

**2443-23**

**Winter College on Optics: Trends in Laser Development and Multidisciplinary  
Applications to Science and Industry**

*4 - 15 February 2013*

**Laser Industrial production**

B. Previtali  
*SITEC  
Italy*



## Laser industrial production

Barbara Previtali

WINTER COLLEGE 2013

Trends in laser development and multidisciplinary applications to science and industry



## **SITEC Laboratory for Laser Applications**

**Mechanical Engineering Department  
Politecnico di Milano  
Italy**

- 1. didactics.**
- 2. base and applied research** (new laser applications).
- 3. services for industries:** development and tuning of industrial laser processes.

# 1 SITEC video

Barbara Previtali	Associate Professor
Daniele Colombo	Assistant Professor
Bruno Valsecchi	Post-doc, research fellow
Patrick Pradel	Ph.D.st.
Ali Gokhan Demir	Ph.D.st.
Stefano Zarini	Ph.D.st.
Emiliano Verga	research fellow
Giovanni Riva	research fellow
Pietro Maressa	research fellow

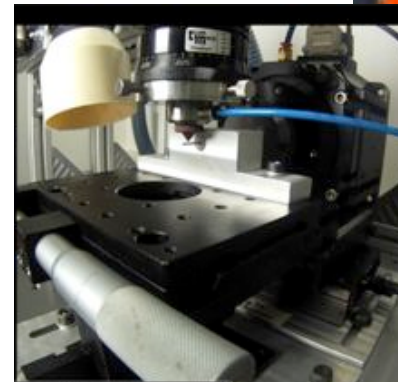


Laser Industrial production

Barbara Previtali

## LASER SOURCES

- Fiberlaser, IPG YLS3000, 3000 W MM cw
- Fiberlaser, IPG YLR1000, 1000W MM cw
- Fiberlaser, IPG YLR100, 100W SM cw
- Fiberlaser, IPG YLP, 50W pw
- Diode laser, Rofin, 2200W, 6300W
- Nd-Yag, Trumpf Powerweld, 120W pw
- Nd-YAG, Lumonics JK701, 500W pw



## LASER EQUIPMENT

- Precitech HP SSL
- LaserMech heads
- Aerotech stages and spindle
- HighYag BIMO
- HighYag  $\mu$





# Our competencies in laser applications

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- Laser welding;
- Laser cutting and drilling;
- Laser hardening;
- Laser cladding;
- Laser microprocessing;
- Control and monitoring of laser processes
- Modelling of laser processes;

