



Communications analytical
Industrial Aerospace

Fibre lasers - Enabling Micromachining Applications

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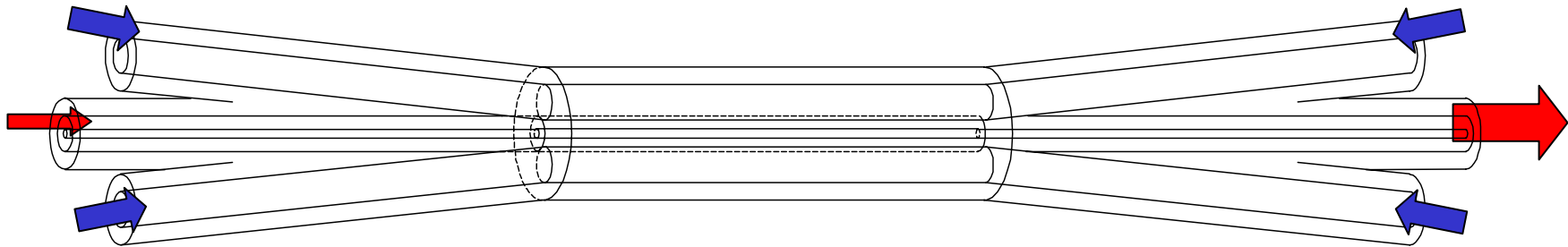
SPI

- Formed in 2000
- Focussed on Industrial Fibre Lasers
- Backed by long term investors from Europe and USA
- Production in UK, sales offices and applications laboratory in USA
- ISO9001
- Happy to share our technical and applications related experience
- Customers are welcome to tour our facilities in the UK
- We meet deadlines
- We listen to our customers business and technical needs
- We aim to deliver significant business advantage to our users

SPI Manufacturing Facilities



GTWave Bi-directional Pumping: Increasing Pump Flexibility



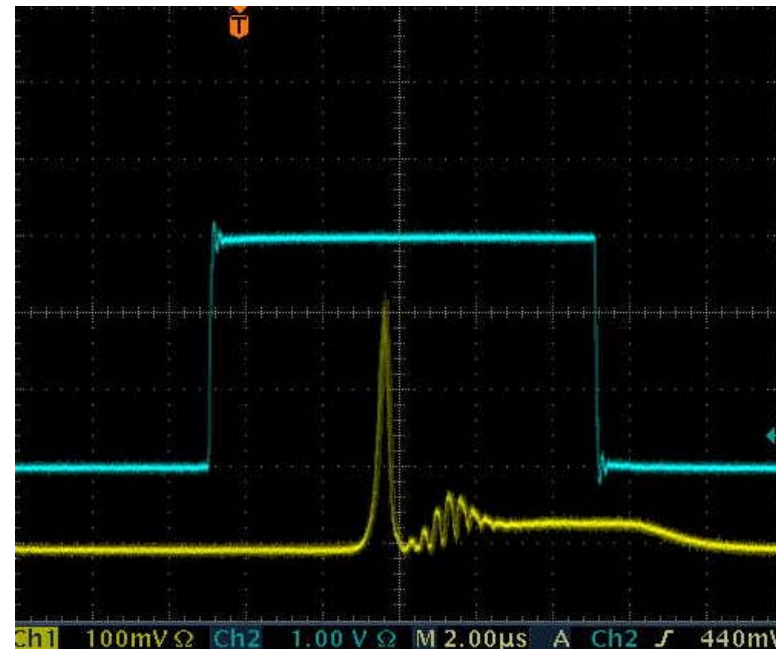
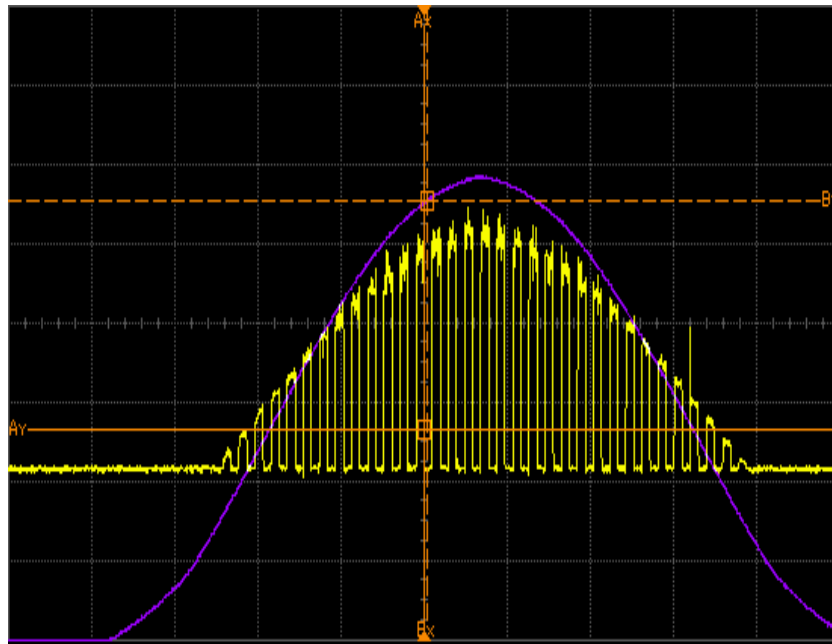
- ✓ Increased pump ports for higher powers
- ✓ Enhanced performance:
 - ✓ Very low signal insertion loss
 - ✓ Bi-directional pumping without need for signal interruption (no dichroic components required)
- ✓ Enhanced reliability:
 - ✓ No physical interruption of coating along fiber length
 - ✓ Back-reflected signal decoupled from pump diodes

Operational flexibility

Open or Closed Loop Control

Pulses from 10us up to CW , fast or slow rise times

- Pulse shape profiling
- High speed modulation



Key Benefits of Fibre Lasers

- Thermal Stability Over Time: Thermal Effects and Laser Resonators

- ALL gas lasers suffer from thermal cycling of resonator
- ALL solid state lasers suffer from “Thermal Lensing”

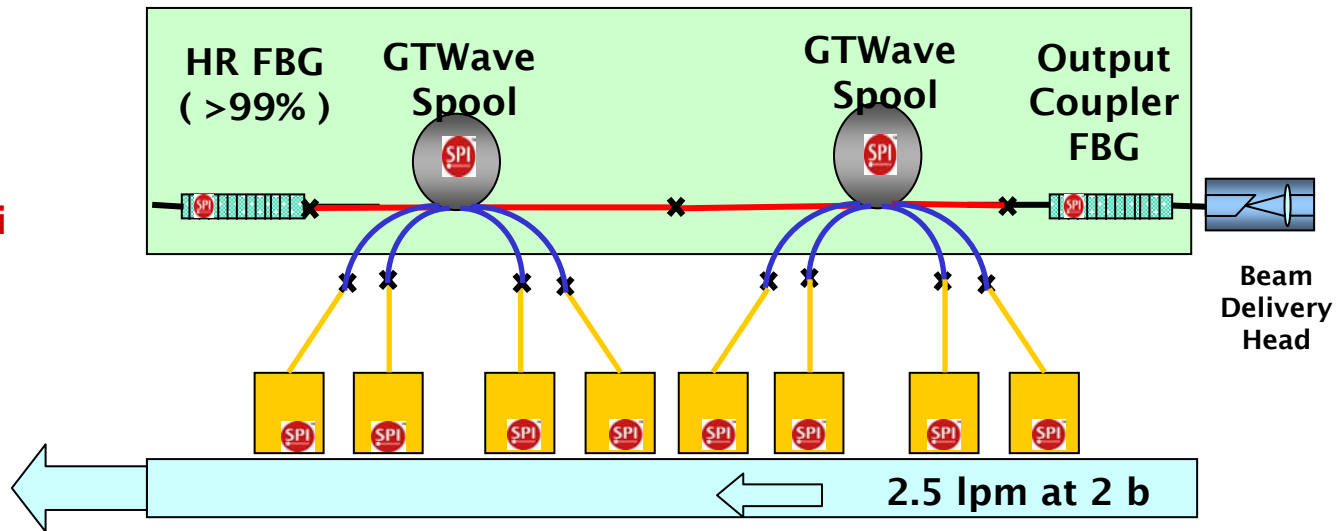
“A technique that determines the alteration in the refractive index of a medium as a result of the temperature rise in the path of a laser beam absorbed by the medium. The lens produced (usually divergent) causes a change (usually a decrease) in the irradiance measured along the laser beam axis”.

