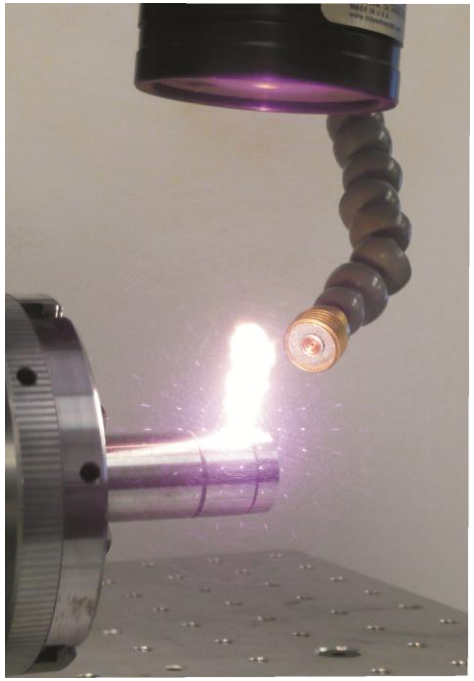
Laser Source Selection for Micro-welding Processes

Comprehensive Manufacturer of Metalworking Machinery



AMADA MIYACHI EUROPE

Dr. Mark Boyle – America
Ing. David Van de Wall – Europe

March-2016

About us

- Manufacturers of innovative equipment for advanced processes
- Expertise in metal processing – including laser welding, resistance welding, laser cutting, and laser marking

Amada Miyachi America Corporation

- 180 employees
- HQ in Los Angeles Area
- 120+ standard and custom systems built per year
- Applications Labs in Monrovia, CA and Wixom, MI
- ISO9001, CCC, CE and CSA Certified

Amada Miyachi Europe Corporation

- 120 employees in Europe
- 2 production facilities + 7 sales offices
- 100+ standard and custom systems built per year
- Application labs in Helmond (NL) and Puchheim (DE)
- ISO 9001 and DEKRA certified

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Contents presentation

- Definition of the range of Micro welding Applications
- Comparison of the Different Laser Types for Micro welding Applications
  - Laser Features
  - Welding examples
  - Laser source selection
- Summary

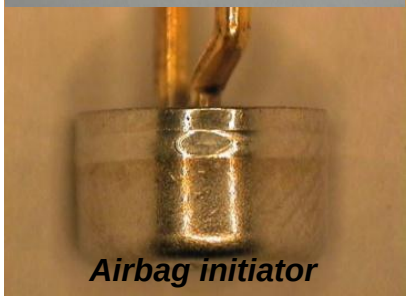
Definition of Micro-welding applications

- Typical penetration depth less then 0.04” (1mm)
- Typical spot sizes at the surface less then 0.04” (1mm)
- Welds can be Spot (round) and Seam (linear) types
- Typical Average Laser Power less then 1 kW

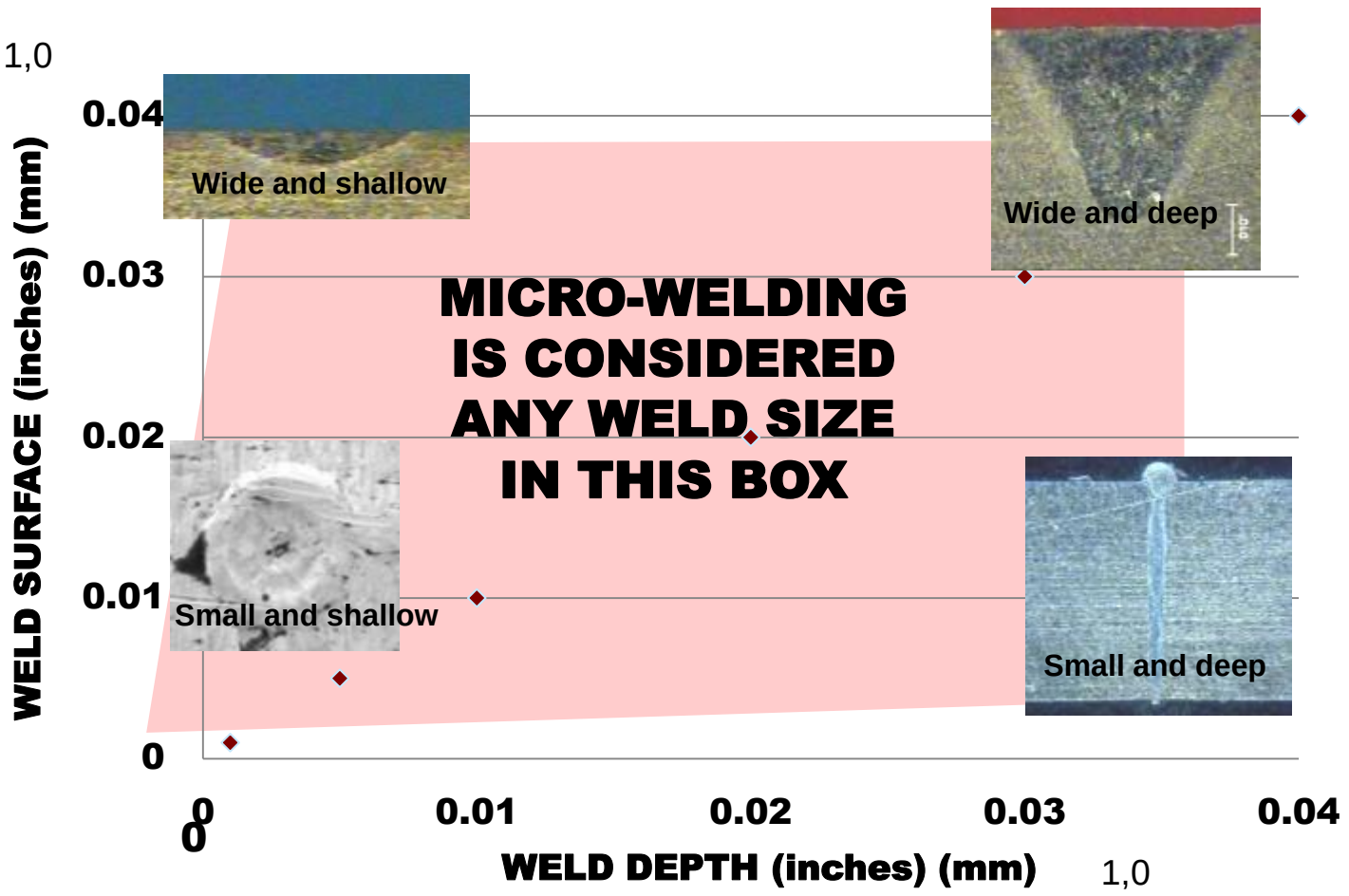
- These are found in a wide range of markets – including automotive, batteries, medical, aerospace and electronics


