Use of Pulsed Nd:YAG-Lasers in the Medical Industry

-The pulsed Nd:YAG (1.06 μm) : Processing of biocompatible Material

-Cutting, drilling, welding for Instruments and Implants
Laser in Medical Industry

- DIAGNOSTIC
- Therapy
  - Radiation Therapy
  - Medical Technology
Laser in Medical Industry
(Material Processing)

- Production-Equipment
  - Casting Moulds
  - Spinnerets
- System-Components
  - Electronic
  - Dosing
  - μ-Filter
- Instruments
  - Needles
  - Cannule/Tube
  - Endoscope Catheder
  - Saws
  - Forceps etc
- Implants
  - Stent/Hypotube
  - Seeds
  - Pacemaker
  - Transponder
Which laser for which material (metal)?

<table>
<thead>
<tr>
<th>Material</th>
<th>CO₂</th>
<th>Laser Jet</th>
<th>YAG µs/ns</th>
<th>Excimer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>-</td>
<td>-</td>
<td>0/0+</td>
<td>+</td>
</tr>
<tr>
<td>Light Metals(Ti)</td>
<td>+</td>
<td>0</td>
<td>+/0</td>
<td>slow</td>
</tr>
<tr>
<td>Precious Metals</td>
<td>+</td>
<td>+</td>
<td>+/0</td>
<td>slow</td>
</tr>
<tr>
<td>Hard Metall</td>
<td>+</td>
<td>-</td>
<td>+/-</td>
<td>-</td>
</tr>
<tr>
<td>Ceramics</td>
<td>+</td>
<td>+</td>
<td>+/0</td>
<td>0</td>
</tr>
<tr>
<td>Crystals</td>
<td>(+)</td>
<td>+</td>
<td>(+)/0</td>
<td>0</td>
</tr>
<tr>
<td>organic Material</td>
<td>0</td>
<td>0*</td>
<td>0/0</td>
<td>0</td>
</tr>
<tr>
<td>Glasses</td>
<td>+</td>
<td>0*</td>
<td>0*/0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;2D-Contour</td>
<td>+</td>
<td>0</td>
<td>+/+</td>
<td>0</td>
</tr>
<tr>
<td>Precision:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1mm</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>0.01mm</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>0.001mm</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+Mask</td>
</tr>
<tr>
<td>Roughness(Rₚ)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.05(mm)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>0.005</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>0.0005</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>HAZ/deformation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1(mm)</td>
<td>+</td>
<td>+</td>
<td>+/+</td>
<td>-</td>
</tr>
<tr>
<td>WEZ/Verformung</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01</td>
<td>-</td>
<td>+</td>
<td>+/+</td>
<td>+</td>
</tr>
<tr>
<td>0.001</td>
<td>-</td>
<td>+</td>
<td>0/+</td>
<td>+</td>
</tr>
</tbody>
</table>

Absorption (%) - Wavelength (μm)

LASAG Industrial Lasers

A COMPANY OF THE SWATCH GROUP
Which laser for which material (non metal)?

<table>
<thead>
<tr>
<th>Laser</th>
<th>CO₂</th>
<th>Jet</th>
<th>μs/ns</th>
<th>YAG</th>
<th>Excimer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abtragen</td>
<td>-</td>
<td>-</td>
<td>0/+</td>
<td>+/0</td>
<td>slow</td>
</tr>
<tr>
<td>Bohren</td>
<td>+</td>
<td>0</td>
<td>+/+</td>
<td>+/0</td>
<td>slow</td>
</tr>
<tr>
<td>Schneiden</td>
<td>+</td>
<td>+</td>
<td>+/+</td>
<td>+/0</td>
<td>slow</td>
</tr>
<tr>
<td>Schweissen</td>
<td>+</td>
<td>-</td>
<td>+/-</td>
<td>+/0</td>
<td>-</td>
</tr>
</tbody>
</table>

### Material

- **Stainless Steel**: + + +/+0 0
- **Light Metals (Ti)**: 0 + +/+0 0
- **Precious Metals**: - + +/+0 0
- **Hard Metals**: - + +/+0 0
- **Ceramics**: + + +/+0 0
- **Crystals**: (+) + (+)/0 0
- **organic Material**: 0 0* 0*/0 0
- **Glasses**: + 0* 0*/0 0

