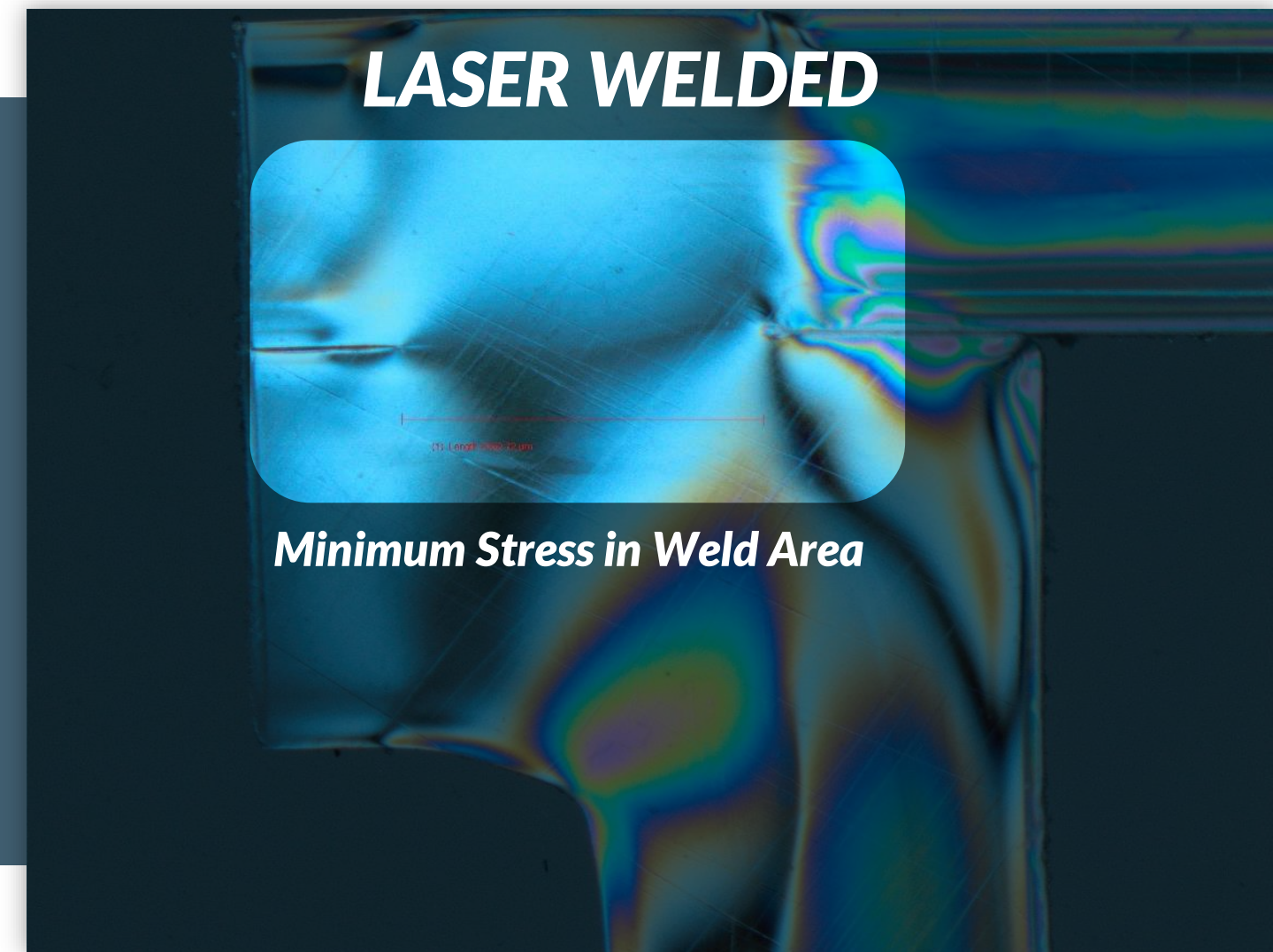


# MINIMAL PART STRESS



## THERMAL

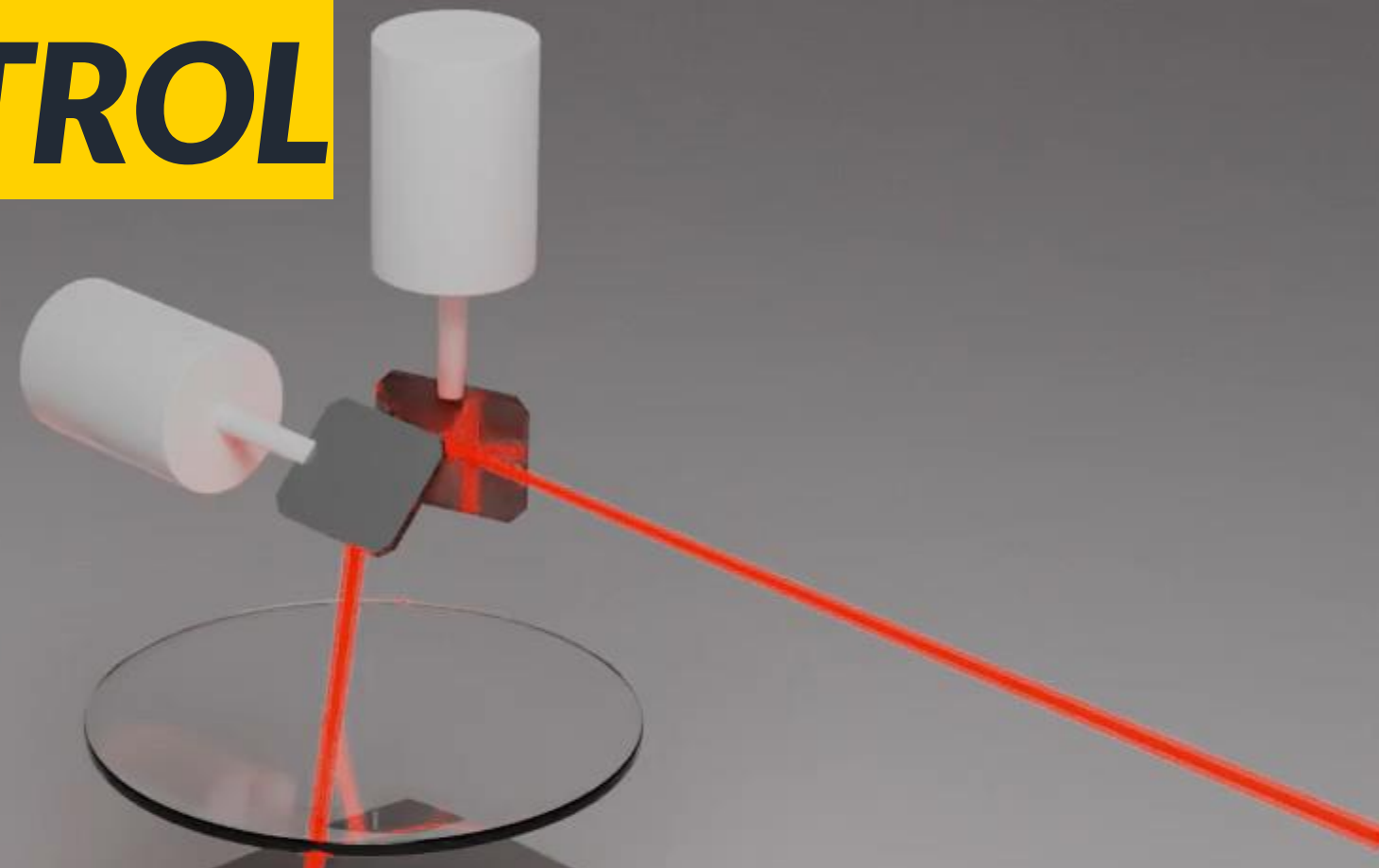
- *Precise control of the heat affect zone means minimal thermal stresses to the part*
- *Control of beam speed, power, and number of passes allows for gradual increase in plastification*



## MECHANICAL

- *The only mechanical stress to the part is from clamping to ensure joint contact during welding*
- *No (or precisely controlled) relative motion between parts*