IUPAC Compendium of Chemical Terminology 2nd Edition (1997)

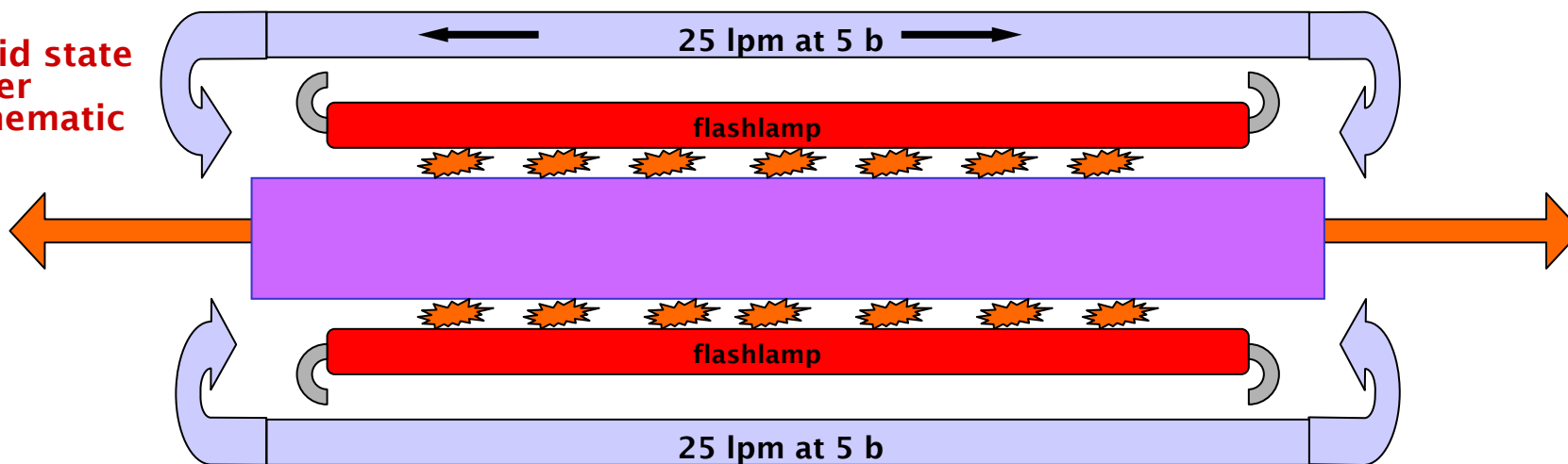
- 3/8” or 5/16” rod heats and cools
- Changes power density and beam size when power changes
- No thermal lensing with fiber lasers
 - due to stable benign low temperature environment

Thermal Stability of Fibre Lasers

Fiber Laser schematic



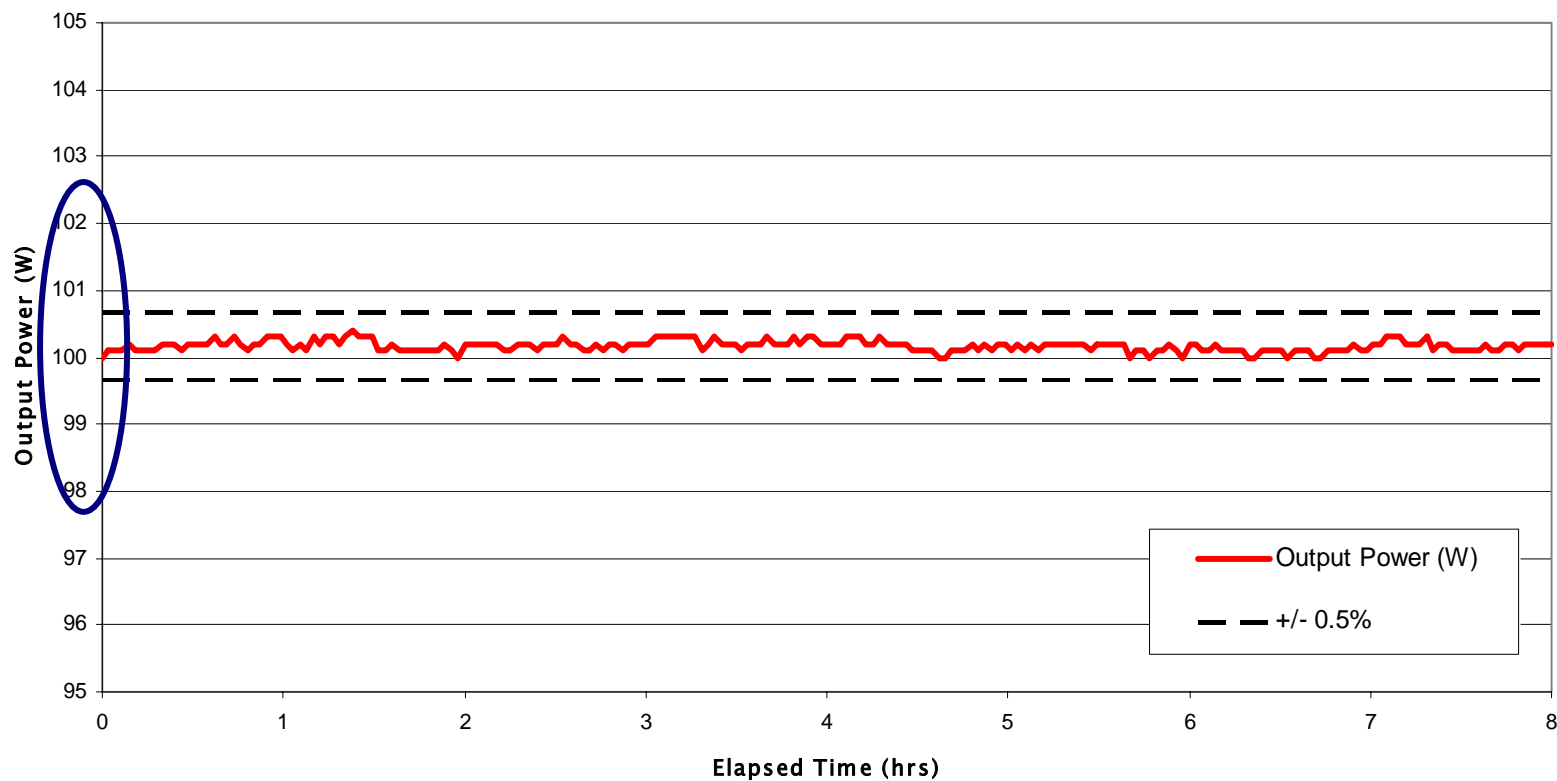
Solid state laser schematic



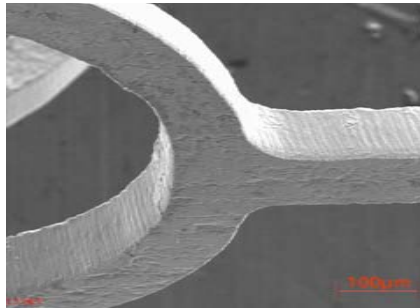
Typical Output Power Stability of +/-0.5% over 8 hour shift

