University of Diyala
College of Engineering
Dept. of Mechanical 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?

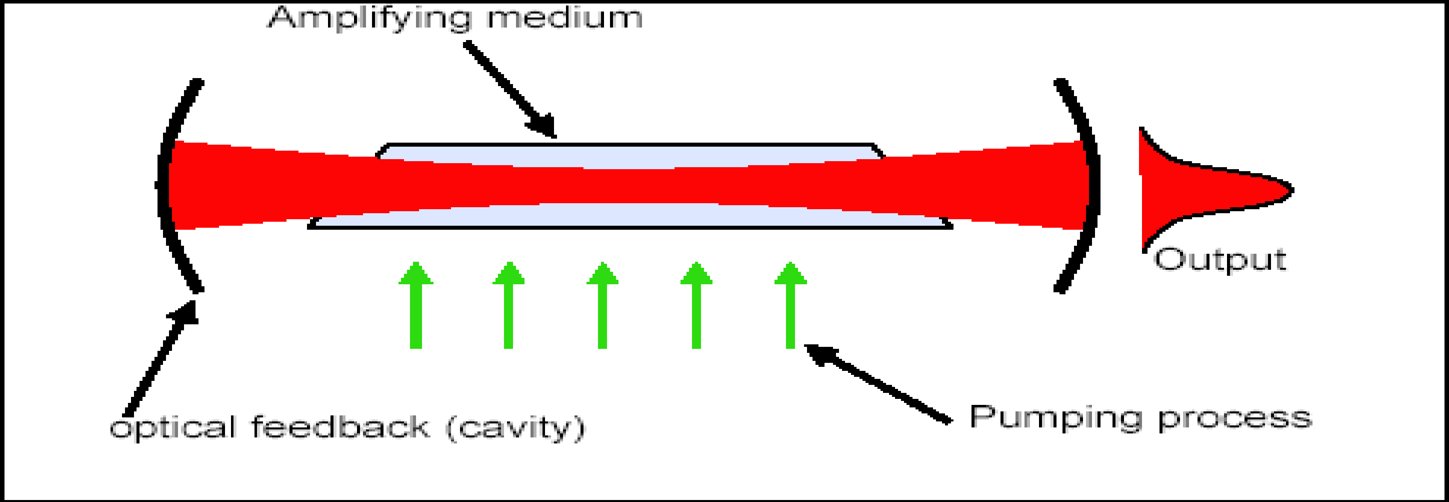
Definition of laser

- LASER stands for Light Amplification by Stimulated Emission of Radiation

- A coherent beam resulted which all of the photons are in phase.

