University of Diyala

College of Engineering

Dept. of Material Engineering

Seminar Presentation

About

Laser Applications

By

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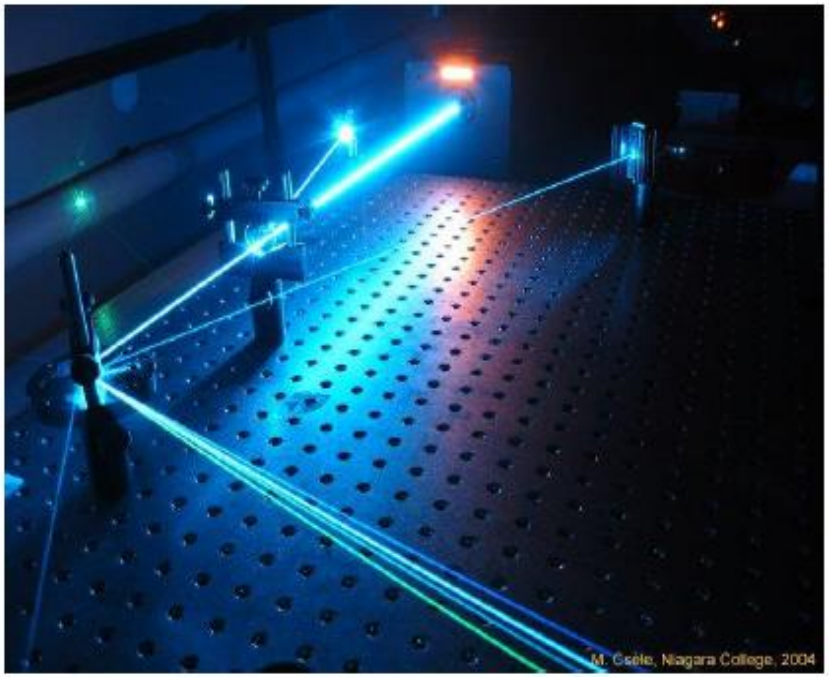
Overview

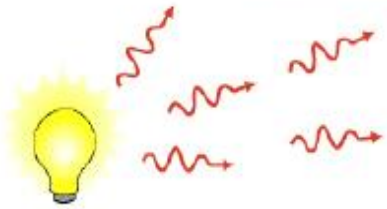
- What is laser ?
- How can laser be generated ?
- How laser interacts with metals ?
- What are the laser applications?

Definition of laser

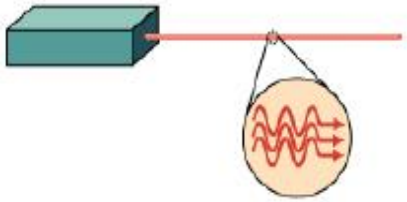
LASER stands for

Light Amplification by Stimulated Emission of Radiation





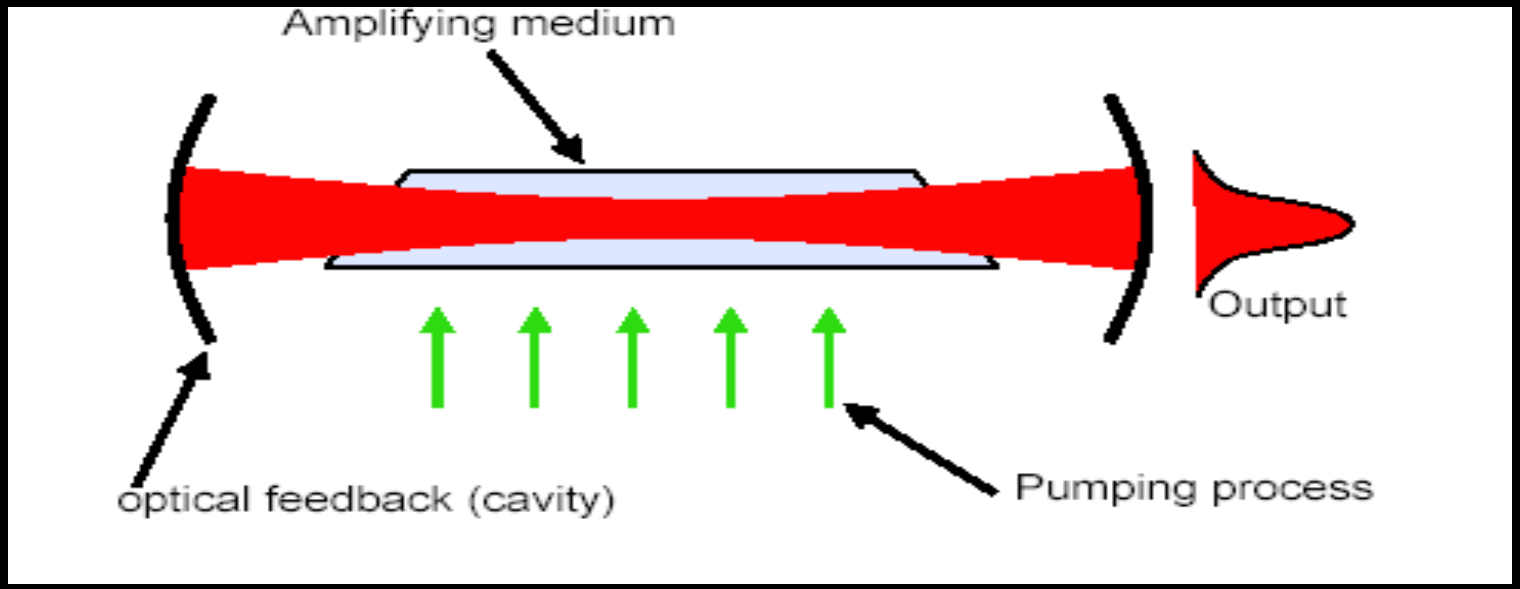
Spontaneous emission



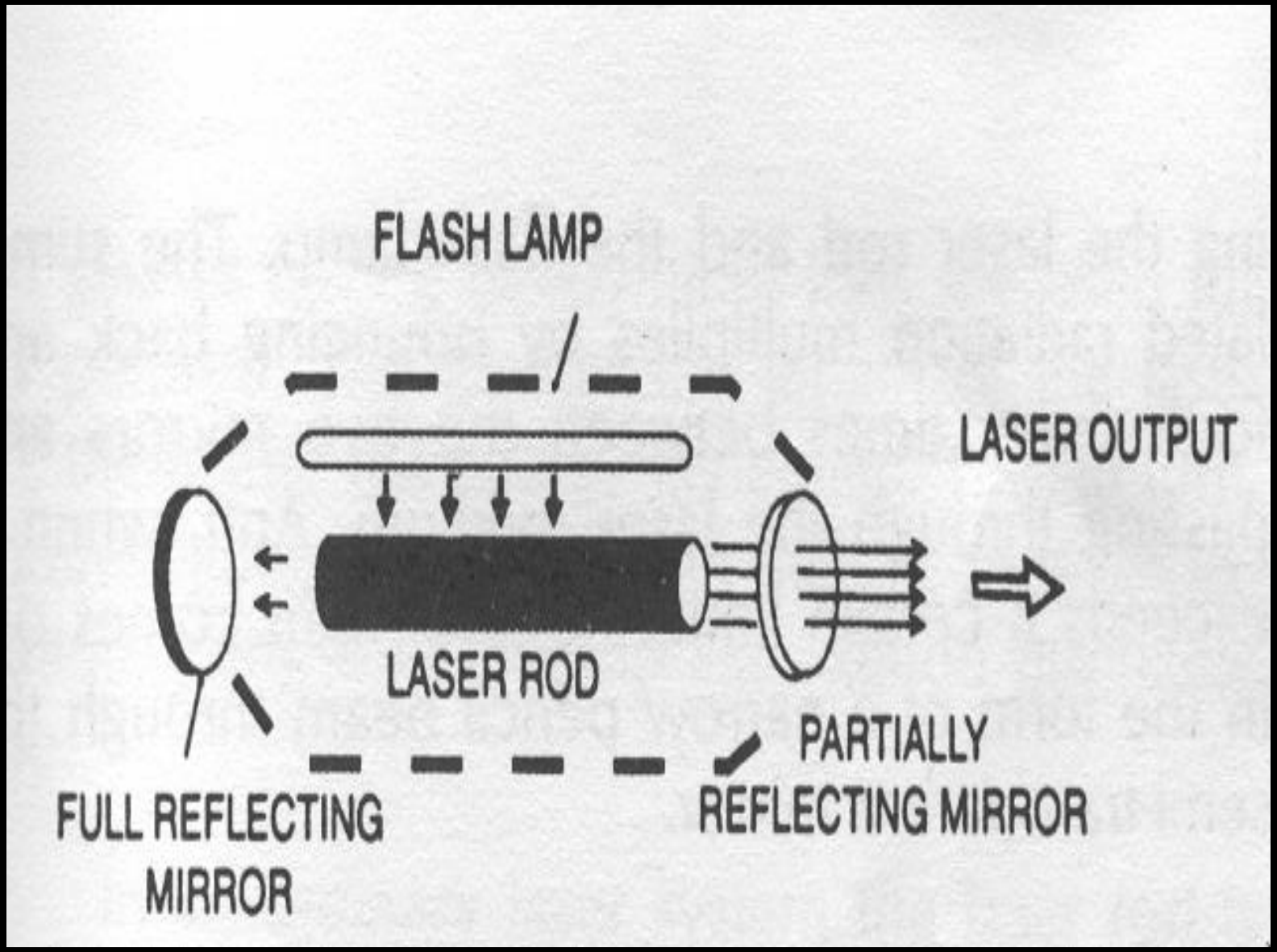
Stimulated emission

Key elements in laser

- **Amplifying Medium: provides transition, determines the wavelength**
- **Pumping : provides energy necessary for population inversion**
- **Optical Cavity: amplifies and produces a directional beam**



Key Elements in Laser



Laser Generator Set-Up

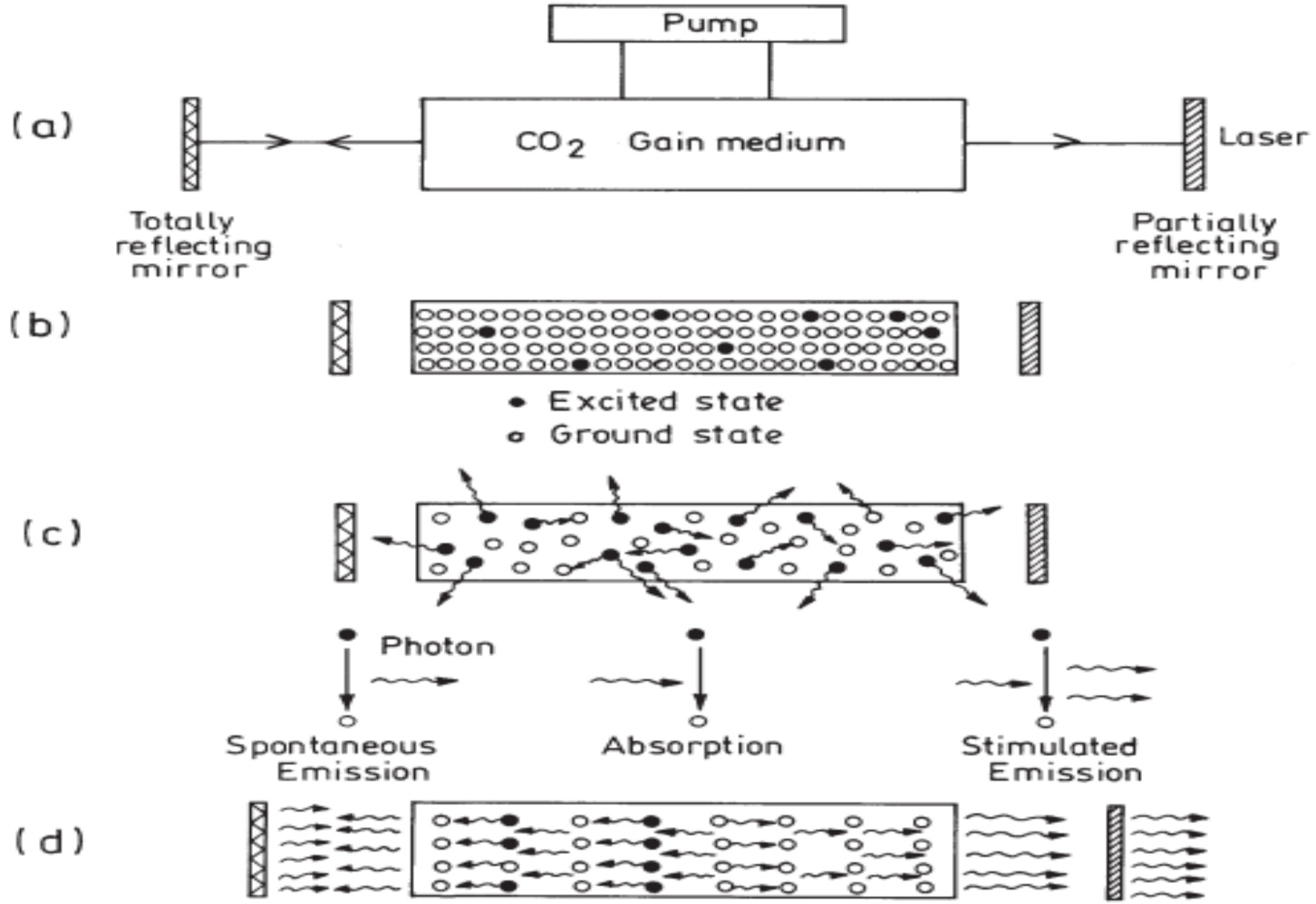
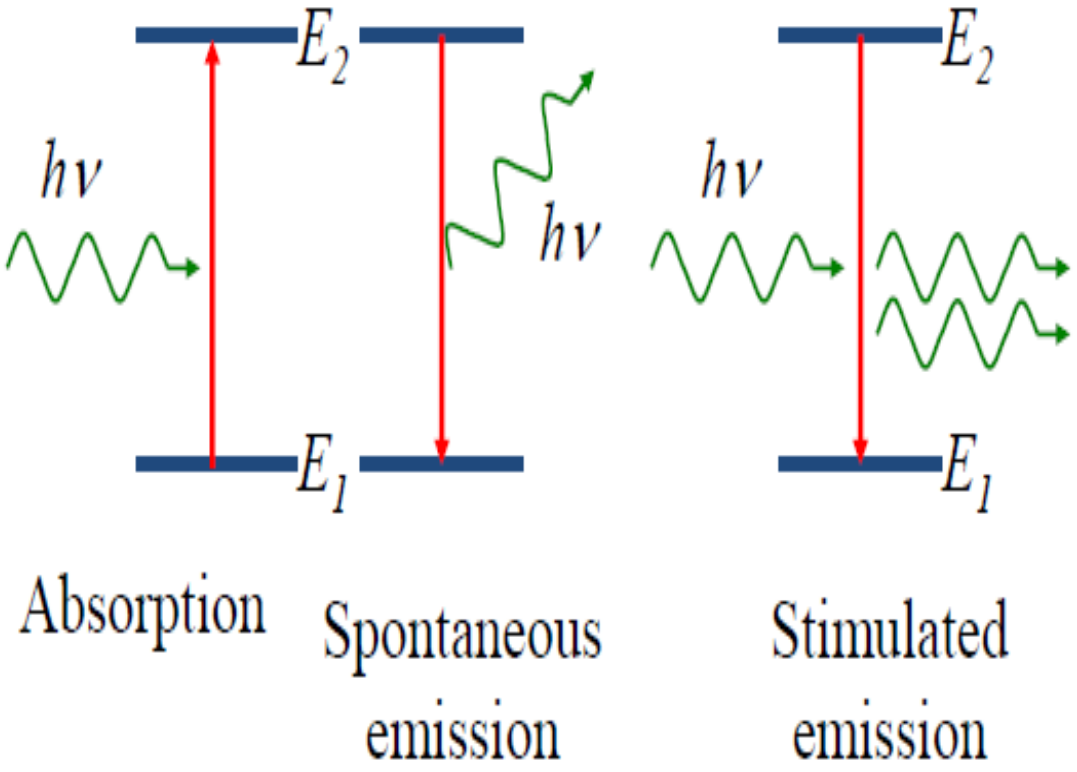