SP-100C

CW Output Power Stability at 100W Nominal Output Power



Applications



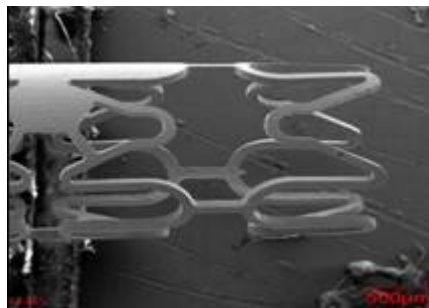
Stent manufacture



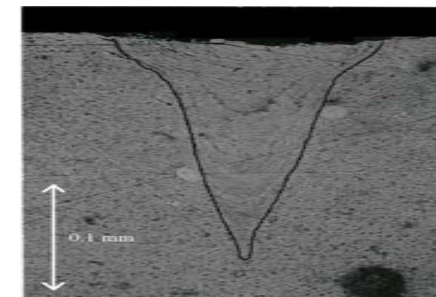
Micro-bending



Printing/gravure



Marking



Welding



Pacemakers



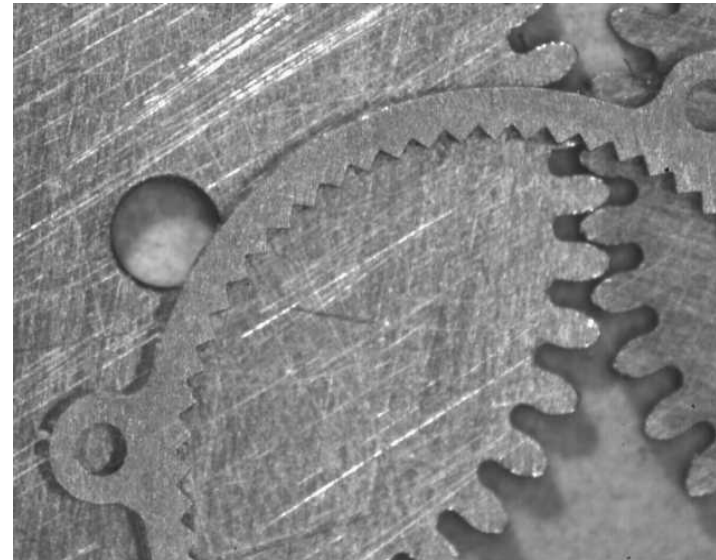
Microwelding



Cutting

Focus on Cutting

- Wide pulse width window us to ms allowing greater control of HAZ
- Small spot sizes
- Fine Kerf Widths



**Parts 2mm
across**

Cutting Results - <100 watts

Power (W)	Thickness (mm)	Cut speed (mm/min)	Kerf width (μm)
100	0.1	5000	28
100	0.1	4000	26
20	0.1	3000	16
20	0.1	2500	18
20	0.1	2000	19
20	0.1	1500	17
20	0.1	1000	17

Table 1: Laser cutting of thin 304 stainless steel
50 mm lens retro-fitted onto workstation

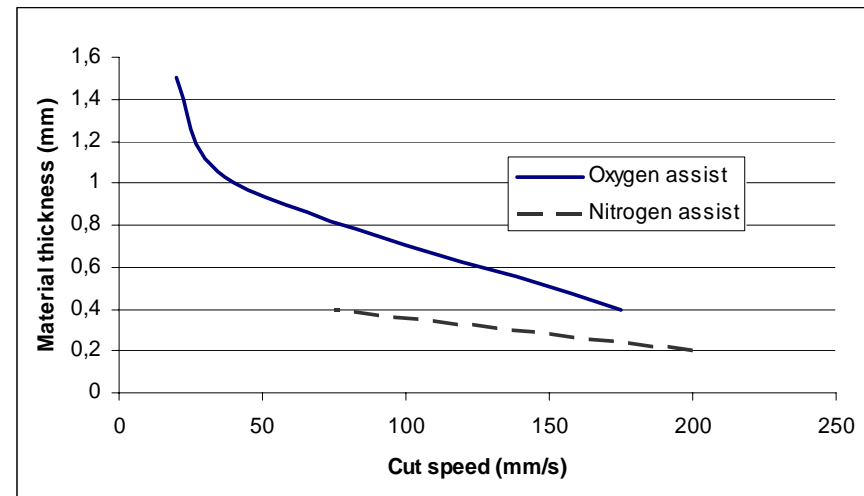
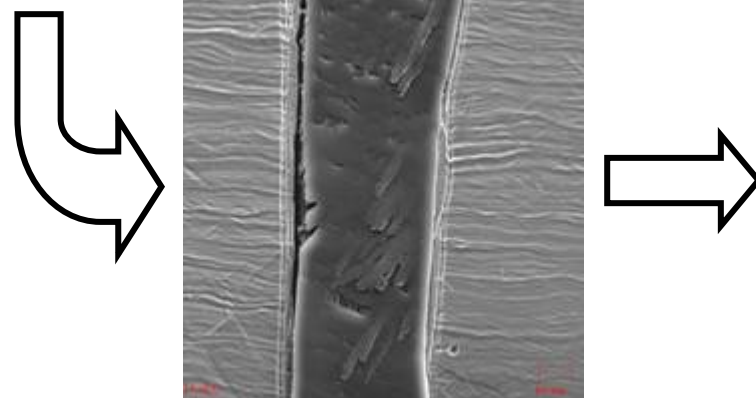
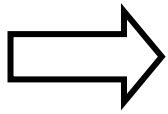
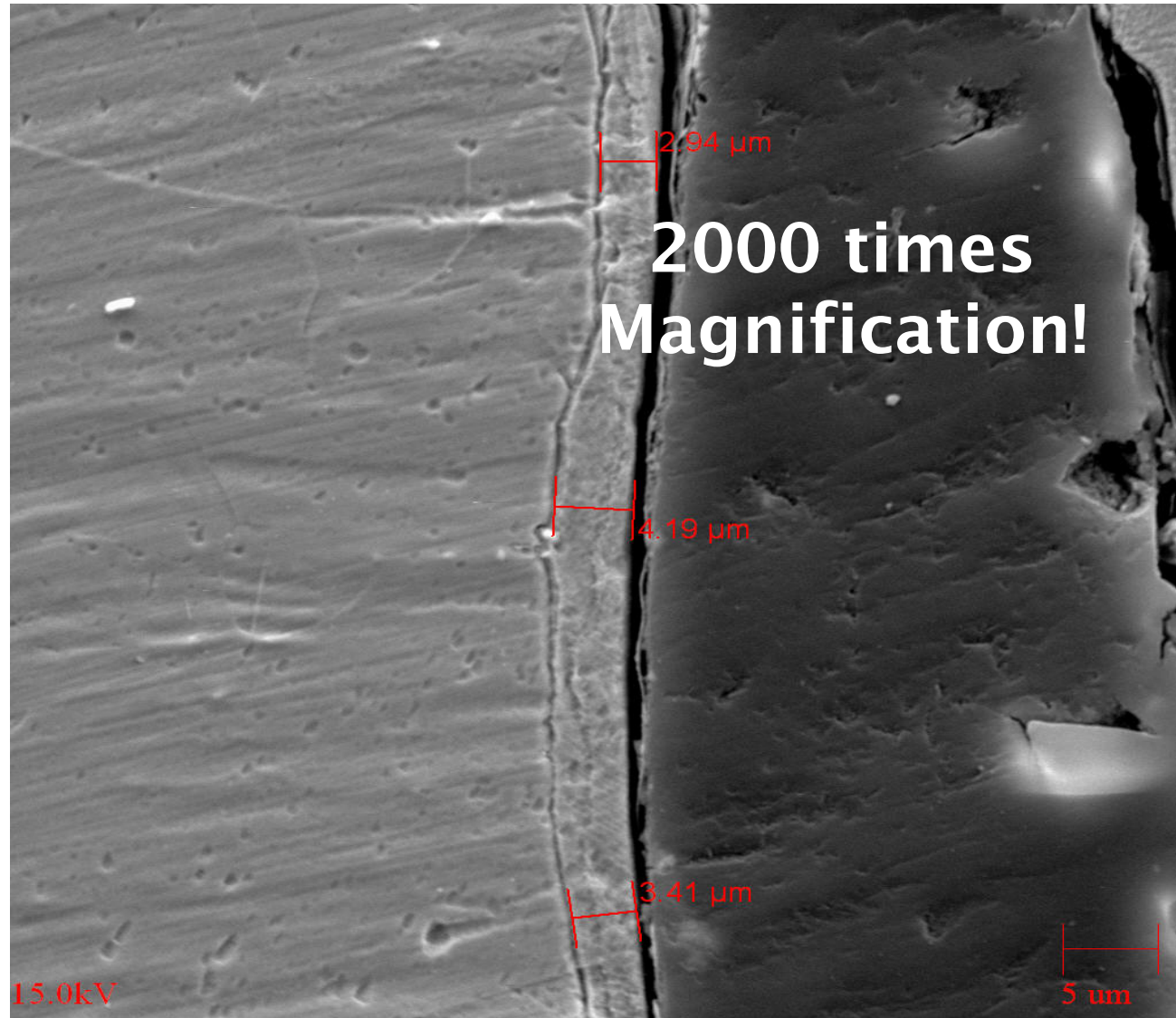