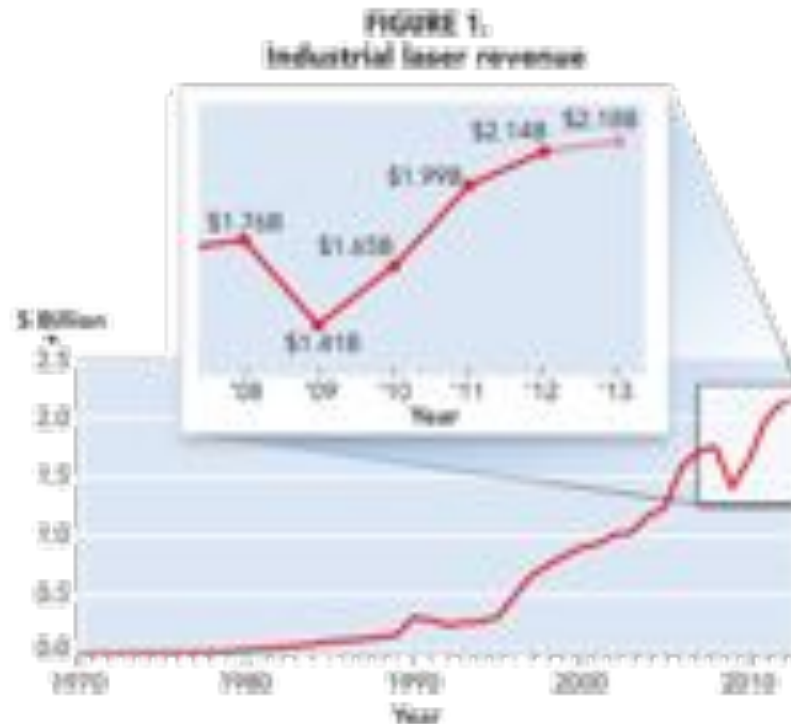


# LASER INDUSTRIAL PRODUCTION



# Laser industrial production

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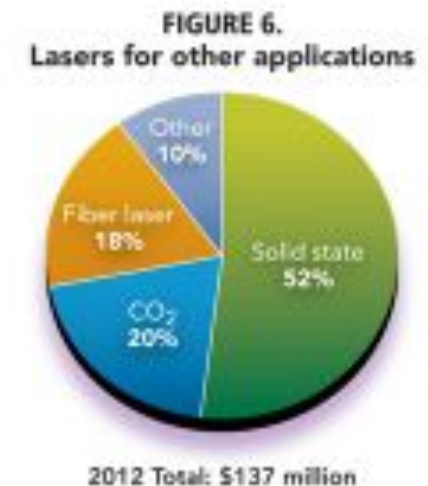
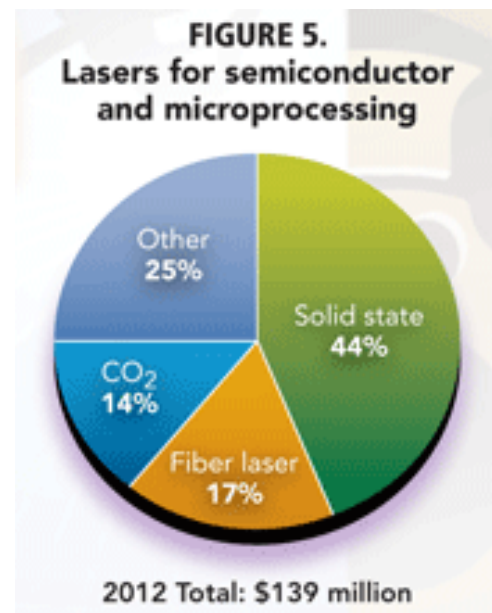
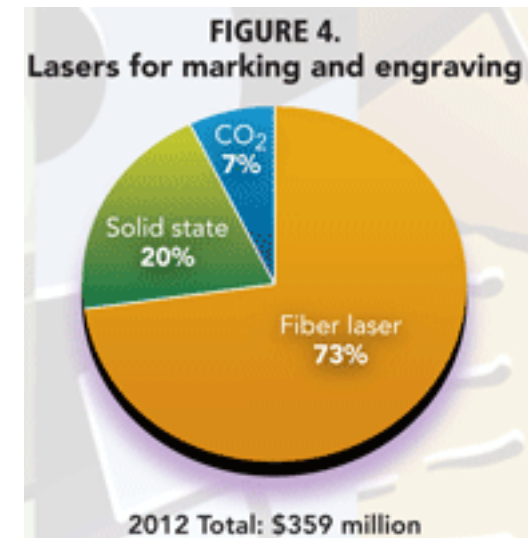
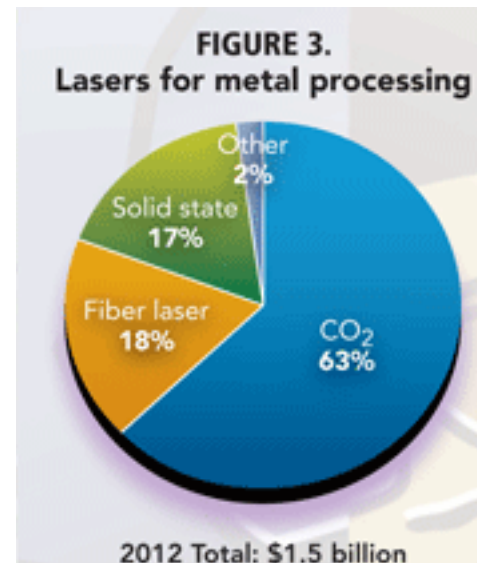
**TABLE 3.** Global laser system revenues (\$M)

TYPE/YEAR	2011	2012	%	2013	%
CO <sub>2</sub>	4100	4244	4	4300	1
SOLID STATE	1611	1665	3	1695	2
FIBER	1164	1350	16	1465	8
OTHER	200	216	8	240	11
<b>TOTAL</b>	<b>7075</b>	<b>7475</b>	<b>6</b>	<b>7700</b>	<b>3</b>

