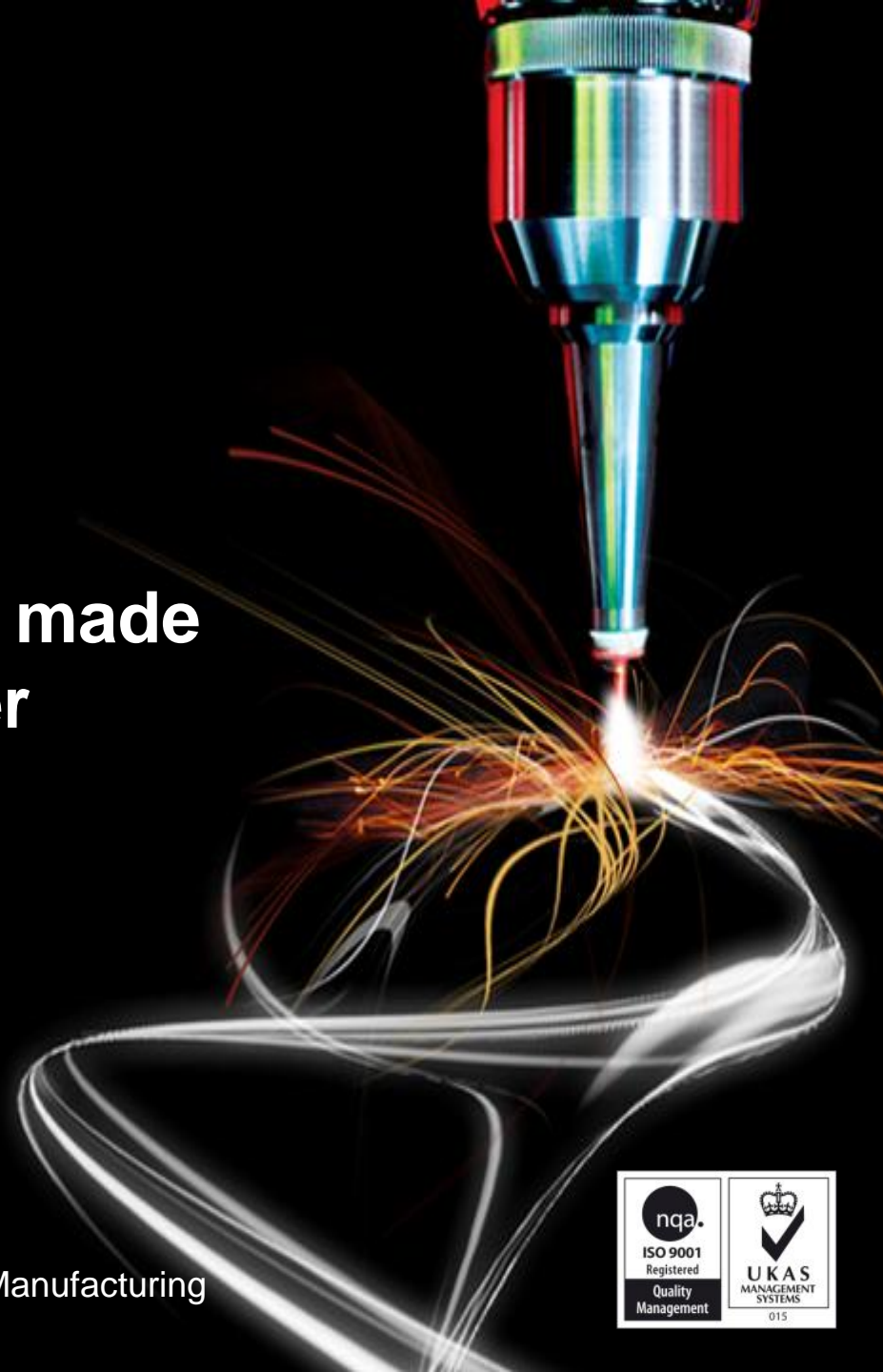




Joining dissimilar metals made possible with pulsed laser nano second welding

March 2018



Marking | Cutting | Welding | Micro Machining | Additive Manufacturing



Micro joining of dissimilar metals

Problem

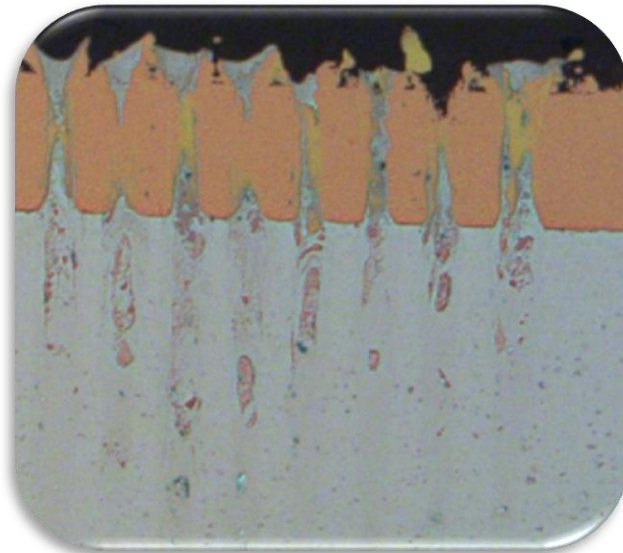
Reliable joining of thin section dissimilar materials

Challenge

Overcome the problems of brittle inter-metallics

Solution

Novel ns welding process not based on large weld pool



CW Lasers

Laser measured by power – able to provide continuous stable laser output at rated power

