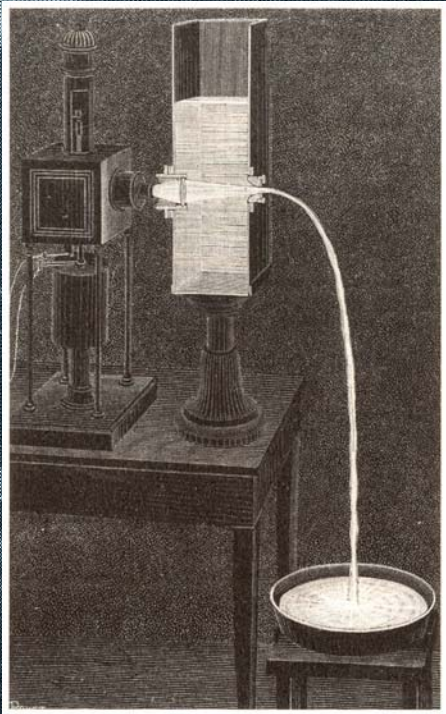


# Micro-cut applications with the Laser Microjet

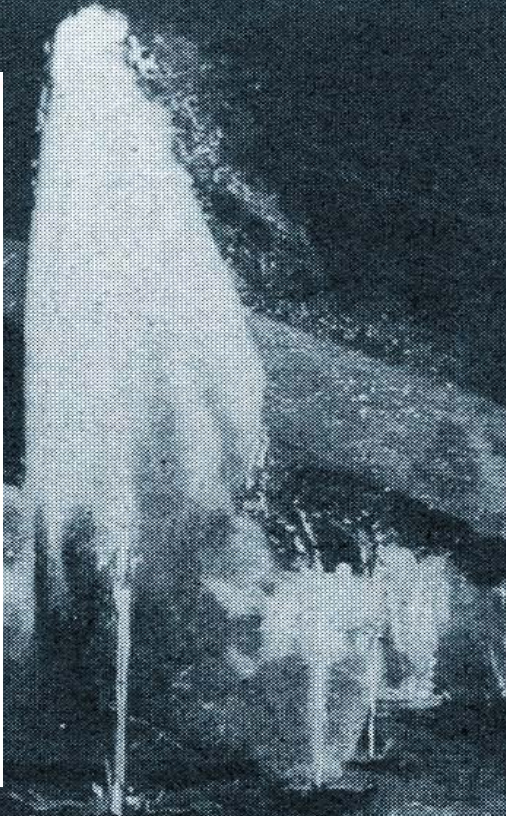
Simone Amorosi  
Bernold Richerzhagen

**Synova SA**

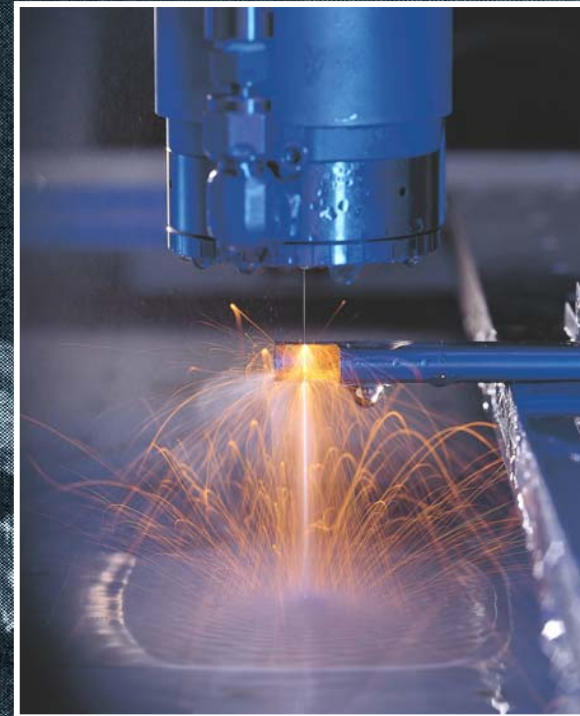
# History



The Colladon fountain  
1841



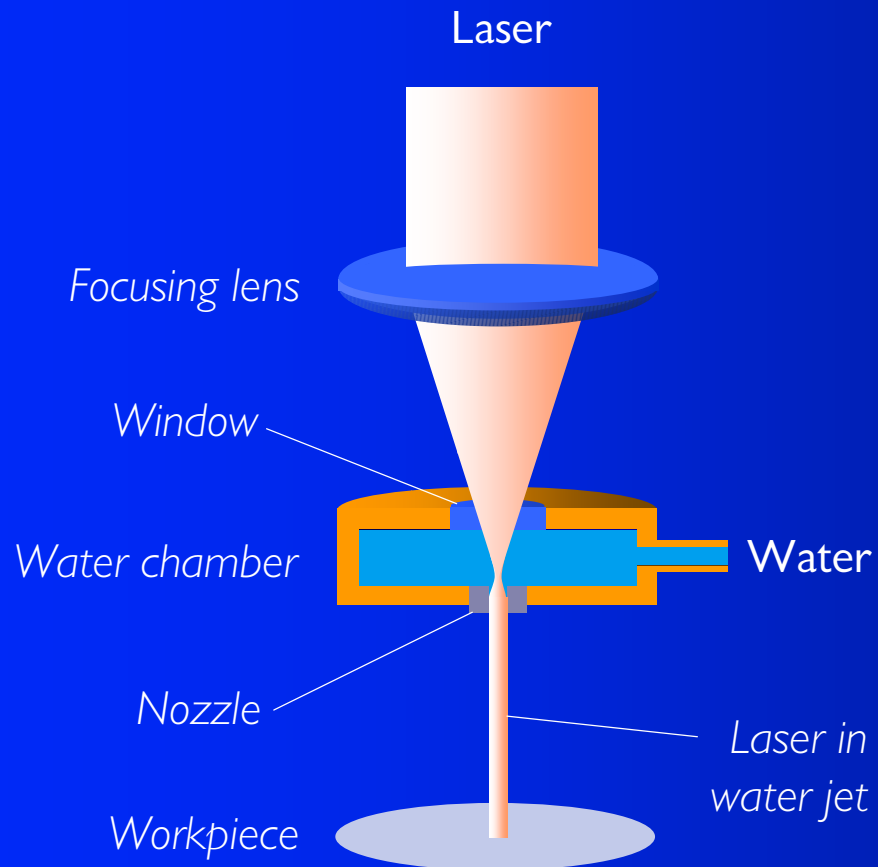
World exposition, Paris 1889



Laser Microjet  
1997

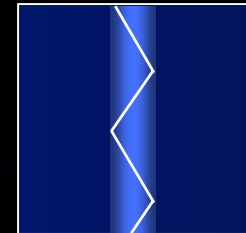


# The water-jet guided laser principle

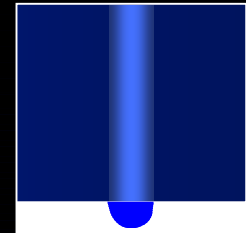


## Advantages:

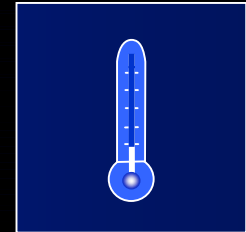
The water jet works as a **fiber** of variable length for **guiding** the laser beam