**FIGURE 7.**  
Global system installations

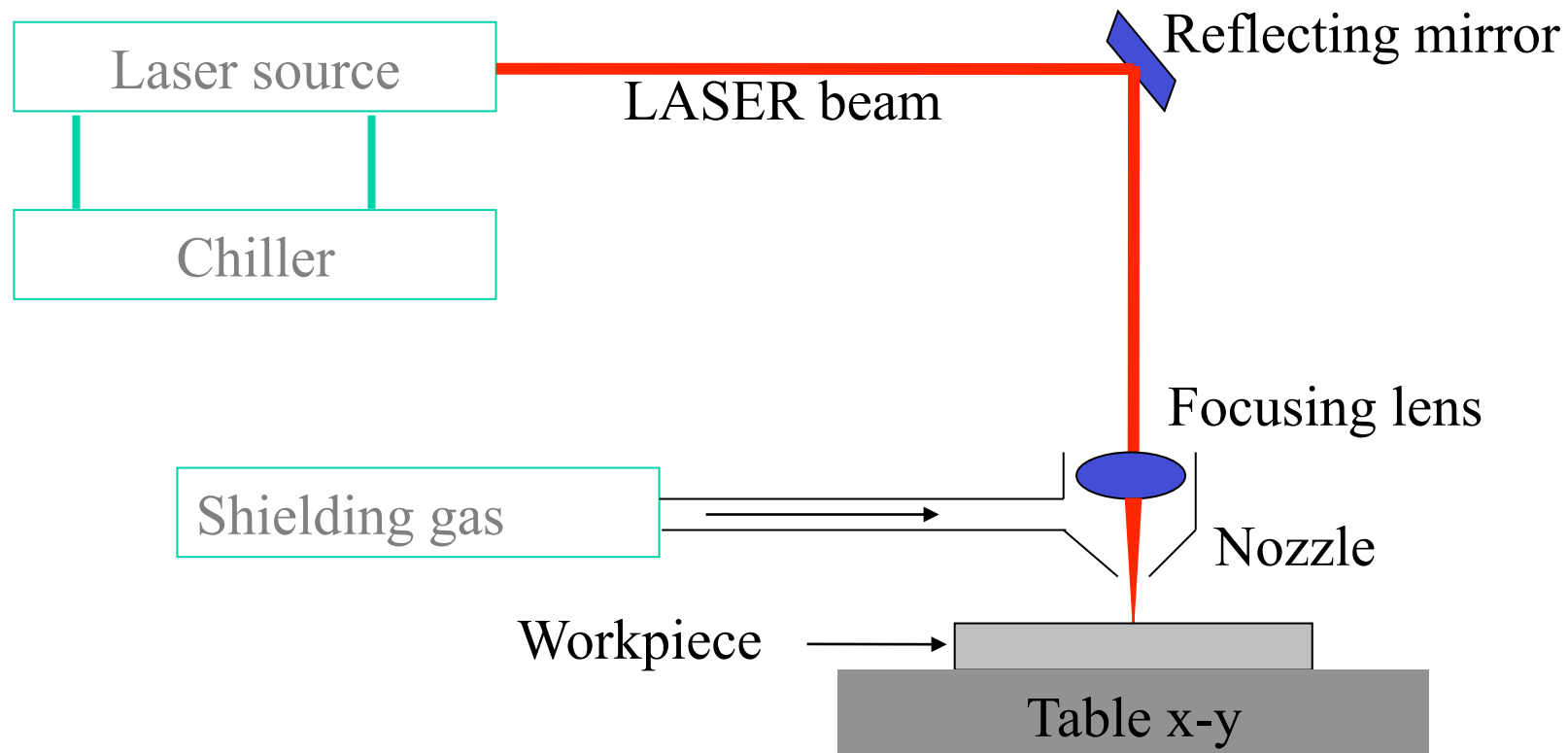


2012 Annual Economic Review and Forecast – Industrial Laser Solutions, February 2013



- Sales of high power laser metal cutting system is 60% (5b) of the total

# LASER INDUSTRIAL PRODUCTION BY APPLICATION SECTOR



**Cutting**

**Welding**

**Heat treatment**

**Cladding**

**Drilling**

**Marking**

**Scribing, milling**

**Cleaning**

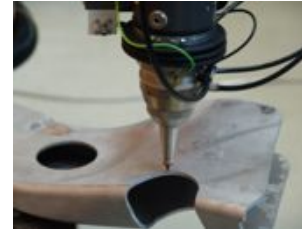
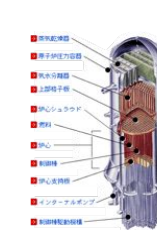


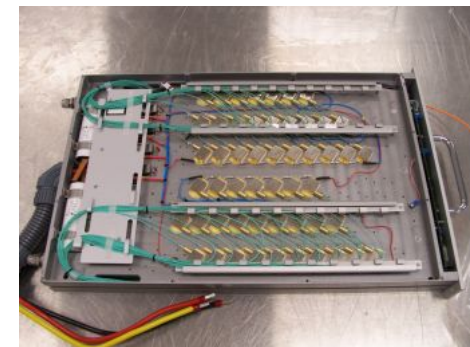
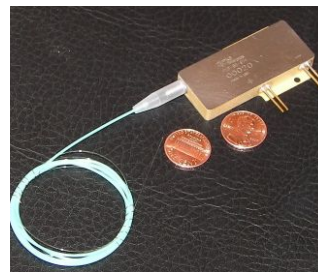
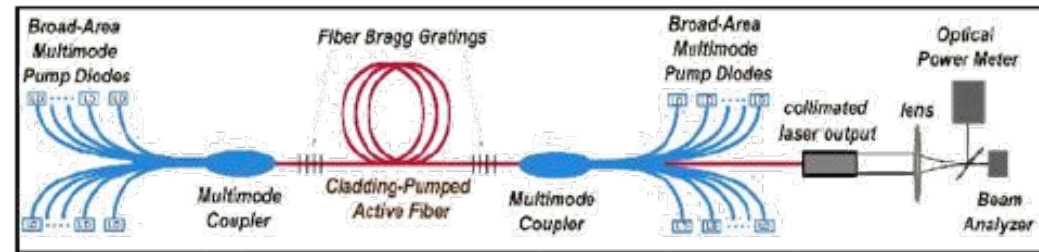
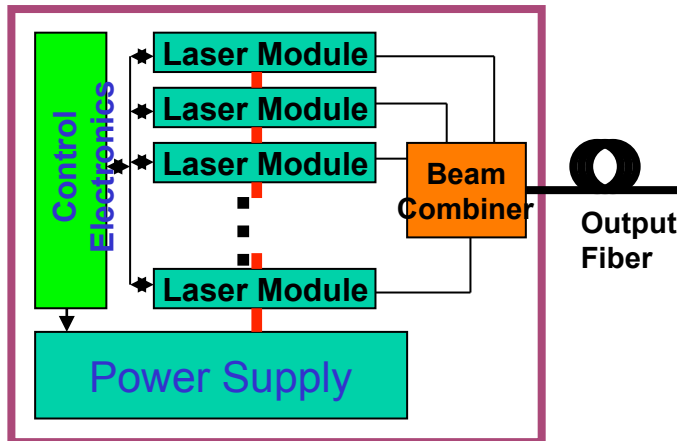
図12-10 車体組立工程で、車体部分「リアハッチ」の溶接にレーザー溶接が採用されている。この溶接は、レーザー溶接機を用いて行われ、溶接部の強度が向上している。また、溶接部の形状もレーザー溶接機によって制御されている。



図12-11 車体組立工程で、車体部分「リアハッチ」の溶接にレーザー溶接が採用されている。この溶接は、レーザー溶接機を用いて行われ、溶接部の強度が向上している。また、溶接部の形状もレーザー溶接機によって制御されている。