CW/Modulated Lasers

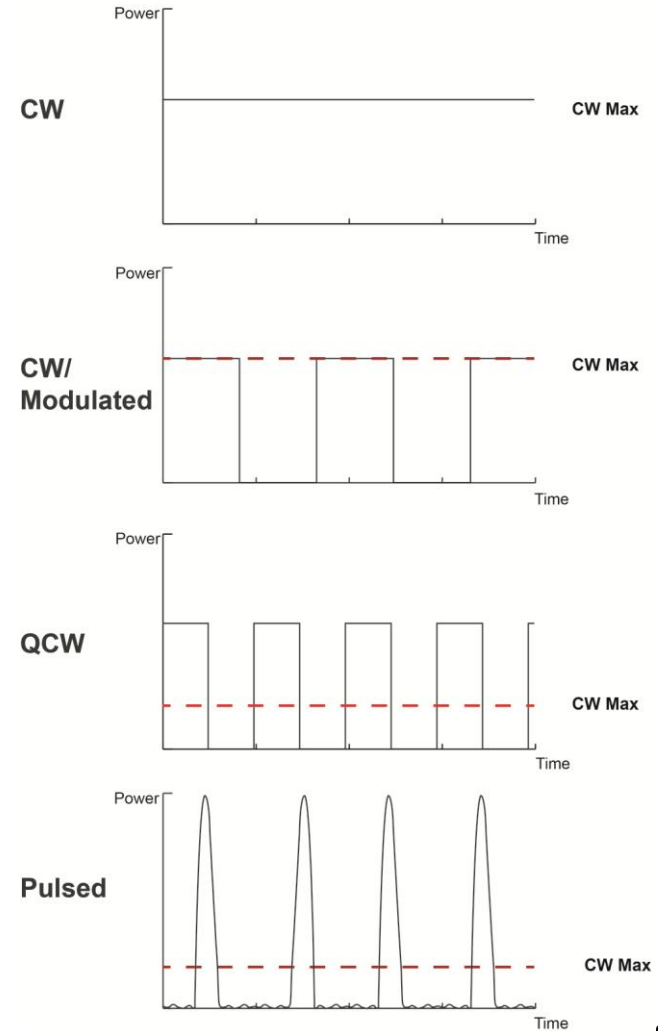
Lasers that produce a gated output with the maximum power being the CW limit

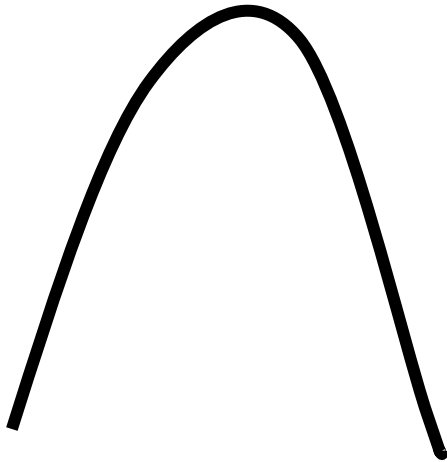
QCW Lasers

Able to produce ms pulses at higher peak powers at reduced average power than their continuous duty operation

Pulsed Lasers (ref FLP Nd:YAG)

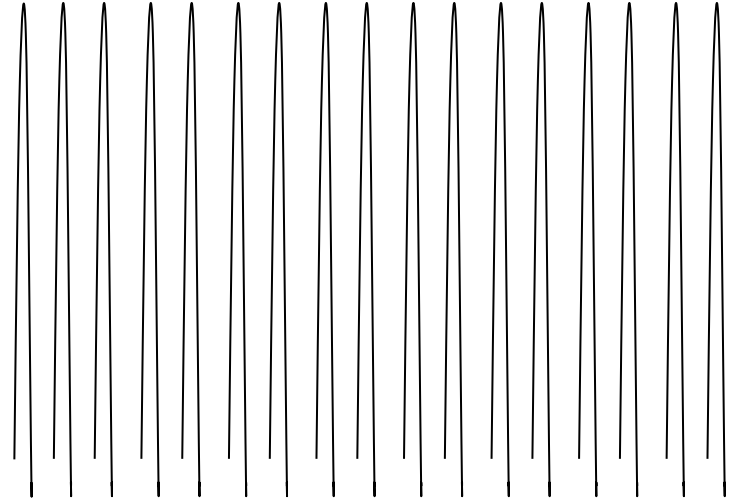
Producing short high peak power pulses with low average power.





OLD (FLP Nd:YAG)

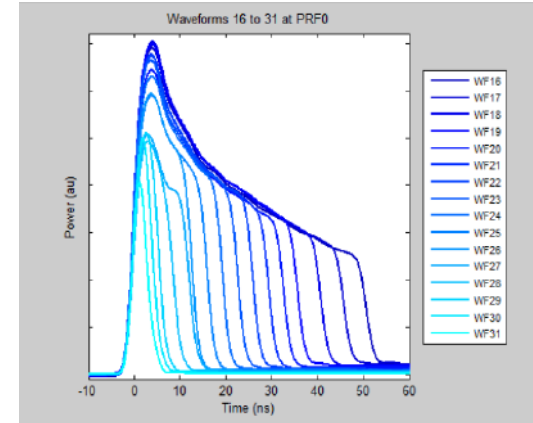
- 6-10kW peak power
- ms pulse duration
- >J pulse energy
- <1kHz Rep Rate
- <15% DF
- <100W average power