The water jet **ejects** the molten material

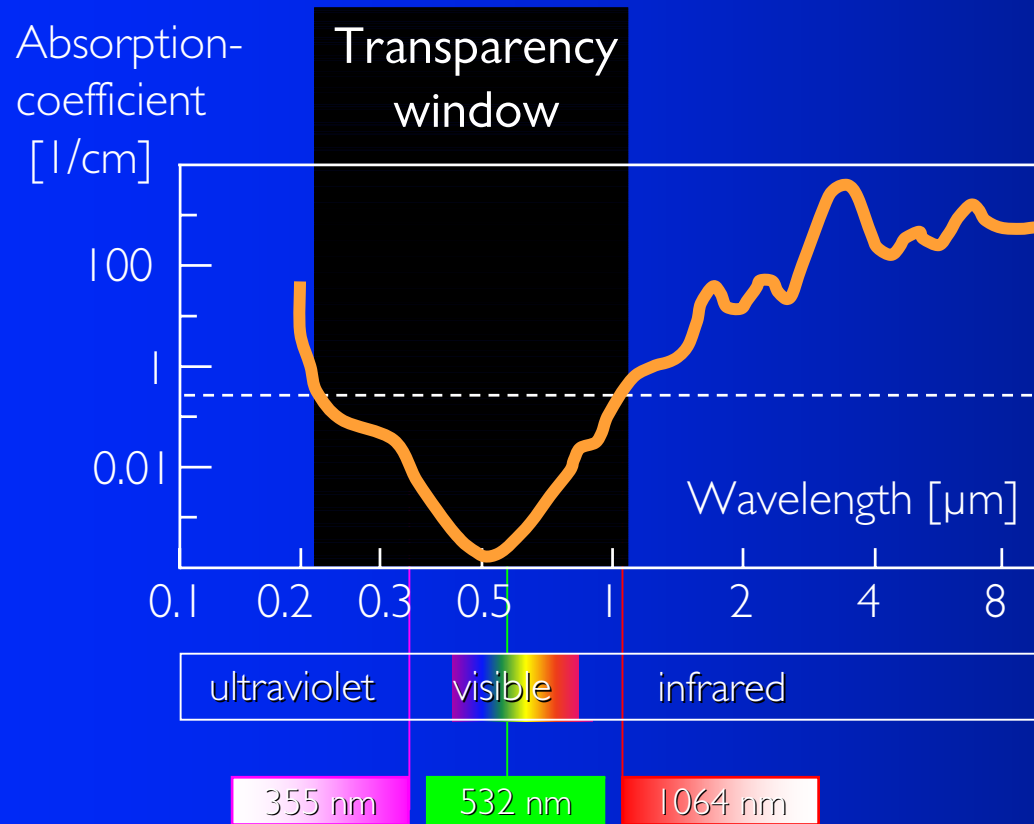


The water jet **cools** the work piece during laser ablation



# Laser sources

## Pulsed solid state lasers (Nd:YAG)



Average Power

50–200 W

Pulse duration

0.1–100  $\mu\text{s}$

Pulse repetition rate