- monolithic laser source: no ordinary maintenance (lamps, mirror re-alignment), compact footprint
- 1 micron wavelength
- high plug efficiency: 30%
- high beam quality (BPP or  $M^2$ )
- scalable power

$$d_0 = \frac{4 \cdot M^2}{\pi} \frac{\lambda \cdot f}{d_f}$$



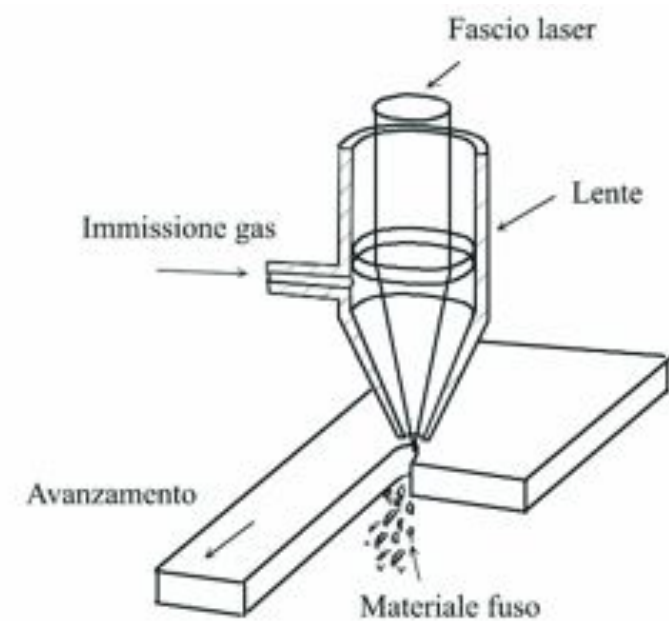
That consolidates some applications:

Laser cutting:

- High and low thickness
- High reflective materials

Three fundamental methods

- fusion (melt and blow & reactive fusion cutting)
- vaporization
- cold cutting



# 2 LaserCutting video

### 3 LaserMicroCutting video

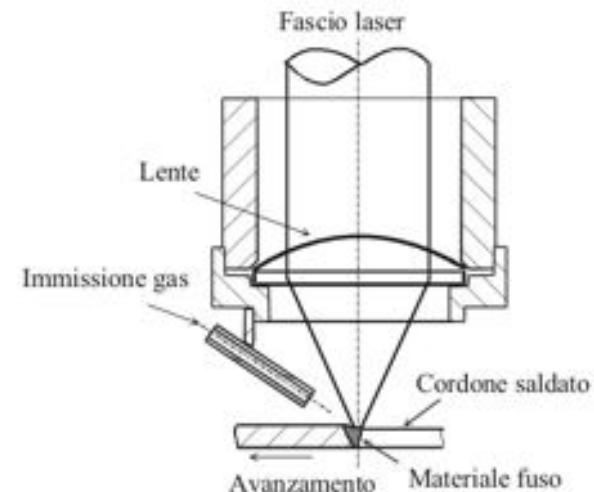
That consolidates some applications:

Laser cutting:

- High and low thickness
- High reflective materials

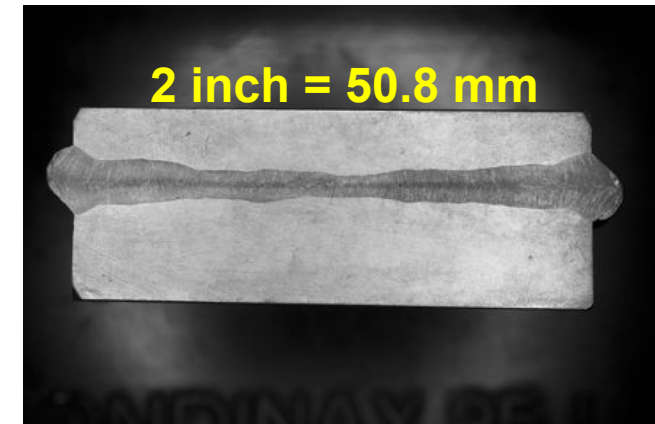
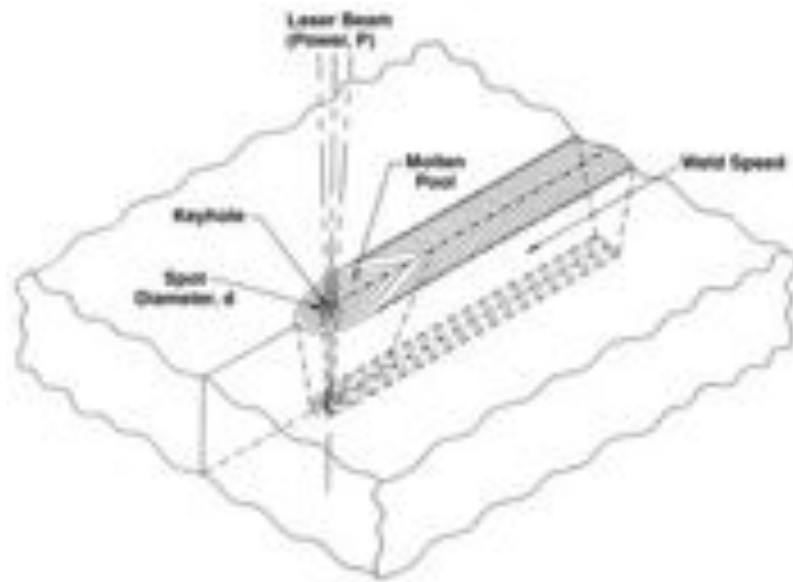
Laser welding