Aluminum battery and supercap casings


Pressure sensor


Airbag initiator

Depth and surface dimension range of Micro-welding applications



Existing and Emerging Laser Welding Technologies

Type	Pulsed YAG	CW Fiber Laser	QCW Fiber Laser	Direct Diode Laser
Features	• Pulsed • High peak power • Green wavelength option • Most mature technology	• CW or modulated up to 100% • Low peak power • Excellent beam quality • Established technology	• Pulsed or CW • High peak power • Emerging technology in welding	• CW or modulated • Low peak power • Low beam quality • New technology

Wide selection of source types is currently available
Select the right laser for the application

Micro Weld Considerations

Pulsed YAG

Fiber Laser

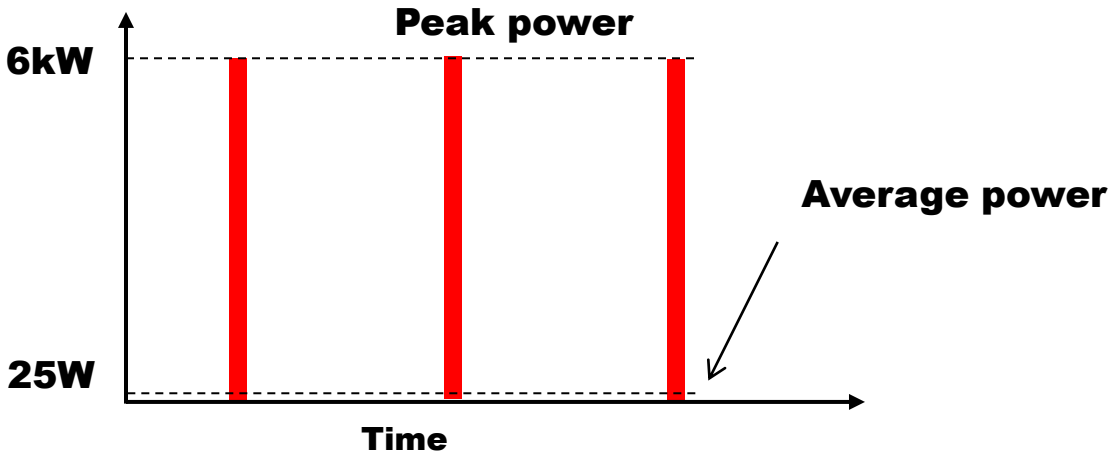
QCW Laser

- Does it need to be a Spot or Seam weld
- Type of weld
  - Lap
  - Butt
  - Fillet
- Material selection
- Part fit up
- Required weld properties
  - Strength?
  - Hermetic?
  - Cosmetic?
  - How much heat input?

Pulsed Nd:YAG Lasers

Based on Lamp pumped Solid state laser technology

Pulsed YAG



The high peak power is good for significant and consistent penetration
- the ratio of average to peak power can be as high as a factor of 240x!