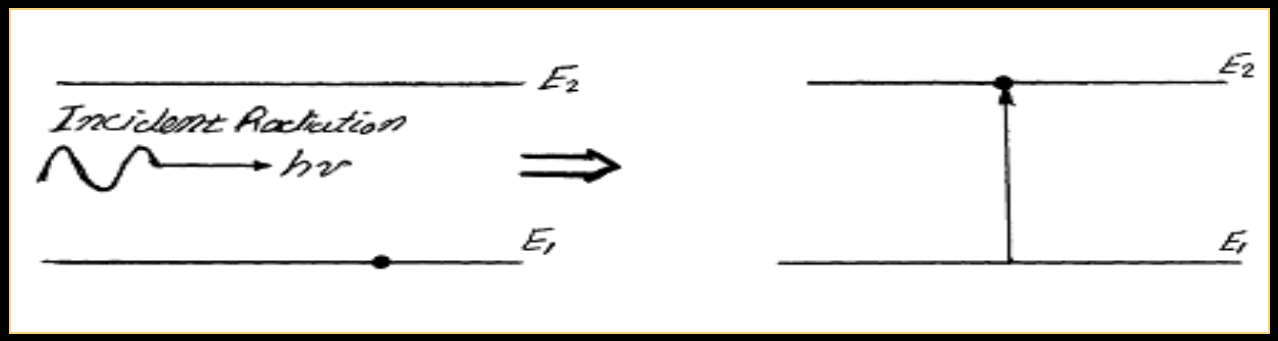
Figure 2. Schematic set-up of continuous wave CO_2 laser. **(a)** The major constituents of the ma **(b)** initial stage of energy pumping, **(c)** excitation and de-excitation of the atoms in the medium l to emission of laser and **(d)** stimulated emission and formation of laser beam.

Working Principle of Laser

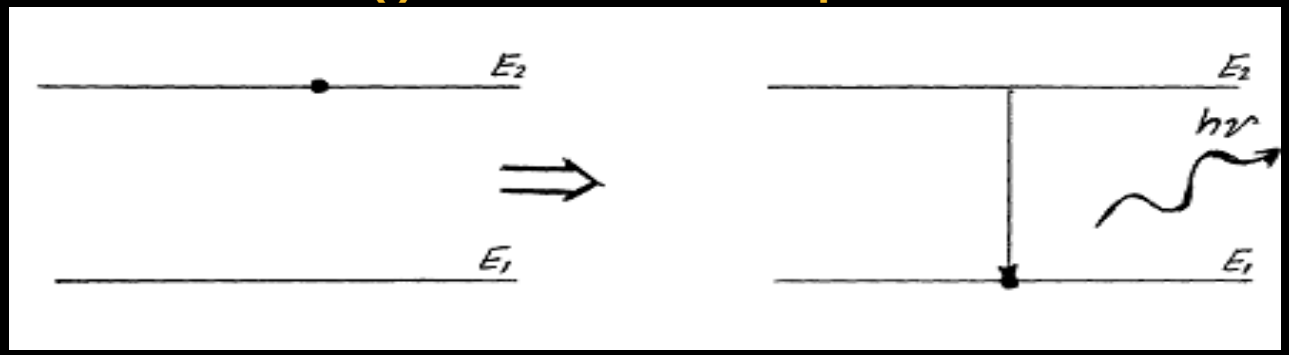
$h\nu = E_2 - E_1$



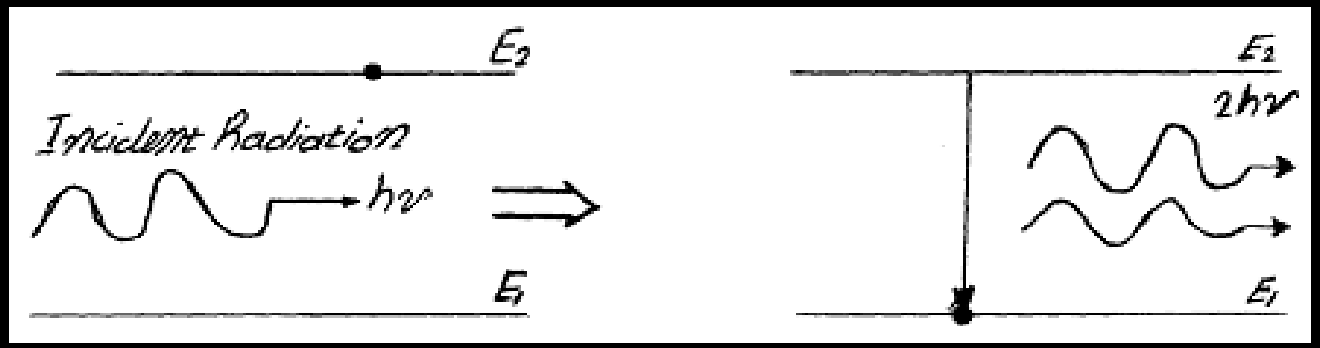
Before **After**



(i) Stimulated absorption



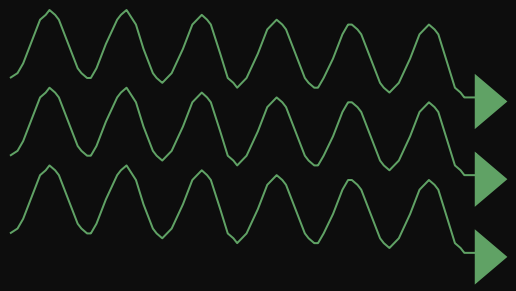
(ii) Spontaneous emission

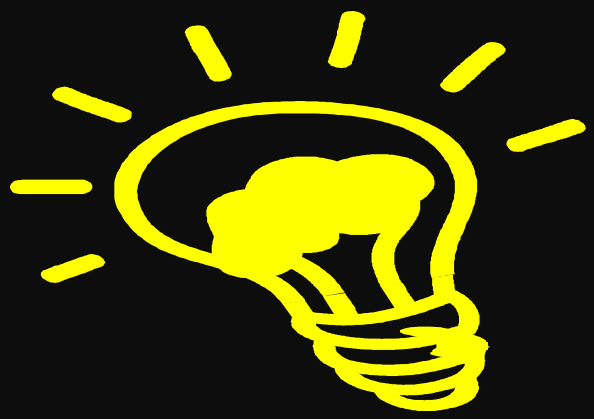


(iii) Stimulated emission

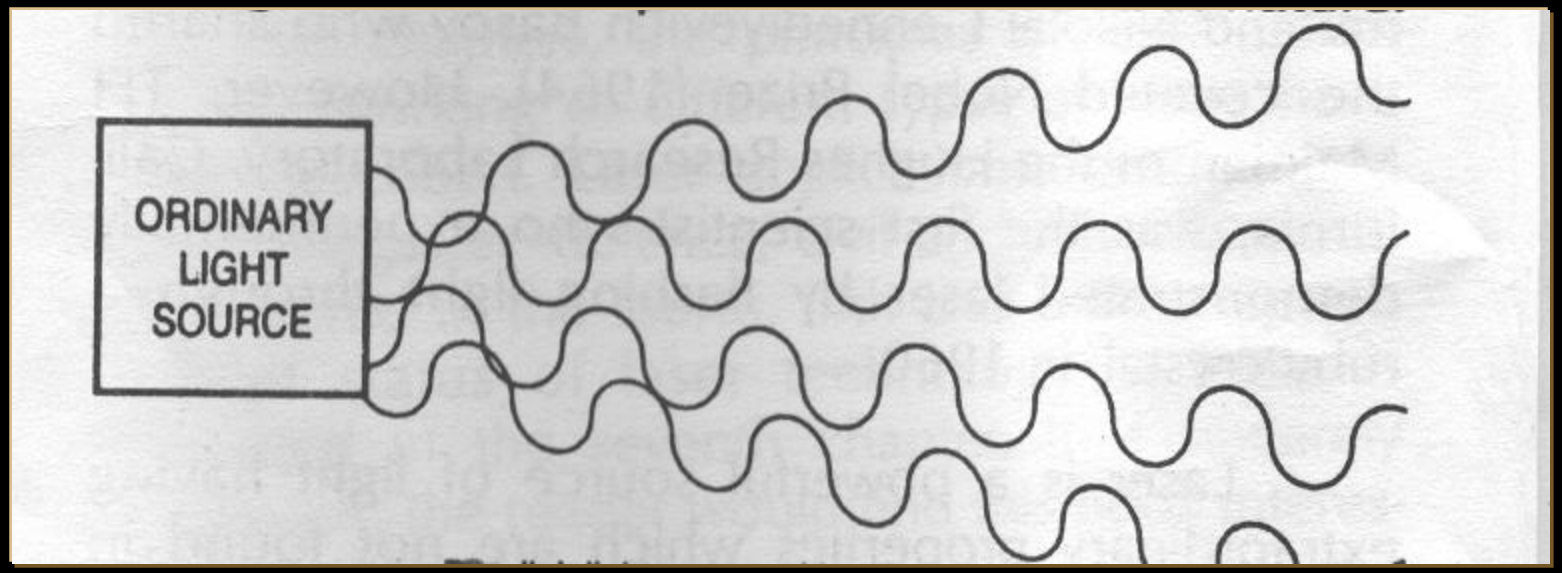
Properties of Laser

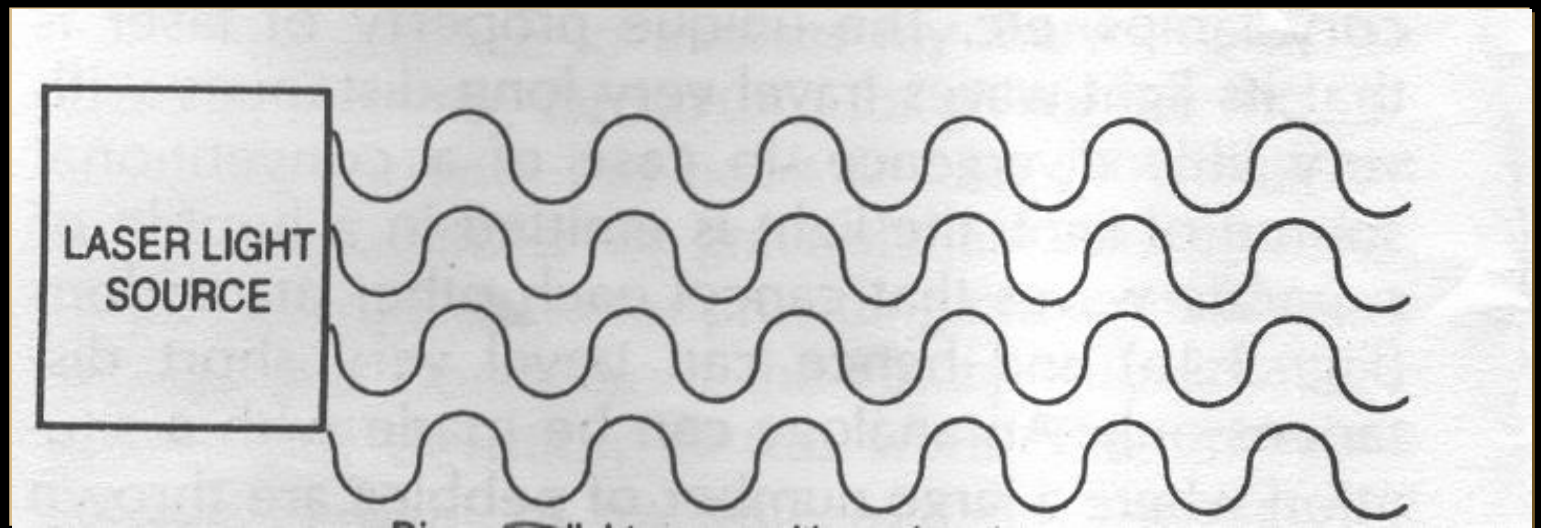
- Coherent (synchronized phase of light)
- Collimated (parallel nature of the beam)
- Monochromatic (single wavelength)
- High intensity (~$10^{14} W/m^2$)
- Short pulse duration