Fig. 1. Laser cutting of 304 stainless steel



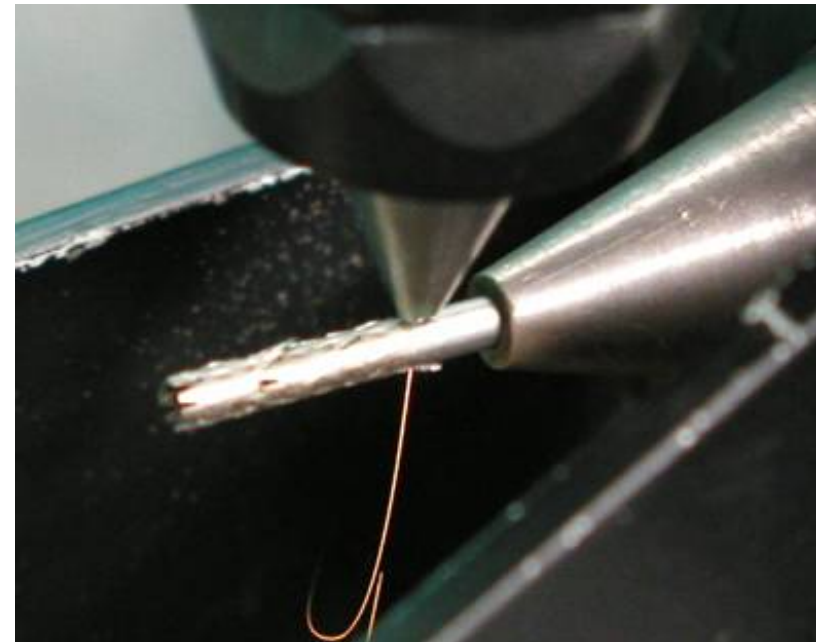
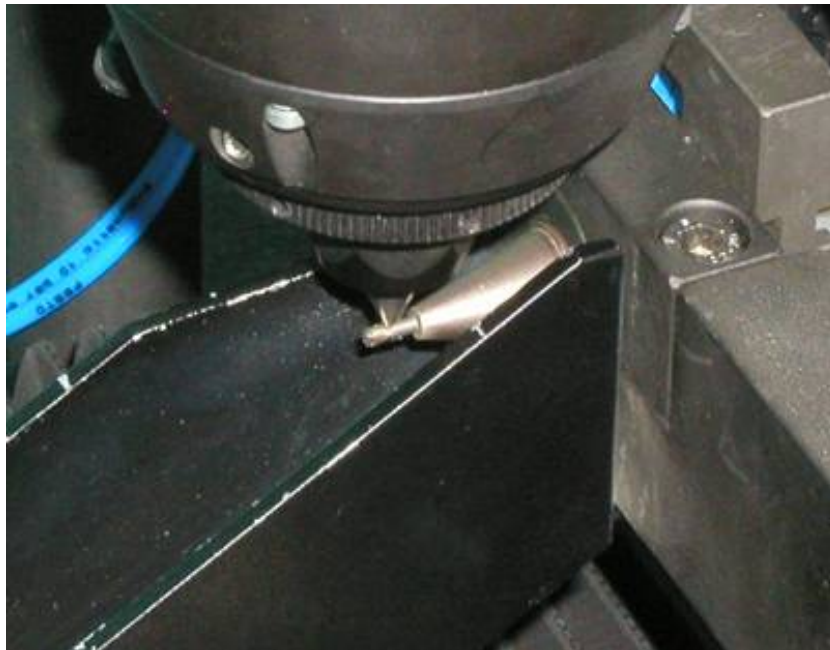


No other laser manufacturer will show you pictures at this magnification!