Pulsed Nd:YAG Laser Features

Pulsed YAG

Feature	Welding benefit
Real time power feedback	Highly consistent welding
Free space resonator	No sensitivity to back reflection
Spot Size	0.01 – 0.04” (0.25 to 1.0mm) optical spots for fit-up accommodation
High peak power	Deep penetration even with low average power
Time and Energy Share	Multiple outputs from a single laser
Mature laser design	Highly reliable

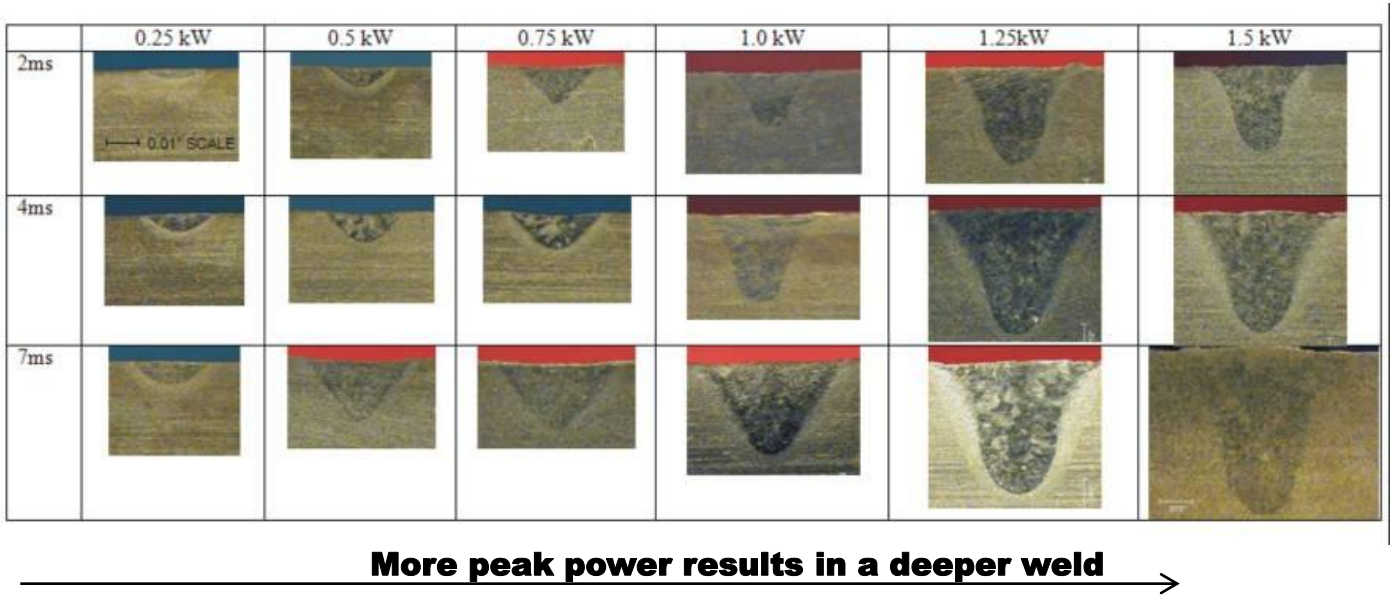
Application example: Spot Welding

Pulsed laser source with high peak power for penetration

Pulsed YAG

Material: Titanium (0.02” or 0.5mm spot size)

Effect of Peak power & pulse width



Longer weldtime results in a wider weld

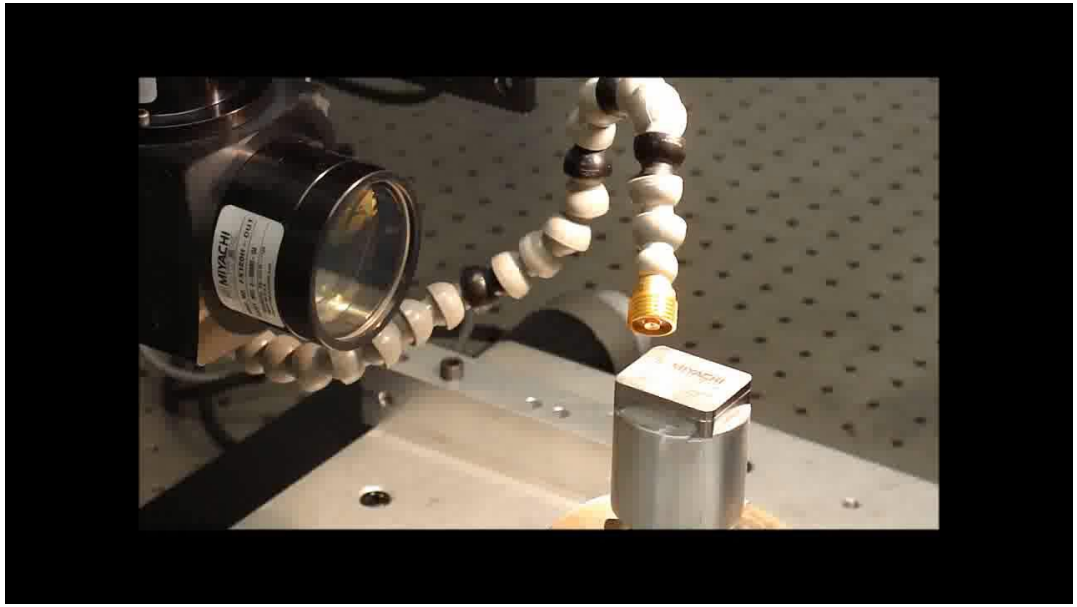
More peak power results in a deeper weld