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



Laser Generator Set-Up

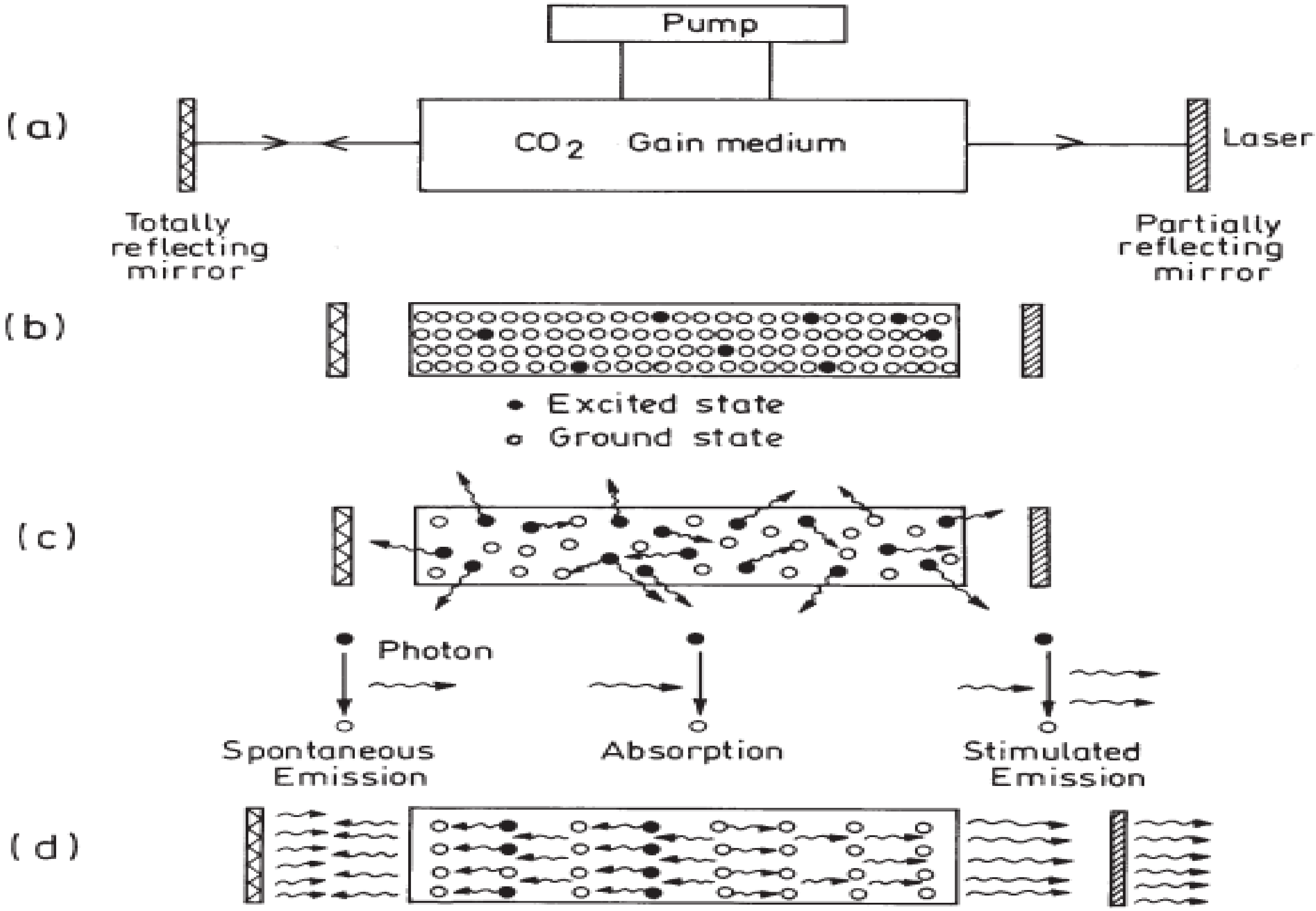
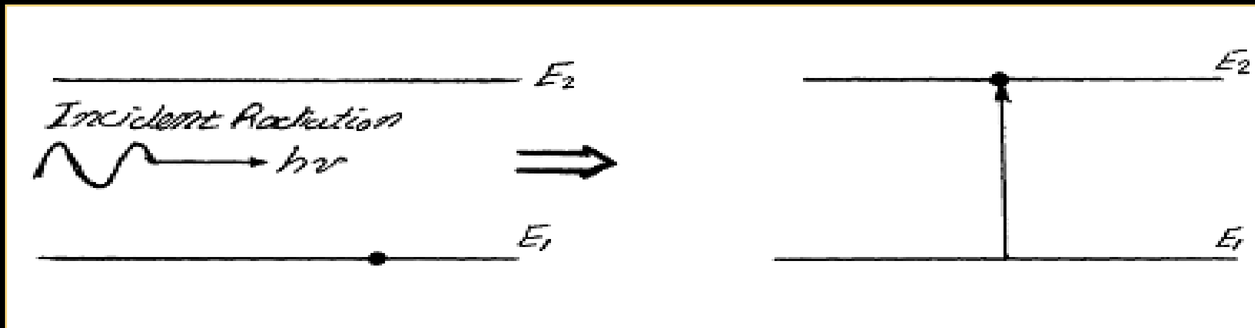
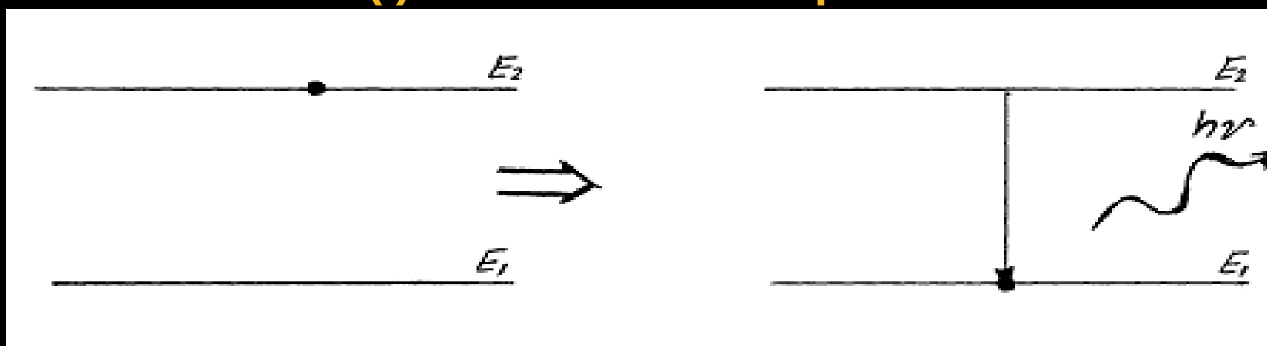


Figure 2. Schematic set-up of continuous wave CO_2 laser. (a) The major constituents of the ma
(b) initial stage of energy pumping, (c) excitation and de-excitation of the atoms in the medium l
to emission of laser and (d) stimulated emission and formation of laser beam.