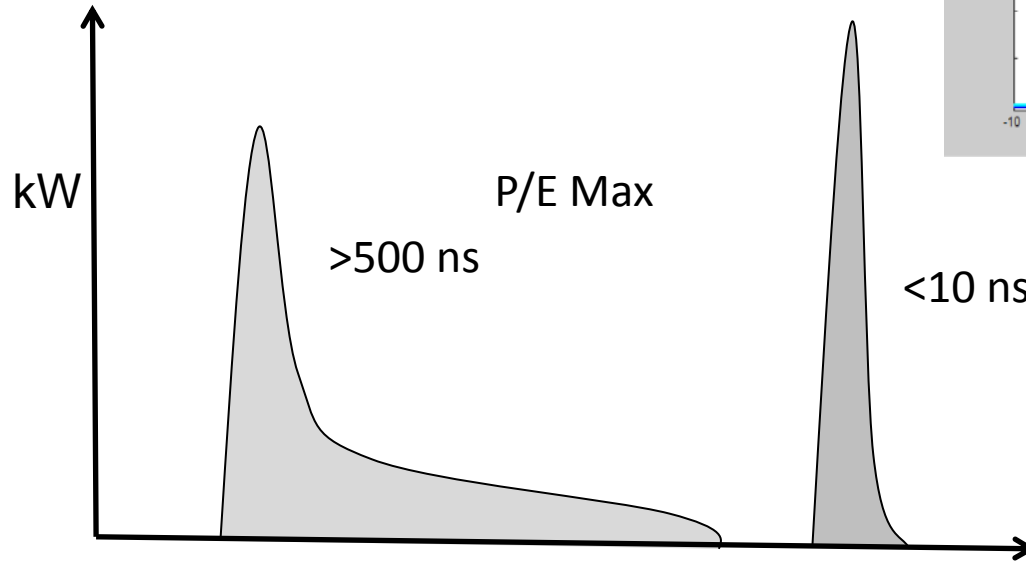
NEW (ns Joining)

- 6-10kW peak power
- ns pulse duration
- <mJ pulse energy
- >100kHz Rep Rate
- <15% DF
- <100W average power

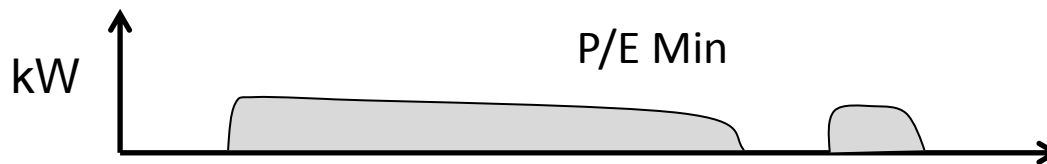
Flexibility in ns lasers in optimising pulses to match application requirements.



Low kHz
High kW

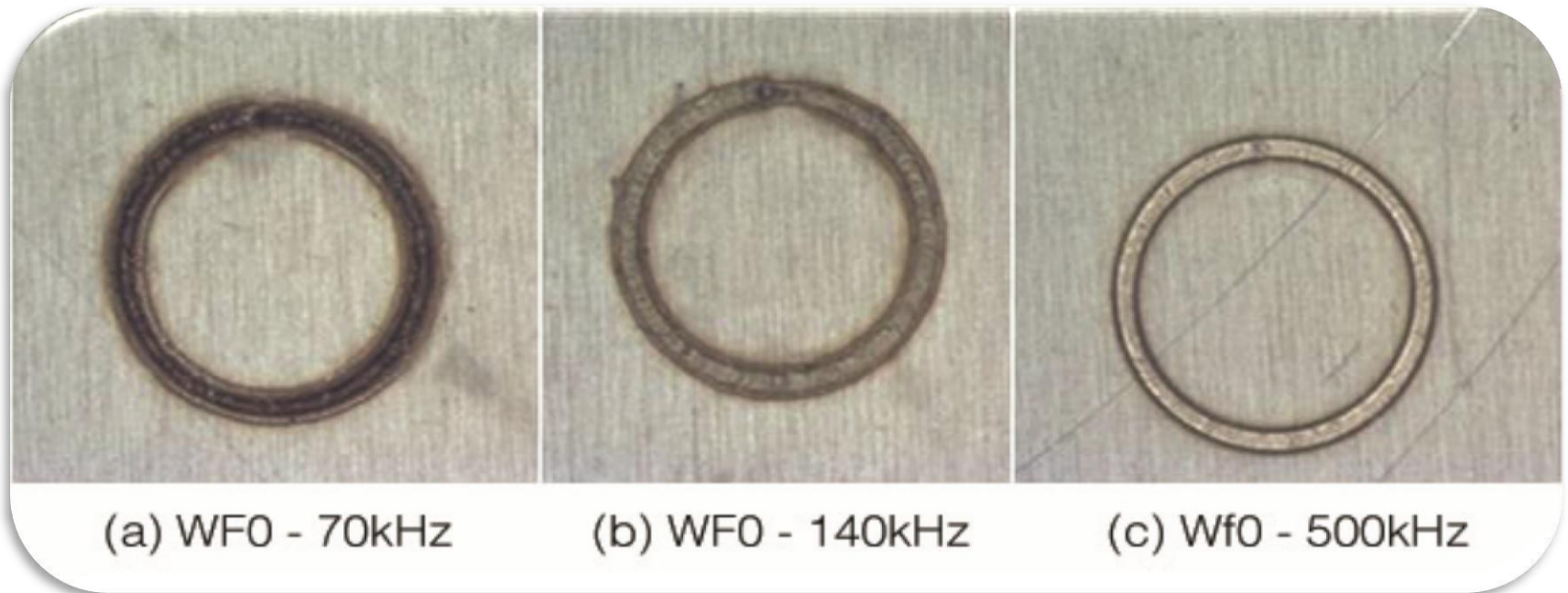


High kHz
Low kW

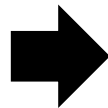


Metallic welding using ns pulses

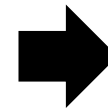
Use pulse waveforms & frequency to tune parameters from vaporisation/melt ejection to melt generation.