Precise input of energy to get various weld profiles

Application: Seam Sealing Heat Sensitive Parts

Pulsed YAG

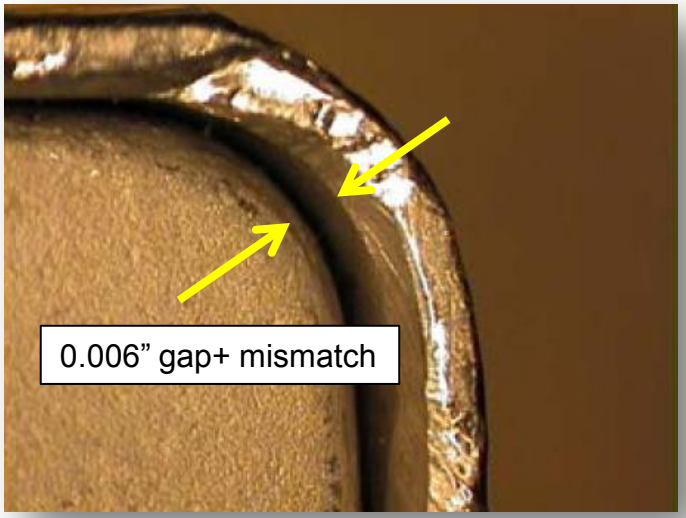
- Heat input is linear with the average power
- Typical Applications: Sensors, Batteries, Implantable medical devices, RF/microwave devices
- Typical materials: Aluminum (3003, 1050, 1100), Titanium



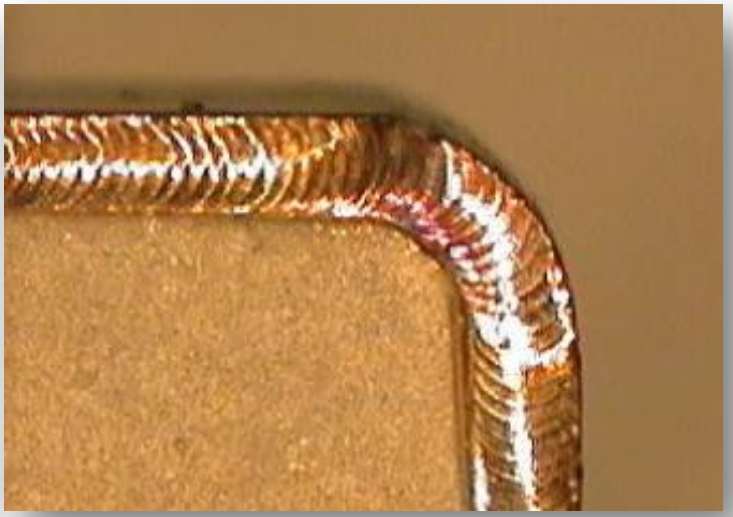
Application: Seam Sealing Butt Weld with loose tolerance

Pulsed YAG

- Large spot size helps bridging gaps
- The required tolerance of fit-up is reduced
- This is lowering machining costs
- And maximum yield and quality of welded part



Before weld a 0,15mm gap

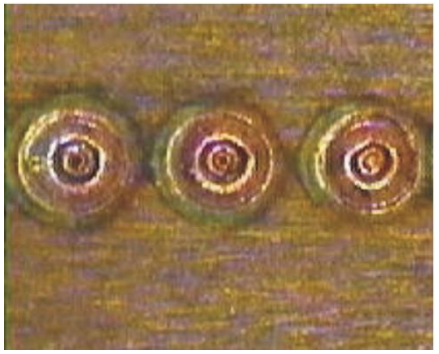


After welding a perfectly sealed part

Application: Small conductive parts

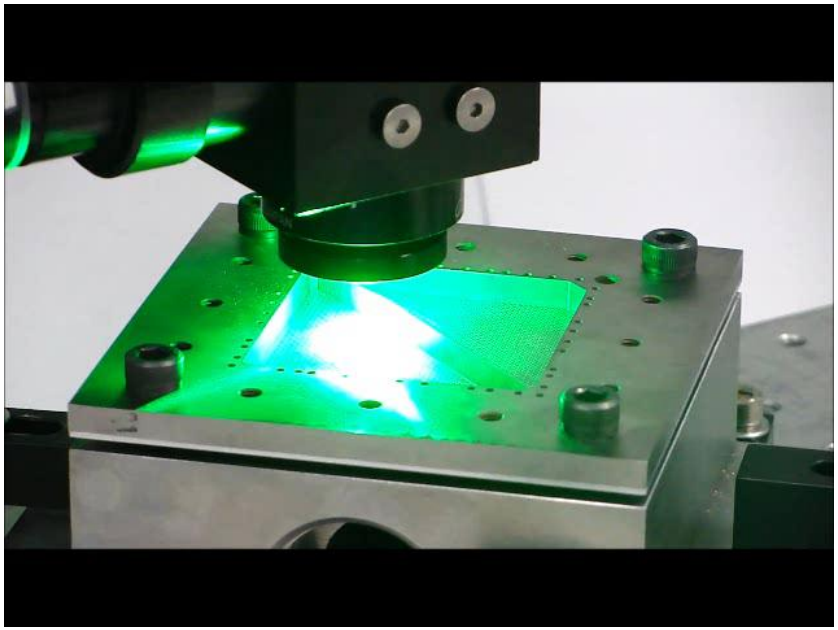
- A challenge for any joining technology
- Lasers offers good non contact, high speed solution
  - Inconsistent results due to high material reflectivity at 1 micron
  - Frequency doubled YAG aka “**Green Laser**” has improved results