# PRECISION CONTROL



## Repeatability

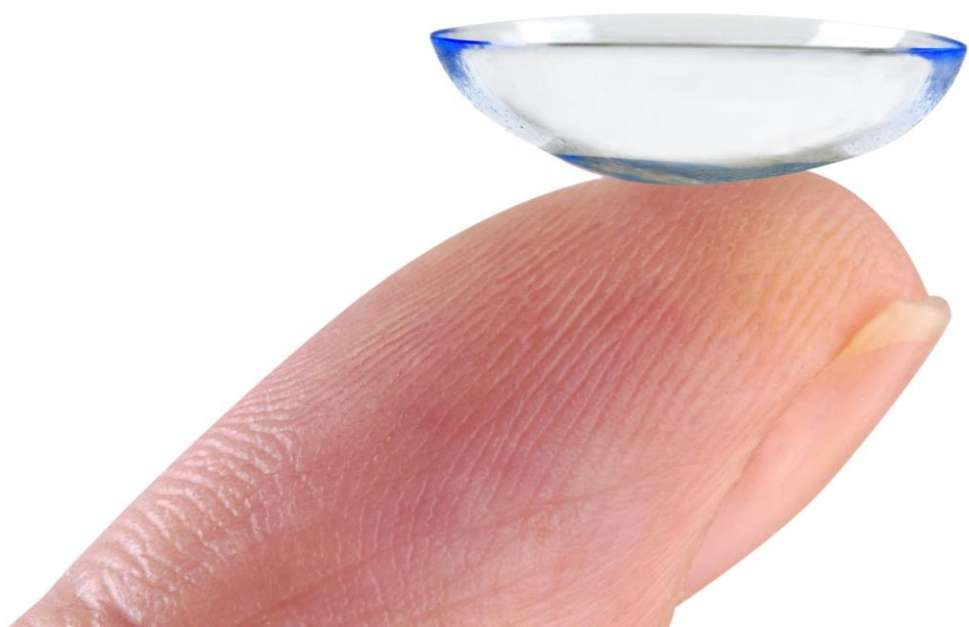
+/- 5 microns

## Beam Spot Size

1 $\mu$ m: <0.5mm

2 $\mu$ m: 0.3mm

# **SMALLER PARTS**



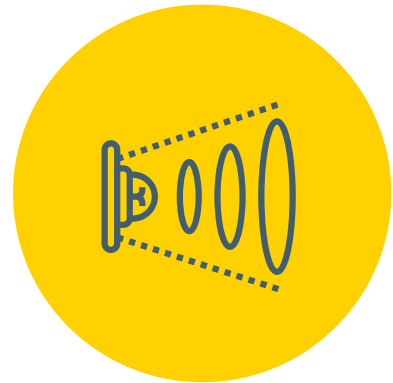
# **AESTHETICALLY PLEASING WELDS**

**Laser welded joints are consistent and clean**



**No need to hide weld joints behind bezels**

# QUALITY CONTROL



## Infrared Machine Vision Inspection

Non-destructive, post-weld inspection



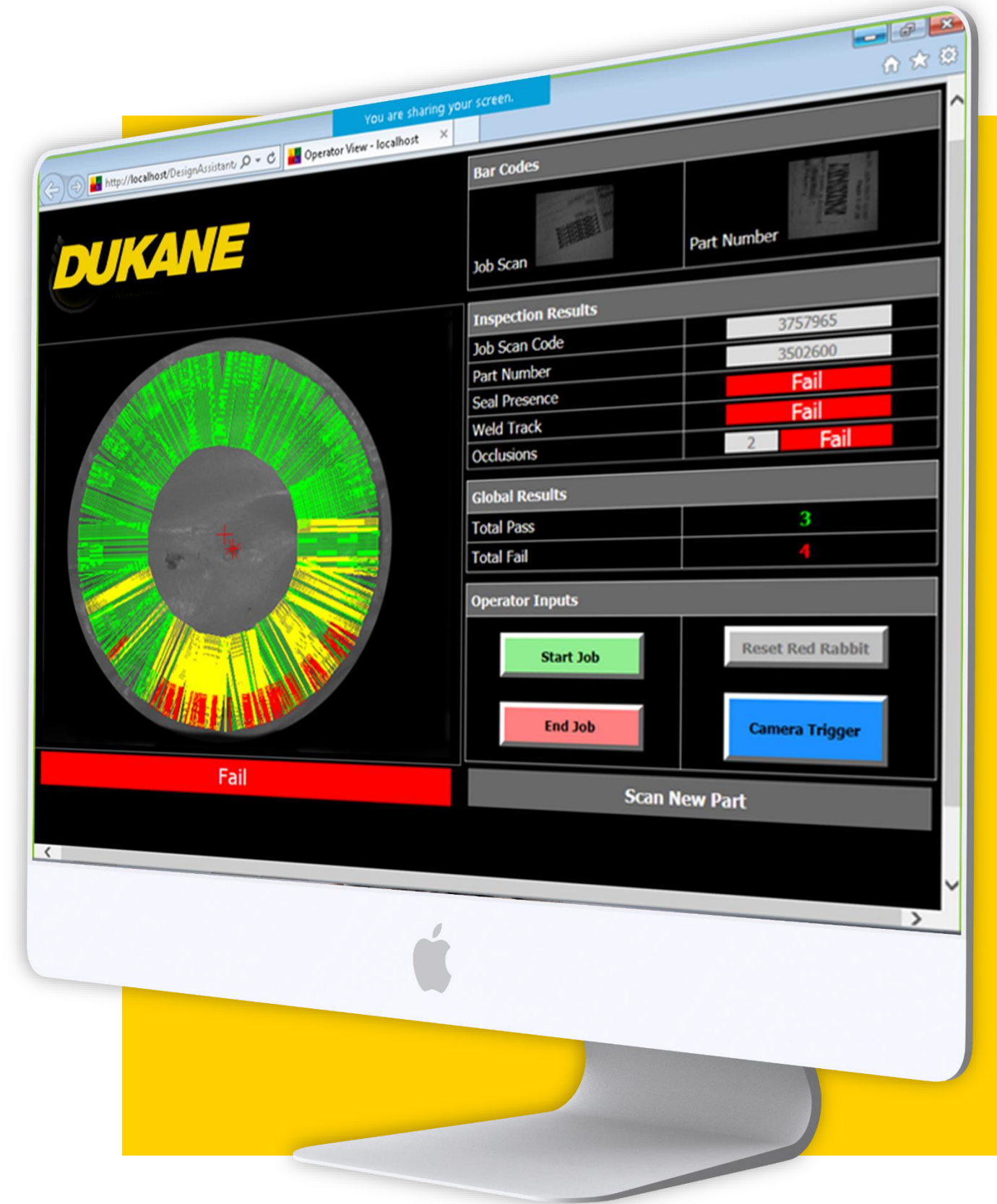
## Pyrometer

Thermal energy at joint, in-process



## Collapse Monitoring

Joint rib melt travel



# DISADVANTAGES

## Both

Requires good/excellent part tolerances

Learning curve, lot's of gray areas

Higher upfront capital expense, ~\$190k+ USD

## TTLW / 1 $\mu$ m

Requires transmissive and absorptive layers (dissimilar color or additive make-up = separate molds)

## TLPW / 2 $\mu$ m

Max upper layer thickness 3.5mm

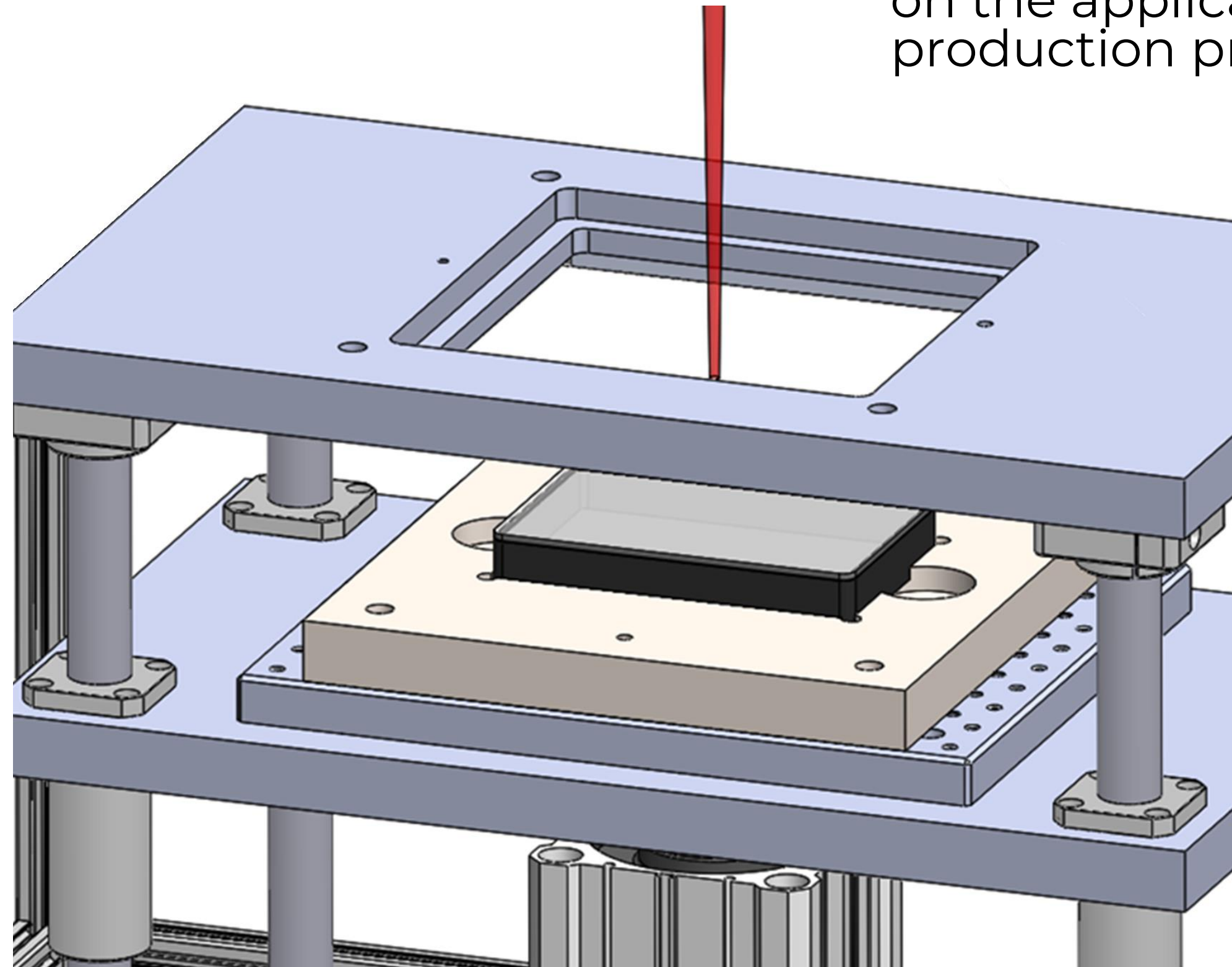
Speed

Volumetric heating of joint typically requires clamping directly on joint surface = typically only glass can be used to clamp



# BASIC CLAMP UNIT

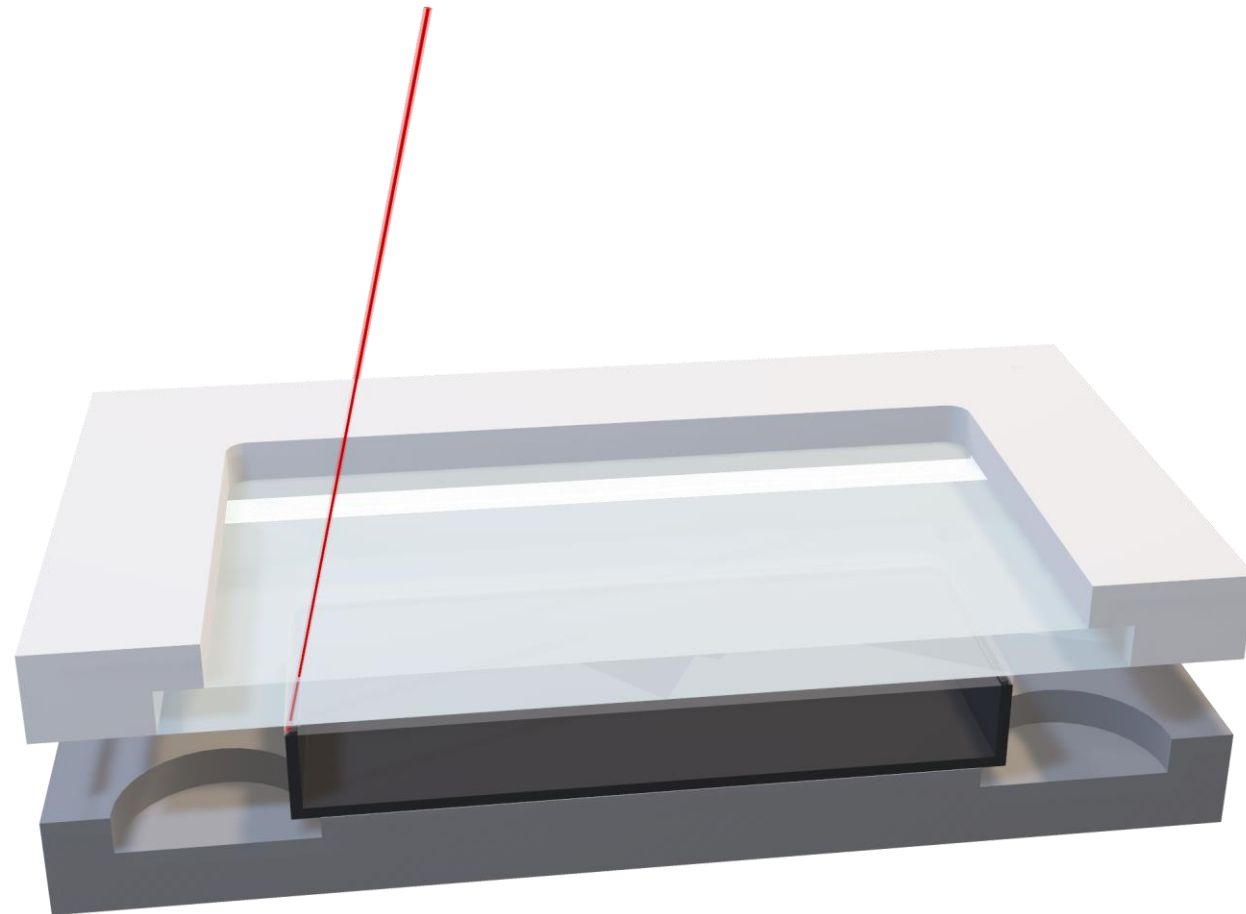
Clamp up or down depends on the application and production process