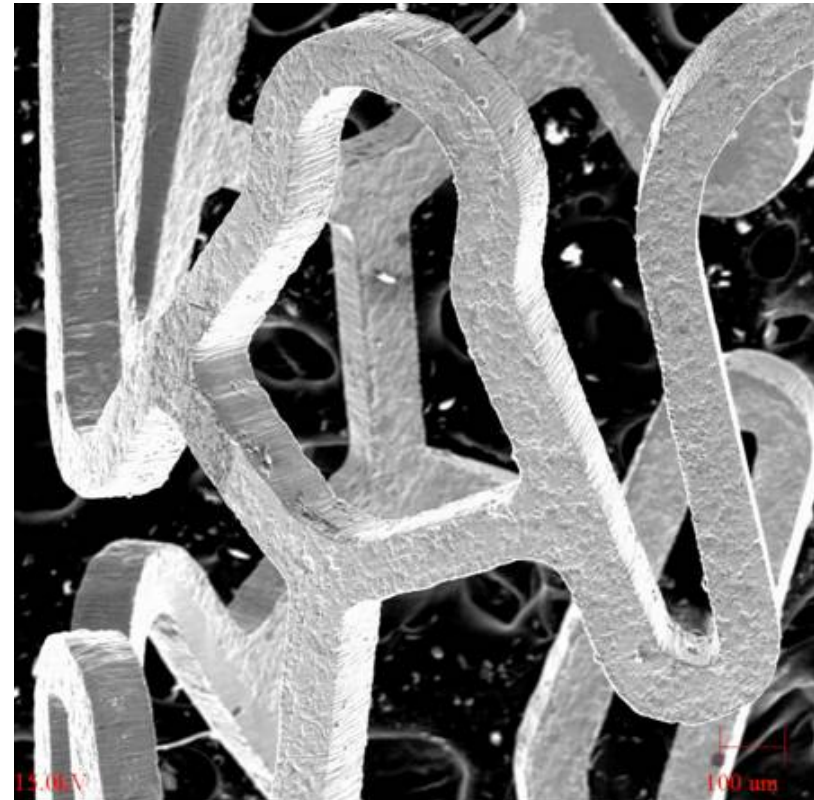
Medical Stent Manufacturing

(Stainless Steel, Cobalt Chrome , Nitinol)

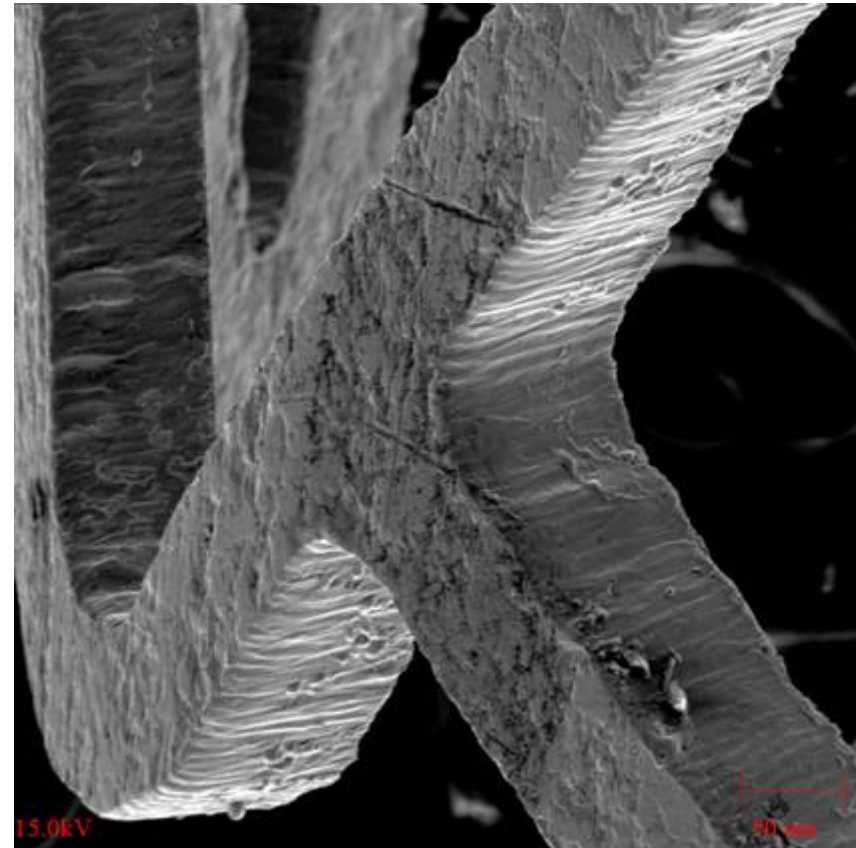
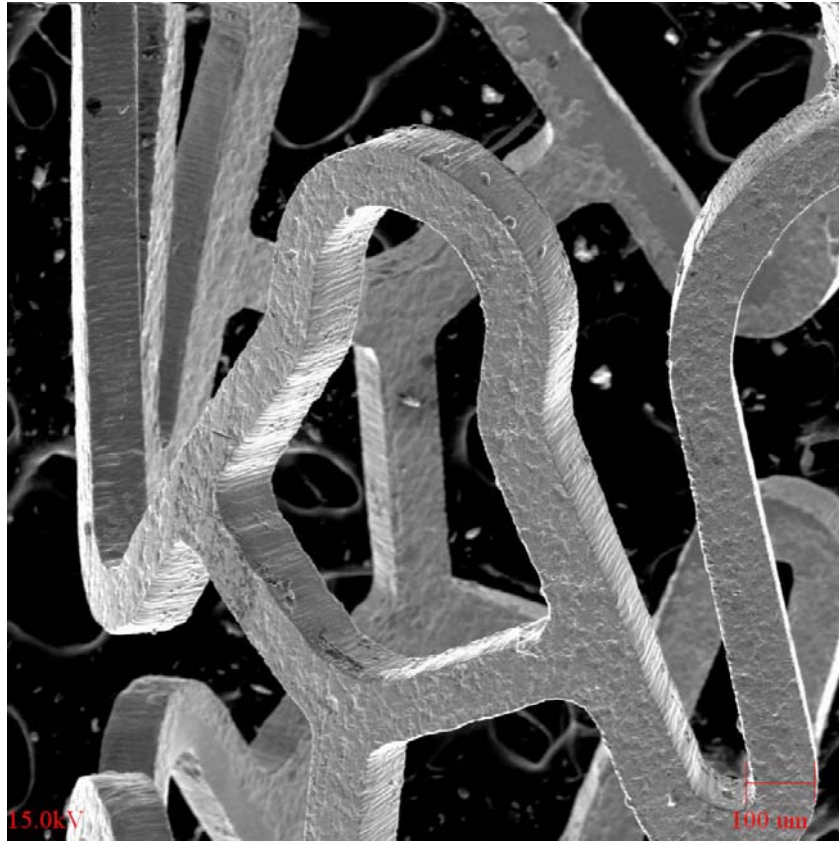