0.5–50 kHz

# Water pump

## Intensifier pump

Water

De-ionized  
filtered  
De-gased

Pressure range

20–500 bar

Flow

5–75 ml/min



## Water jet nozzles

Sapphire  
Diamond

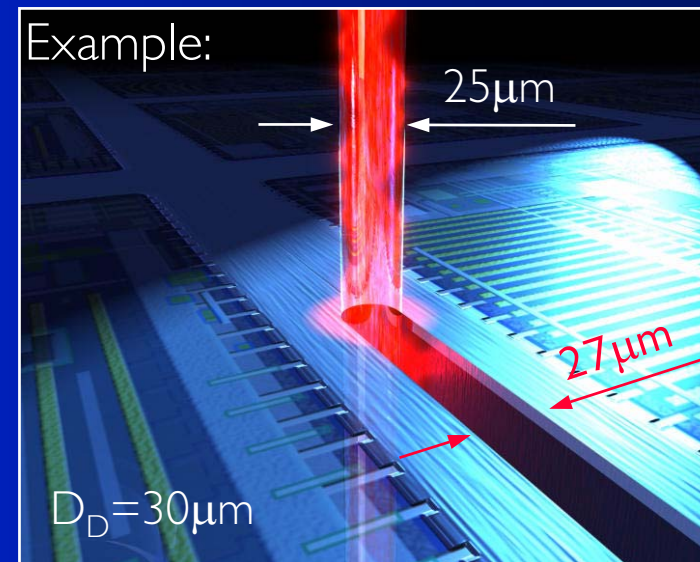
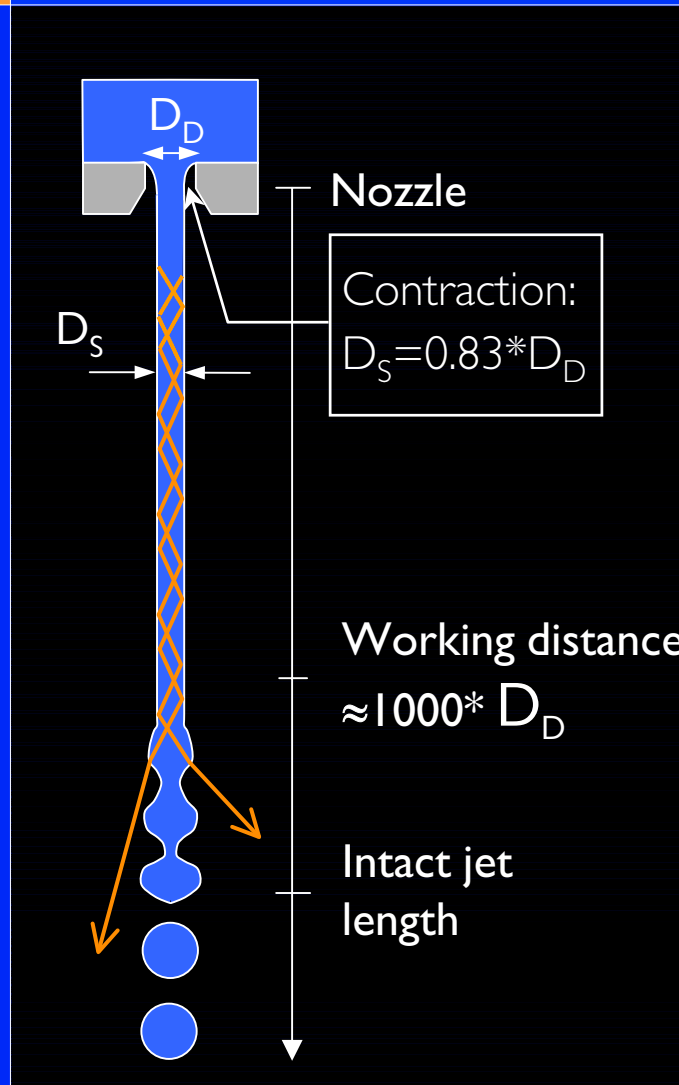
Nozzle diameter:

30 -150  $\mu\text{m}$



10  $\mu\text{m}$

# Laser guidance in a water jet



The laser energy is guided to the bottom of the kerf.

Cutting in any position.

Cutting through a thin water film.

# Advantages

Cooling between pulses



No heating

No grain size changes

No micro cracks

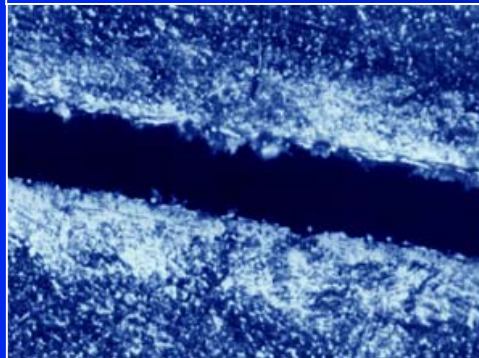
No oxidation

No warping

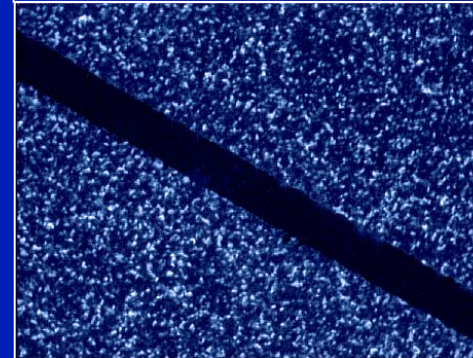


Better quality

Conventional Laser

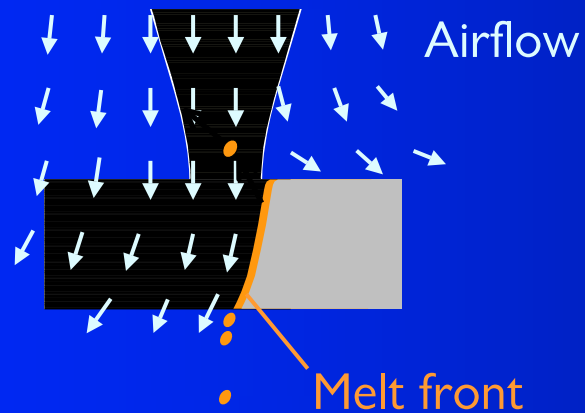


Laser-Microjet

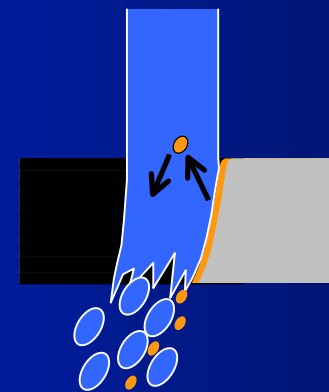


# Advantages

Air: 15 bar  
Nozzle diameter 1000  $\mu\text{m}$



Water: 330 bar  
Nozzle diameter 50  $\mu\text{m}$



High momentum of water jet  $\rightarrow$  Efficient melt expulsion

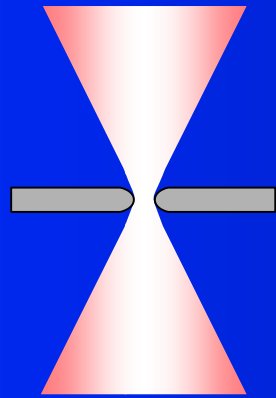
No redeposits or debris

Cutting products dissolved in water

Small force on the work piece

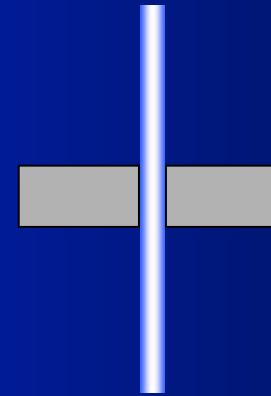
# Advantages

Conventional laser



Divergent laser beam

Laser-Microjet



Parallel laser beam

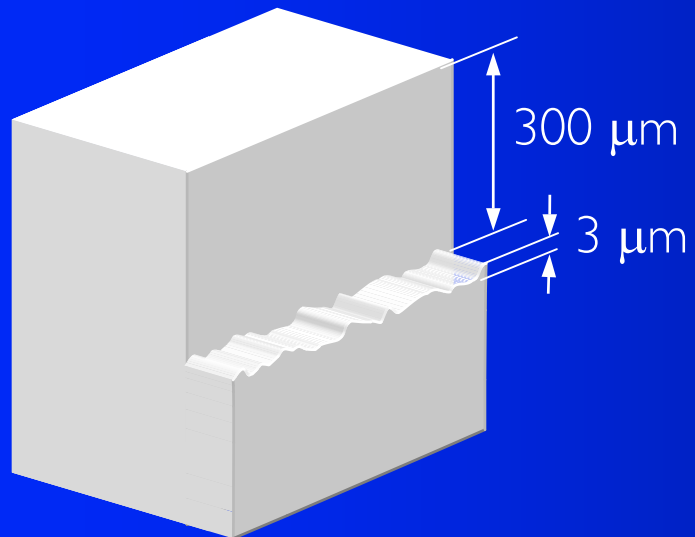
Larger working distance

Constant machining quality (no focal point)

High precision ( $1\ \mu\text{m}$ )

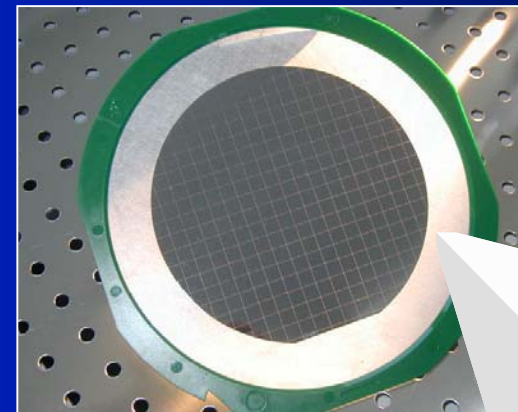
# Advantages

## Scribing

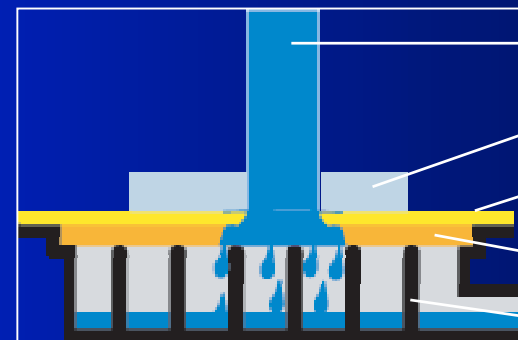
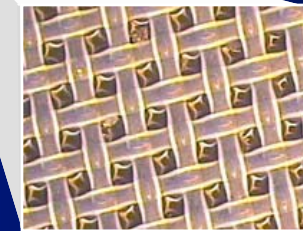