Lower fixture to house the part accurately

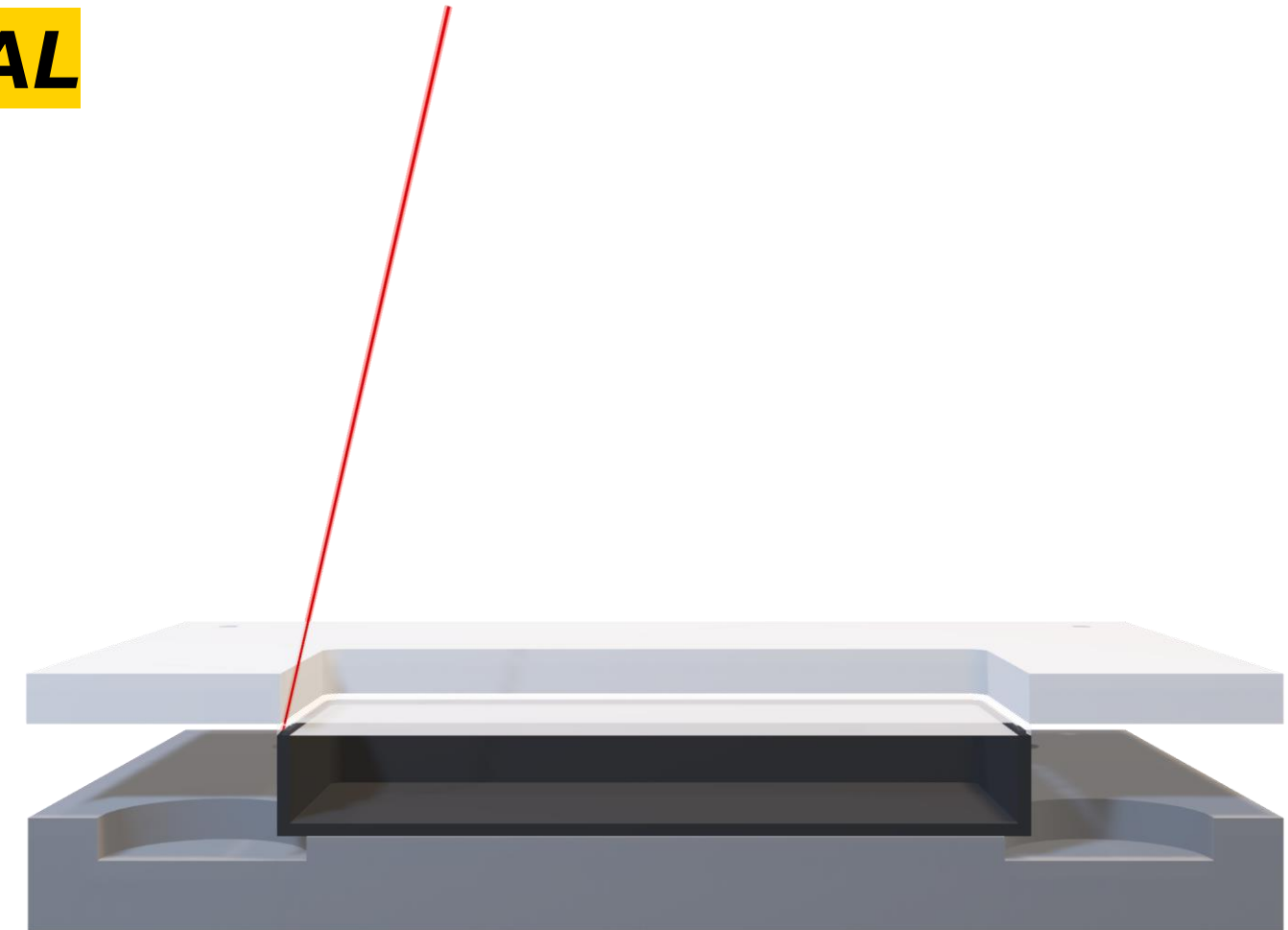
# TYPES OF CLAMP TOOLS

## GLASS/ACRYLIC



- Easy to build
- Relatively less expensive
- Used in Lab/Prototyping
- Requires cleaner environments

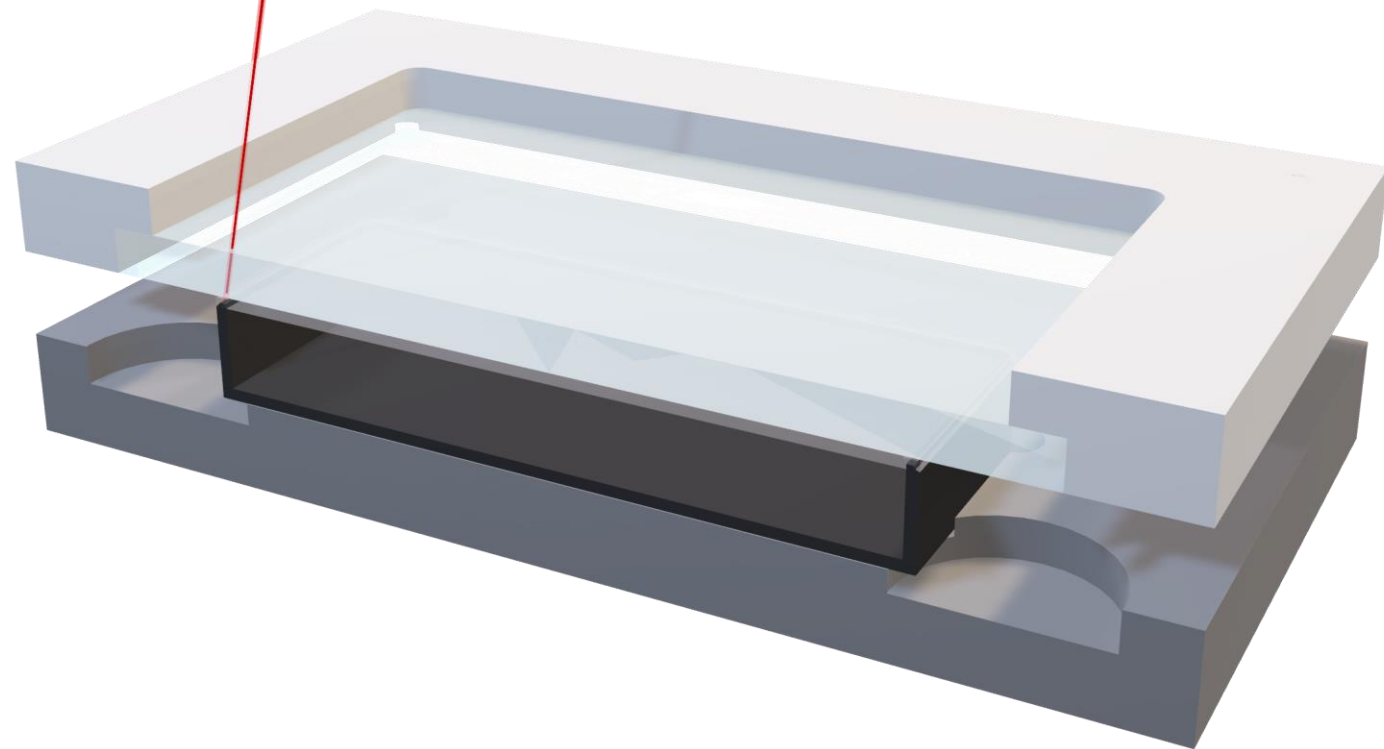
## METAL



- Clean and Robust
- Inside, or Outside Clamp Pressure depending on the application
- Not suited for parts that are flexible

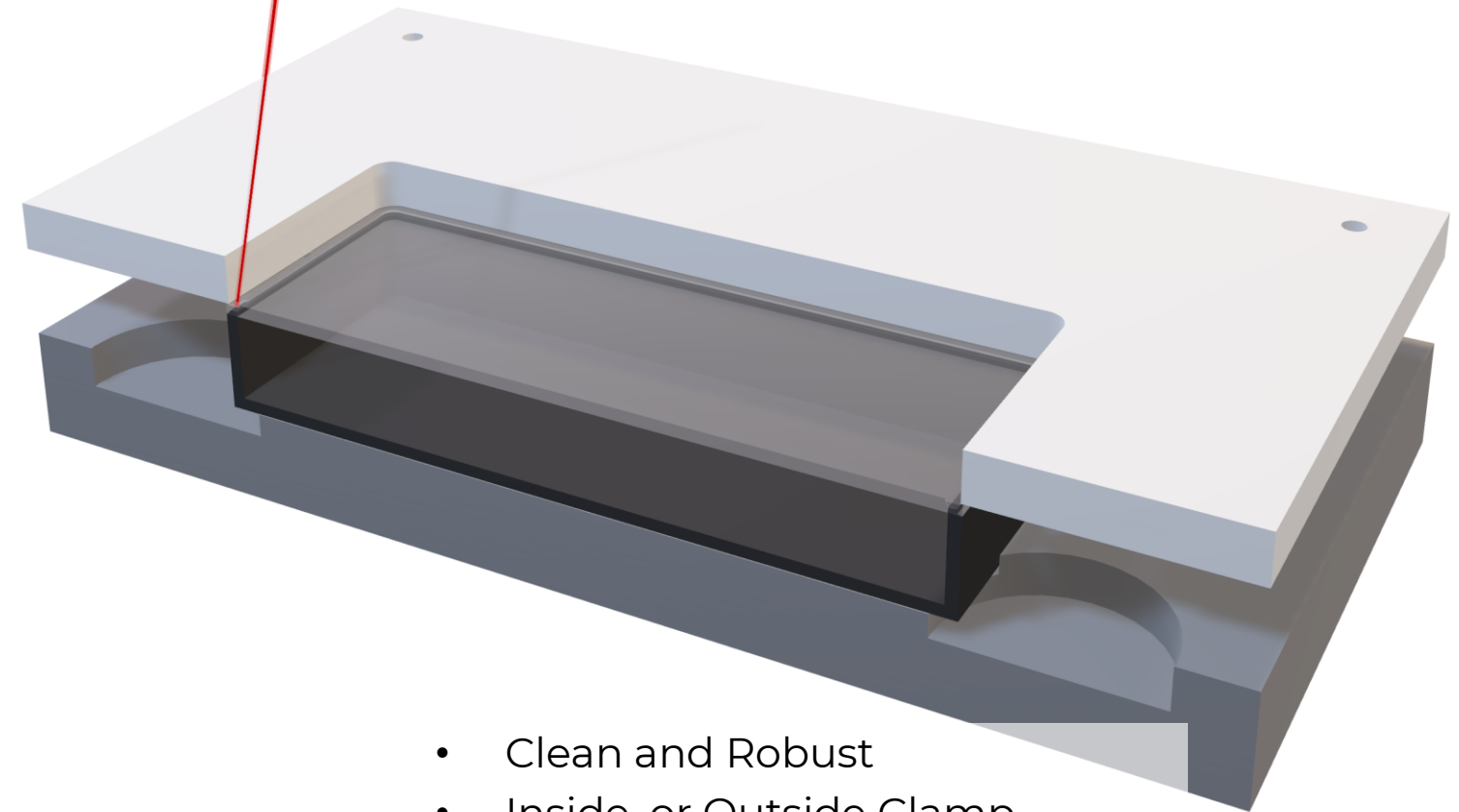
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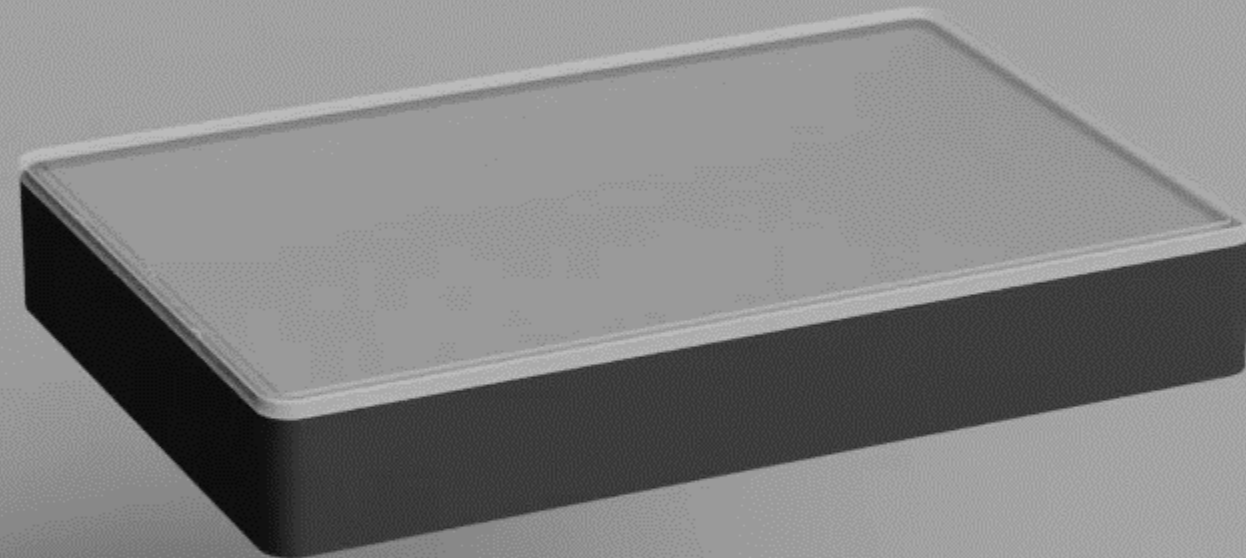
## METAL