### >2D-Contour

- **Precision**: + 0 +/+ 0

### Precision:

- **0.1mm**: + + + +
- **0.01mm**: - - + +
- **0.001mm**: - - - +Mask

### Roughness (Rₚ)

- **0.05(mm)**: + + + +
- **0.005**: - + + +
- **0.0005**: - 0 0 +

### HAZ/deformation (0.1(mm))

- **WEZ/Verformung**: + + +/+ +
- **0.01**: - + +/+ +
- **0.001**: - + 0/+ +

### Strahlführung

- **Mirror**
- **Mirror Fiber**
- **Mirror Fiber**
- **Mirror**
Laser-Drilling: Typical Side Effects

Laser Beam

Gas

Material

Plasma

Ejected molten material

Surface debris

Recast layer

Surface ripples due to shock wave

Long pulse laser beam

Damage caused to adjacent structures

Micro cracks

Shock wave

Melt zone

Heat affected zone

Heat transfer to surrounding material
Laser in Medical Industry
(Material Processing)

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  - μ-Filter

- Instruments
  - Needles
  - Cannule/Tube
  - Endoscope Catheder
  - Saws
  - Forceps etc

- Implants
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  - Transponder
Cutting of Stents

Laser:
KLS 246 FC

Material: Steel, Nitinol
Wall-Thickness: 0.2 mm

Result:
Kerf width:
0.015-0.05mm
Speed:
> 200 mm/min
HAZ: < 0.01 mm
Cutting of Stents (S.St or Nitinol)
Cutting of Stents

Material: Nitinol
Laser: KLS 246 FC
Parameter: 0.04 J Pulse energy,
            500 mm/min Speed,
specs: crackfree, 10 μm gap
Cutting of Hypotubes

Laser: KLS 246-046FC

Material: S.St

Process result:
Kerf: 0.023mm
Speed: 200 mm/min
HAZ: < 0.01 mm
Welding of dissimilar biocompatible Alloys

Welding Of S.St, Gold, Pt, Ti)
Welding Markers on Stents

Material: Nitinol, Tantalum
Laser: Easywelder SLS 200 CL32
Parameter: 0.065 J Pulse energy, 100 mm/min Speed
Pulse form: modulated, trailing edge
Spot Weld of Ti-Tubes (Seeds)

Radioactive Prostata Seeds

Ti housing
Silver Marker
Radioactive Implant (J124, Pd 103 decay 50 days)

Wall: 0.04mm
Diameter: 0.8mm
Laser cutting and sealing of Transponder

Material: IR-Glass

Processing result:
- Laserscribing and cracking
- Champering of entrance
- Vacuum tight sealing
Ti- Welding

425.7 μm

1 mm

Medical Industry/DU/06_#016
Welding of Pacemakers (Housing and Wirebonding)

Material: Titanium grade 2
Laser: Easywelder SLS 200 CL60
Parameter: 1.43 J Pulse energy,
          1200 mm/min Speed
Pulse form: modulated, trailing edge
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Cutting of Bone Saw

Laser: KLS 246

Material: S.St
Thickness: 1.2 mm

Process result:
Speed: 250mm/min (N₂)
Hardening of teeth

Ablation structure:
Less vibrations
Straight cut

Quelle: LLT (Dr.Pause)
Behaviour of Laser Cutted and Structured Saw
Cutting of Cannulas

Laser:
KLS 246-046FC

Material: S.St
Thickness: 0.1mm

Process result:
Time per piece: 2s
Kerf: 0.02mm
HAZ: < 0.01 mm
Cutting of Medical Tubes

1978.1 μm

2030.5 μm

1 mm

2 mm
Cutting of Endoscope Parts

5 mm
(SHADOW) Single Pulse Welding of Endoscope Tubes
Laserdrilling, Annealing, Chamfering of blind Holes in Surgical Needles

**Material:** Stainless Steel

**Process results:**
- Entrance: 0.05-0.4 μm
- Entrance: rund oder scharf
- Aspect: 1:4-1:8
- Hardness << 400HV
Summary:

Processing of biocompatible Materials
With the pulsed Nd:YAG Laser:

- Fine-/Precision Cutting with Kerf \(<15\mu m\) und Aspect \(>10:1\)

- Fine-/Precision Drilling with hole-Diameters \(<15\mu m\) und Aspect \(>15:1\)

- Precision Welding of similar and Dissimilar function oriented metals With new welding strategies with High geometrical quality and low Thermal side effects