70W, 1mJ
>10kW peak,
<2% duty.



70W, 0.5mJ
>2kW peak,
<4% duty.



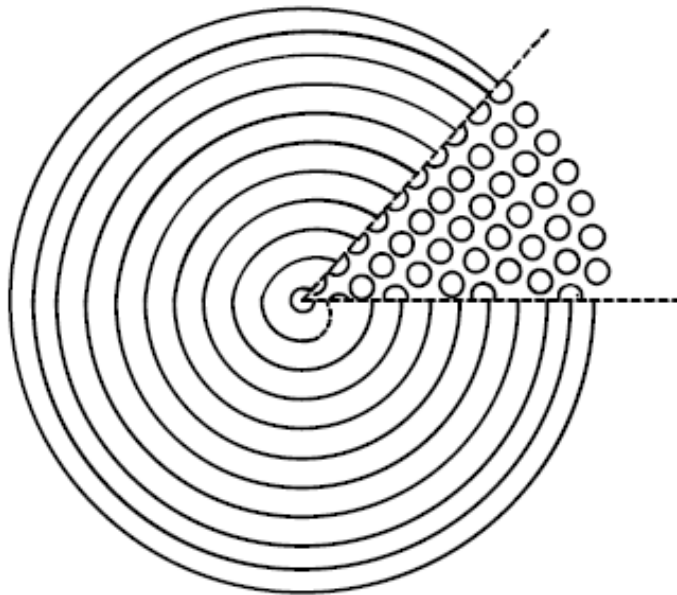
70W, 0.15mJ
>500W peak,
<15% duty.

Focus on ability to weld bright metals:

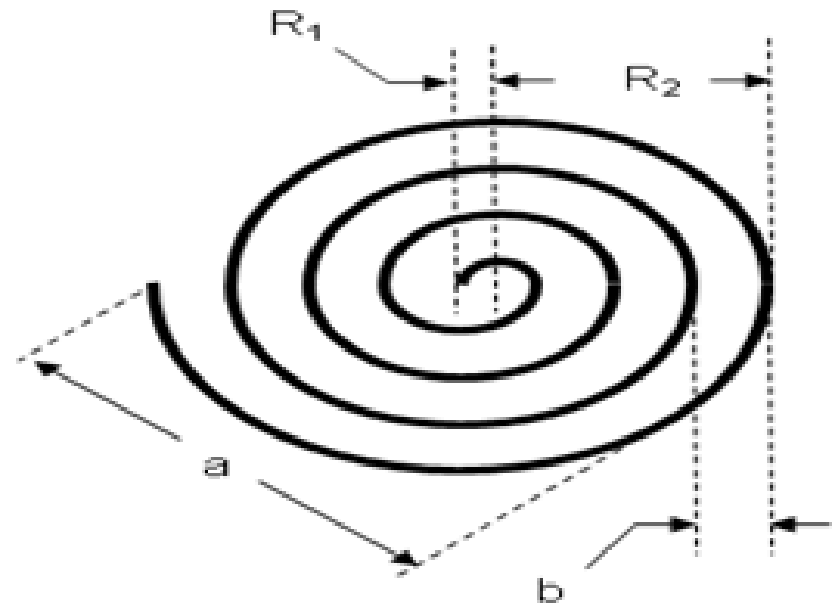
- Range of material types and dissimilar combinations
- Using novel weld configurations..



Method for making spot welds.



Spatially overlapping spots >98% linear fill
separated by 50% the F_s on the rise radius.