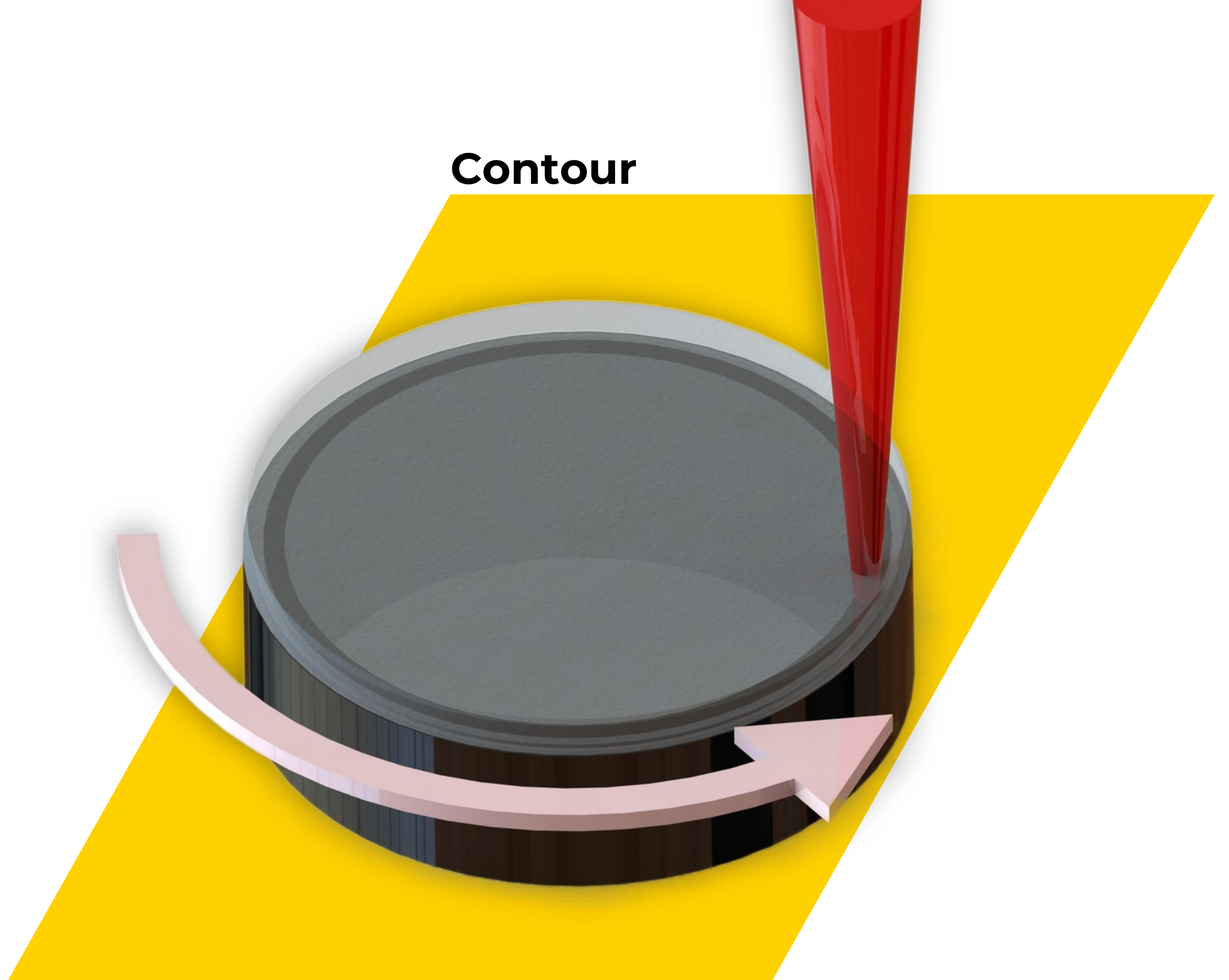
- Clean and Robust
- Inside, or Outside Clamp Pressure depending on the application
- Not suited for parts that are flexible

# TYPES OF CLAMP TOOLS

## HYBRID CLAMPING

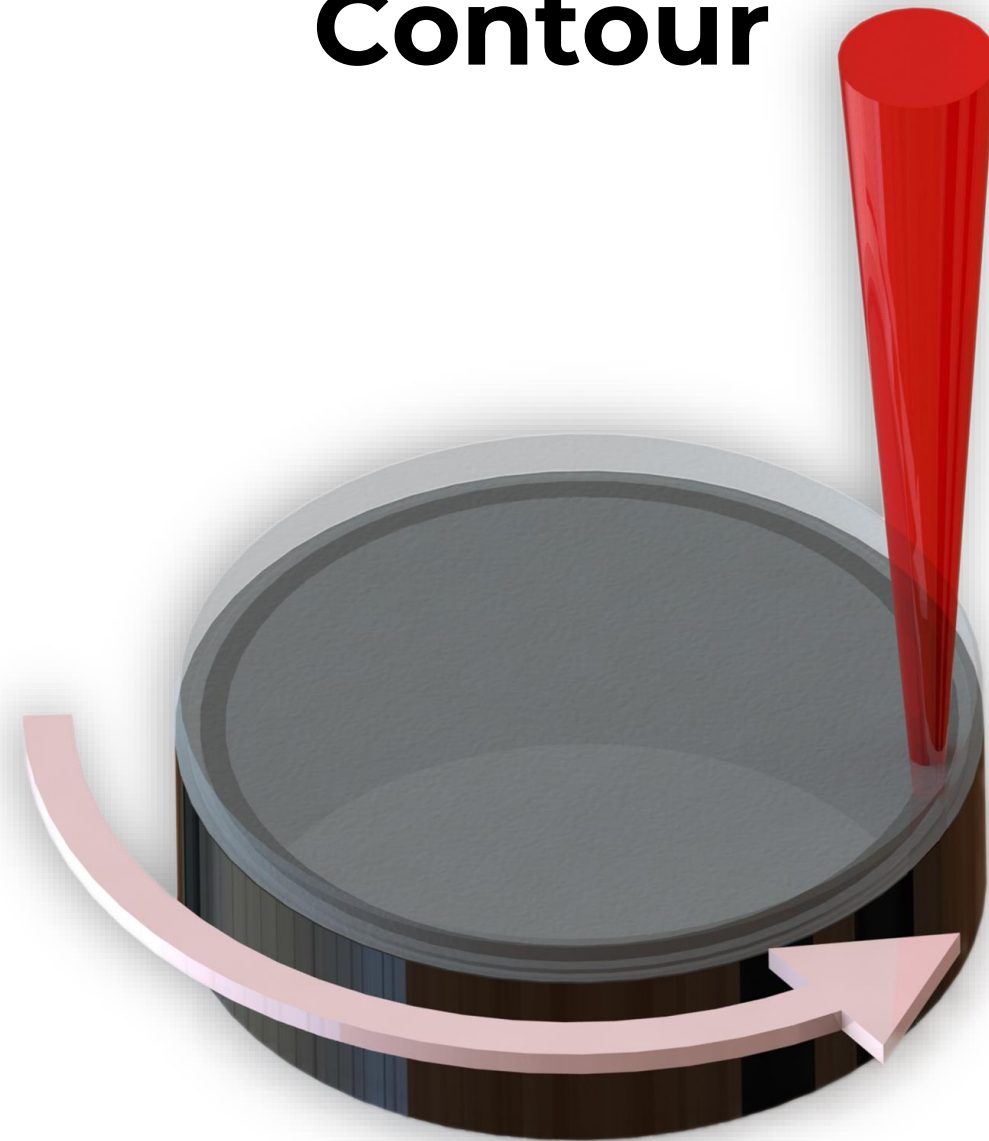


**PROCESS  
TYPES FOR  
2 $\mu$ M**



# LASER WELDING PROCESS TYPES FOR 1 $\mu$ M

## Contour



- Laser beam moves once around the weld area
- Well Suited for Lap Joints on flat parts

## Simultaneous

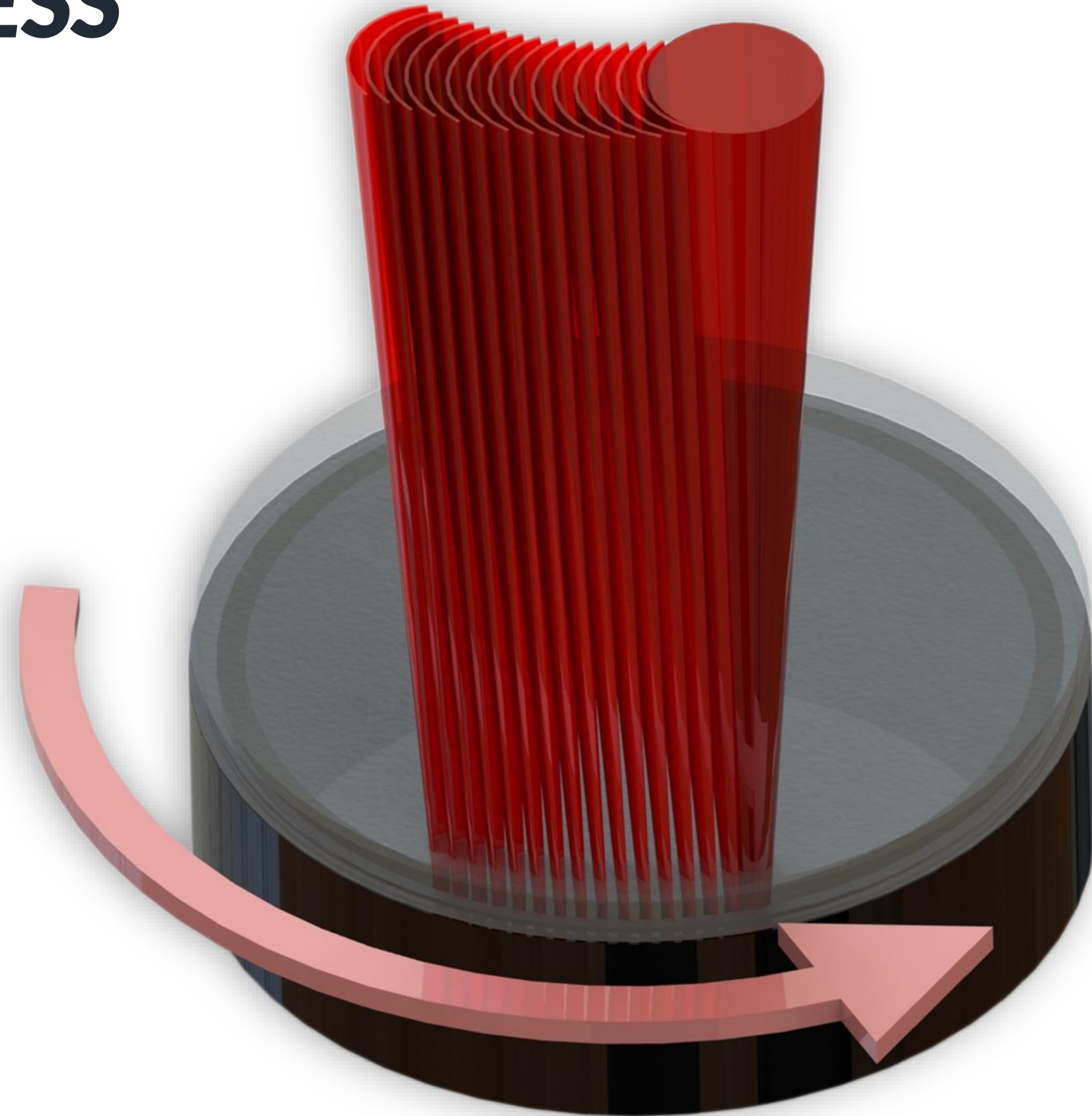


- Laser beam falls on the entire weld area at once
- Locked in to follow the same weld pattern
- No flexibility in changing the weld pattern if part changes anytime