Small roughness

## The LaserTape<sup>®</sup>



Web structure



Water jet

Chip

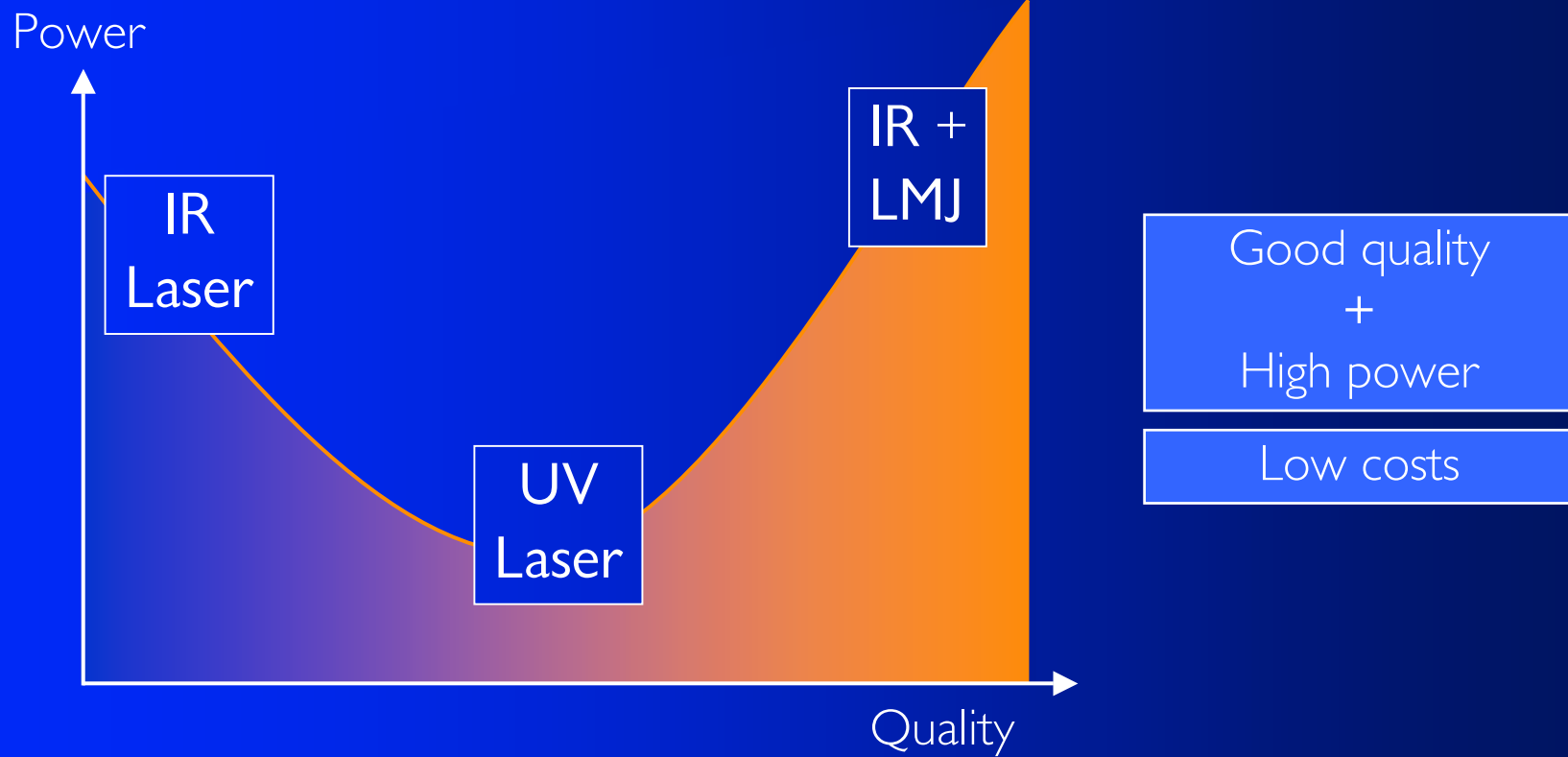
LaserTape

Porous support

Chuck housing

# Advantages

## Laser cutting

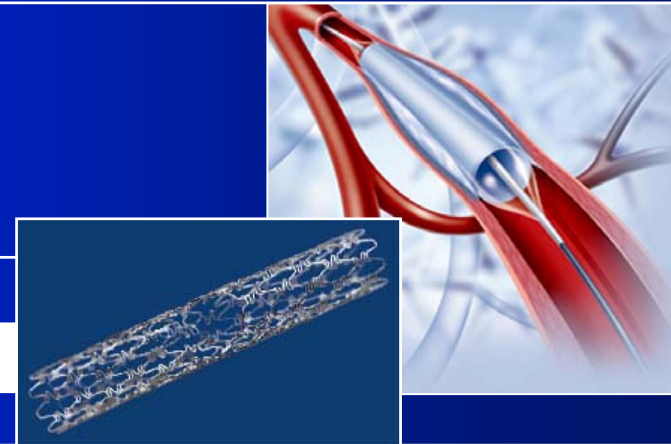


# Medical stent cutting

Medical stents allow normal blood circulation in plugged blood vessels

Laser cutting

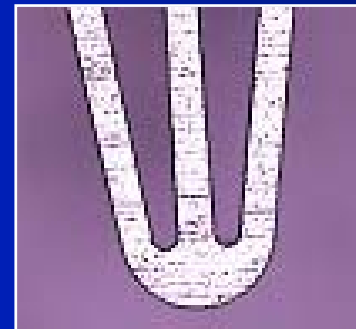
Stainless steel, Nickel-Titanium



Stainless steel  
150  $\mu\text{m}$



conventional  
laser



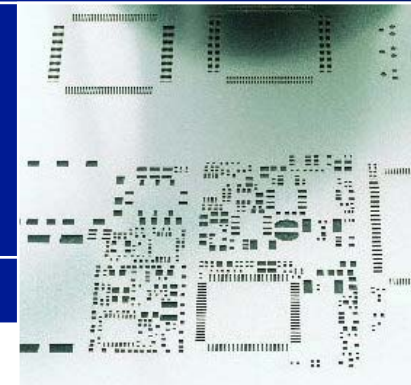
LMJ