- High thickness laser welding
- Hybrid laser welding
- Remote laser welding

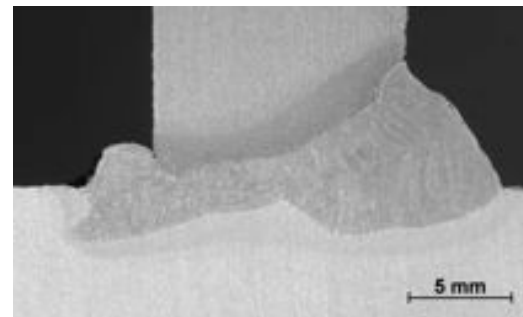


# High thickness laser welding

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$P=10\text{kW}$   $v=1,5\text{m/min}$



**Conventional  
Laser Welding**



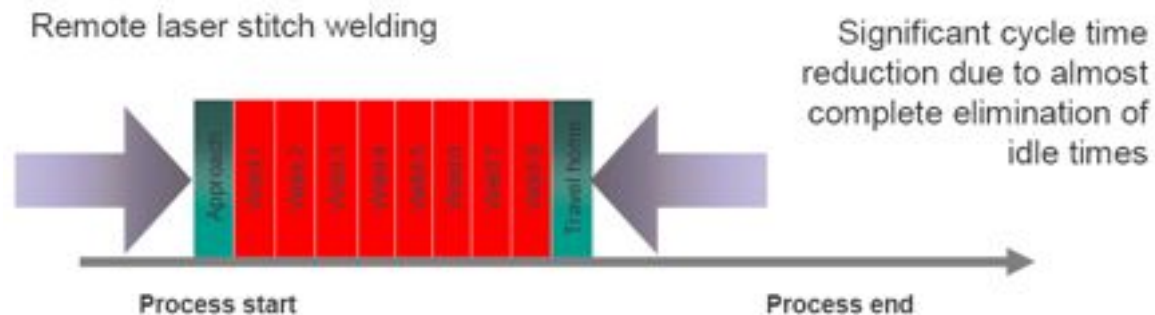
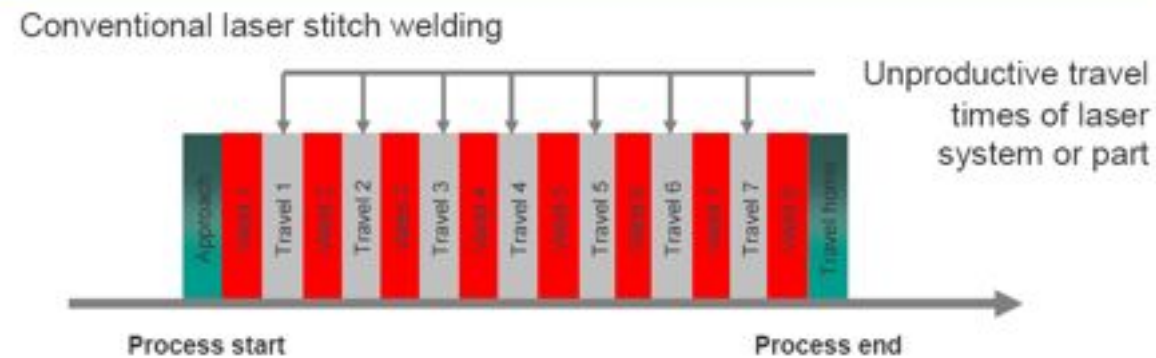
**Remote Welding**

## Characteristics of RW

- long process distance
- positioning via mirror system
- large working area
- varying angle of incidence
- highly dynamic positioning
- working space is a sphere







## That consolidates some applications:

### Laser cutting:

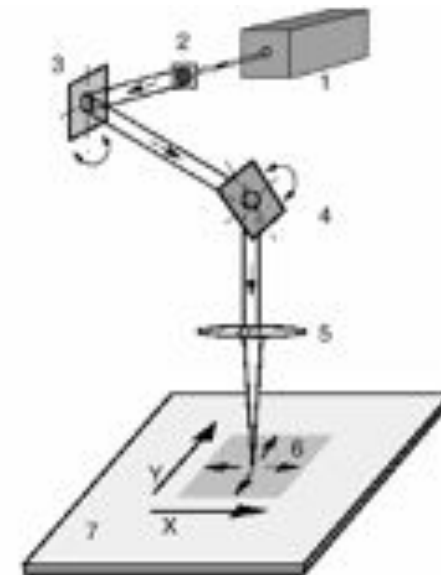
- High and low thickness
- High reflective materials