# LASER WELDING PROCESS TYPES FOR 1 $\mu$ M

## Quasi-Simultaneous

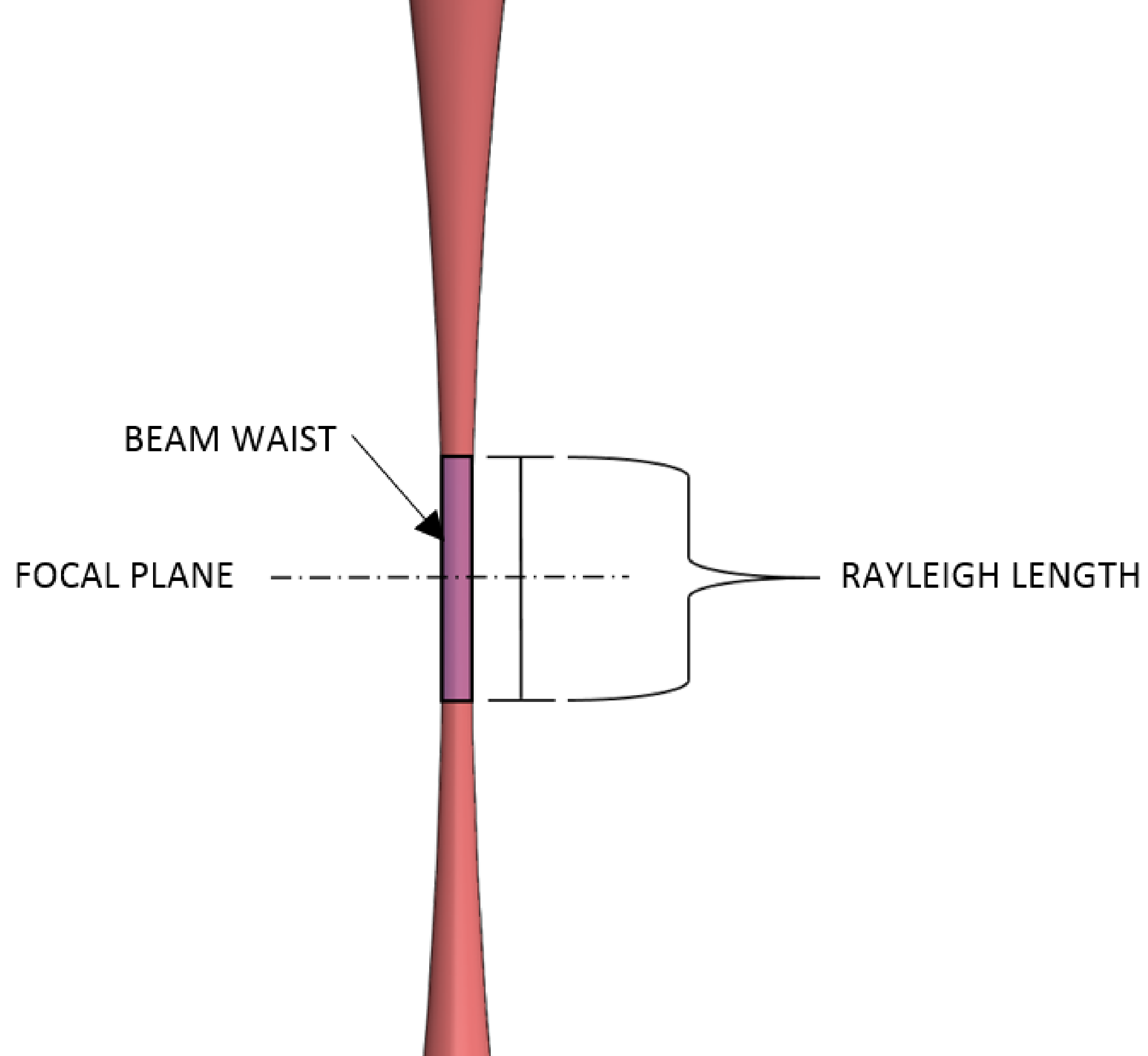
- Laser beam moves multiple times on the part at a very fast speed
- Produces uniform melt with less mechanical stress
- Overcomes part tolerances with collapse
- Flexibility to change weld paths if needed using the software
- Very well suited for Large Parts



# BEAM PROPERTIES

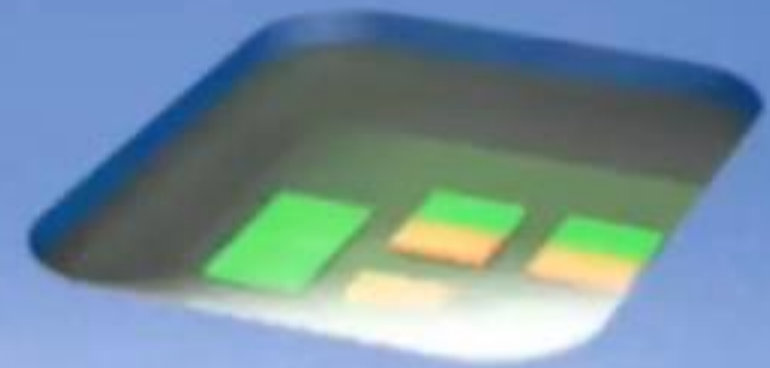
## Rayleigh length

- Area that welding can be non-planar
- Beam is still “focused”
- Non-planar welds need to be less than 30deg. from normal





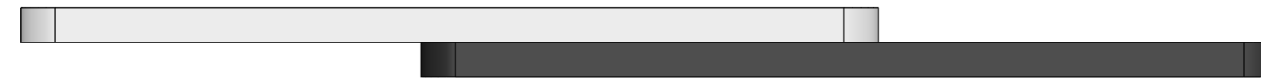
# ***GALVO SCANNER: HOW IT WORKS***



# JOINT PROFILES

## LAP STYLE

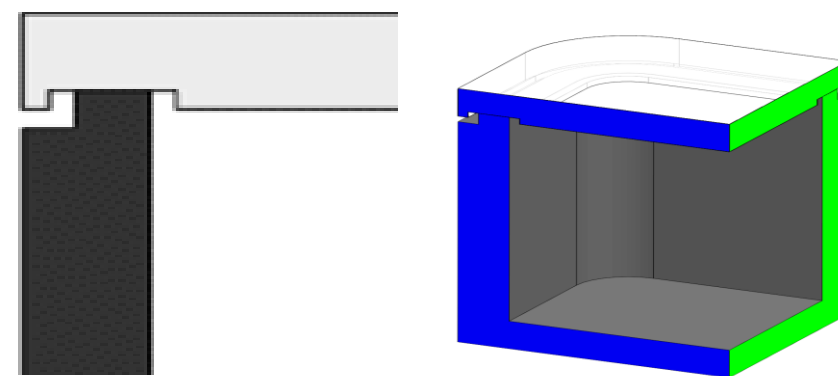
Well suited for small parts



## STANDARD SACRIFICIAL RIB

0.5mm height (collapse 0.35mm)

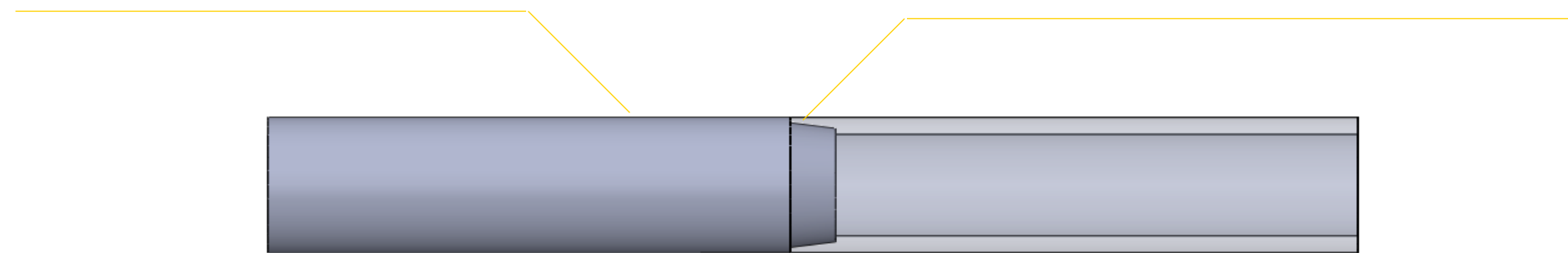
Large parts with tolerances  
Automotive Lighting or  
sensor housings