Pulsed YAG

Material - Copper		
Wavelength	1064nm	532 nm
Spot Weld results		

Application: Small Scale Electrical Interconnects

Pulsed YAG

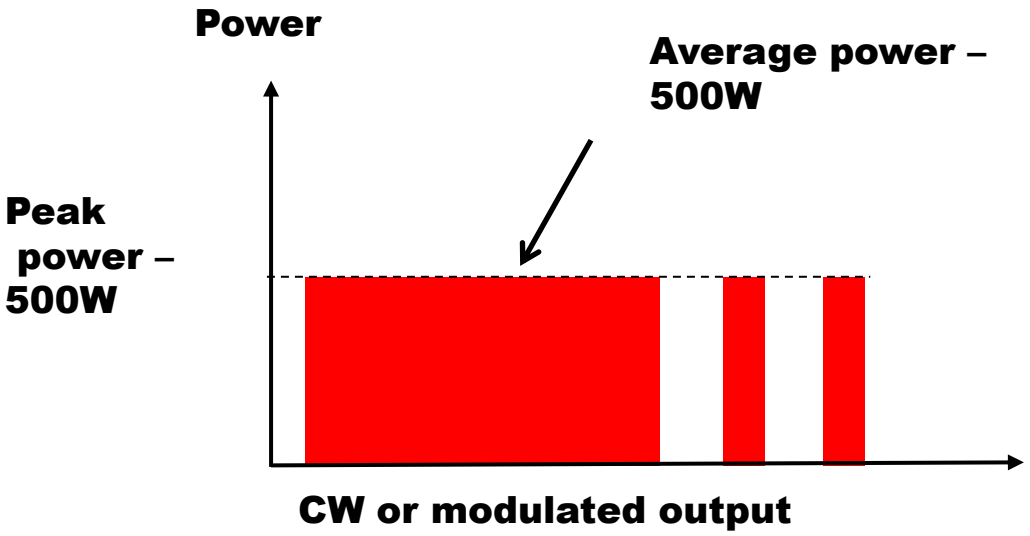


4000 Individual Welds – all must be successful
0.003” Phosphor Bronze to 0.003” Cu - Epoxy below
Penetration depth controlled within 10 um

CW/Modulated Fiber Lasers

Fiber Laser

Based on CW fiber laser technology



Average CW power and Peak power are the same

CW/Modulated Fiber Laser Features

Fiber Laser

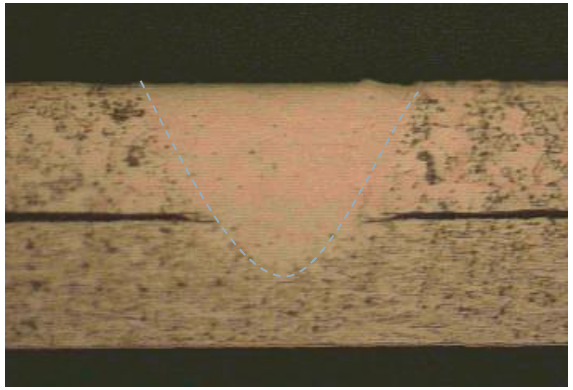
Feature	Welding benefit
High beam brightness (high beam quality)	Optical spot sizes can be as small as < 30mm (~0.001”) for welding the finest parts
Selectable beam brightness	Weld performance can be tuned to fit the joint geometry & fit-up
Continuous Beam	Good for seam sealing at high speeds
Efficient laser generation	Small & compact, electrically efficient
Single emitter pump diodes	No laser consumables

Application: Very Small Spot Welds

Fiber Laser

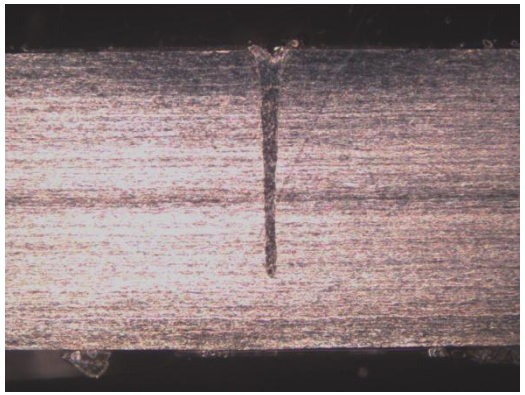
- Thin materials require small spot size
  - Single mode laser provides sub 0.001” (25 um) spot
  - Laser power requirement < 100W

Wide and shallow
(multimode laser)

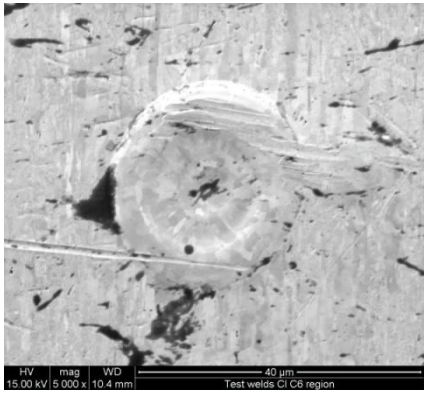


0.003” (75 um) diameter
0.0025 (60 um) deep
430 SS , 100W fiber laser

Small and deep
(singlemode laser)