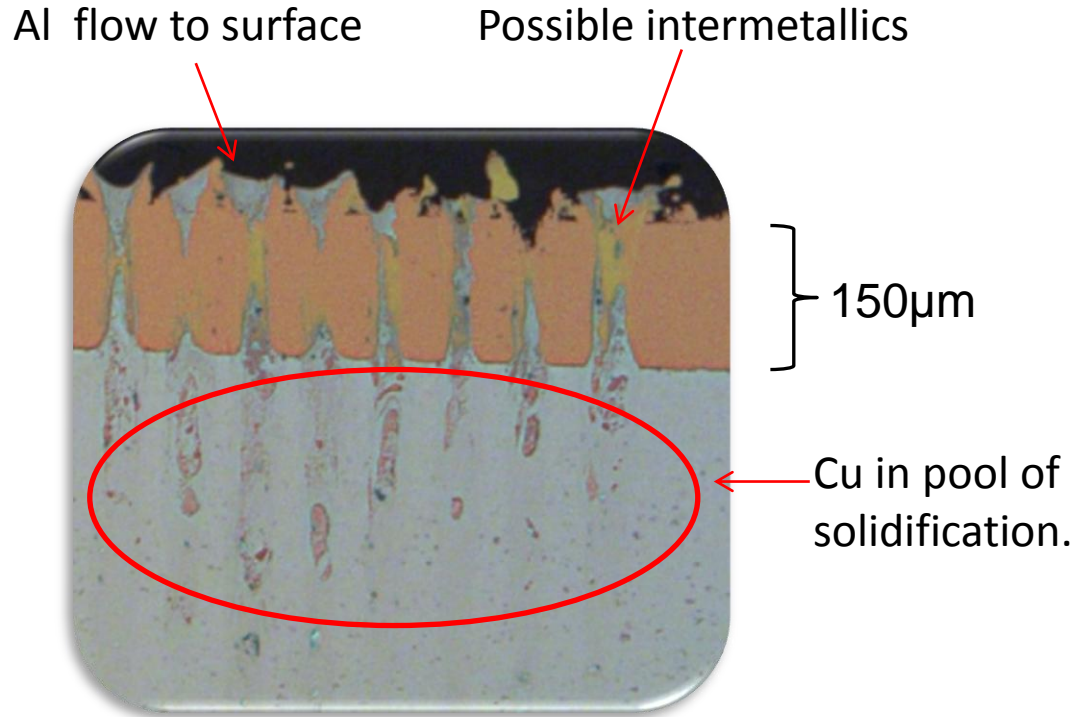


R_1 , Inner Radius, 0.02mm
 R_2 , Outer Radius, 0.5mm
 a, Ramp, 3mm
 b, Rise, 0.02mm

Metallurgically interesting Cu/Al

Spot welds do not show characteristic form of conventional pulsed spot welds

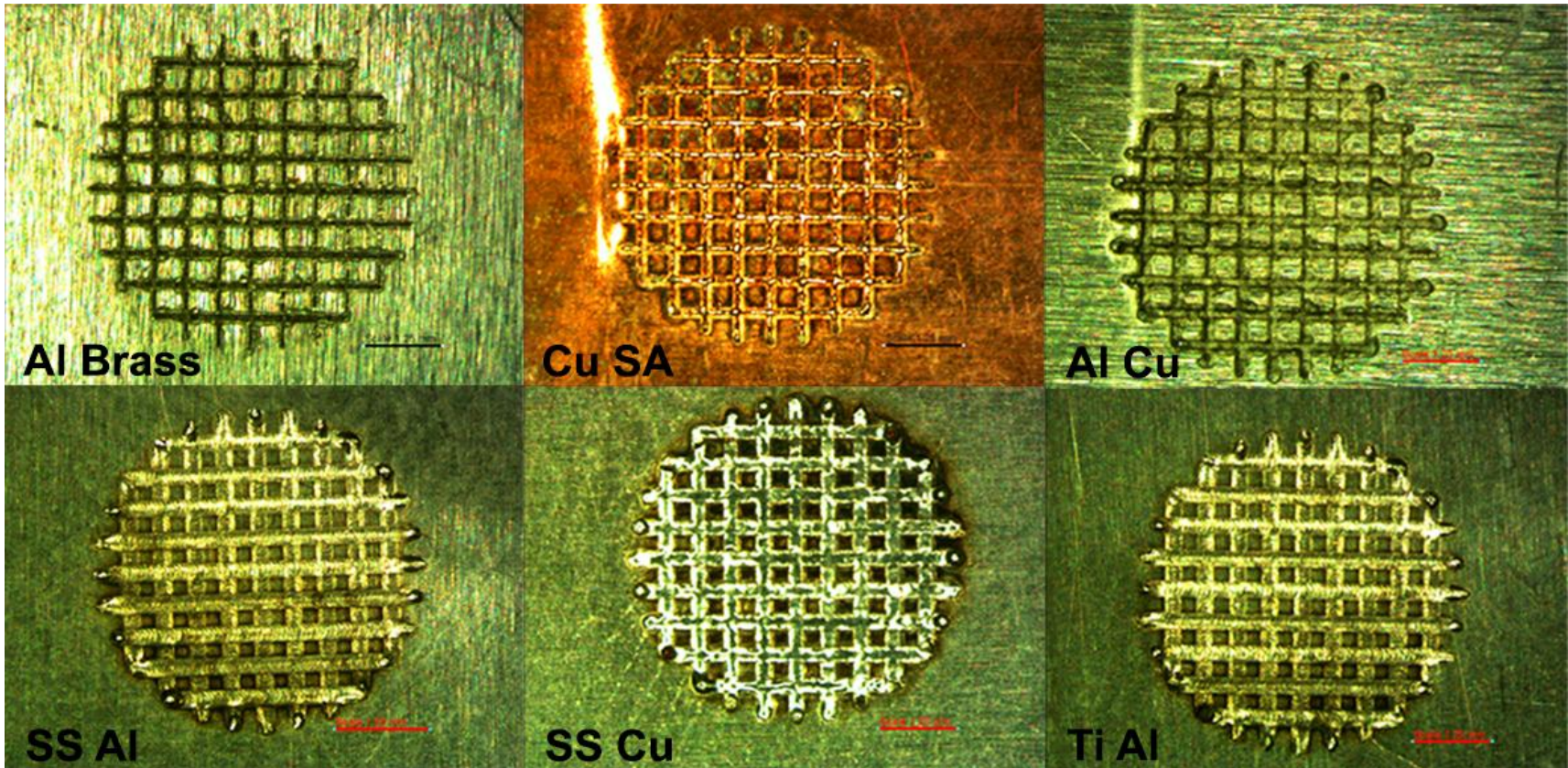
More closely resembles multi-staking



WF 36, 520ns, 70 KHz

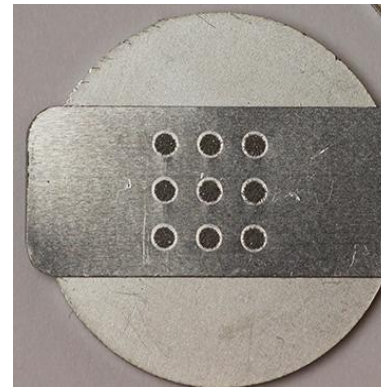
Grid patterns

Fast and flexible applicable to multiple material combinations 4mm Ø in 1sec!