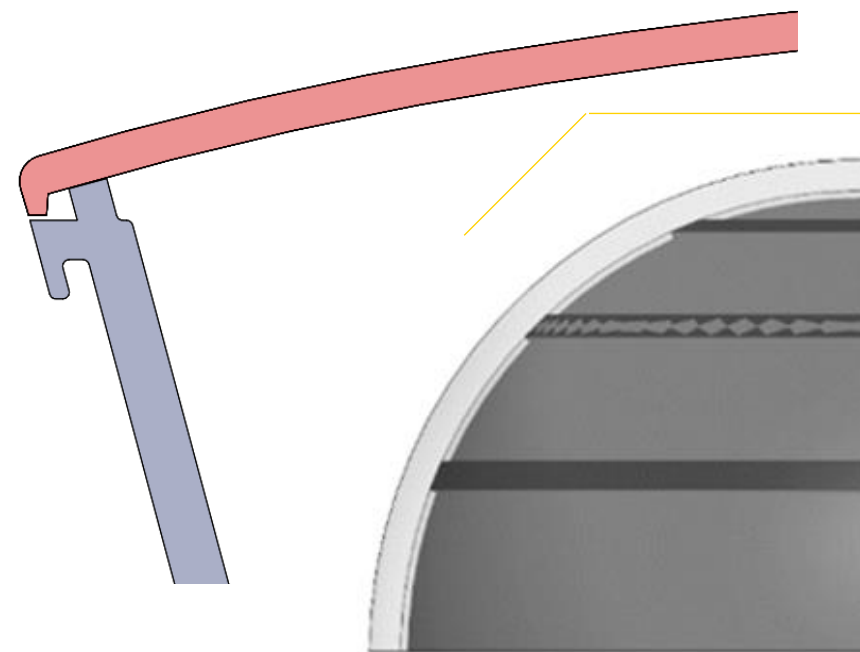
# JOINT PROFILES

## INTERFERENCE / RADIAL

Tubing Application  
Automotive filters



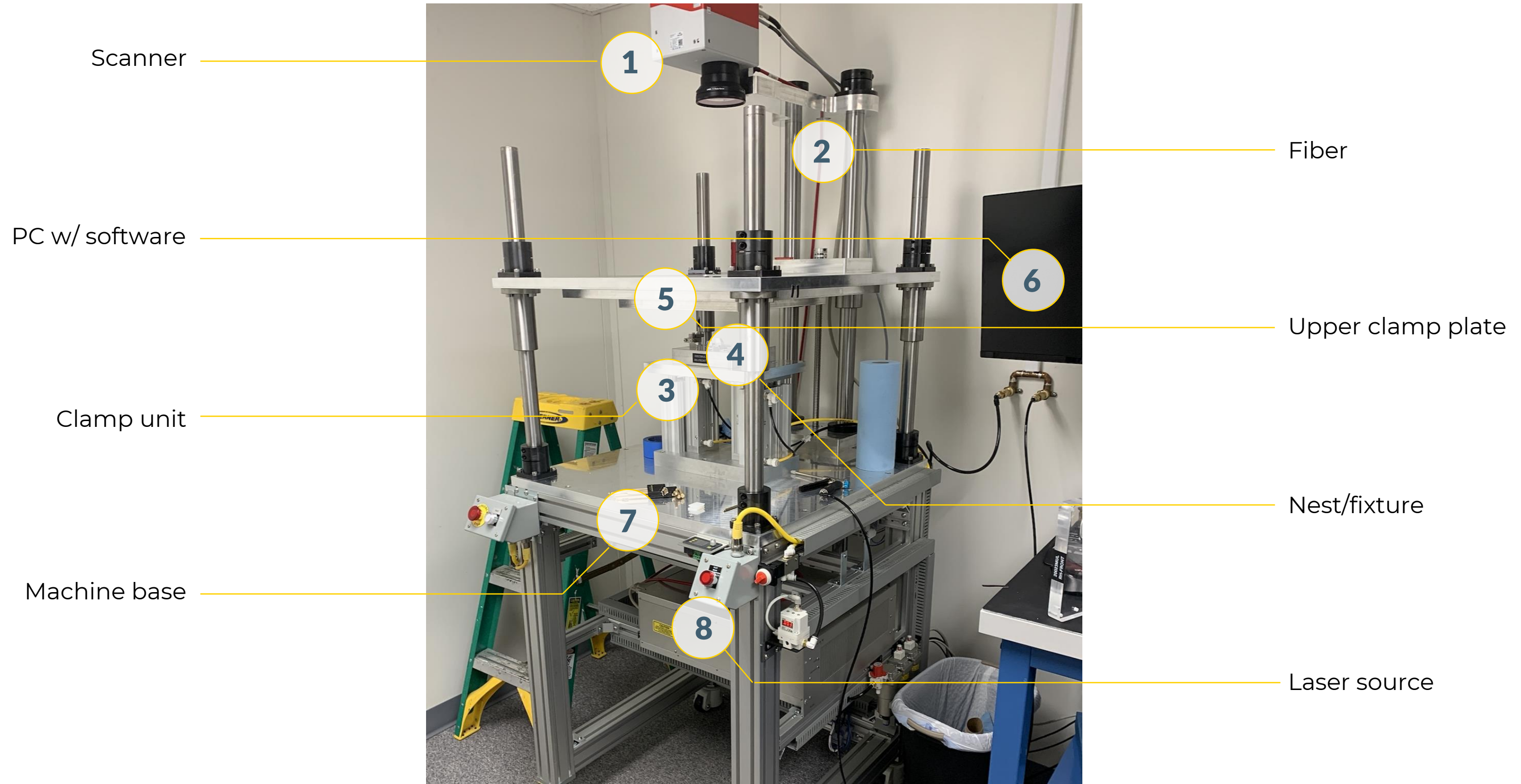
Creating contact at weld surface with interference



## 3D JOINTS / SPECIALTY

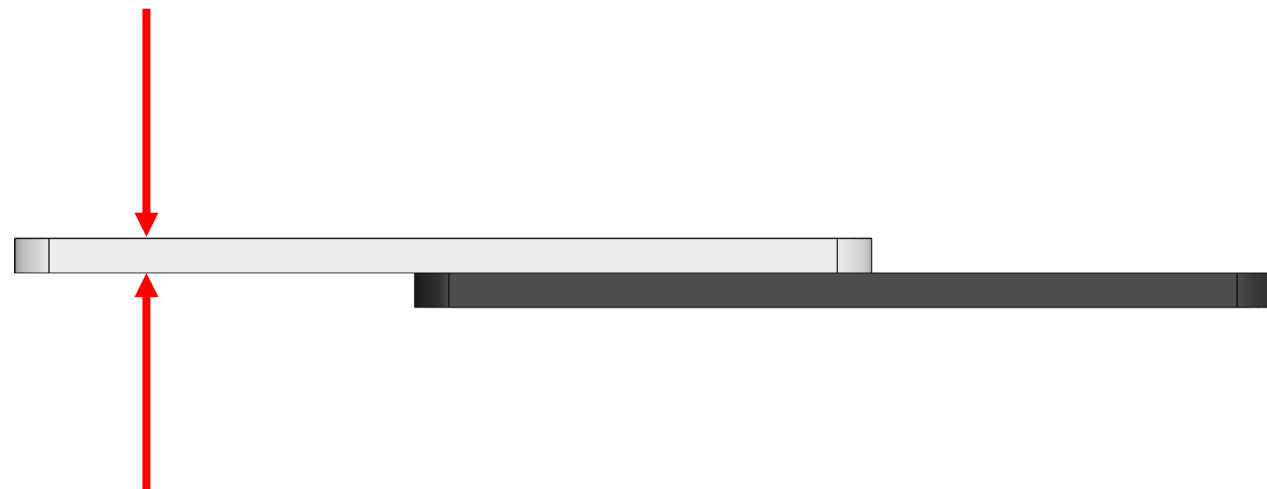
If the parts can be effectively clamped

# LAB SYSTEM



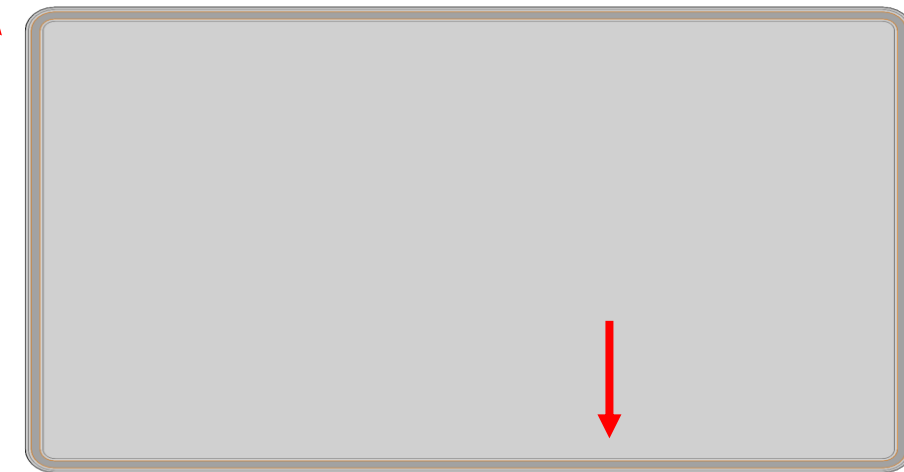
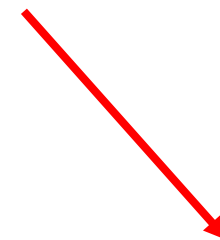
# GENERAL GUIDELINES