Stent Manufacturing as a Case study

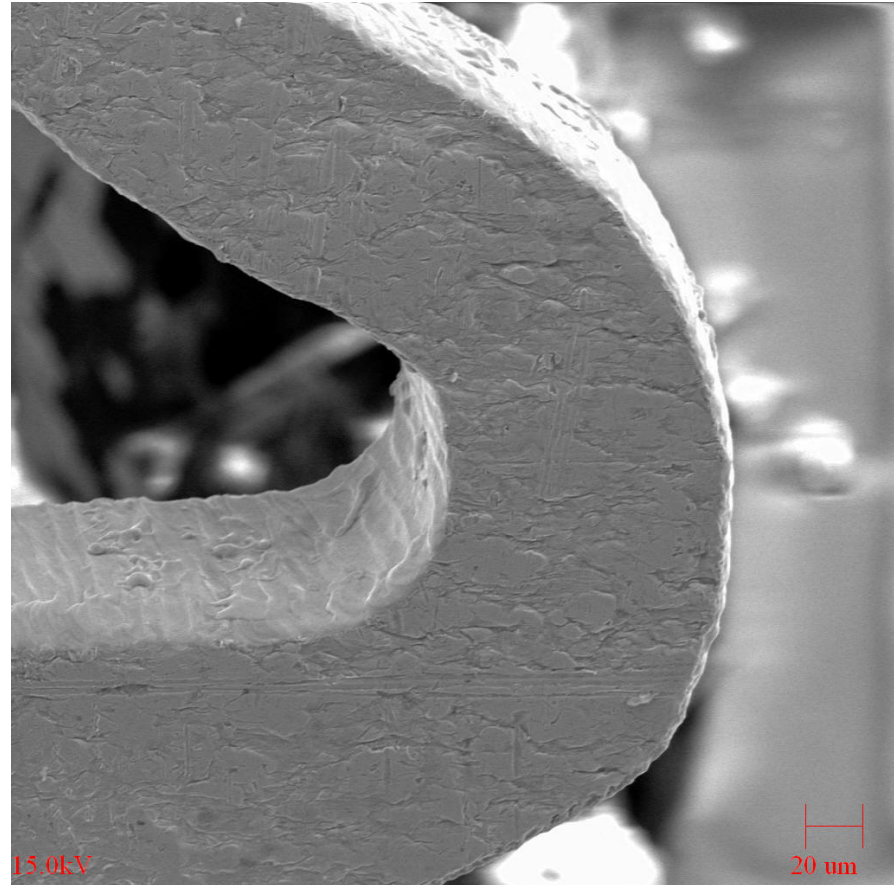
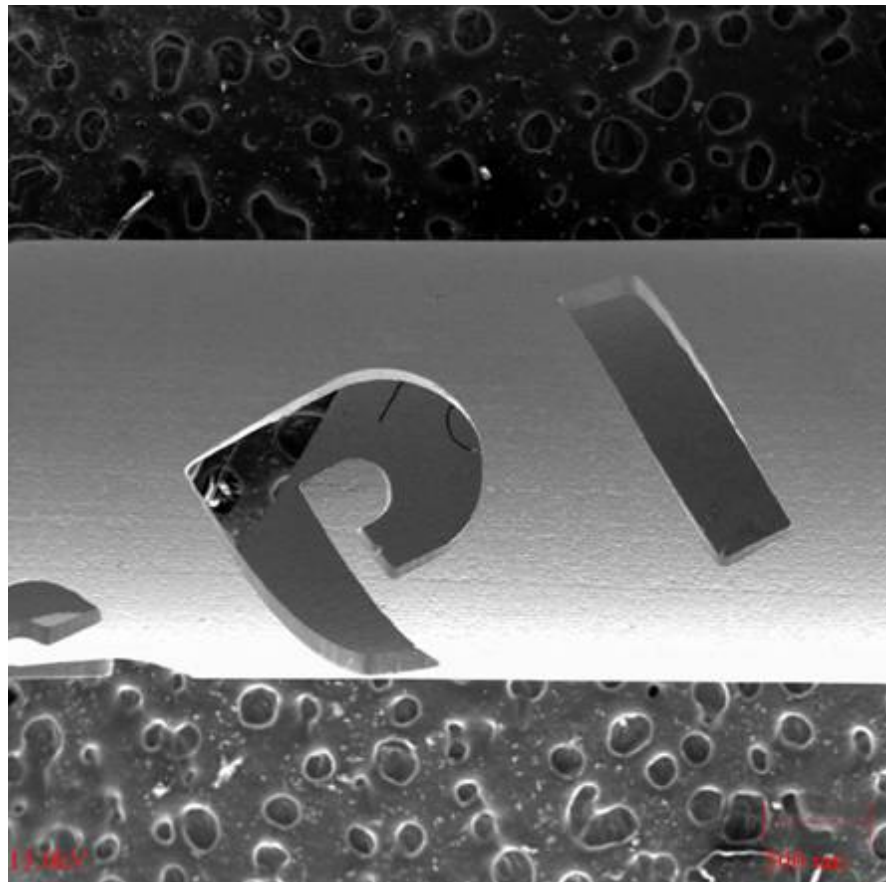
- Problems:
 - Further increase in manufacturing capability required over next 2-3 years
 - Conventional laser systems have high maintenance requirements
- Fiber laser advantage:
 - Higher cut speed due to direct laser modulation
 - Up to **30%** increase in throughput
 - Better cut quality
 - Higher yield, shorter post processing
 - Smaller size
 - Double throughput per square foot of laser facility
 - No maintenance
 - No laser downtime, no maintenance cost



Cut quality is everything!



*Cut quality is everything -
and fibre lasers deliver it!*



Device Manufacturing Cost Benefits of Fiber Lasers

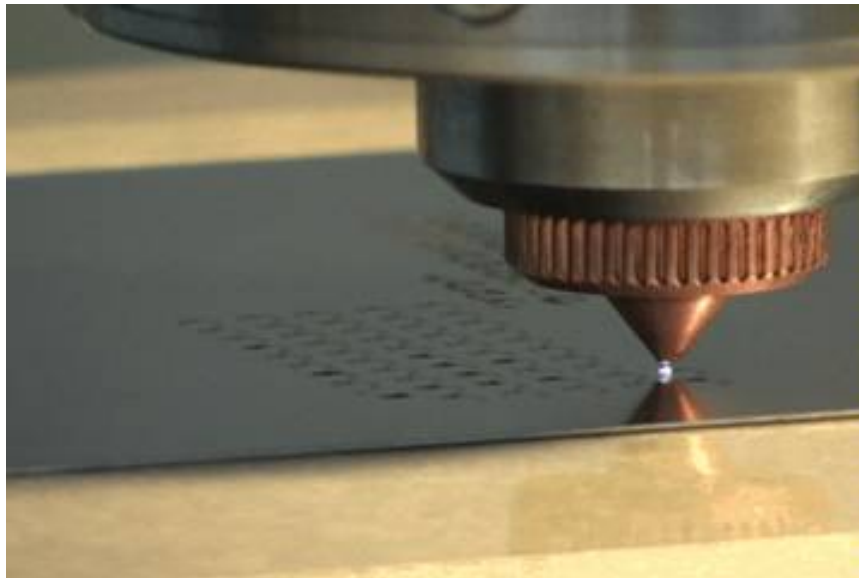
Nd:YAG laser

- <3% efficiency
- 1 billion shots / flashlamps requires weekly – biweekly flashlamp replacement
- 10 ft² clean room floor space
- Poor surface finish