Laser Light *vs.* Ordinary Light





Laser Classification

Types of Lasers(Based on its pumping action) :

- Optically pumped laser
- Electrically pumped laser
- Basis of the operation mode
- Continuous wave Lasers
- Pulsed Lasers

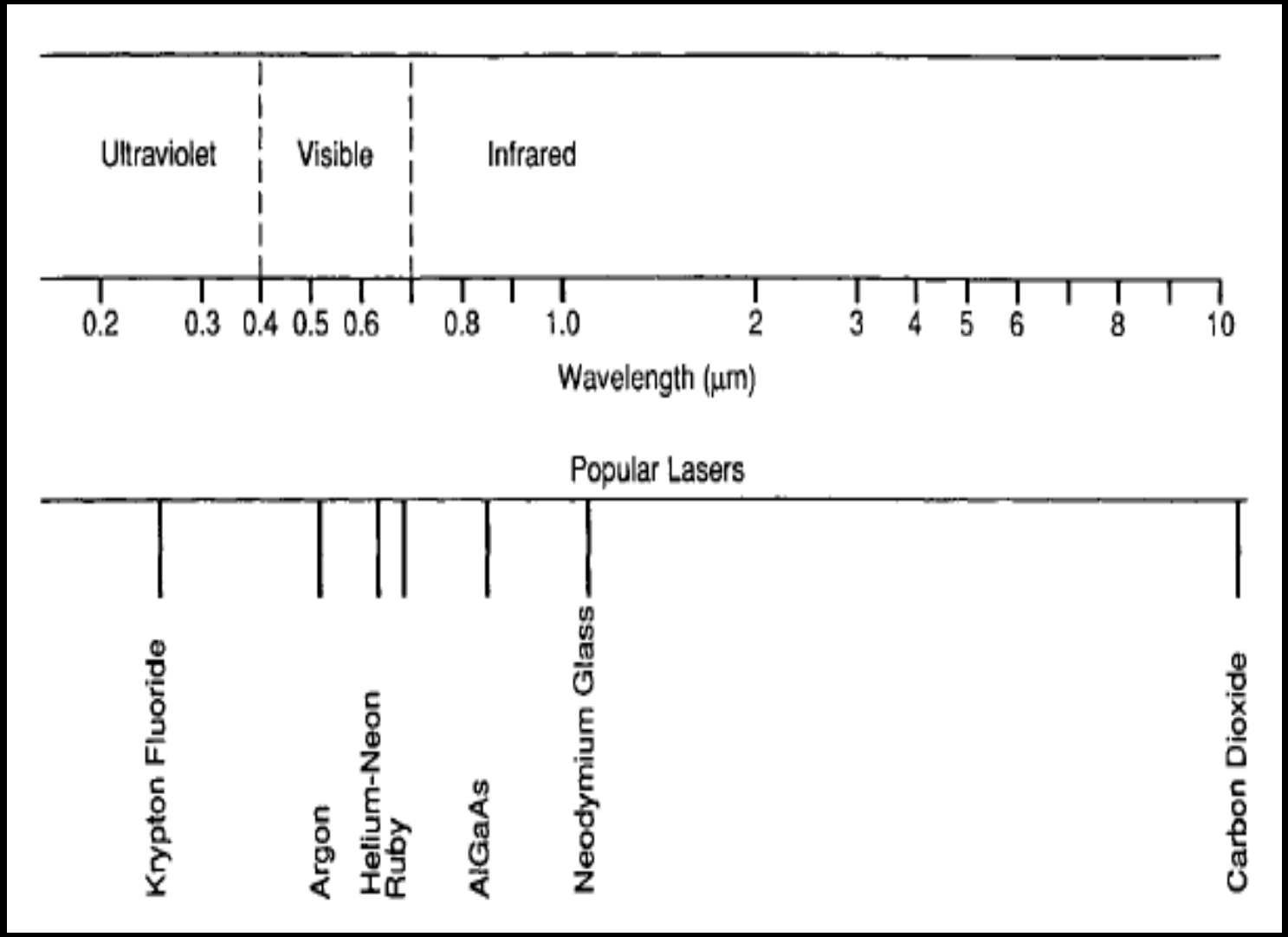
According to their wavelength :

- Visible Region, Infrared Region, Ultraviolet Region, Microwave Region, X-Ray Region and etc.,

According to the source :

- Dye Lasers, Gas Lasers, Chemical Lasers, Metal vapour Lasers, Solid state Lasers, Semi conductor Lasers and other types.

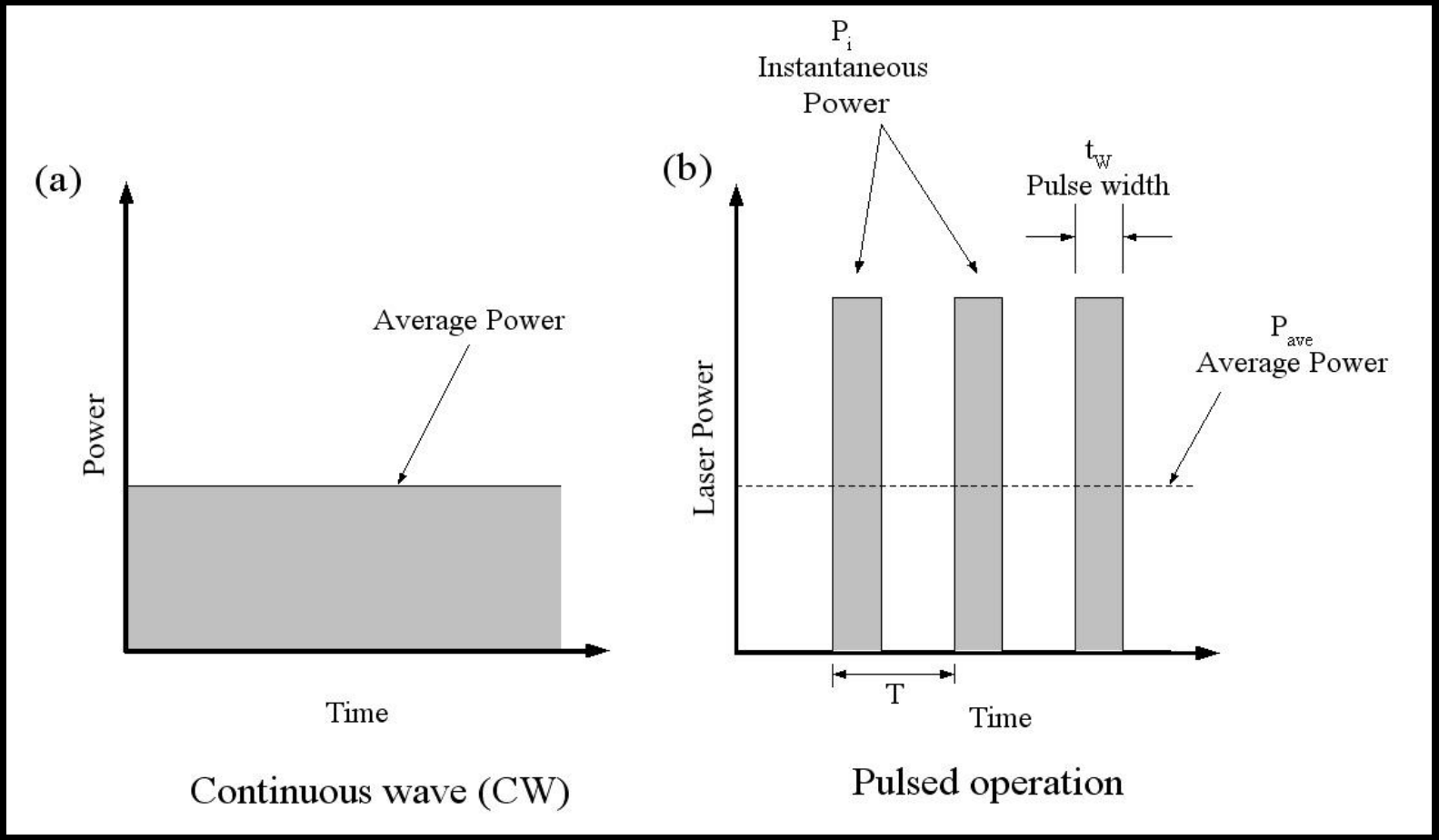
Laser wavelengths



Modes of Laser

-Continuous Waves Laser (CW)

-Pulse Laser



Laser Metal Interaction

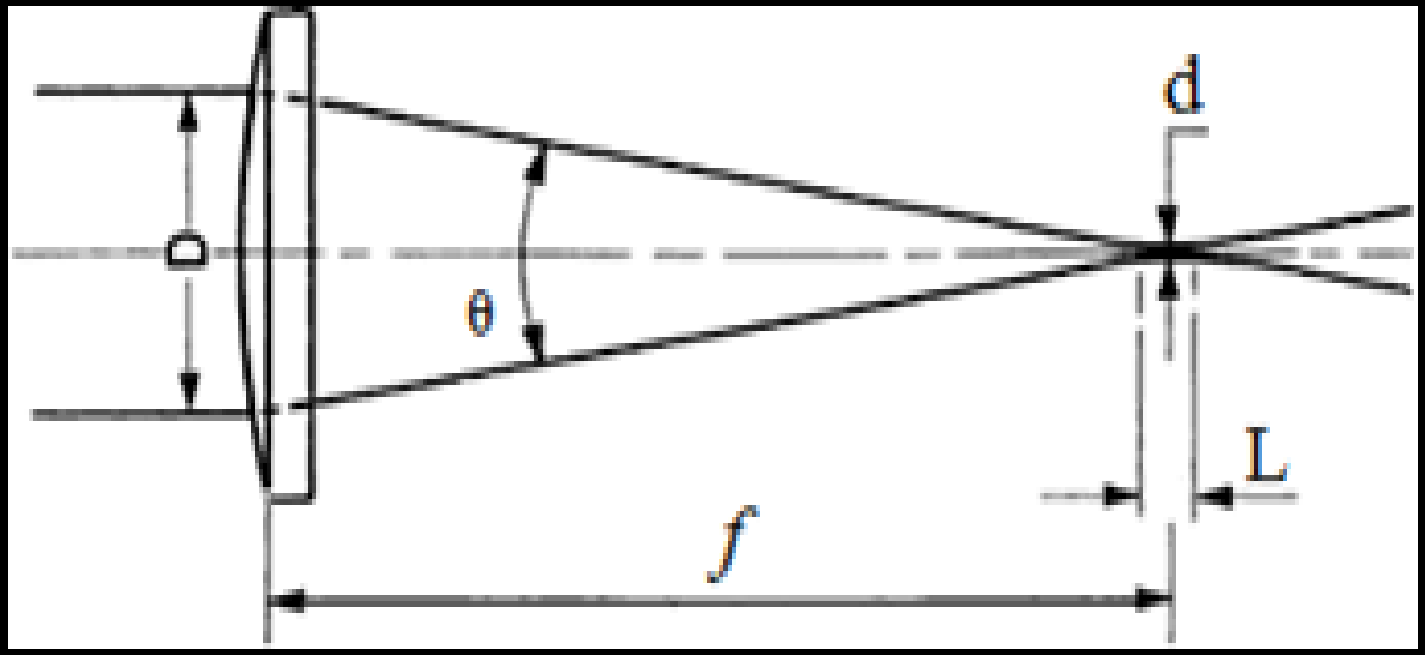
- R + A+ T = 1
- The predominate phenomena depends on

- metal type,
- its temperature,
- surface conditions and
- light parameters

A

Metal	1.06 μm (Nd:YAG)	10.6 (CO_2)
Al	0.06	0.02
Cu	0.05	0.015
Fe	0.1	0.03
Ni	0.15	0.05
Ti	0.26	0.08
Zn	0.16	0.03
Carbon steel	0.09	0.03
Stainless steel	0.31	0.09