0.001” (25 um) diameter
0.008” (200 um) deep
304L, 50W fiber Laser



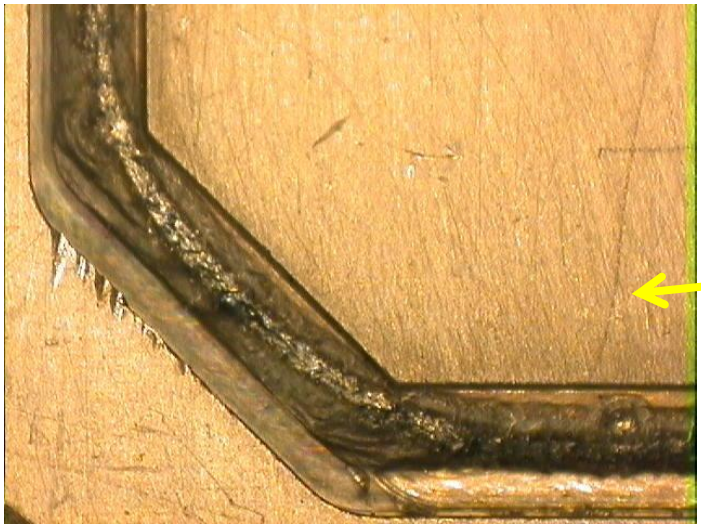
0.001” (25 um) diameter
0.0005” (10 um) deep
Titanium, 20 W, SM laser

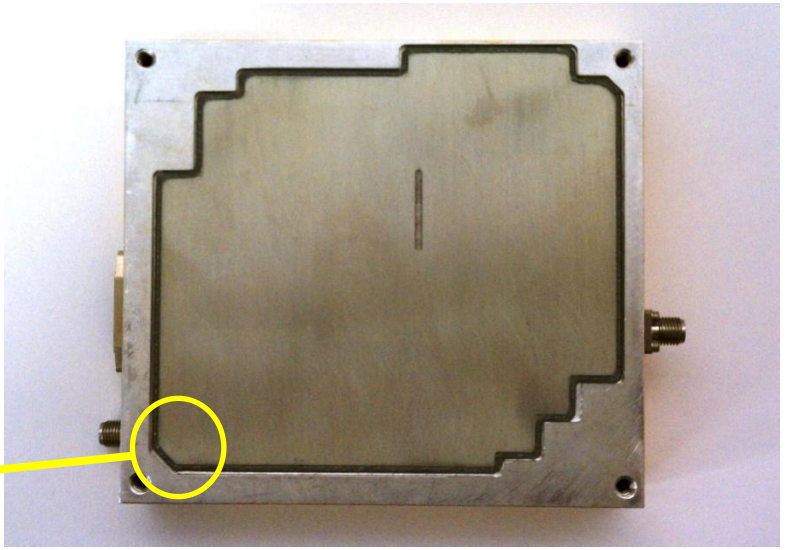
Applications: High Speed Seam Welding

- Hermetic Sealing of 0.02” (0.5mm) and thicker lids
  - Larger packages can take this larger thermal loading
  - 500W, SM, 0.04” (1.0mm) penetration at 1.5”/s (40mm/sec)
  - Weld type: Lap weld