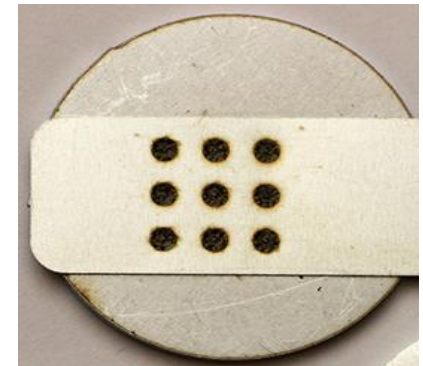
- **Could join stainless, copper, aluminium and brass to stainless steel:**

- Using 100W EP-Z
- 163mm F-theta
- 7.5mm beam diameter
- Single pass to produce weld
- Post process cleaning pass
- No Assist gas used
- Coin 1.5mm thick
- Ribbon 0.3mm thick

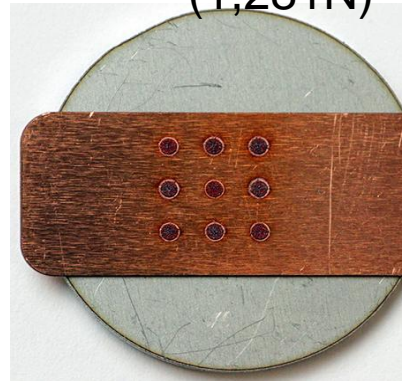


1.38s
(580N)

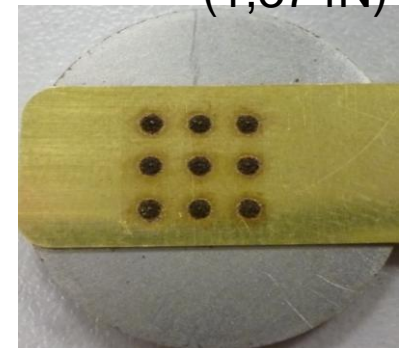
1.60s
(>3,873N)



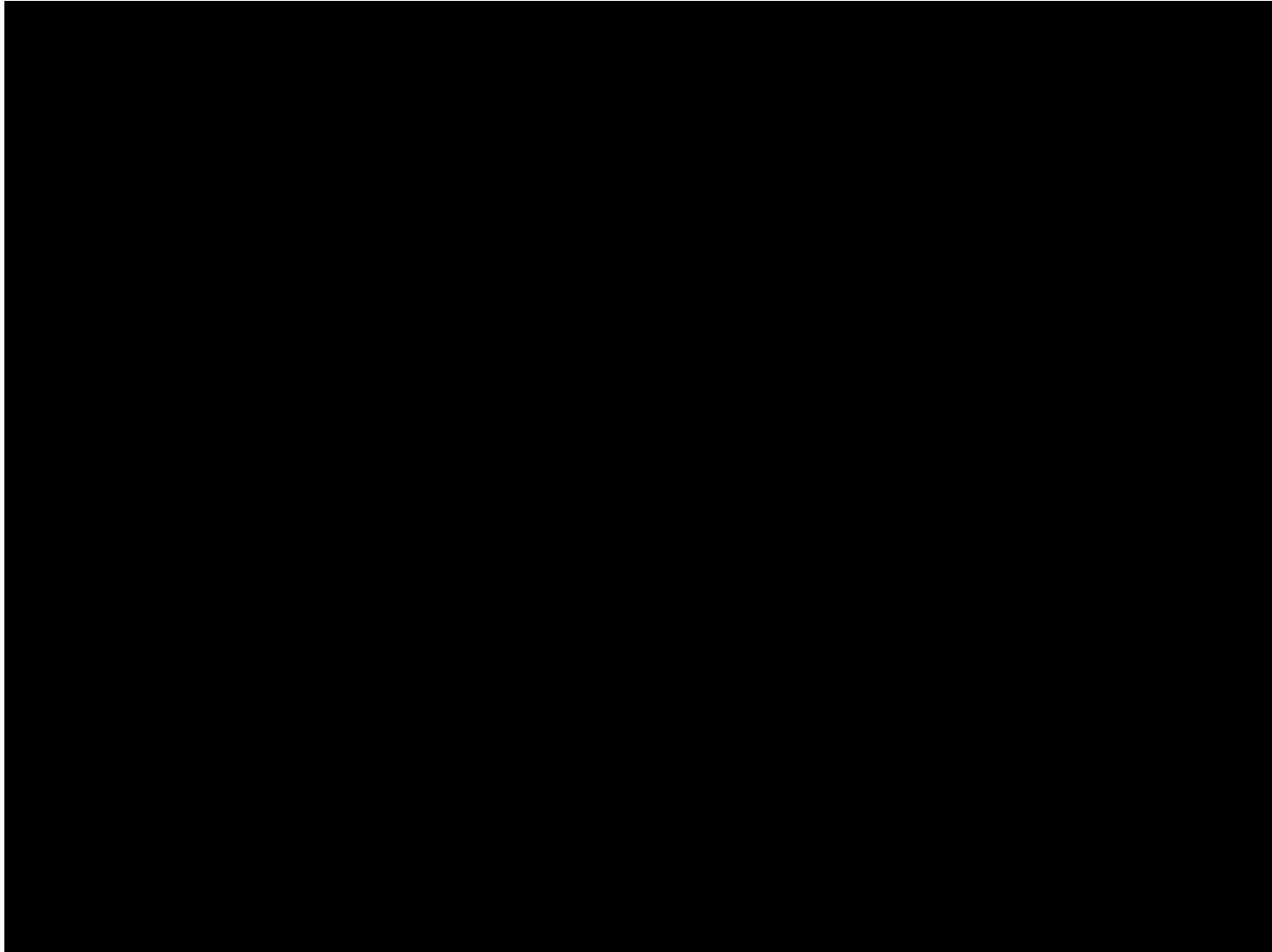
5.53s
(1,281N)