Optical Focusing System



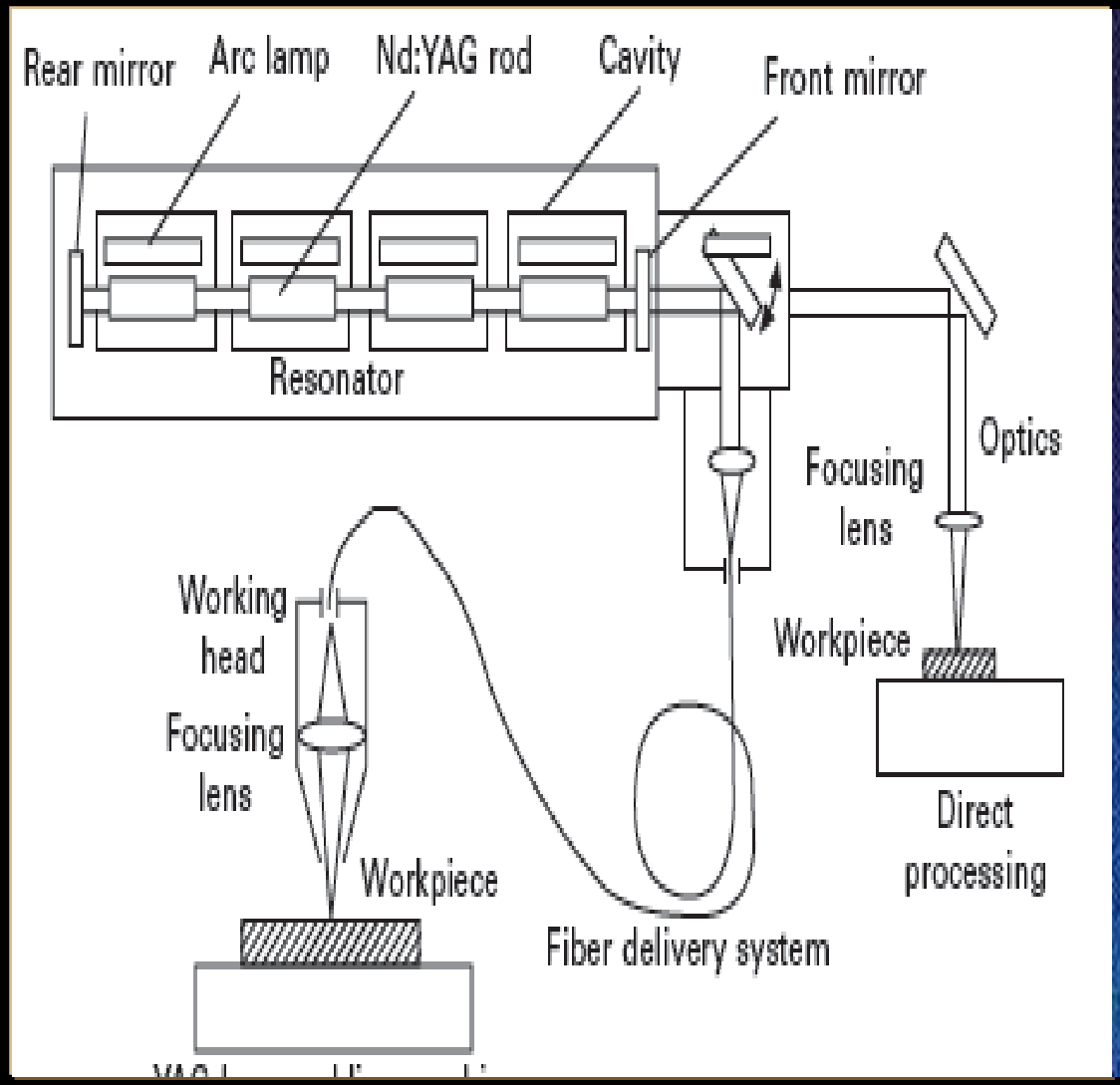
Laser Metal Interaction

- The laser beam absorbed photon interacts only with the electrons
- Electrons give up this energy through collisions with other electrons and with lattice phonons.
- If the absorbed photon has large enough energy it will remove the excited electrons from the metal

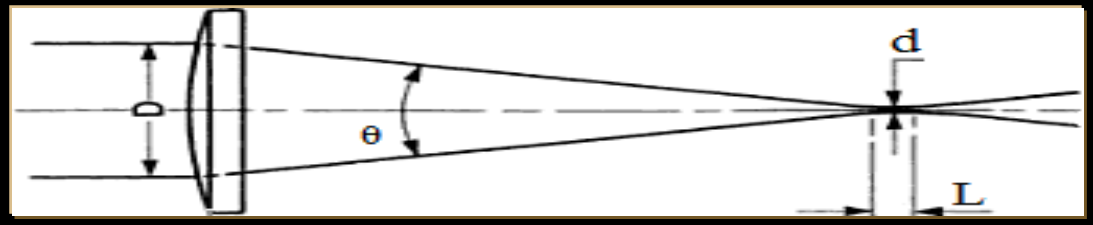
Laser Metal Interaction

- The conversion of the absorbed optical energy to heat in metals in time duration of 10^{-13} s and involves:
- excitation of valence and/or conduction band electrons,
- electron-phonon interaction within a span of 10^{-11} 10^{-12} s,
- electron-electron or electron-plasma interaction