Fiber Laser

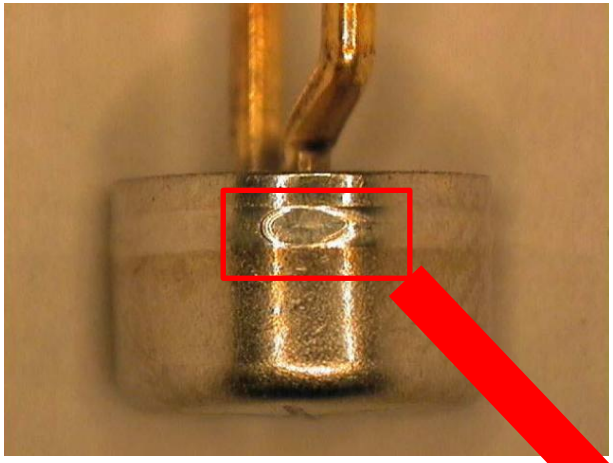
6061 base to 4047 lid



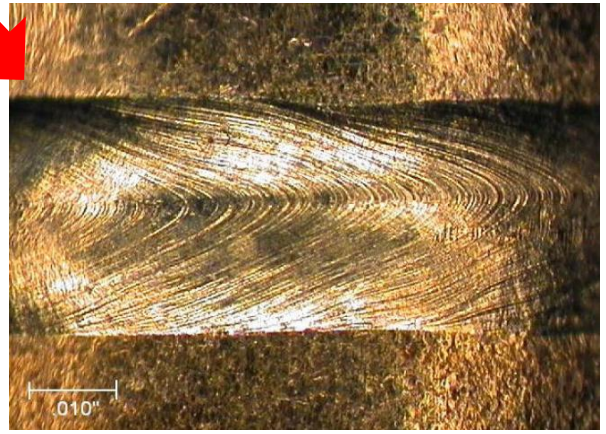


Application: High Speed Seam Welding

Fiber Laser

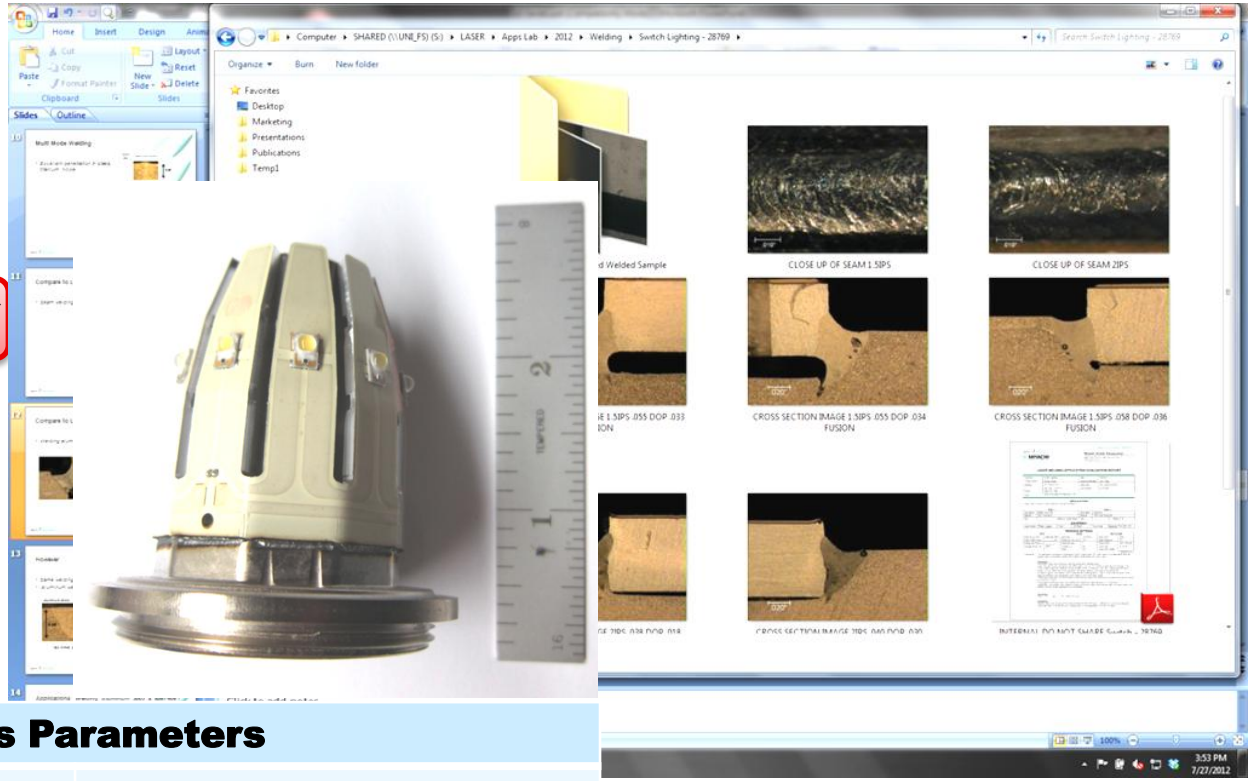


Weld Parameters	
Industry	Automotive
Part	Airbag Initiator
Material	Steel
Equipment	500W, MM Laser
Speed	1250˚ /s
Comments	0.02” (~0.5mm) penetration



Case study - Fiber Laser and Nd:YAG laser
For this product the Fiber Laser is 10x faster

Fiber Laser



500W Nd:YAG laser
30s weld time

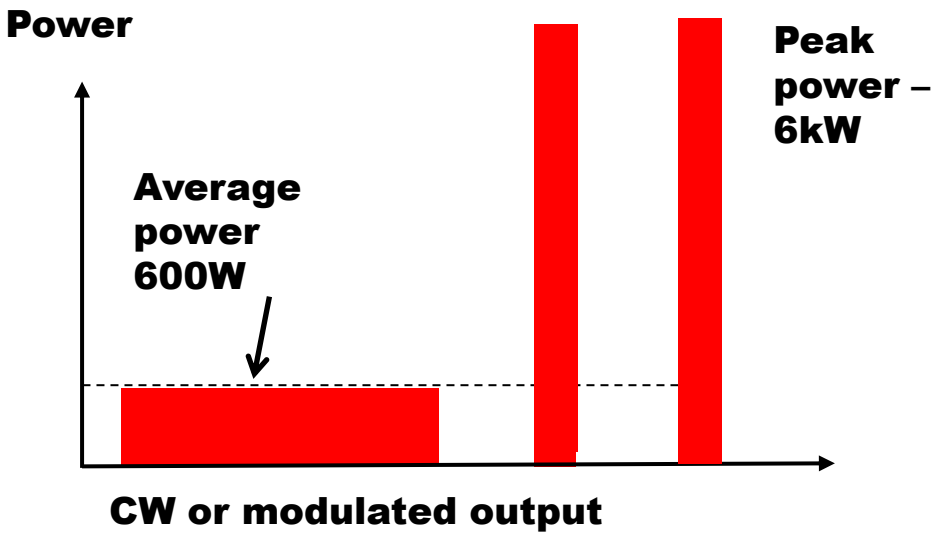
500W, SM fiber laser
3s weld time

Process Parameters	
Industry	Lighting
Part	Bulb
Material	A380 / 5082 aluminum

QCW Fiber Lasers

Based on fiber laser technology, but with a Pulsed output, as opposed to a CW output