Uniform transparent layer thickness



Transparent layer as thin as possible

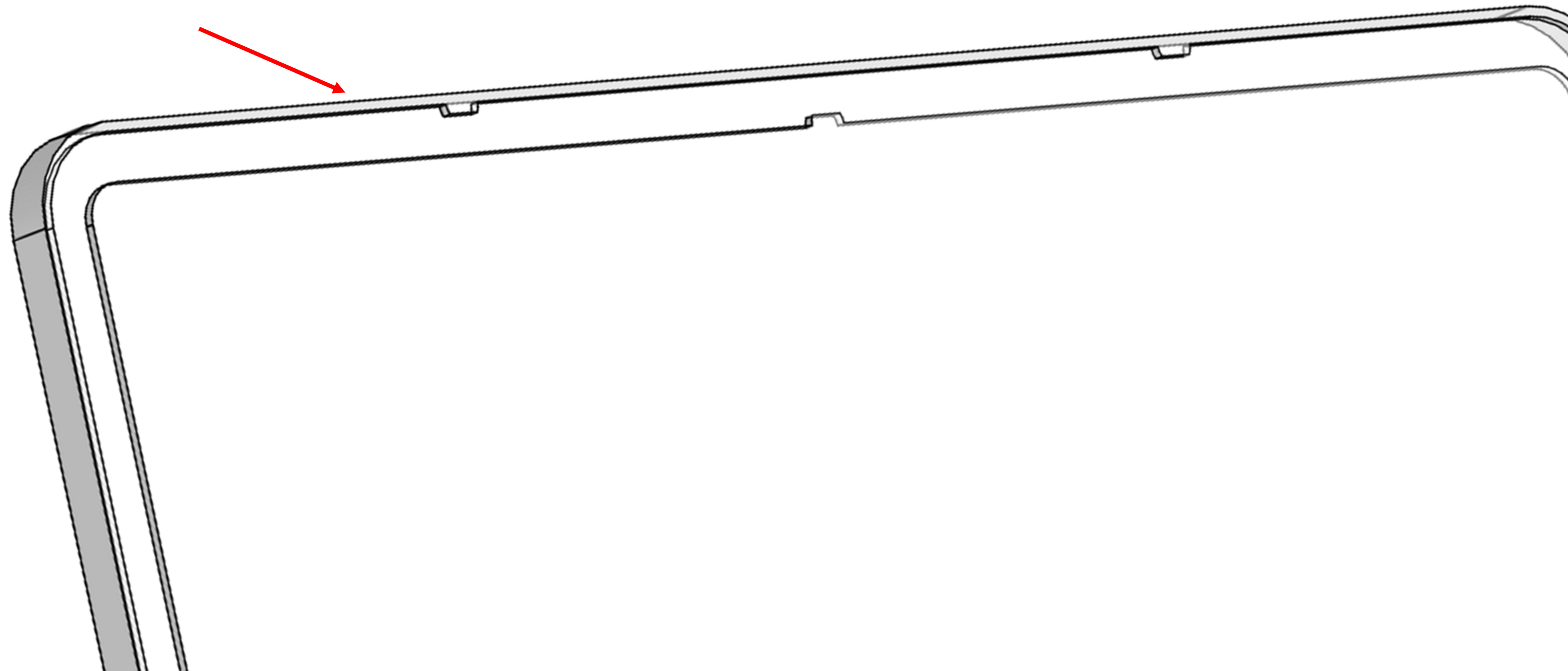
Radius all corners



Uniform joint width

# GENERAL GUIDELINES

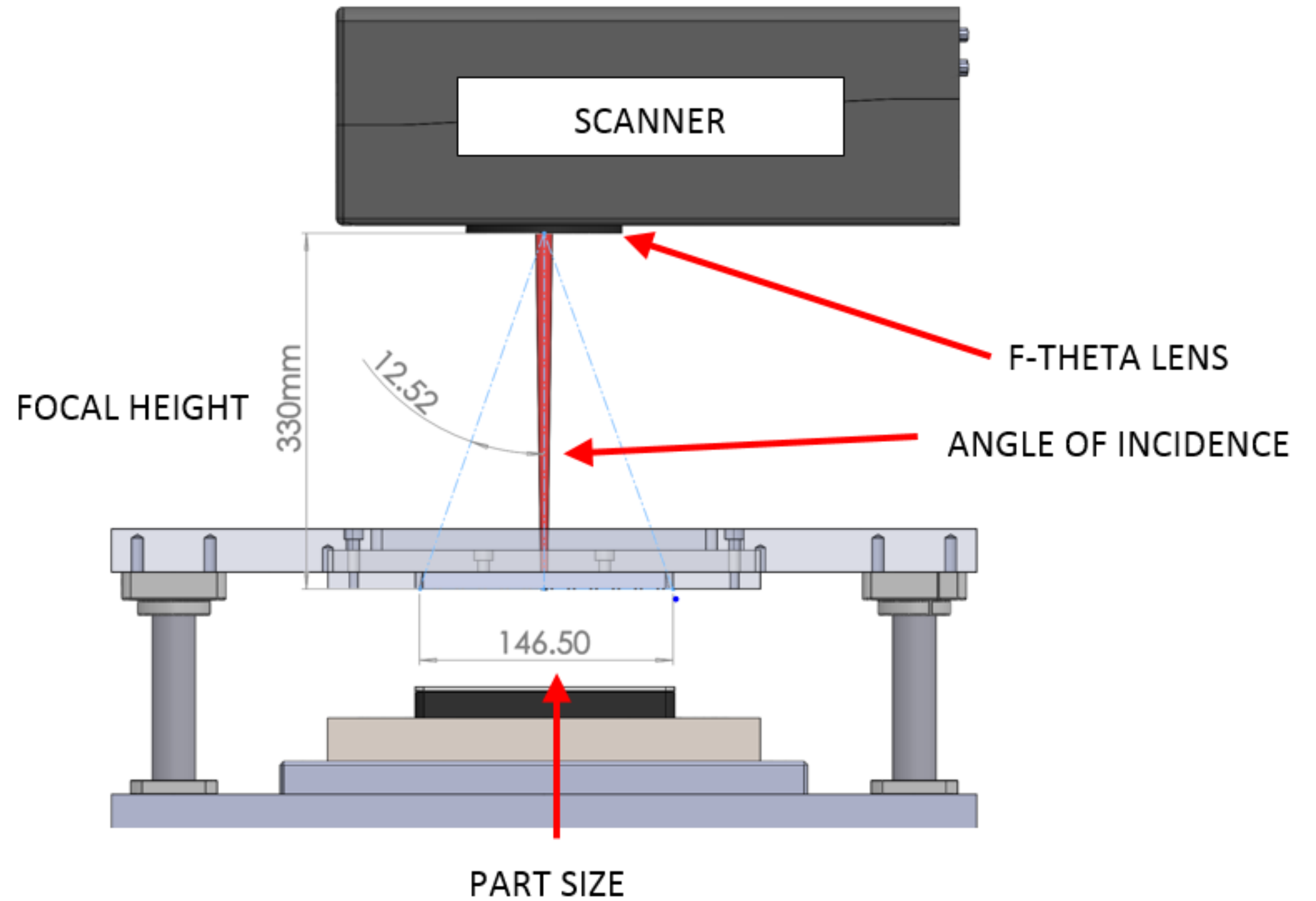
- No ejector pin marks, gates, or other anomalies in welding areas
- Centering features in part



# BEAM PROPERTIES

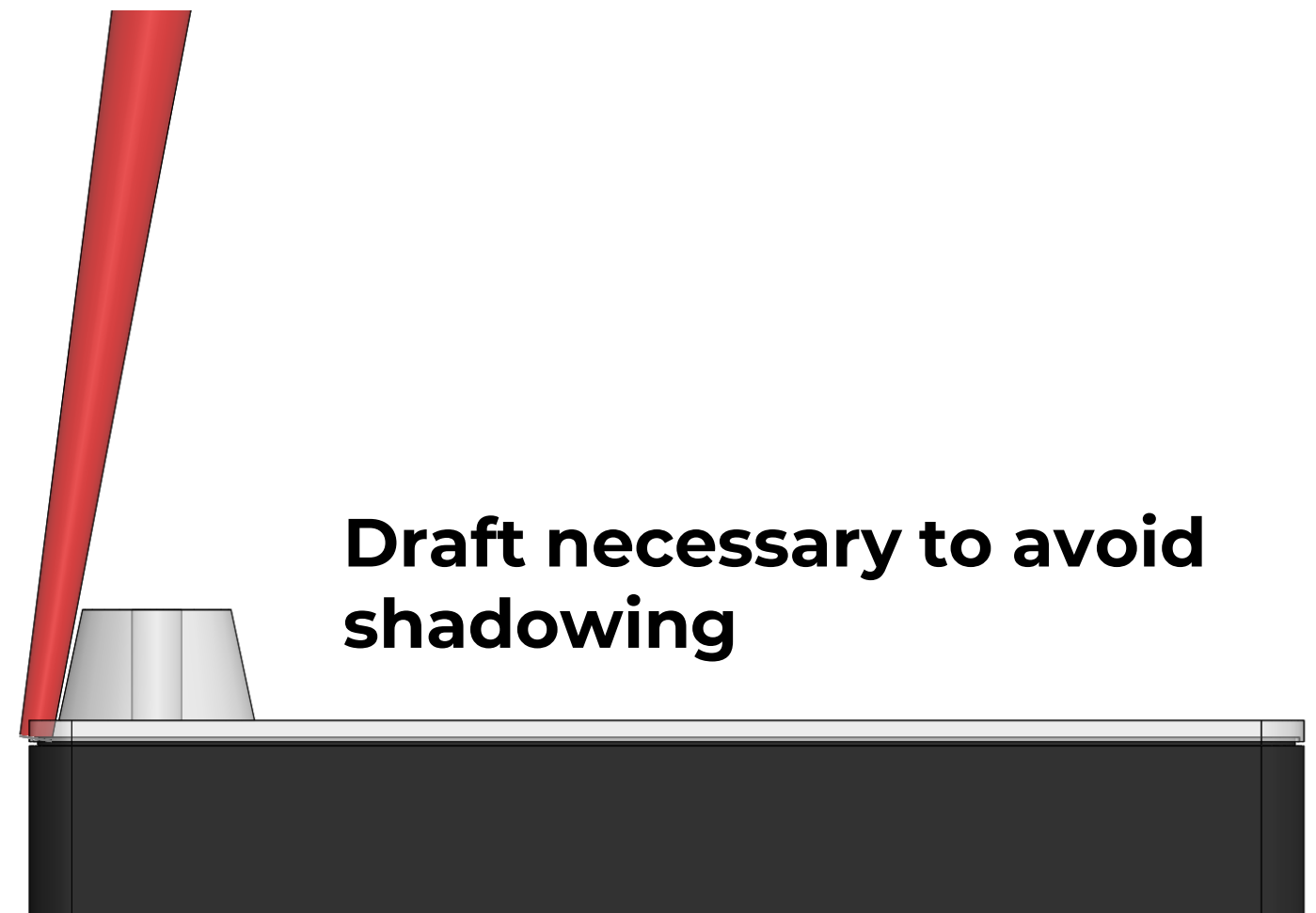
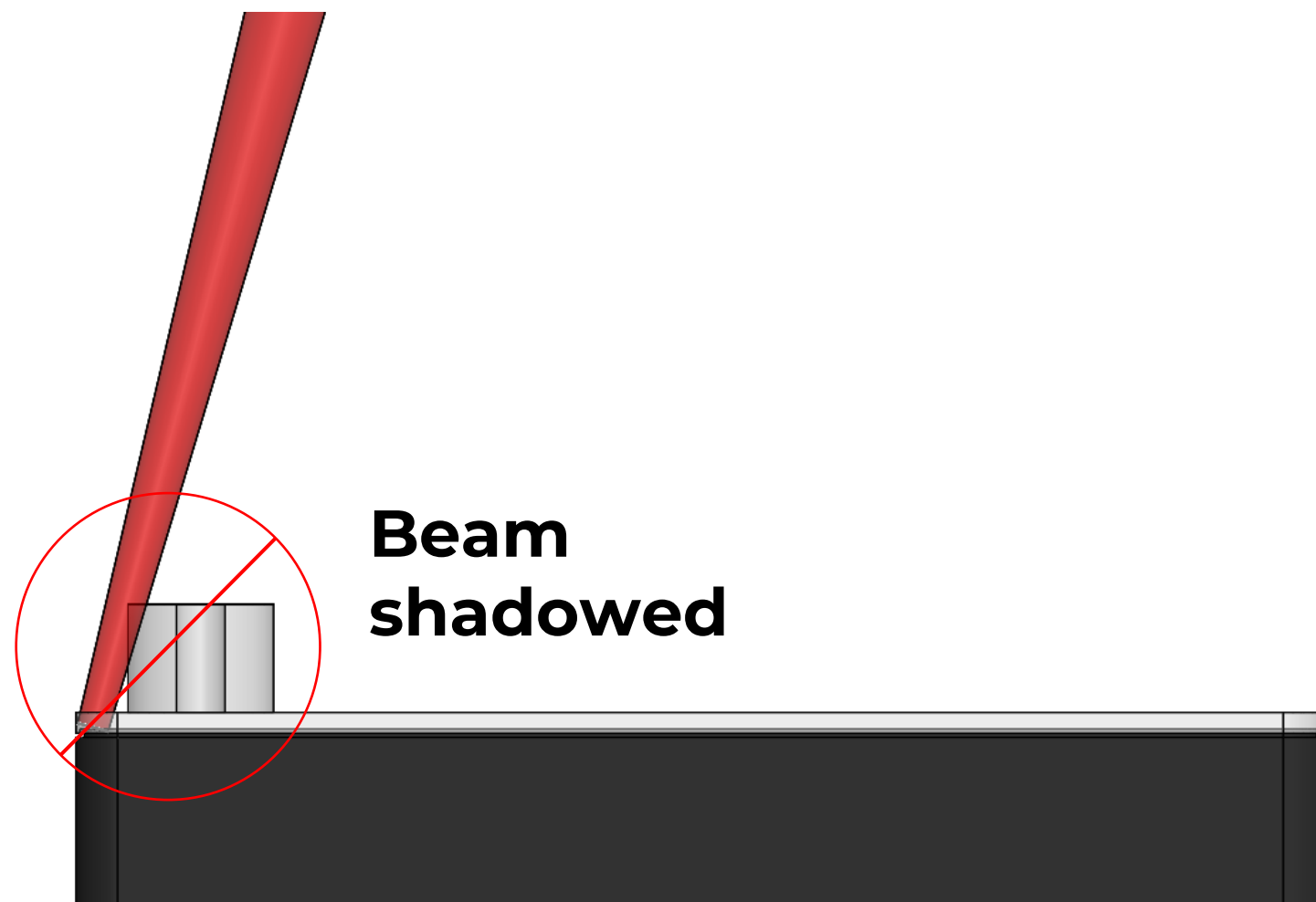


Angle of incidence



# BEAM PROPERTIES

## Design clearances on part features





# **BEAM PROPERTIES**

**Mirror effect  
from 3D  
features**



# **BEAM PROPERTIES**

**Mirror effect  
from 3D  
features**



INTRODUCING THE NRG LASER PLASTIC WELDING LINE FROM DUKANE

# NRGt SERIES



**EXPLORE THE FUTURE OF  
LASER PLASTIC WELDING.**

[DUKANE.COM/NRG](https://www.dukane.com/nrg)

A true, universal, plug-n-play laser welding solution. The modular NRGt platform was designed to handle virtually any size of part at any production scale—from high-mix, low-volume R&D and pilot production to high-volume, fully-automated scenarios. With advanced quality assurance, beam delivery, and automation modules the NRGt laser systems are fully-equipped, out-of-the-box to meet even the most demanding manufacturing requirements.