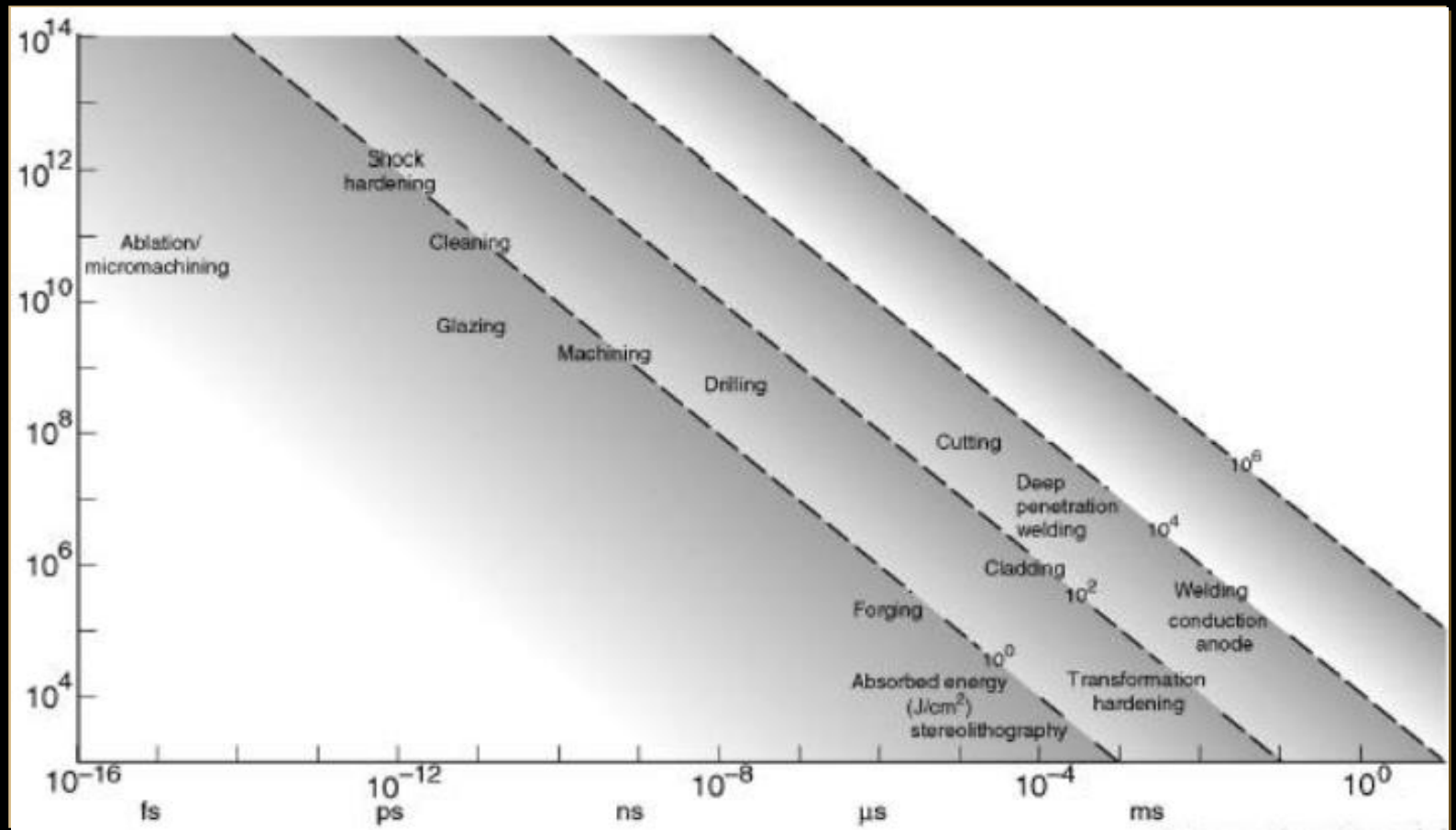
Transferring of the Beam



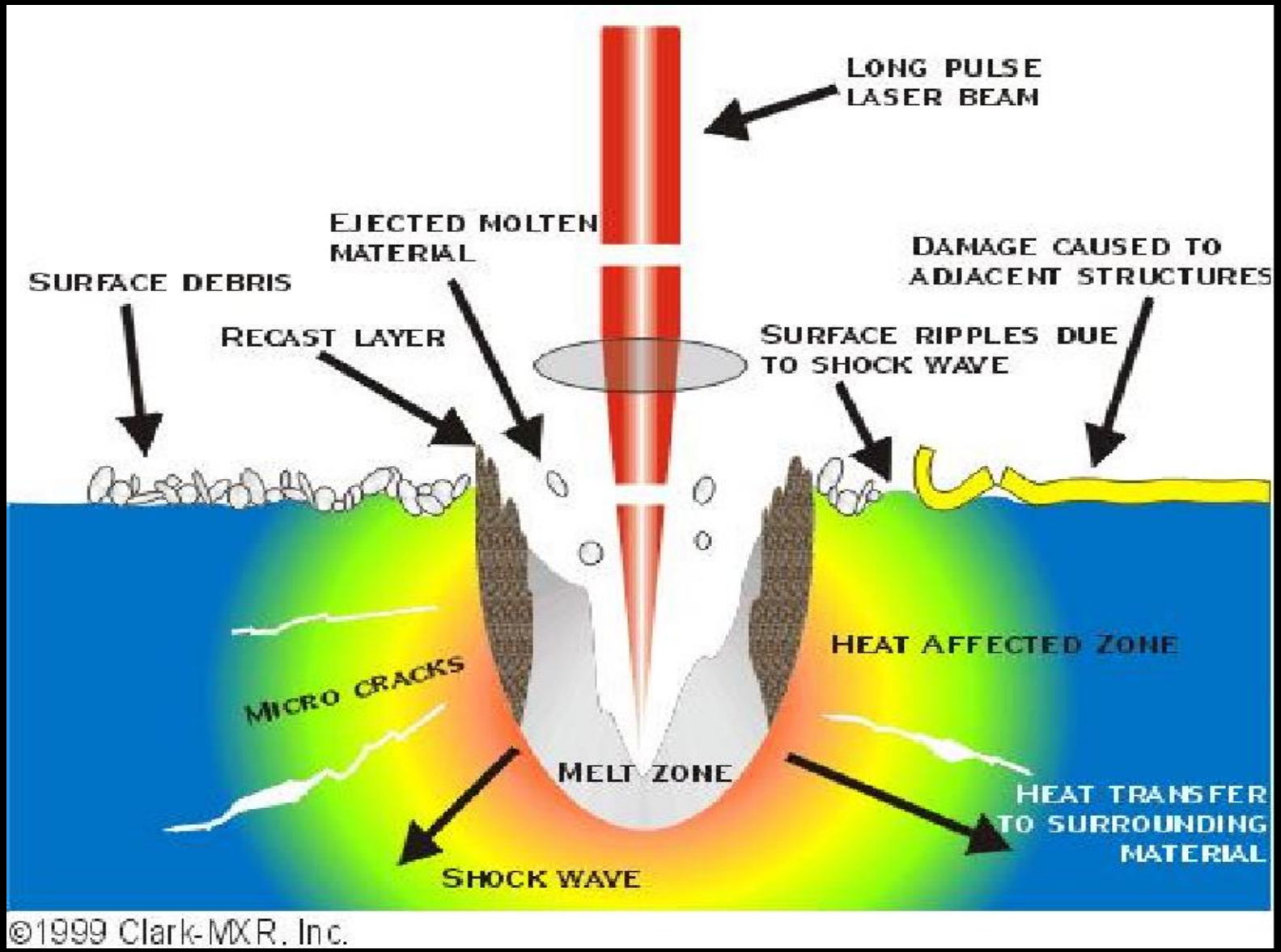
Laser Metal Processing Range



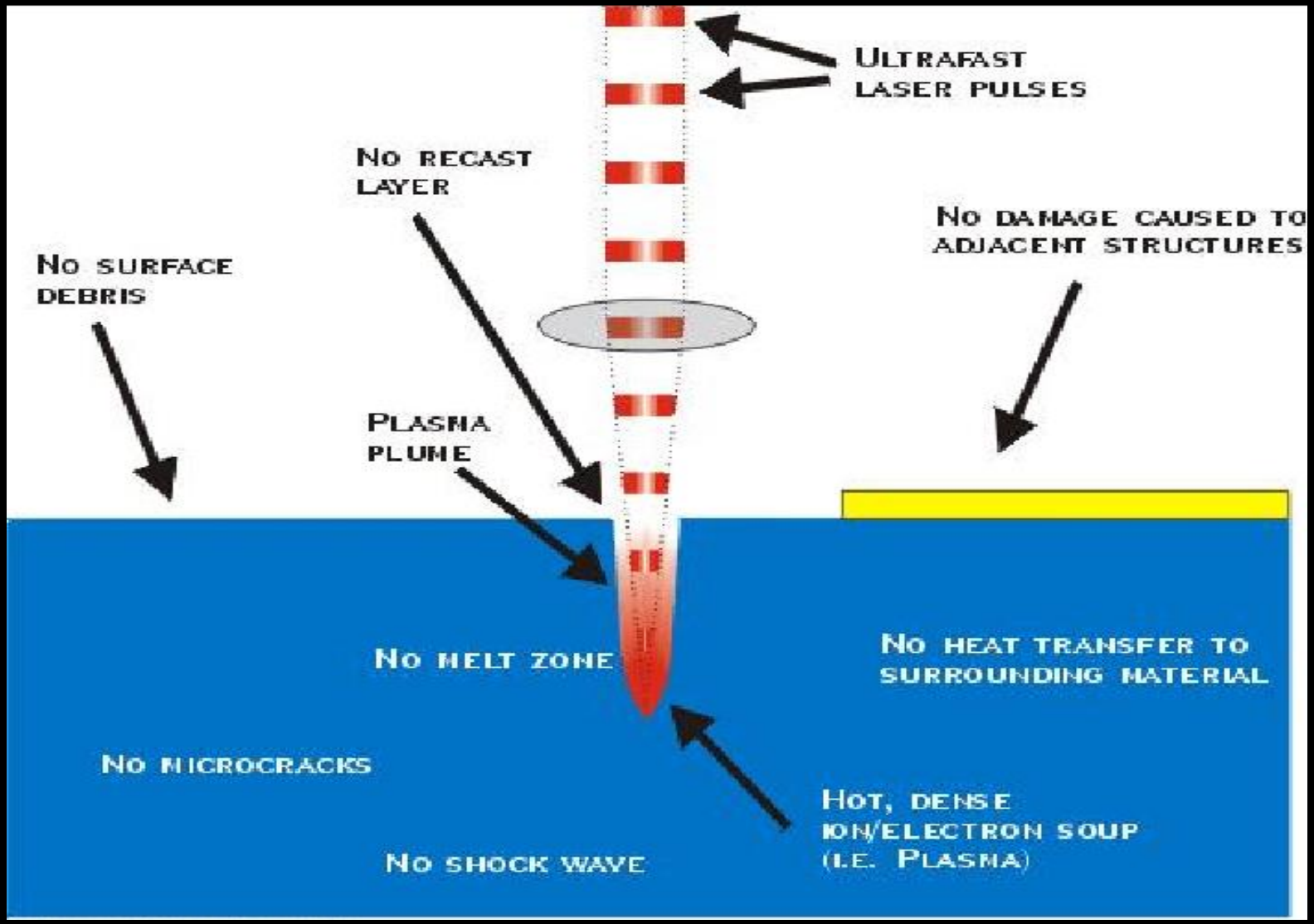
$$I = \frac{P_p}{\pi \omega^2} \quad , \quad P_p = \frac{E_{pulse}}{\tau}$$



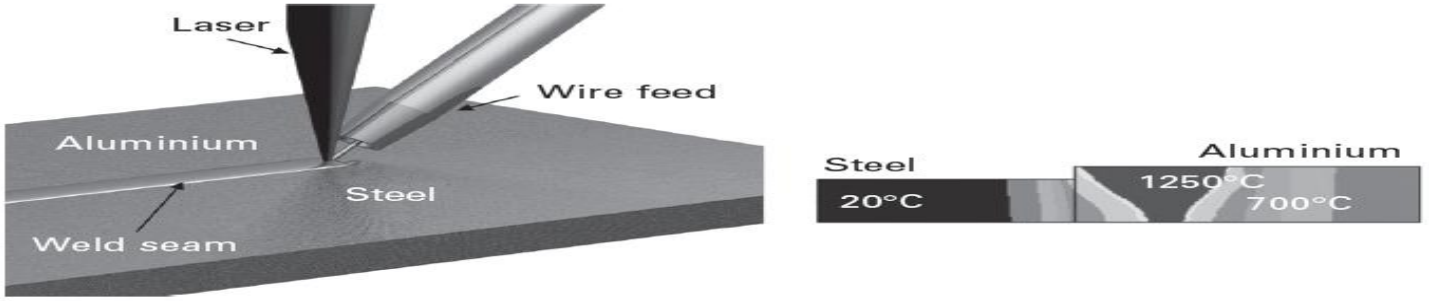
Long Pulse Interaction



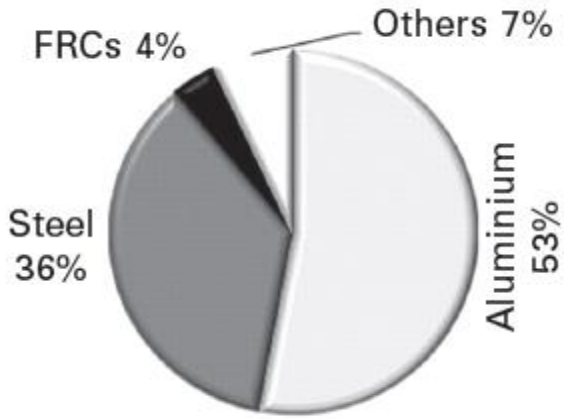
Ultra Short Pulse Interaction



Welding ,Brazing and Soldering of Dissimilar Materials



9.2 Laser welding of aluminium to steel.



- Aluminium sheets
- Aluminium die castings
- Aluminium extrusions

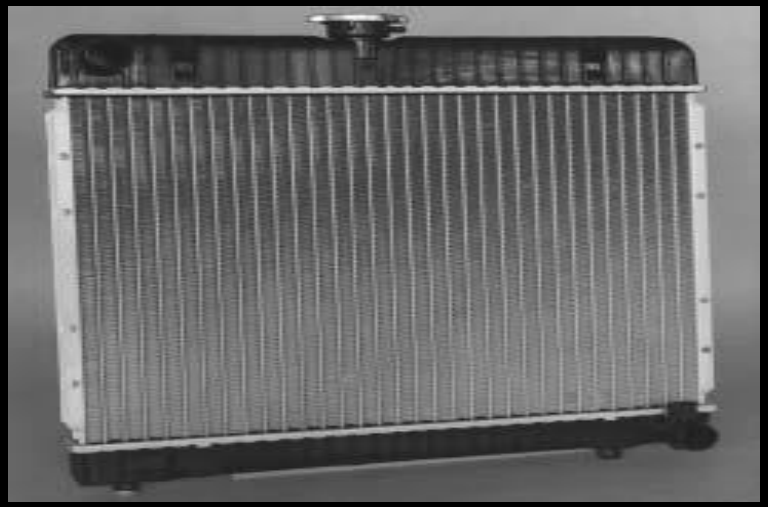
- Magnesium sheets
- Magnesium die castings
- Steel sheets (cold rolled)
- Steel sheets (hot rolled)
- Fibre reinforced polymers

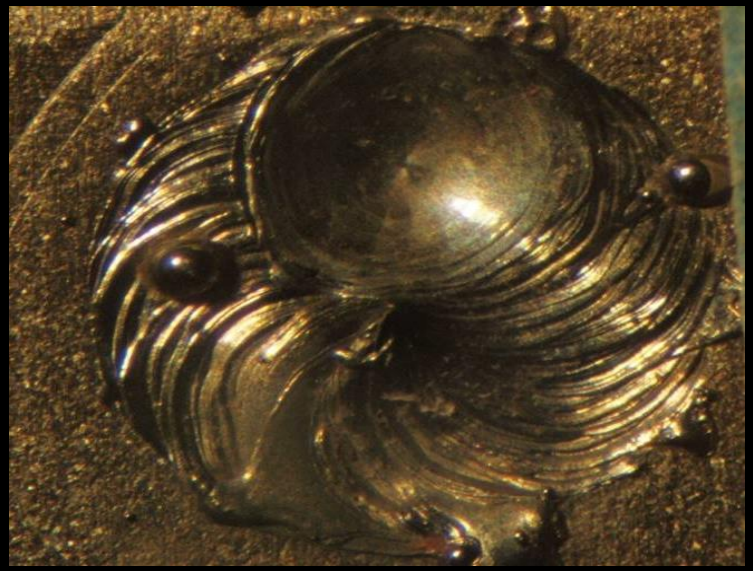
Welding, Brazing and Soldering of Dissimilar Materials

Butt joint: SS and bronze for spring inside a watch

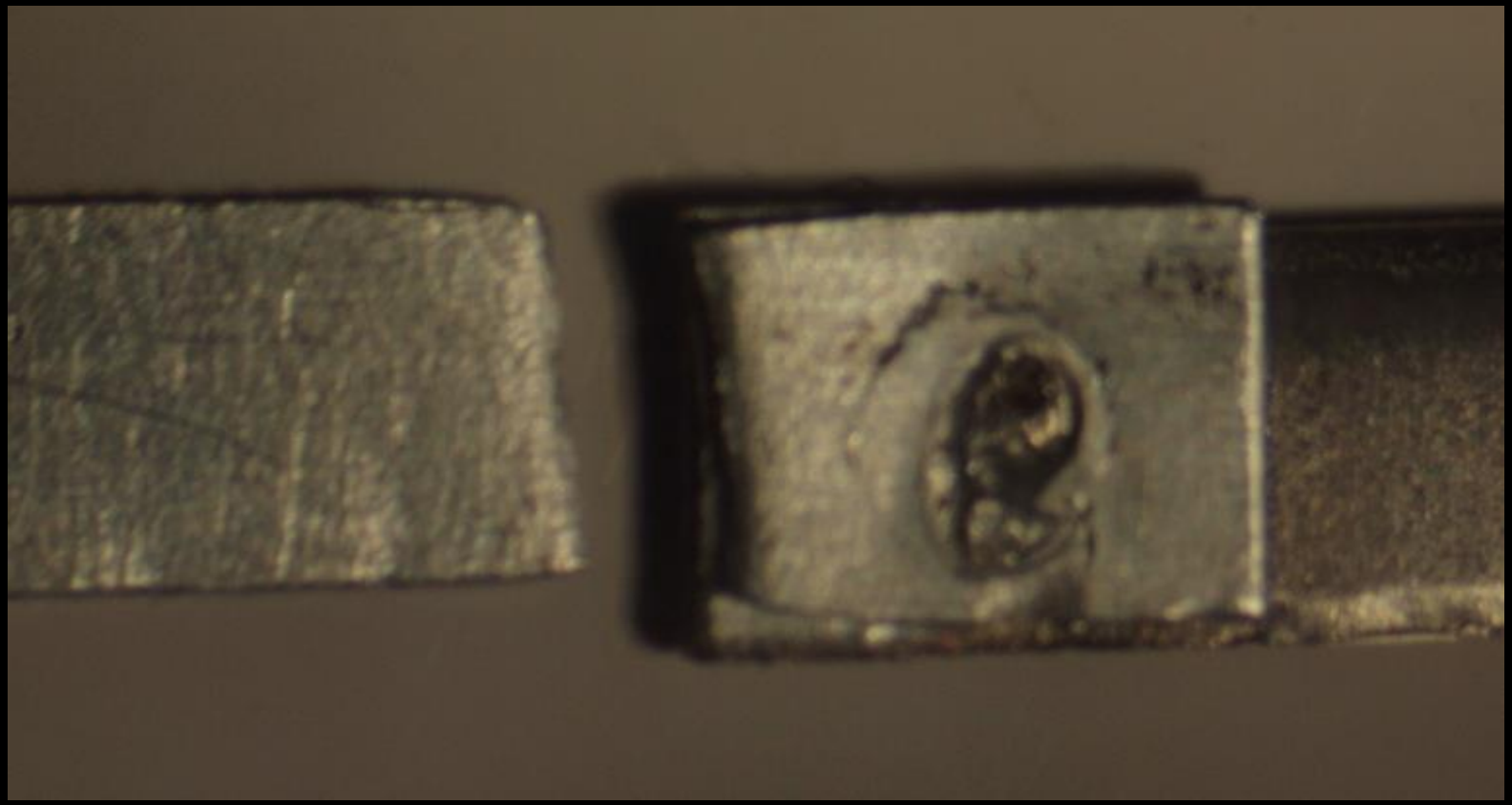
Welding ,Brazing and Soldering of Dissimilar Materials Applications