QCW Laser



Average CW power and Peak power are not the same
Ratio can be up to 1:10

QCW Laser Features

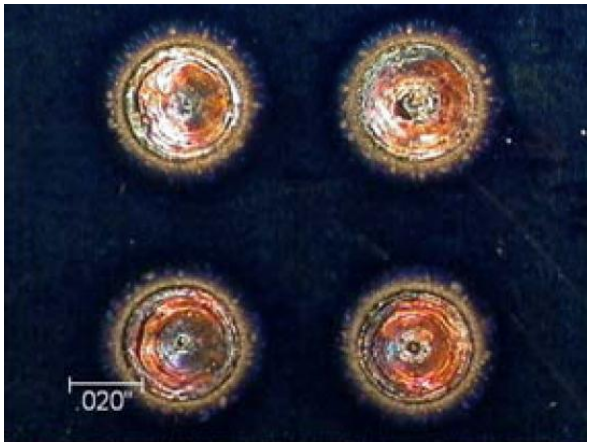
QCW Laser

Feature	Welding benefit
Selectable brightness	Welding of conductive metals
Small Spot Size	Small welds
High peak power	Deep penetration even with low average power
Continuous Beam	High speed seam welding
Air cooled up to high powers	Independence from facility water

QCW Application: Spot Welds

430 Stainless steel PV Substrate to Sn coated Cu Bus bar

QCW Laser



Front side

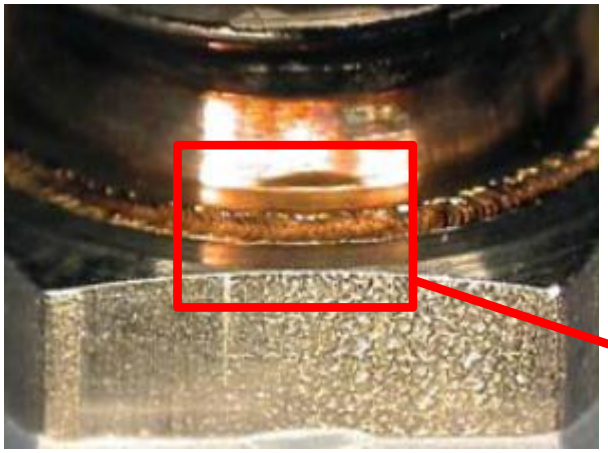
Back side

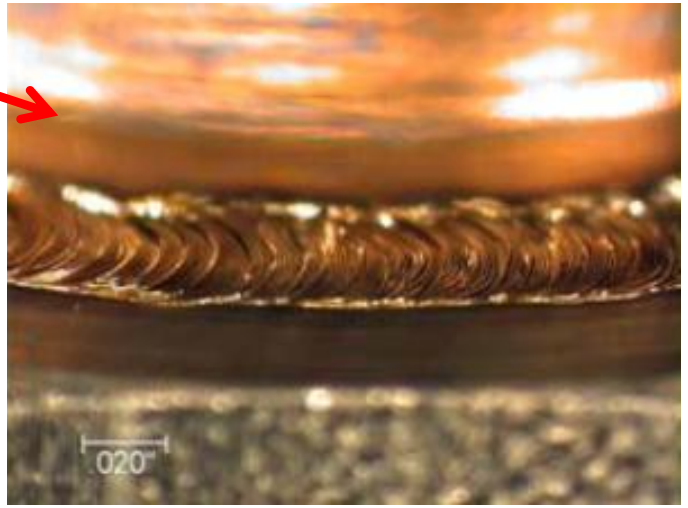
Process Parameters
600um spot size, 0.9kW 7.5J, 6ms pulse

0.004” (0.1mm) thick SS
Sn coating helps, but still copper

QCW Application: Seam Weld

QCW Laser





Process Parameters
17-4 SS to 304L hex nut
600um Spot size, 220W, 4J, 2kW 55pps

Comparison between QCW and Nd:YAG

QCW Laser

Similar pulse energy, peak power, average power, pulse duration and spot size

Summary

Laser Type	Pulsed Nd:YAG	CW/Modulated Fiber Laser	QCW Laser
Weld	• Spot Welds • Seam welds of heat sensitive parts • Weld Reflective material use green (532nm) laser • Large gap butt welding	• High speed seam welds • Thin material spot welding • SM lasers offer very interesting welding properties	• Seam Welds • Spot welds • Similar to pulsed Nd:YAG

These are some basic guidelines, in the end, you should qualify process by testing!

Summary

- A number of sources exist in the micro welding laser toolbox
- Pulsed lasers for spot welding and low heat input seams
- CW Fiber lasers offer excellent seam welding capabilities
- QCW is the latest technology, and deliver similar welding to pulsed Nd:YAG

Further Information

For further information on Amada Miyachi laser welding products, please contact:

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