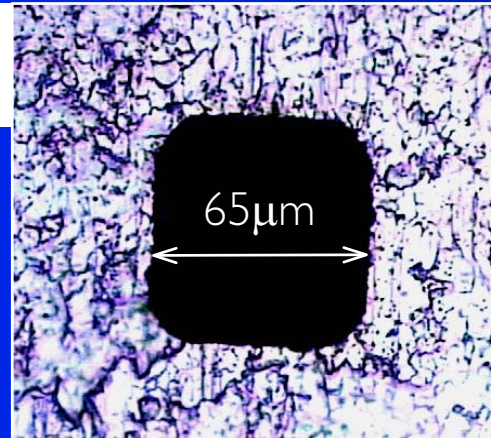
# Stencil cutting

Metal stencils are used to apply solder paste on printed circuit boards.

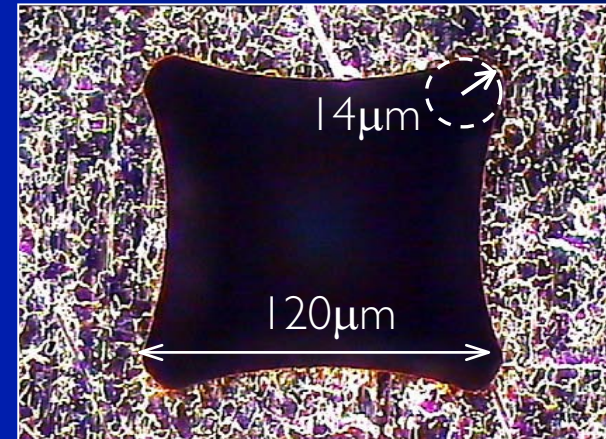
Laser cutting, chemical etching  
Stainless steel



Stainless steel  
80  $\mu\text{m}$



200 milliseconds



300 milliseconds

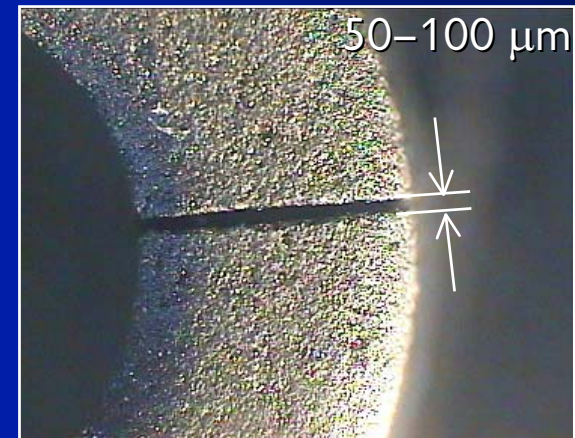
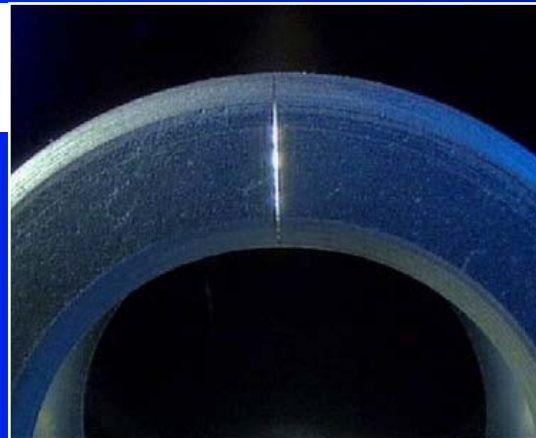
# Ferrite core cutting

Transformers,  
Mobile communication devices

Diamond saws, breaking and gluing  
Ferrite ( $\text{MnO}:\text{ZnO}:\text{FeO}$ )