★ Airplane cabin cooling systems,

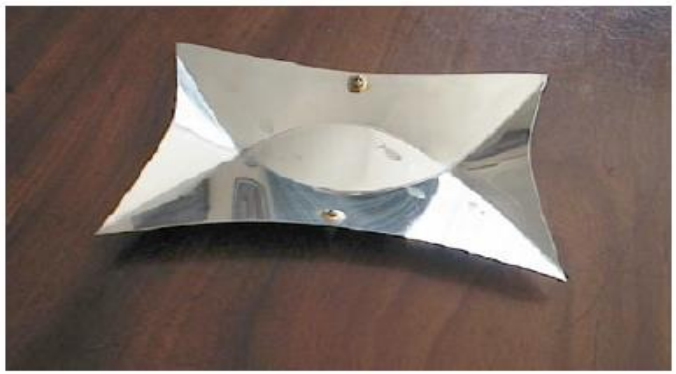




The Result

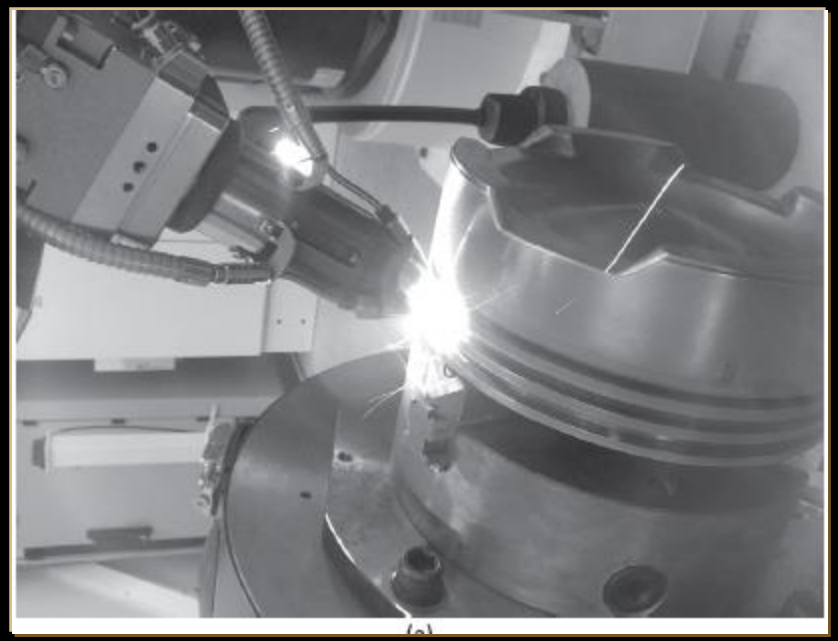


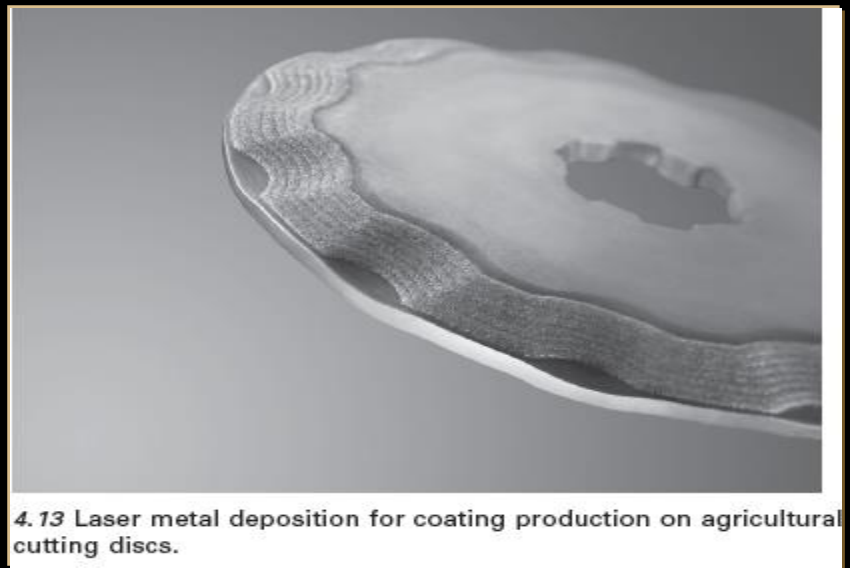
Laser Cutting



A laser cut, marked and bent sushi dish by Silve in aluminium and bronze

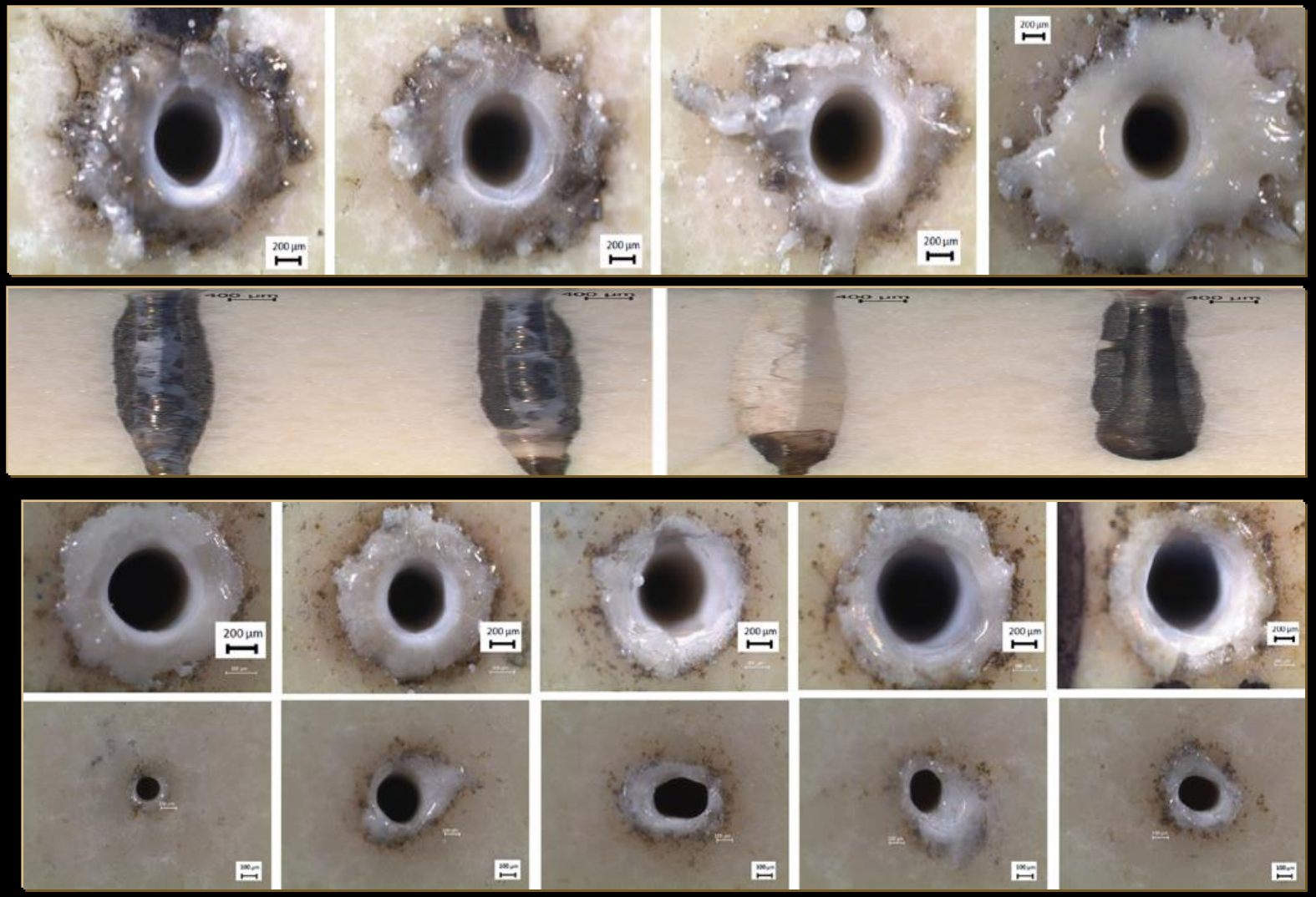
Laser Deposition





4.13 Laser metal deposition for coating production on agricultural cutting discs.

Laser Drilling

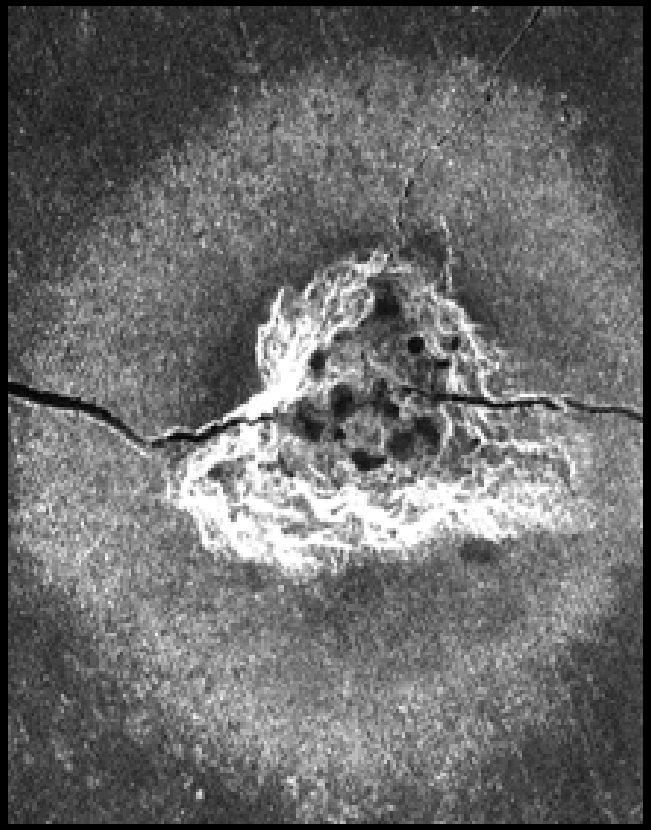


Effects of pulse repetition rate (at 8kW peak power, 2ms pulse duration and -2 mm fpp. Effects of the focal position 10 Hz repetition rate. 0,-1,-2,-3,-4

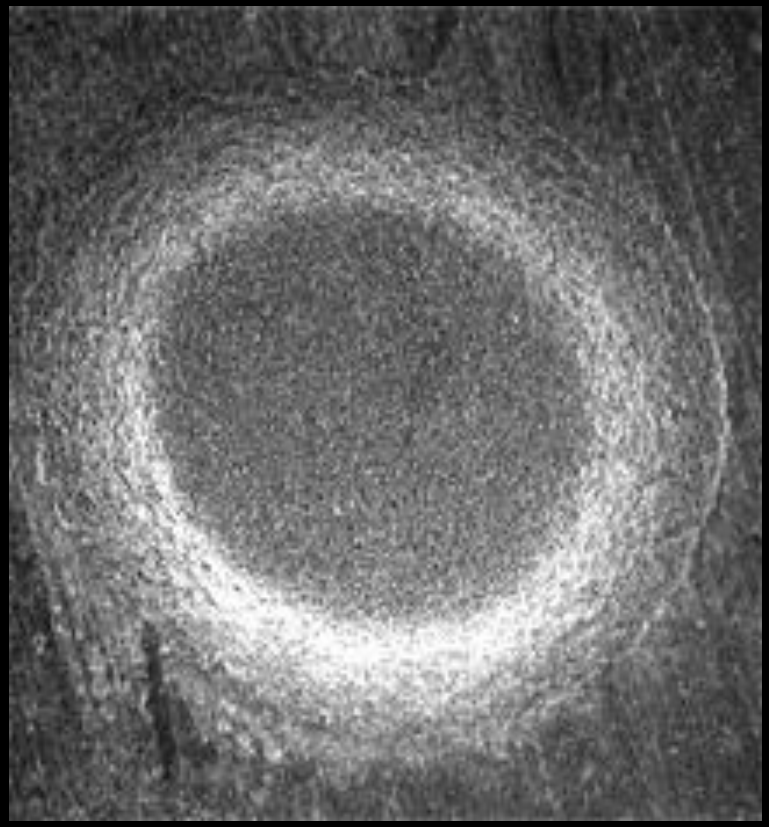
Laser Drilling of Enamel

Laser Drilling of Enamel

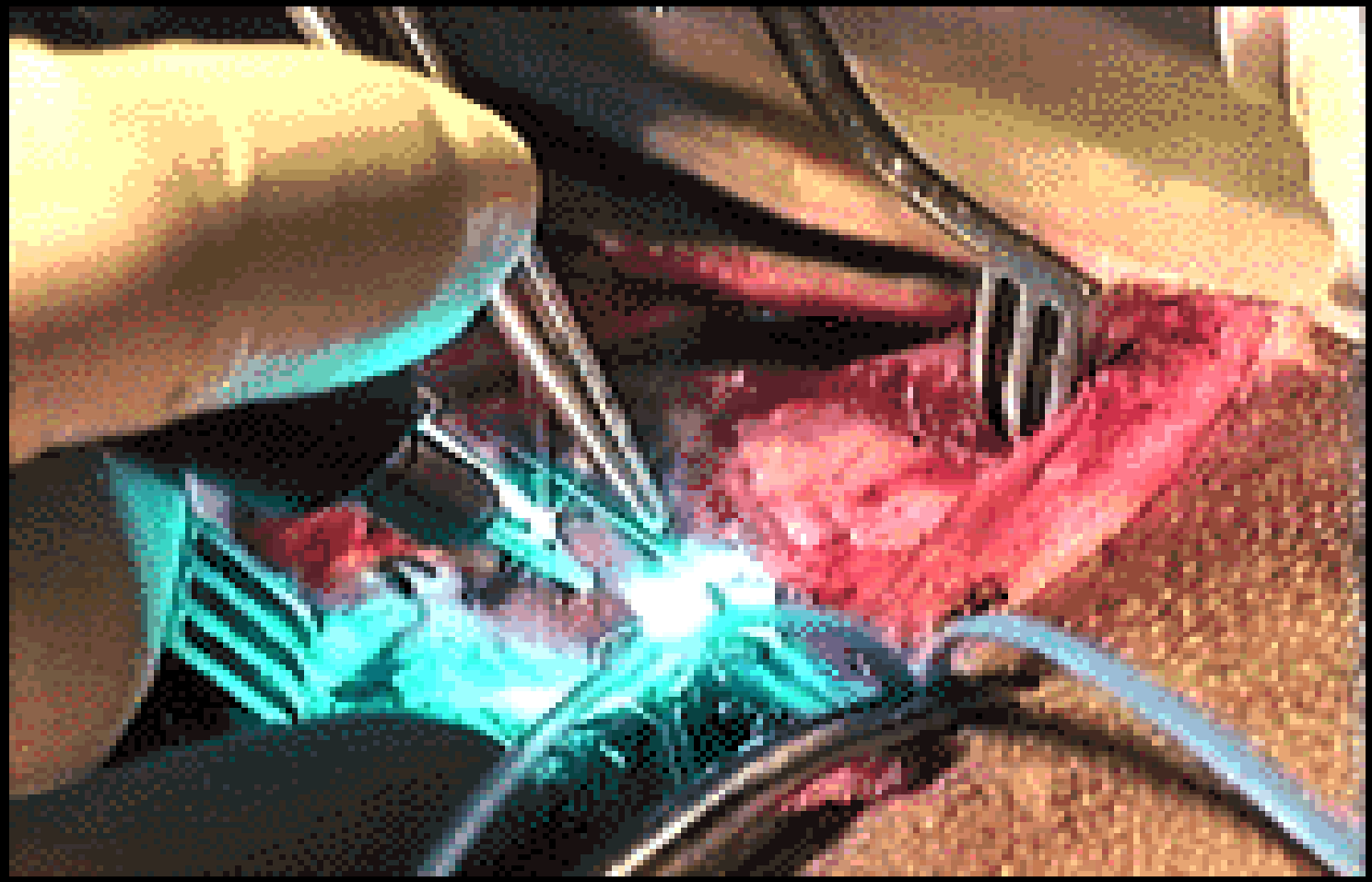
Extensive thermal damage and cracking to tooth enamel caused by 1-ns laser ablation.