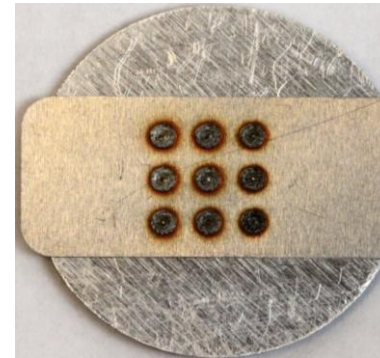
2.47s
(1,374N)



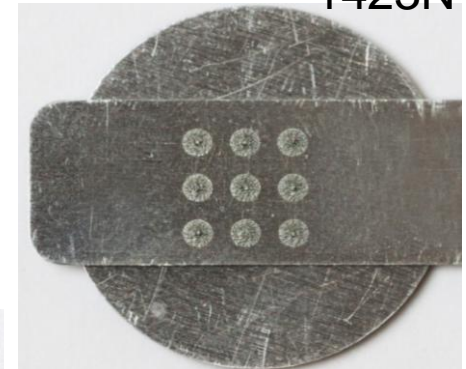
Video of ns welding



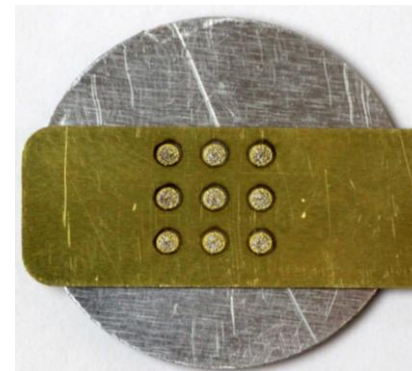
- **Could join stainless, aluminium and brass to aluminium:**
- Using 70W HS-H
- 163mm F-theta
- 7.5mm beam diameter
- Single pass to produce weld
- Post process cleaning pass
- No Assist gas for Al & ss
- Argon for brass
- Coin 1.5mm thick
- Ribbon 0.3mm thick



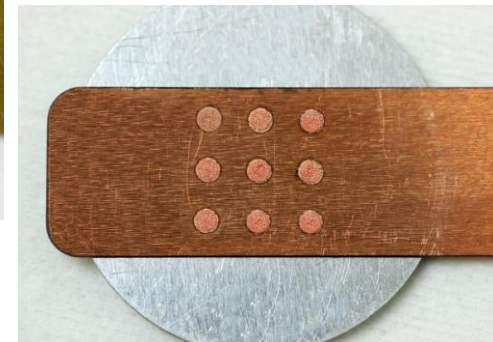
4.96s
474N



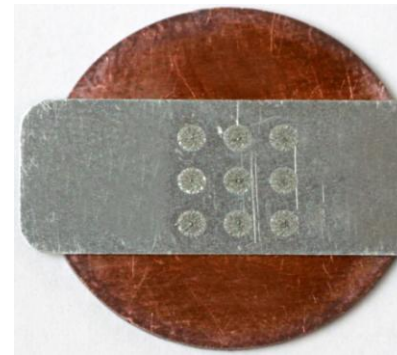
7.53s
1423N



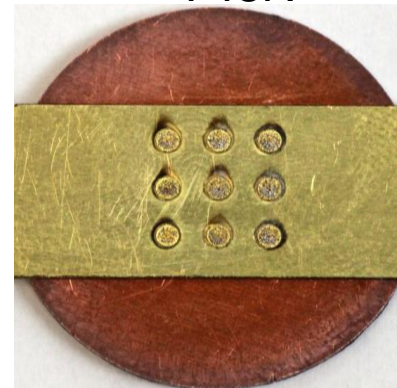
8.53s
610N



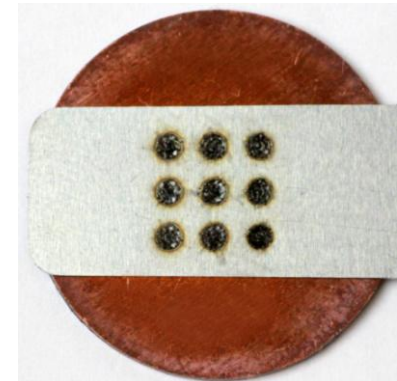
- **Joining stainless, aluminium and brass to copper:**
- Using 70W HS-H for brass & aluminium
- Using 100W EP-Z for stainless
- 163mm F-theta
- 7.5mm beam diameter
- Single pass to produce weld
- Post process cleaning pass
- No Assist gas for Al & ss
- Argon for brass
- Coin 1.5mm thick
- Ribbon 0.3mm thick