Fiber Laser

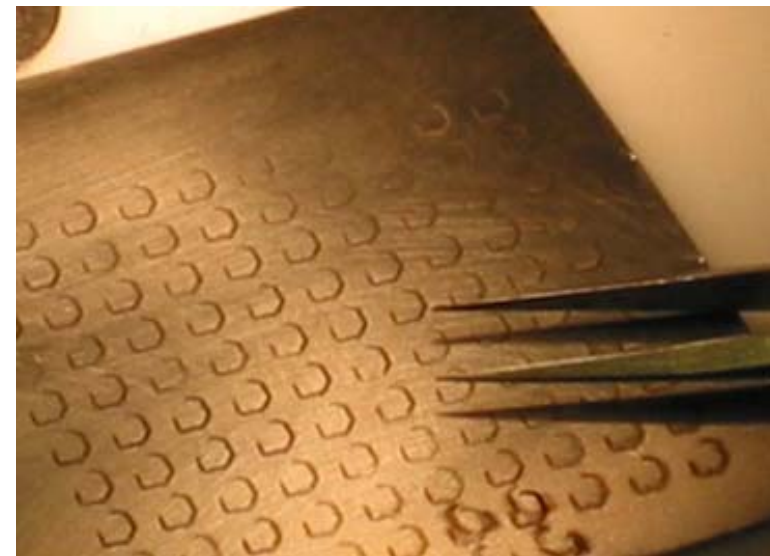
- 25% efficiency
 - \$7.5k pa electricity savings (12c/kWh)
- No flashlamps
 - \$10-15k pa savings for replacement parts
 - No laser technician required
- 3 ft² space
 - VERY significant capital cost saving in clean room space

Other Medical Devices



1KHz, 200mm/min
10W Average Power

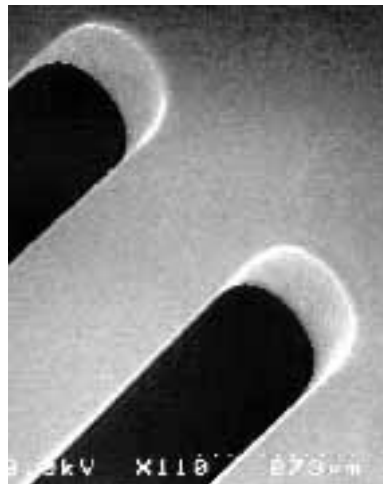
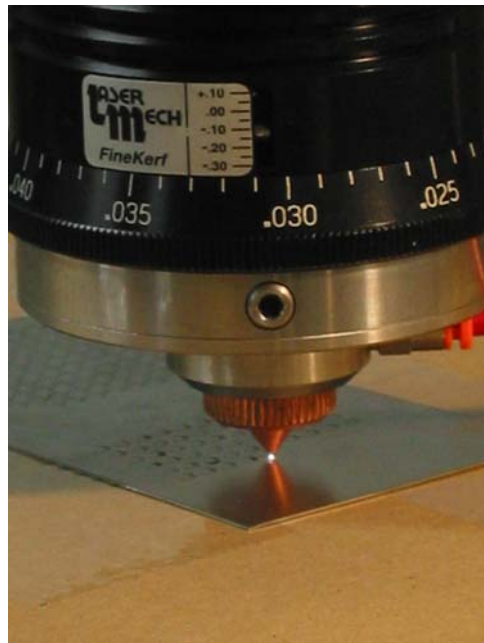
- Small surgical vein closures (complex clothes pegs)
- Small (0.2 mm wide)
- 316 & 304 stainless steel



SPI Fiber Laser Applications – *electronics industry*

Stencils (cutting of stencils used in manufacture of PCBs)

Competitive technology:	NdYAG
SPI value/competitive edge:	Beam quality and beam stability
SPI product fit:	100W 1090nm

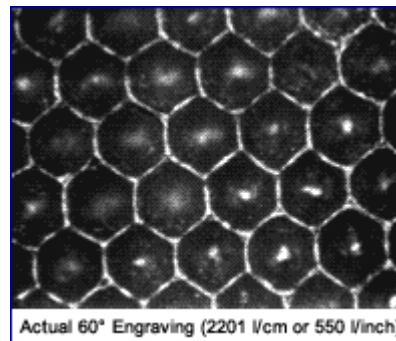


- **Beam quality allows increased throughput and finer detail**
- **Sheets have smooth, burr free walls**
- **No mechanical stress applied to the sheet ensures uniform tension over the sheet being processed and therefore improved solder printing**

SPI Fiber Laser Applications – *Printing industry*

Anilox roll (engraving of ink-holding cells on ceramic rolls)

Competitive technology:	NdYAG/CO2
SPI value/competitive edge:	Beam quality, speed
SPI product fit:	50W-100W 1090nm



- SPI fibre lasers - better quality cell definition for increased detail and faster throughput

- Better release of ink and improved consistency over Nd:YAG for high throughput applications

Micro-Welding

- Reducing component size in certain markets makes the TEM₀₀ fiber laser very appealing
- Weld consistency and quality are key
- High long term output stability, small spot size
30-100W fibre lasers offer precision welding using CW/M operation
- Good consistency, lack of porosity
- Keyhole Welding
 - Good high aspect ratio welding
- Spot welding/Conduction limited welding
 - Good results using CW/M fibre laser

Keyhole Welds to Wide Shallow Welds

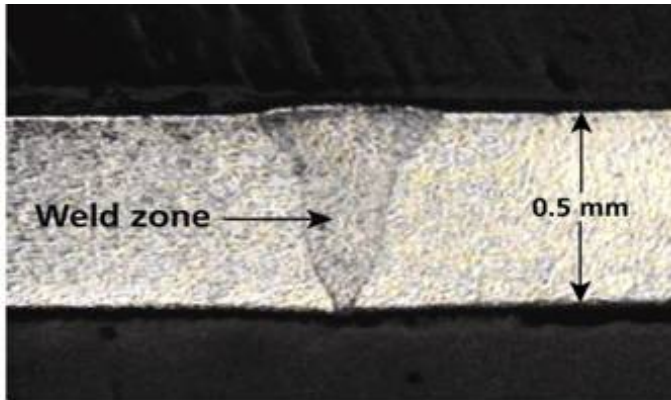


Fig. 1 - Welding speed: 1.5 m/min

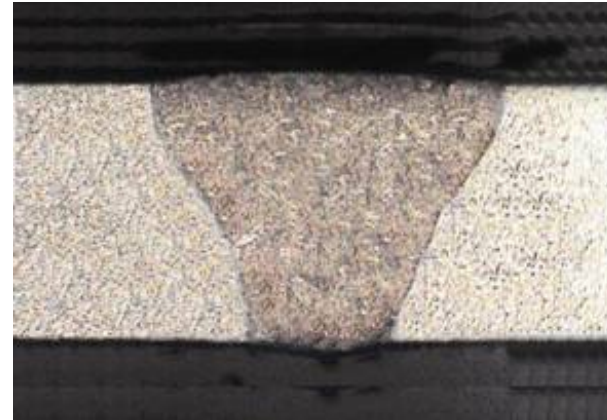


Fig. 2 - Welding speed: 1.0m/min

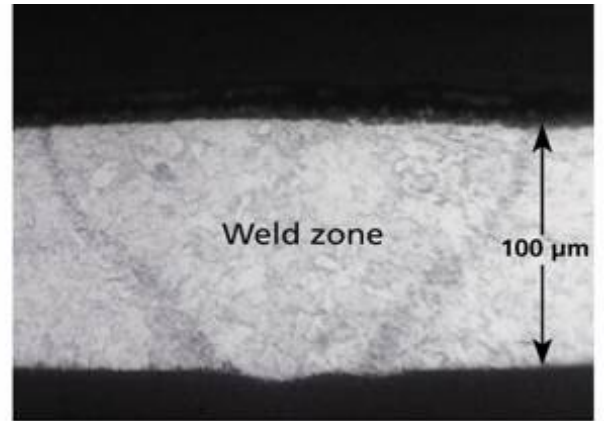


Fig. 1: Welding speed 2.5 m/min, 30 Watts

Key Features of Welds

- **High Aspect Ratio Deep Narrow Weld**
 - Vapour filled hole moves rapidly through the material
 - 2000°C very fast with small spot size, *transverse* weld profile changing with speed
 - High stability SPI Fibre Laser creates stable weld bead allowing better control of potentially unstable dynamic keyhole
 - Reduced porosity (gas holes) due to stable *keyhole*
 - Difficult to achieve on YAG lasers, good results from fibre lasers
- **Wide Shallow Welds**
 - Majority of conduction is from surface melting but not vaporising giving a round base to weld
 - *At low duty cycle* melt pool solidifies between spots giving a hemispherical shaped weld