Smooth hole with no thermal damage after drilling with a USPL.

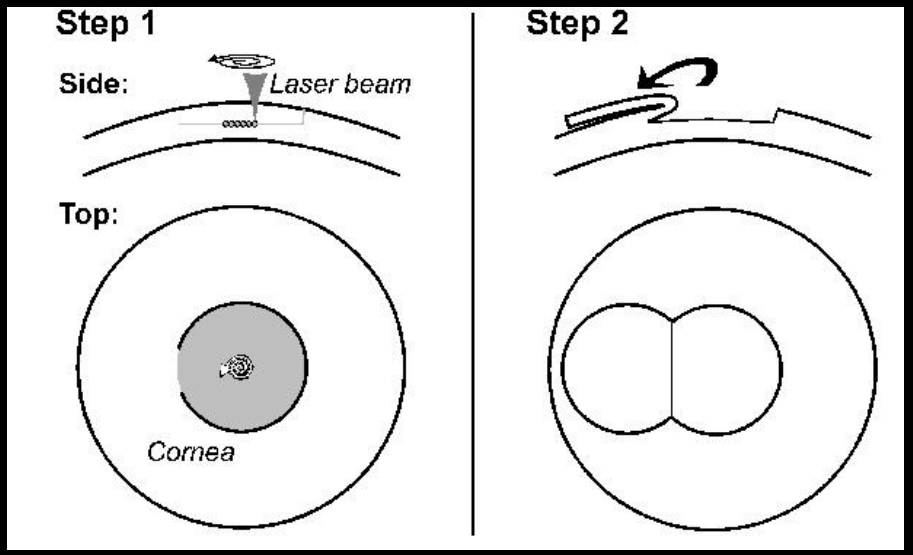


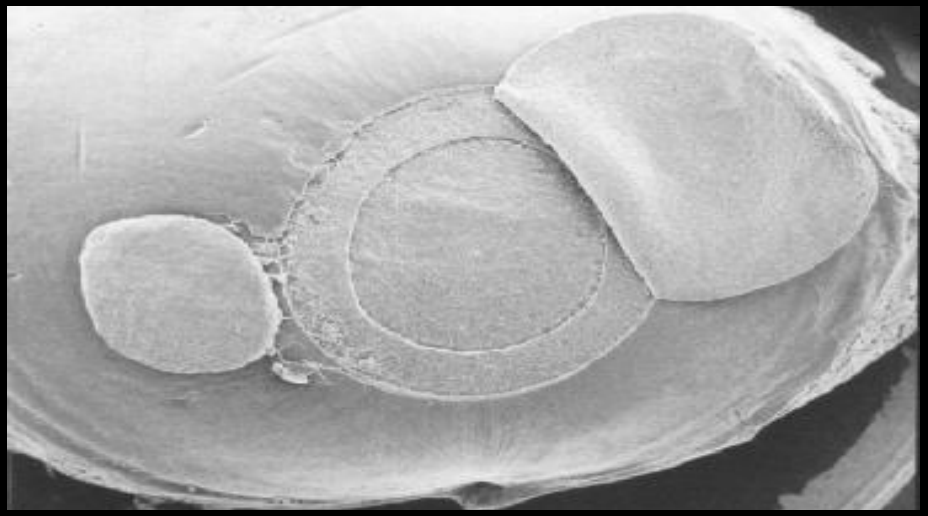
Laser Tissue Welding

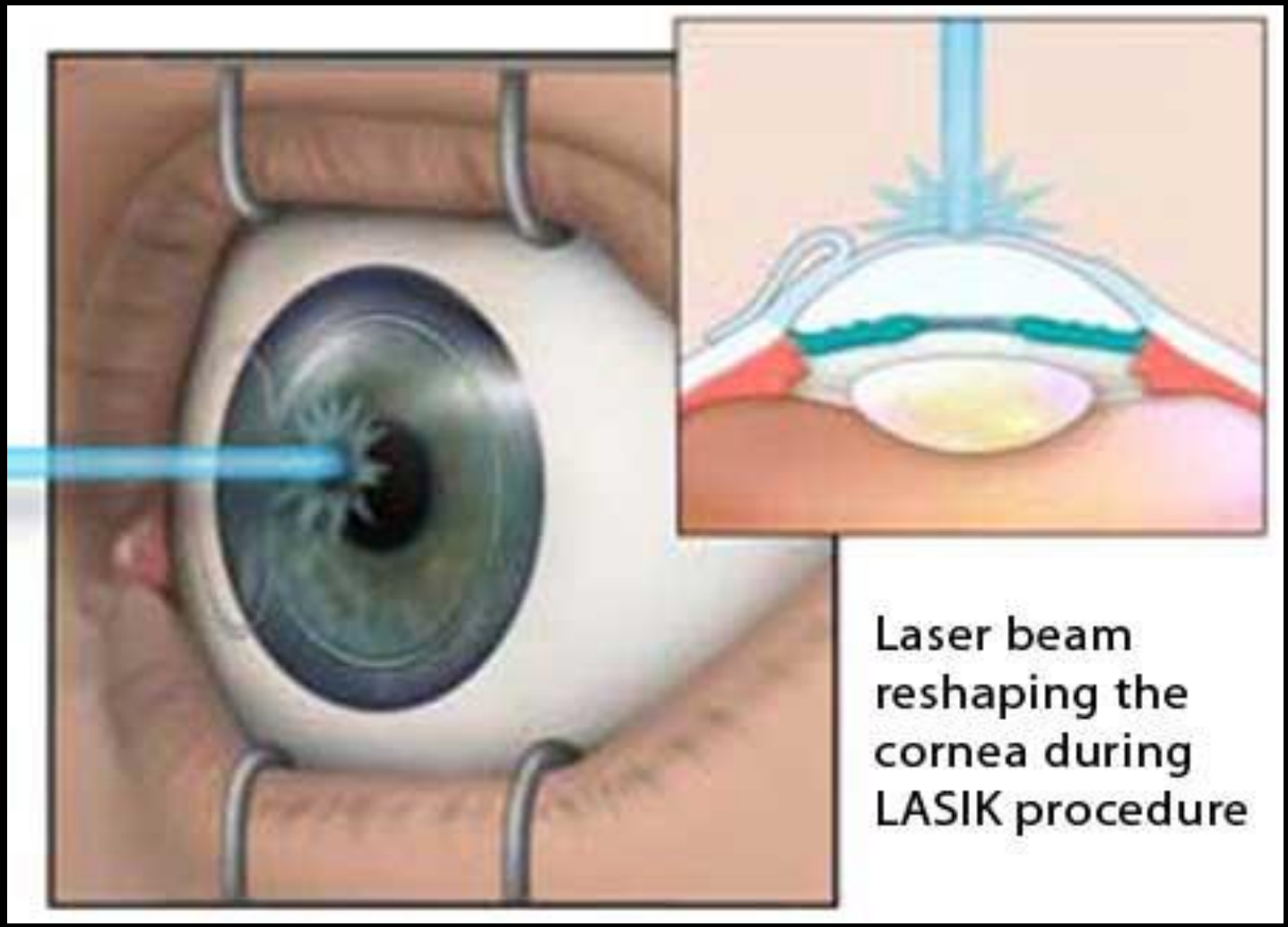


Femtosecond Laser Surgery of Cornea

Femtosecond LASIK

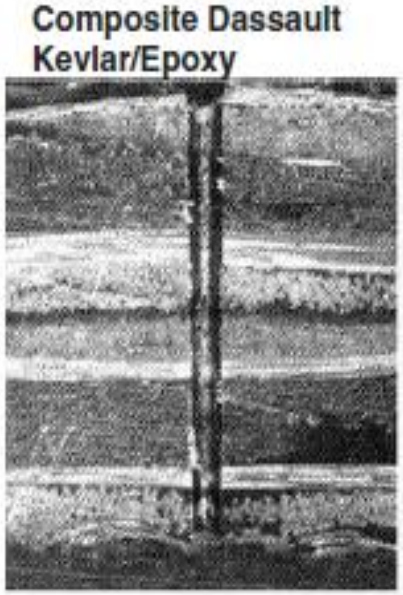


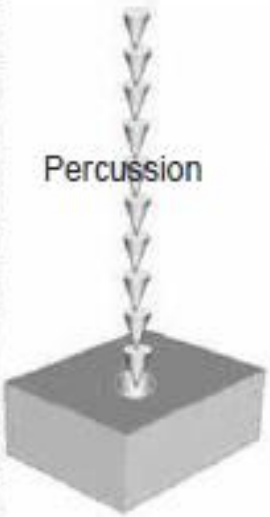


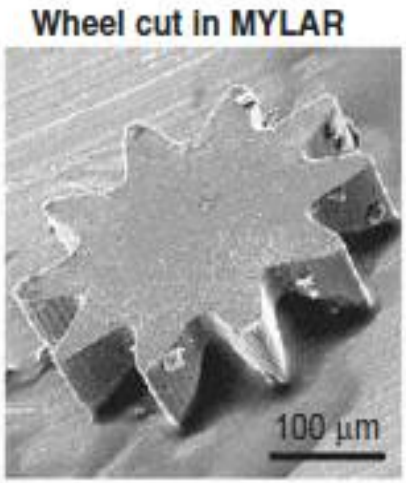


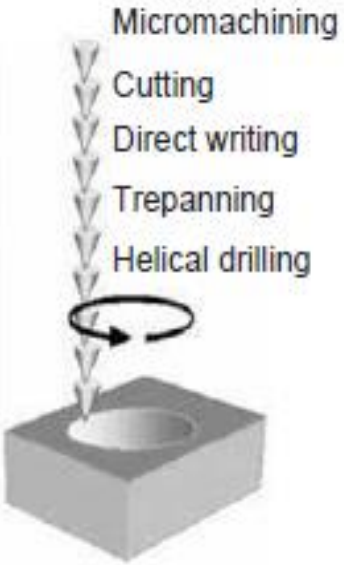
Laser beam reshaping the cornea during LASIK procedure

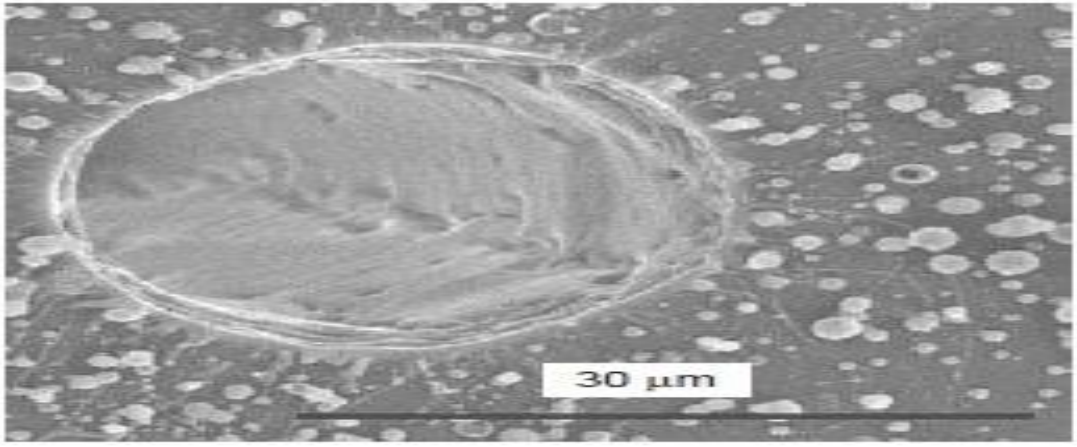
Micromachinating











Micromachinating

- For the fuel injection technology in the automotive sectors reduction of nozzle diameters are of high interest