### Laser welding

- High thickness laser welding
- Remote laser welding
- Hybrid laser welding

### Surface machining (functionalization)

- Marking
- Texturing
- Cleaning

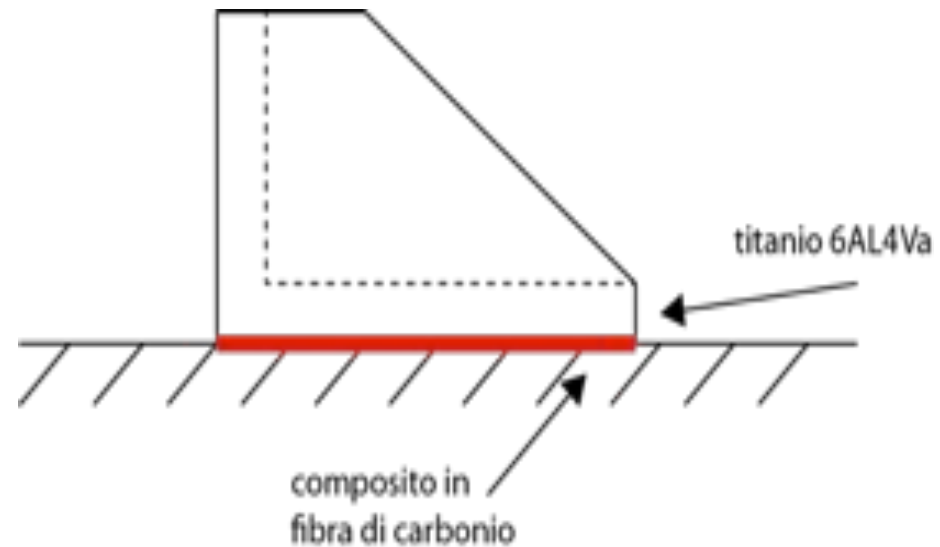


- |   |   |
|---|---|
| 1 Laser                                 | 5 Beam focusing (plane-field focusing lens) |
| 2 Beam widening (telescope)             | 6 Marking field                             |
| 3 Beam deflection, Y direction (mirror) | 7 Workpiece                                 |
| 4 Beam deflection, X direction (mirror) |   |



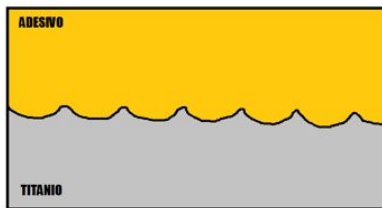
## 4 LaserMicroprocessing video

Component in titanium alloy to be connected (by adhesive) to a carbon fiber reinforced polymer.

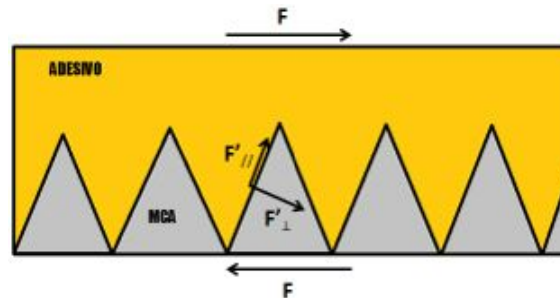


Different types of laser texturing:

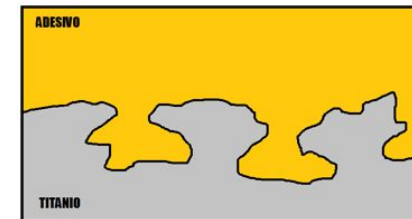
DIMPLING

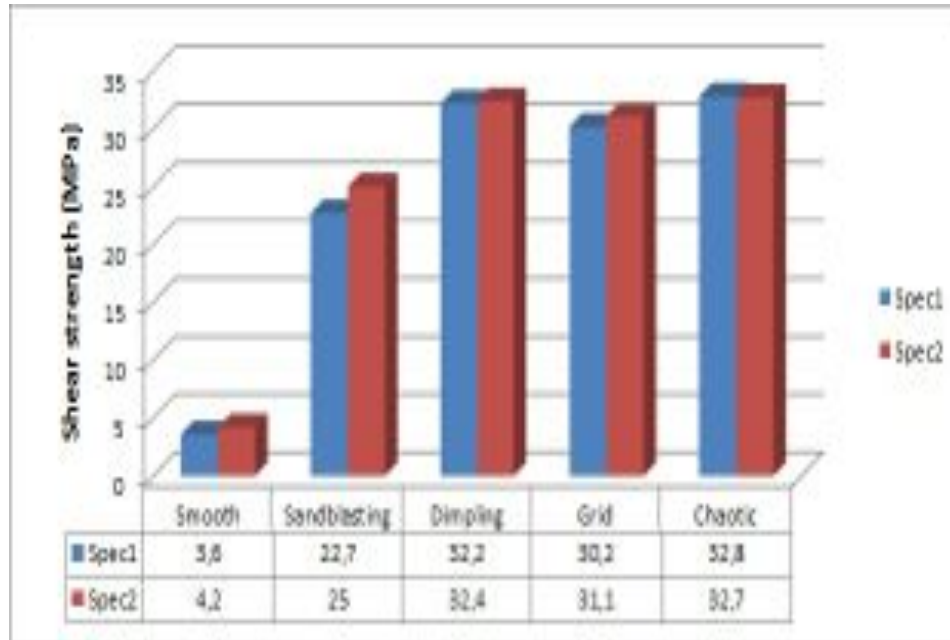


GRID

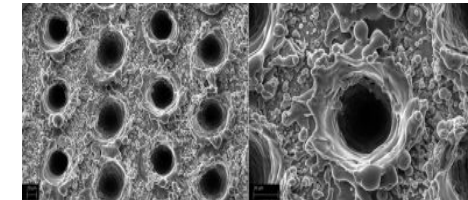


CHAOTIC

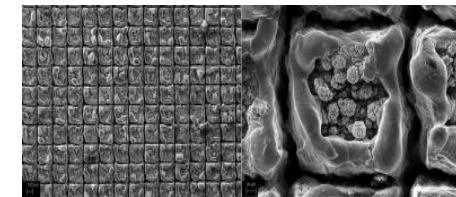




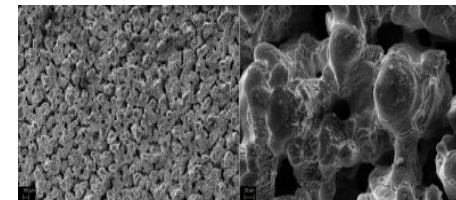
DIMPLING



GRID

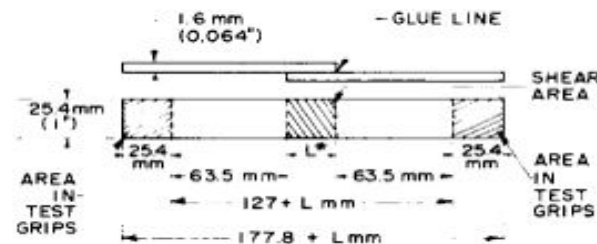


CHAOTIC



## ASTM D 1002-05

Apparent shear strength of single lap joint adhesively bonded metal specimens by tension loading