10x5x5 mm  
toroidal core



# Hard materials cutting

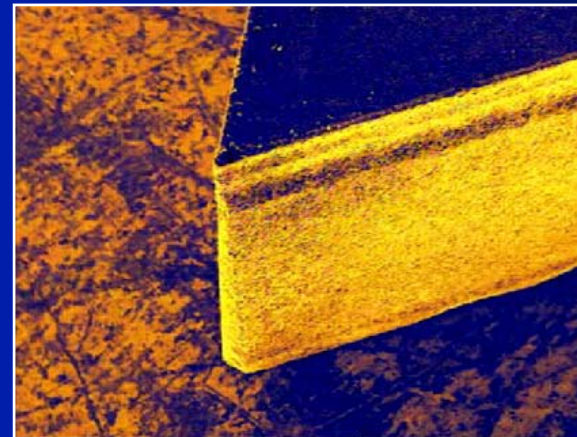
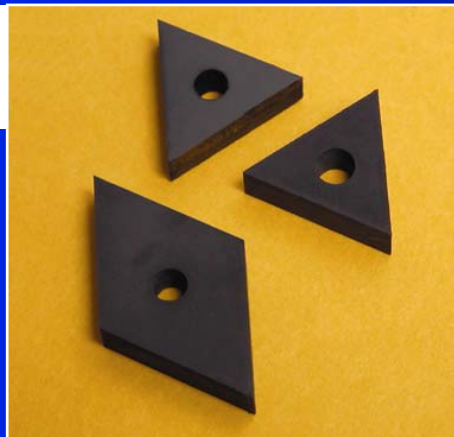
Tool inserts for milling, drilling  
and cutting

Electrical Discharge Machining (EDM),  
Laser cutting

Boron nitride, diamond, silicon nitride



Boron nitride  
3 mm



# Foil cutting for packaging applications

Thin metal foils for packaging application in the food industry

Punching, Cutting with knives

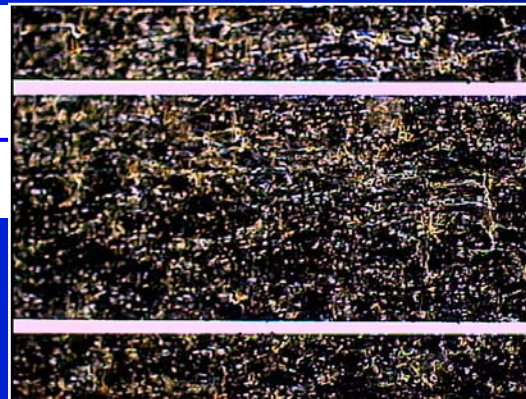
Stainless steel, aluminium, nickel



Nickel

64 $\mu$ m

3m/s @ 600W CW



60  $\mu$ m

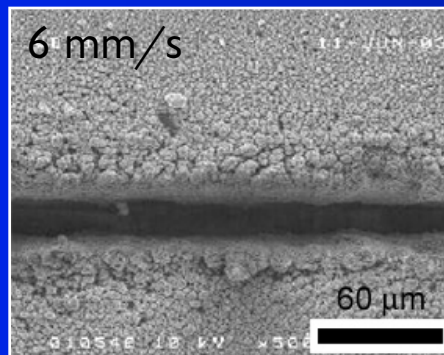
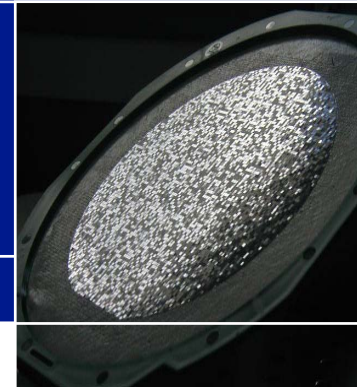


# Singulation of semiconductor wafers

Integrated circuits

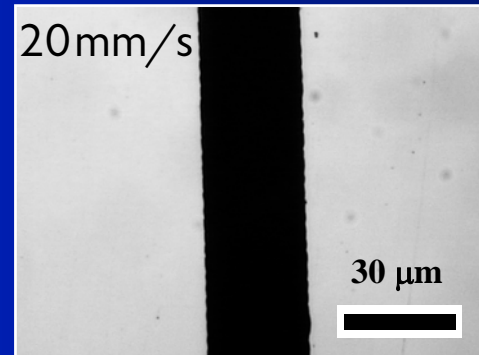
Diamond saws

Silicon, GaAs, InP, GaN



Silicon  
150 μm

UV laser cutting



LMJ

# The water jet guided Laser