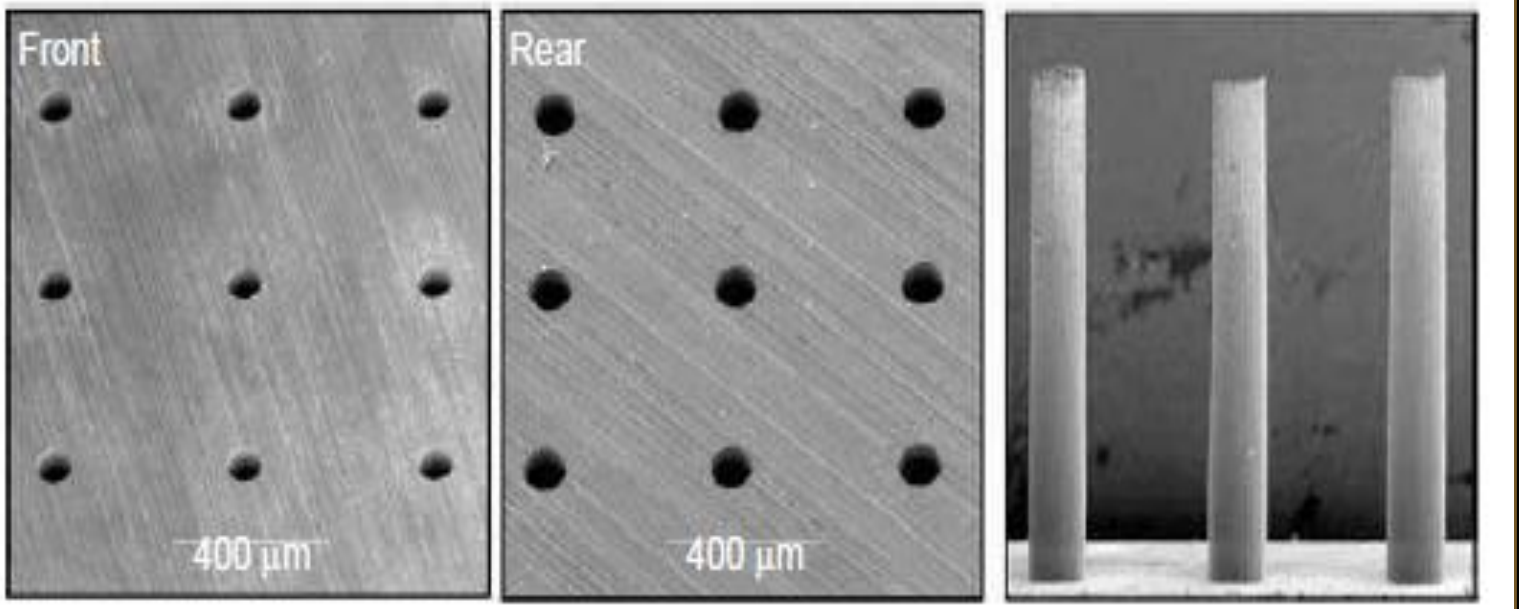
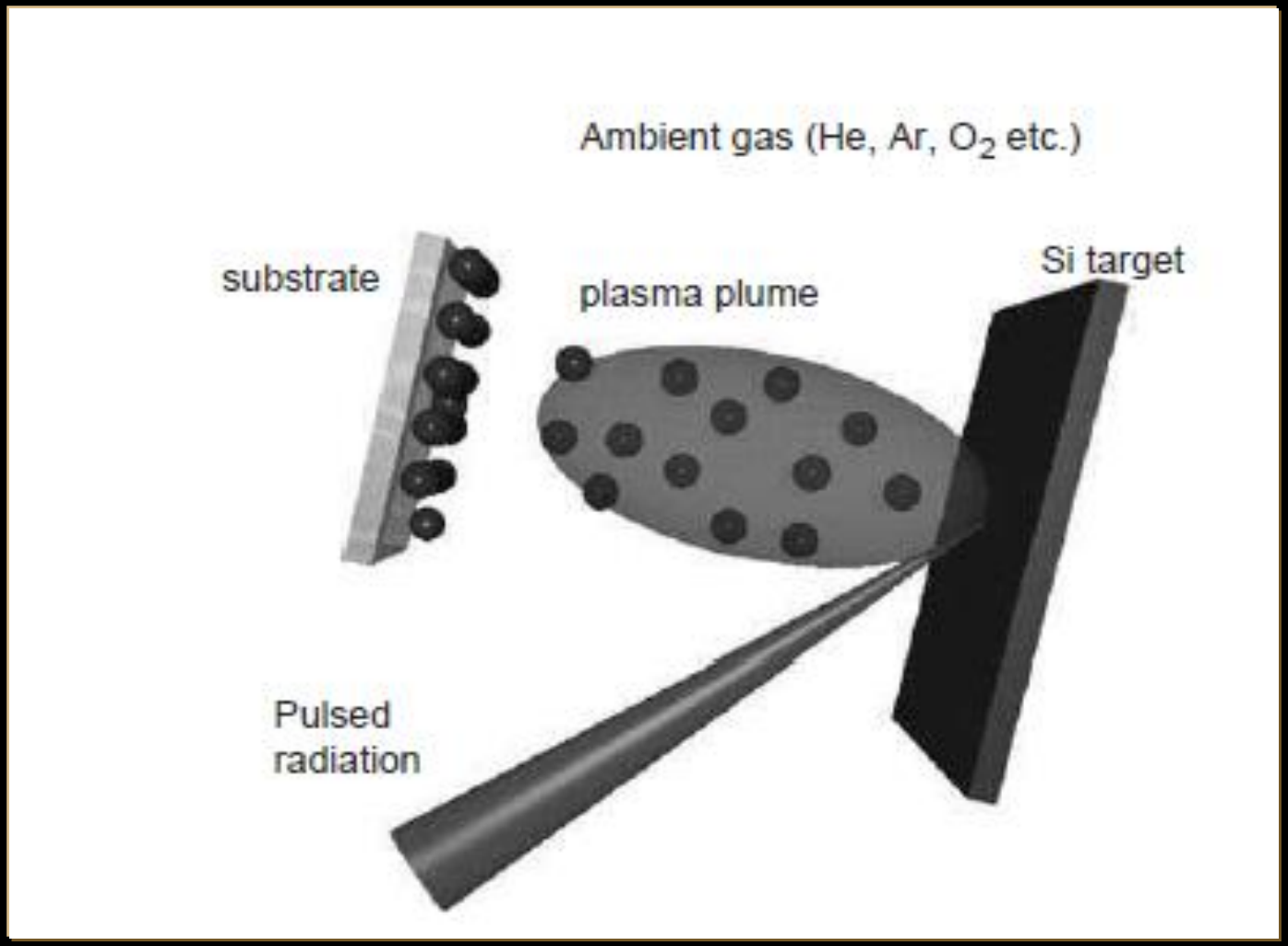


Figure 24: Drilling in 1 mm stainless steel; details of nozzle in- and outlet as well as replica of the channel geometry.

Nanomachaining



PLD experiment for deposition of Si-based nanostructured films

Nanomachaining

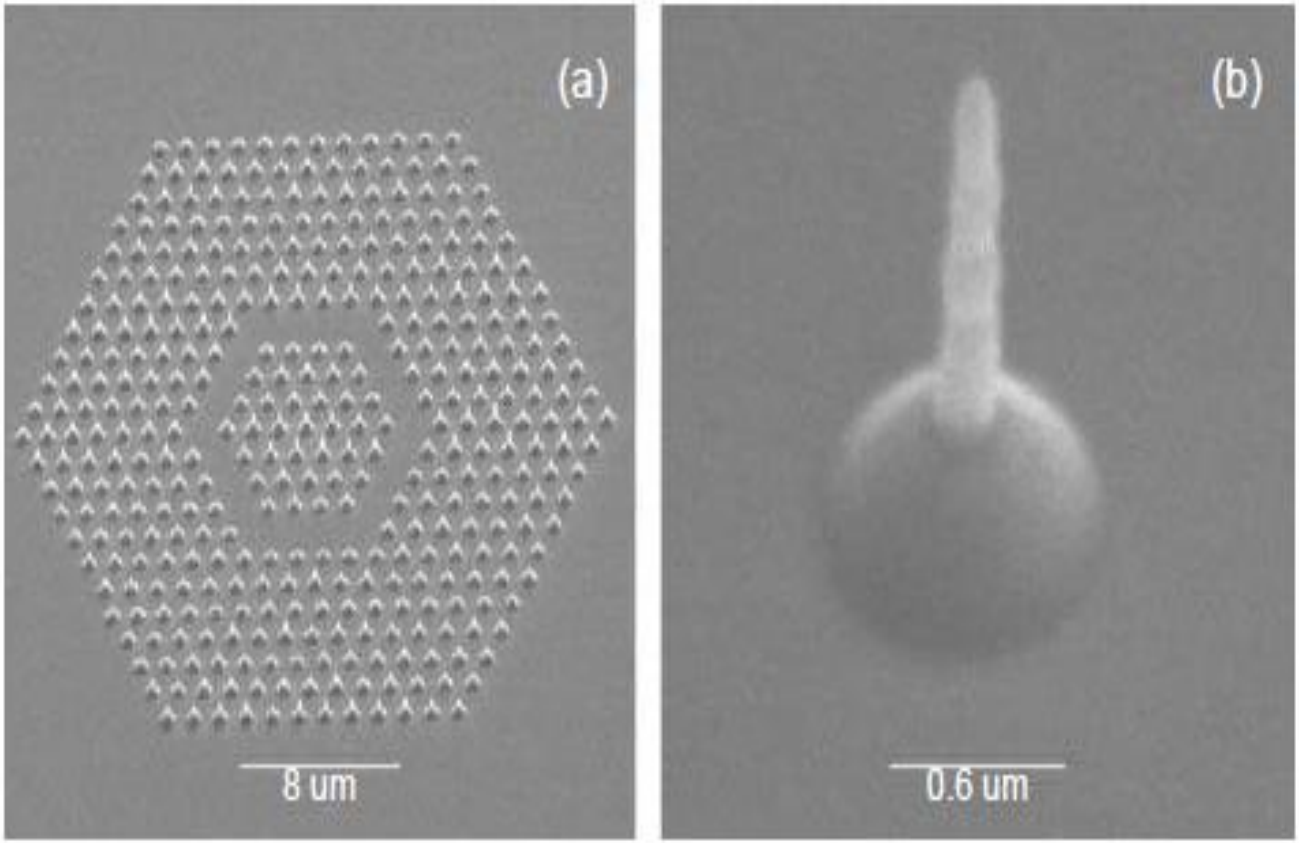
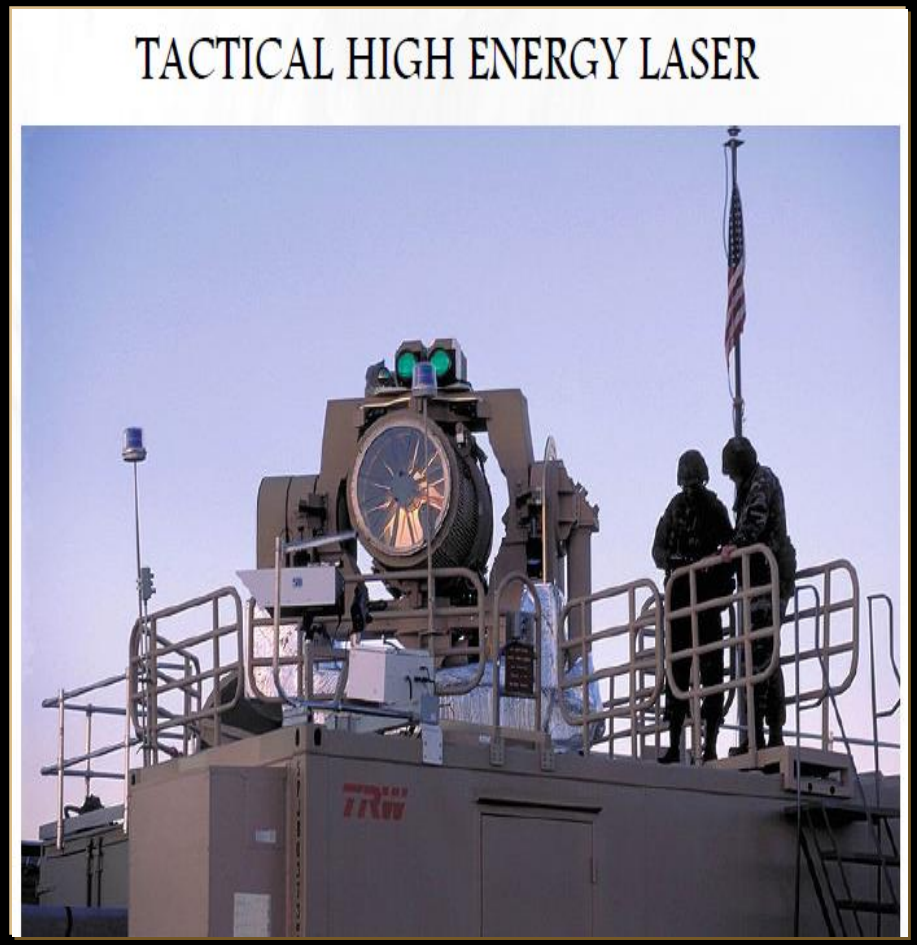


Figure 14: SEM images of an array of nanojets fabricated in a 60 nm thick gold film with femtosecond laser pulses (a) and a single nanojet in detail (b).

Military Applications

missile defense system to destroy tactical ballistic missiles.
the laser produces enough energy in a five-second burst to power
Can destroy targets up to 600 km away



Military Applications

Laser History