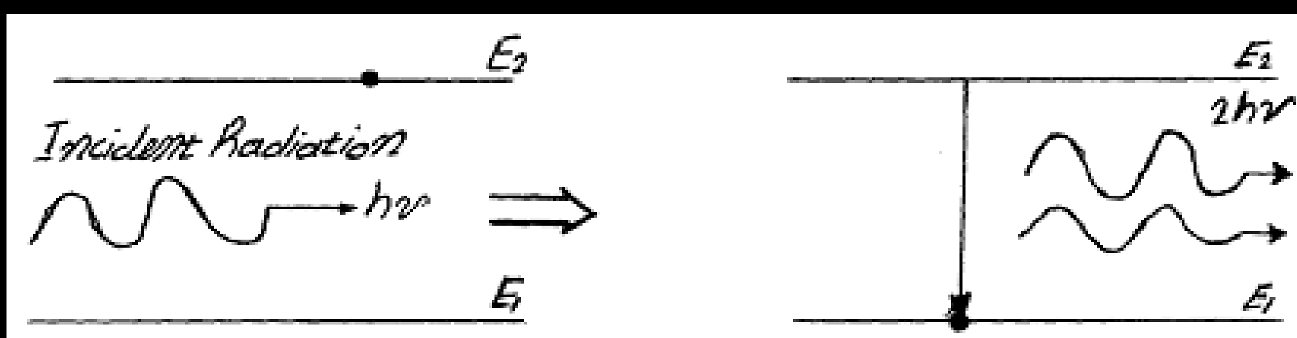
Before **After**



(i) Stimulated absorption



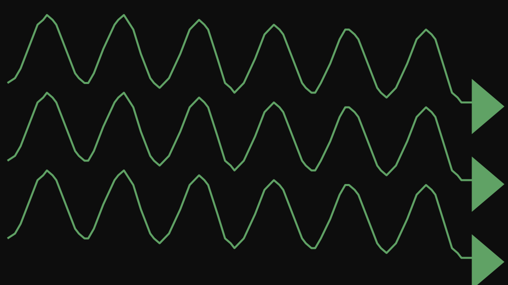
(ii) Spontaneous emission



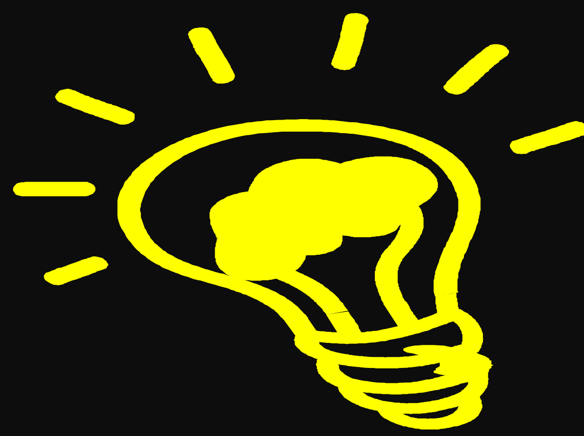
(iii) Stimulated emission