Real control over weld shape

Spot welding of thin sheet steel *Hard disc drive manufacturing*

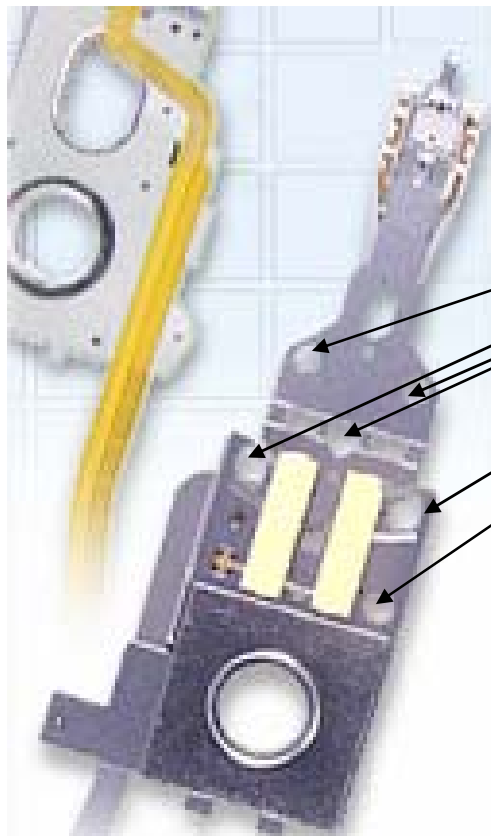
- 20 & 60 μm sheet welded to thicker steel
- 100 & 160 mm scan lenses used
 - 40 & 65 μm focus spots
- Parameters typically 2KHz, 200ms pulses , 80% duty cycle

RESULTS

- Spatter free welds were possible for all four combinations
- Peak power required was in the 50W region
- Actual weld spot diameters were 130-170 μm
- Weld time was 2.5 ms

Hard Disc Drive Manufacture

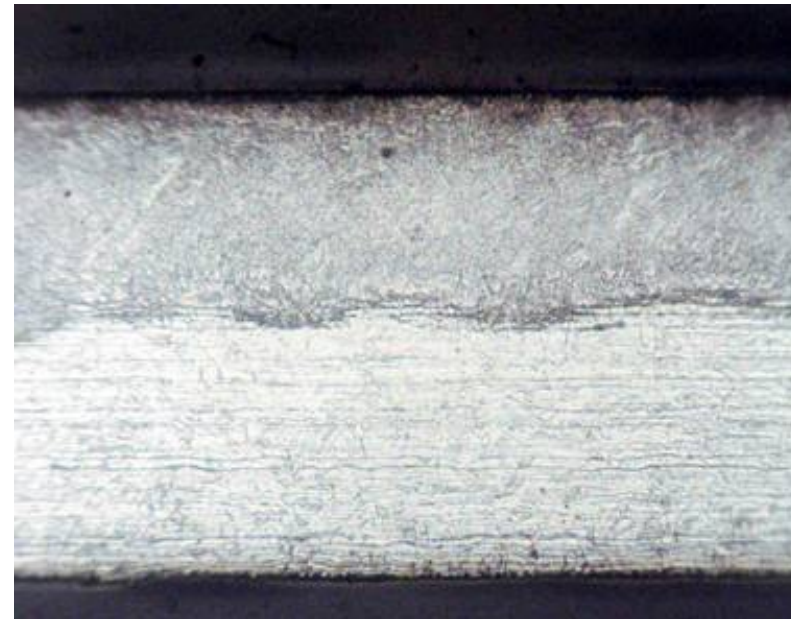
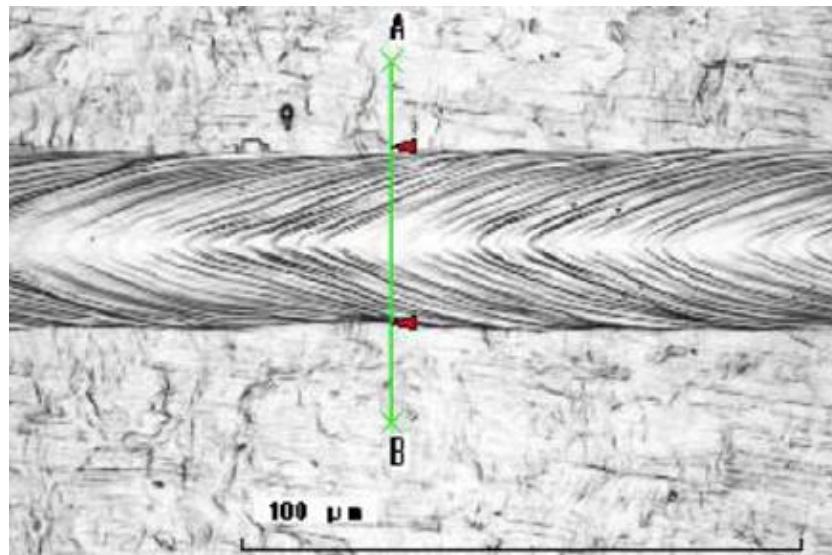
- process window established



- Scanner based system
- High speed process
- Very high weld quality required
- Spot may be < 50 microns

Weld quality is everything and fiber lasers deliver it!

Weld approx. 0.1 mm wide
Weld smoothness is key



Longitudinal weld section on stainless steel shows very consistent penetration
- evidence of power stability

Weld quality is everything and fiber lasers deliver it!



- < 2" diameter part
- Weld approx. 0.1 mm wide
- Weld smoothness of top bead is key
- Therefore sterilizable (food / medical)



Fiber Laser Applications - *other medical device apps*

Micro Welding

Pacemakers, Defibrillators, Batteries, Capacitors, Lead/guide wires, Birth control devices

Competitive technology:

NdYAG

SPI value/competitive edge:

Beam quality/no maintenance

SPI product fit:

100W 1090nm







Fiber Laser Advantage:

- Smaller spot for precision process
- Faster weld speed for higher throughput
- Higher yield due to high beam quality combined with stable beam
- High stability at low duty cycle higher yield
- High quality weld ensures a repeatable process
- Dissimilar metal welding

Fibre Laser Applications

Fiber lasers have come a long way in a short time

-  Quickly establishing themselves across industries,
-  Much more work to be done to educate potential users regarding the business benefits
-  Many more real applications underway in the lab
-  How many more applications currently done by pulsed and CW NdYAG lasers can be done with fibre lasers?

SPI Products

1550nm - 10W



OEM - building blocks



2-20W CW and Pulsed

10-30Ws
air cooled



100W