- Laser texturing produces 40% increase in the shear strength (in respect to the sand blasted samples)
- Different types of laser texturing do not produce significant differences



That affects:

Cinematic and dynamic behaviour of the laser systems

- linear motors
- hybrid architecture, redundant axis

Laser head and optics

- focus shift
- proper cleaning and maintenance

Monitoring and control

- process
- system

Safety

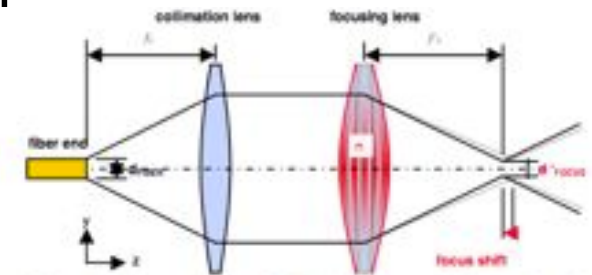


Fig. 3: Absorption of the laser radiation in the focusing lens and effect on the resulting focus shift

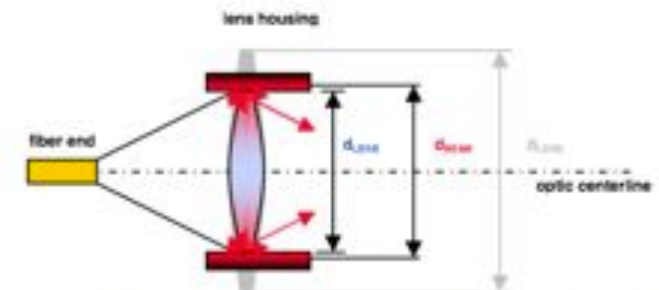


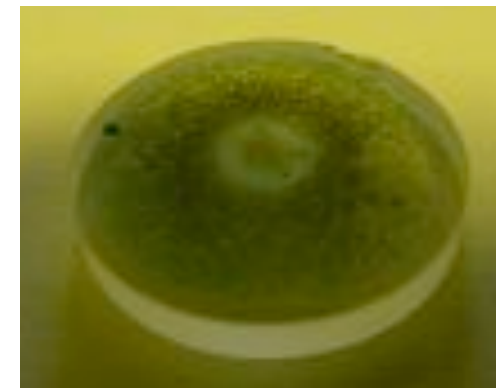
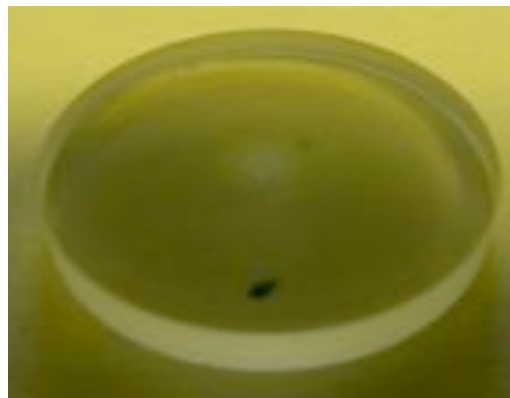
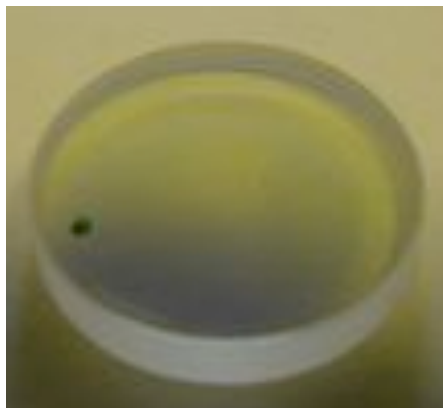
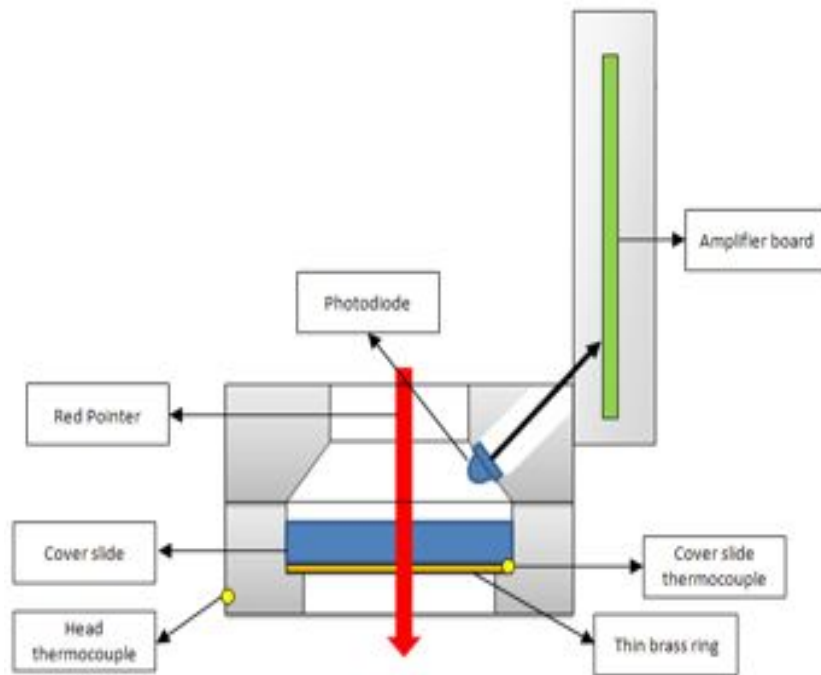
Fig. 7: Thermal load of the lens housing as a result of wrong dimensioning