**NRGt**300

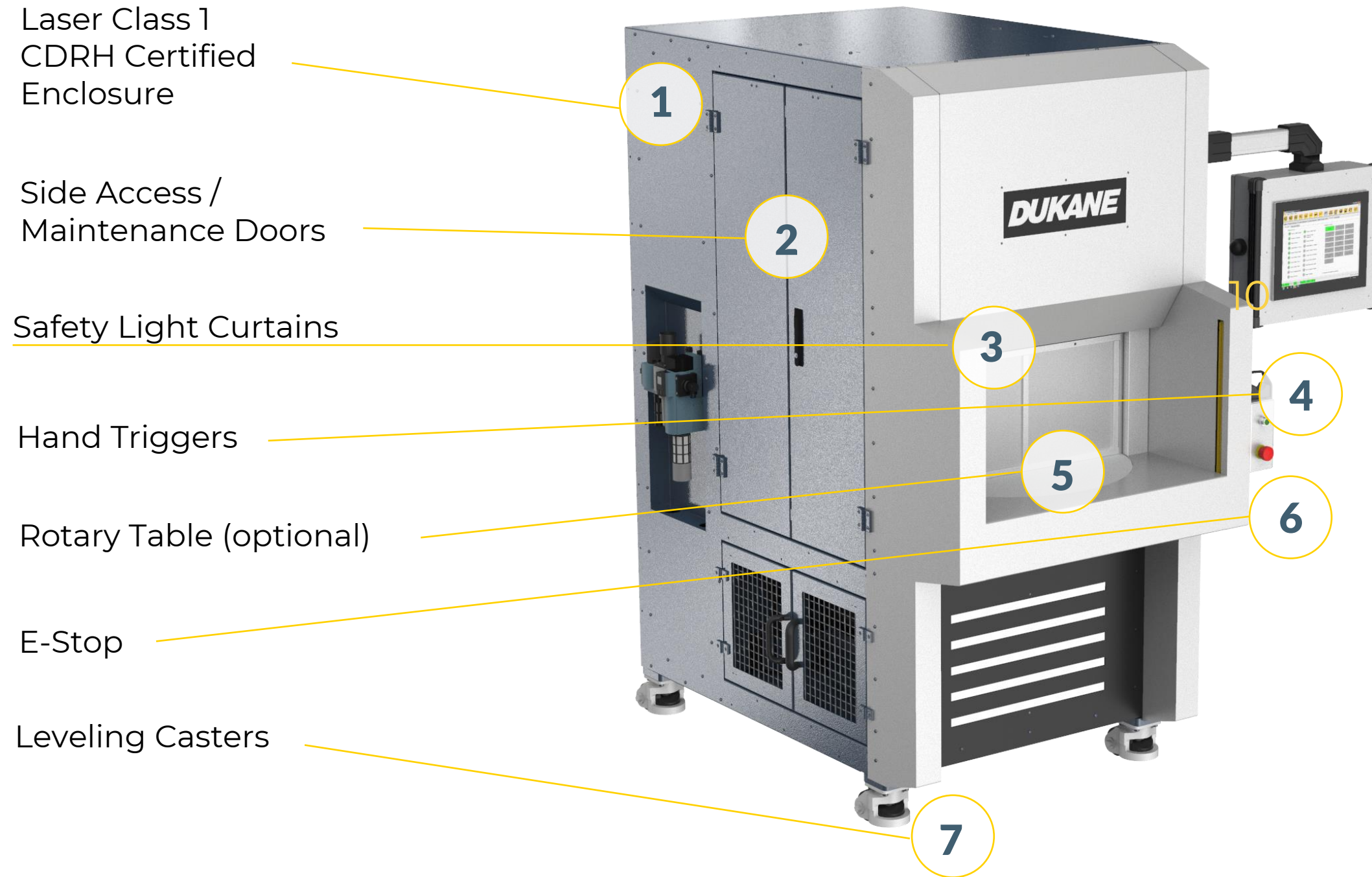


**NRGt**400



**NRGt**600

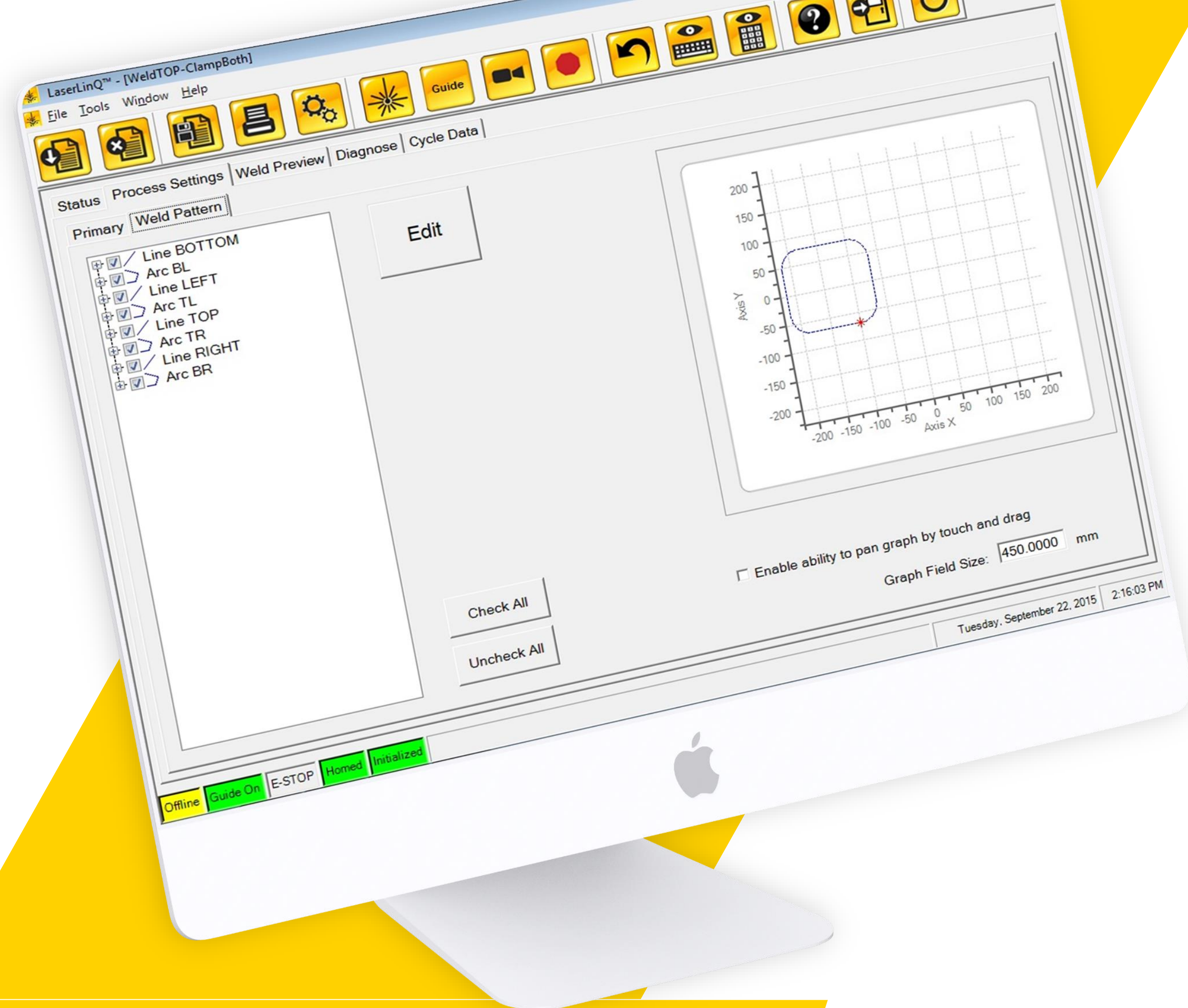
# PRODUCTION EQUIPMENT: TURNKEY



## NOT SHOWN

- Scanner/gantry
- Safety Interlocks
- Internal LED Work Lights
- Tri-Color Status Light Stack
- Hybrid Servo XY + Scanner
- 980nm or 2,000nm Laser Source
- Red Aiming Beam
- Clamping Unit
- Custom Tooling
- Real-Time CCTV Camera
- Fume Extraction Port

# SOFTWARE INTERFACE



# DUKANE WELDING TECHNOLOGIES



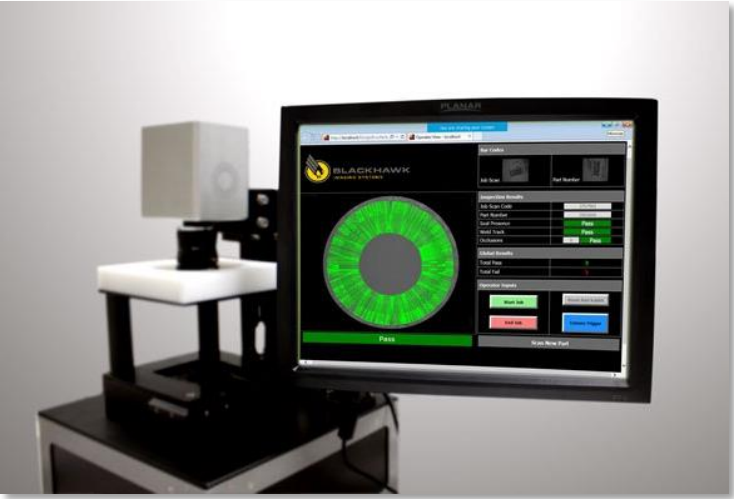
ULTRASONIC



SPIN



LASER WELDING



MACHINE VISION INSPECTION



HOT GAS



INFRARED



VIBRATION



HOT PLATE

# LASER SOURCES

## 1 $\mu$ m Laser Sources



- 980nm Direct-Diode Laser
- Air-Cooled
- 150W – 600W options
- For Through-Transmission Laser Welding

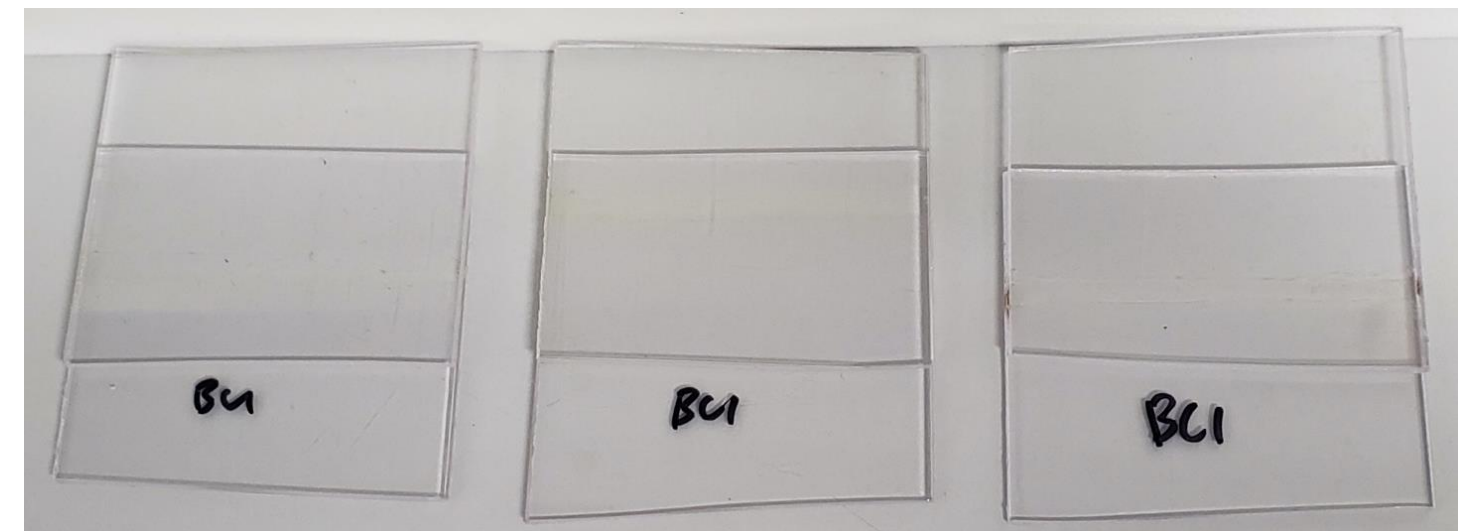
## 2 $\mu$ m Laser Sources



- 2,000nm Thulium Fiber Laser
- Water-Cooled
- 50W – 200W options
- For Clear-to-Clear Laser Welding

# OPTICALLY TRANSMISSIVE LASER ABSORBING ADDITIVES

Doped into plastic



Applied on surface