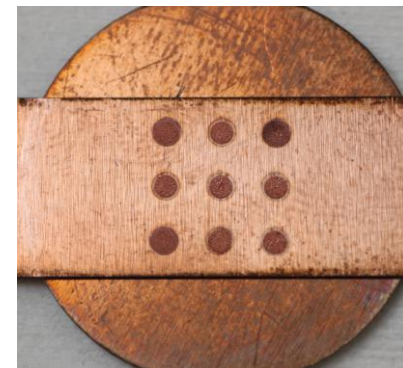
20.53s
748N



4.96s
459N

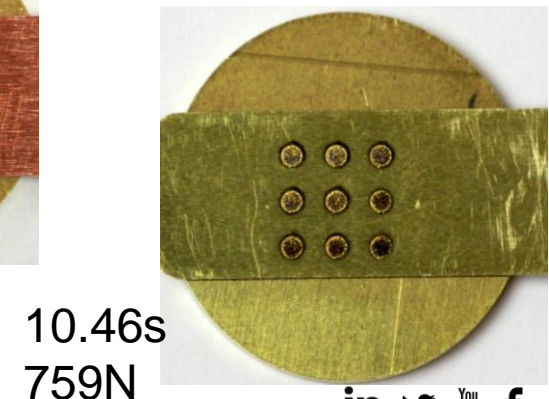
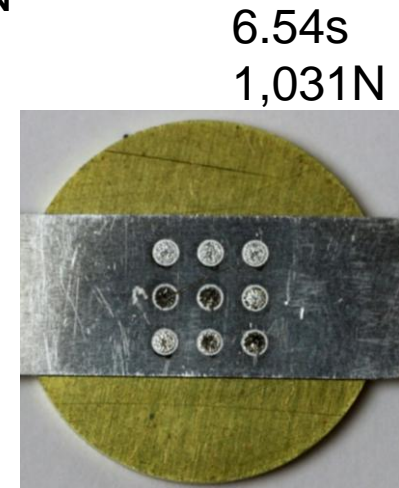
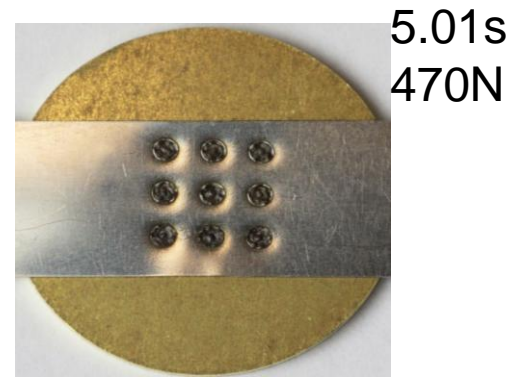


9.95s
2,214N



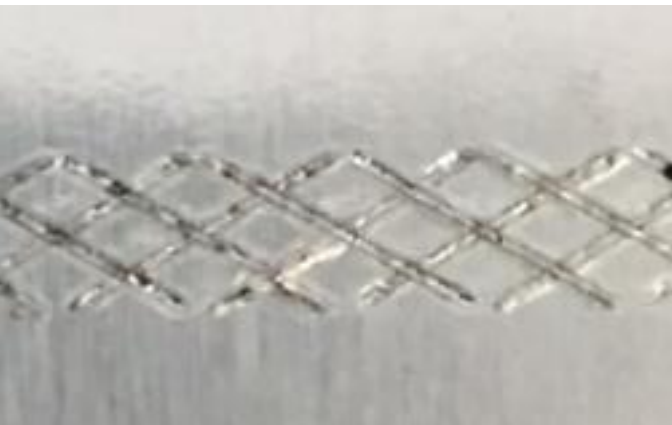
- **Joining stainless, aluminium copper and brass to brass:**

- Using 70W HS-H for all
- 163mm F-theta
- 10mm beam diameter
- Single pass to produce weld
- Post process cleaning pass
- Argon assist gas for all
- Coin 1.5mm thick
- Ribbon 0.3mm thick



Opens up the possibilities to design for purpose:

- Electrical conductivity
- Pull strength
- Penetration and nugget shape
- Available space
- Heat input (witness marks)



G4 lasers for ns welding



70W EP-Z $M^2 < 1.6$
70W HS-H $M^2 = 3$



100W EP-Z $M^2 < 1.6$
>1.2mJ
4 - 2,000ns
1kHz – 4MHz

NEW



130W EP-Z $M^2 < 1.6$
200W EP-Z $M^2 < 1.6$
>1.5mJ
9 – 2,000ns
1kHz - 4MHz

NEW

- **ns pulsed lasers offer a flexible solution with multi process capability**
 - Offer new welding potential particularly for dissimilar metals
 - Enhanced control of thermal input
 - New joint design possibilities.
 - Tailored beam quality options offer the right tool for the job.
- **Customer and integrator training**
 - Under SPI's "Training NDA"
 - Customers and integrators "free to use" with lasers supplied by SPI
- **Patents – China** (CN205764438U CN105855706)
 - Utility Model granted with patent examination report
 - Invention patent proceeding to grant: All claims allowed
 - Patents claim the weld and articles made from the weld

Patent No:
WO2016128704
WO2016128705
Other patents pending