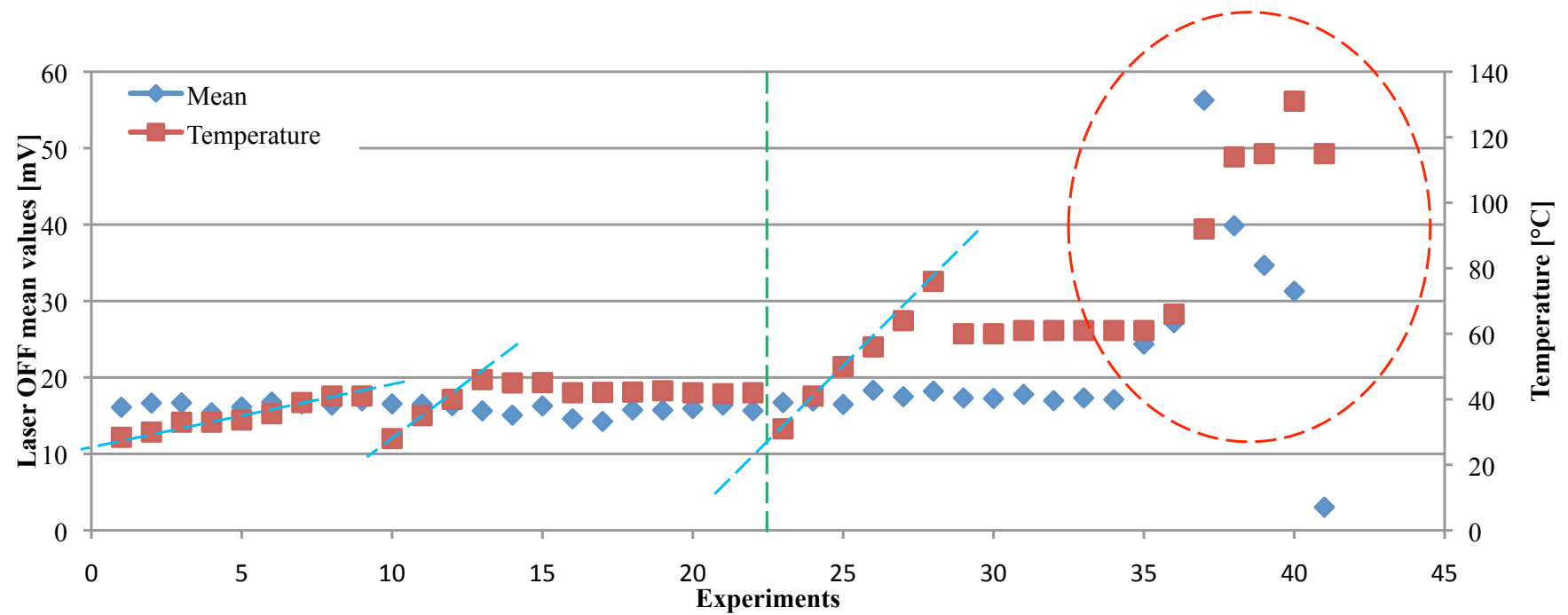
*M. Kogel-Hollacher et al., ICALEO 2009*

# 5 Laser Cladding video

# Monitored head for fiber laser cladding

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That opens to future developments:

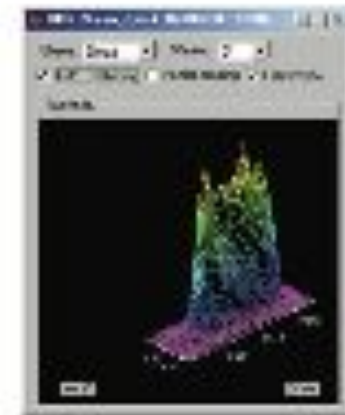
### Beam shaping Laser head and optics

- dual beam techniques
- diffractive optics
- wobbling: high-frequency beam oscillation

Pulsed fiber laser sources:

- short: few ns and ps regimes
- green with high power

High brilliance diode laser



## 6 High Deposition Laser Cladding video



- Laser industrial production has great importance for the photonic applications;
- Active fiber laser sources increased penetration into markets held by other laser types;
- Fiber laser sources have potentialities that can be modulated in view of the applications:
  - Laser cutting: scalable power, high beam quality, long depth of field
  - Laser welding: scalable power, small diameter, high power density,
  - Laser cladding: scalable power, multimode distribution, beam shape-ability
  - Micro-machinig: high peak power, high pulse energy, small diameter, high beam quality, wavelength shorter than 1 mm



Laboratorio per le Applicazioni Laser

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