Properties of Laser

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

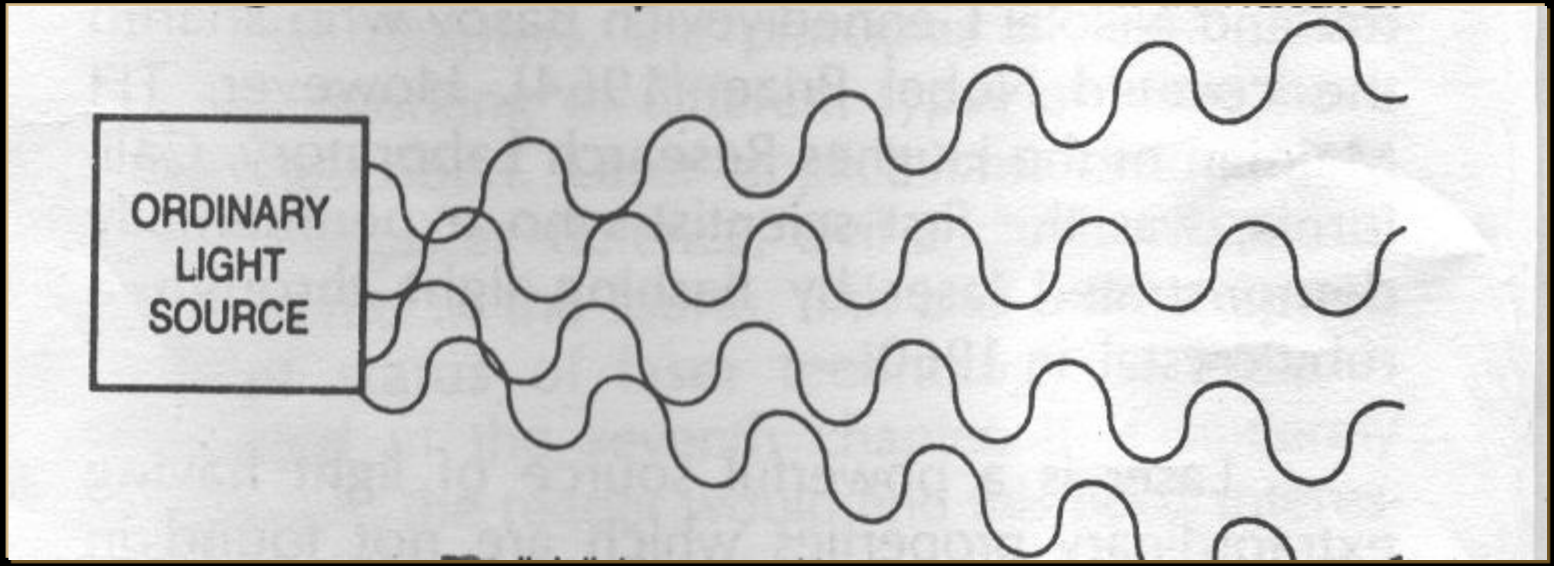


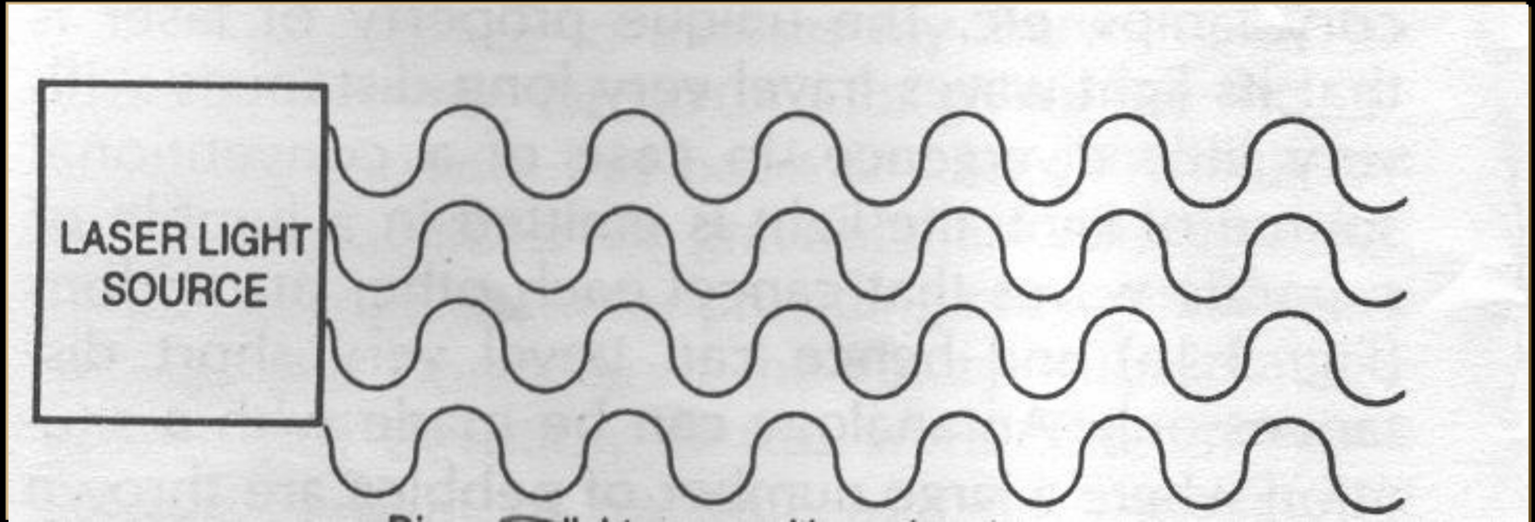
Laser Light



Ordinary Light

Laser Light *vs. Ordinary Light*

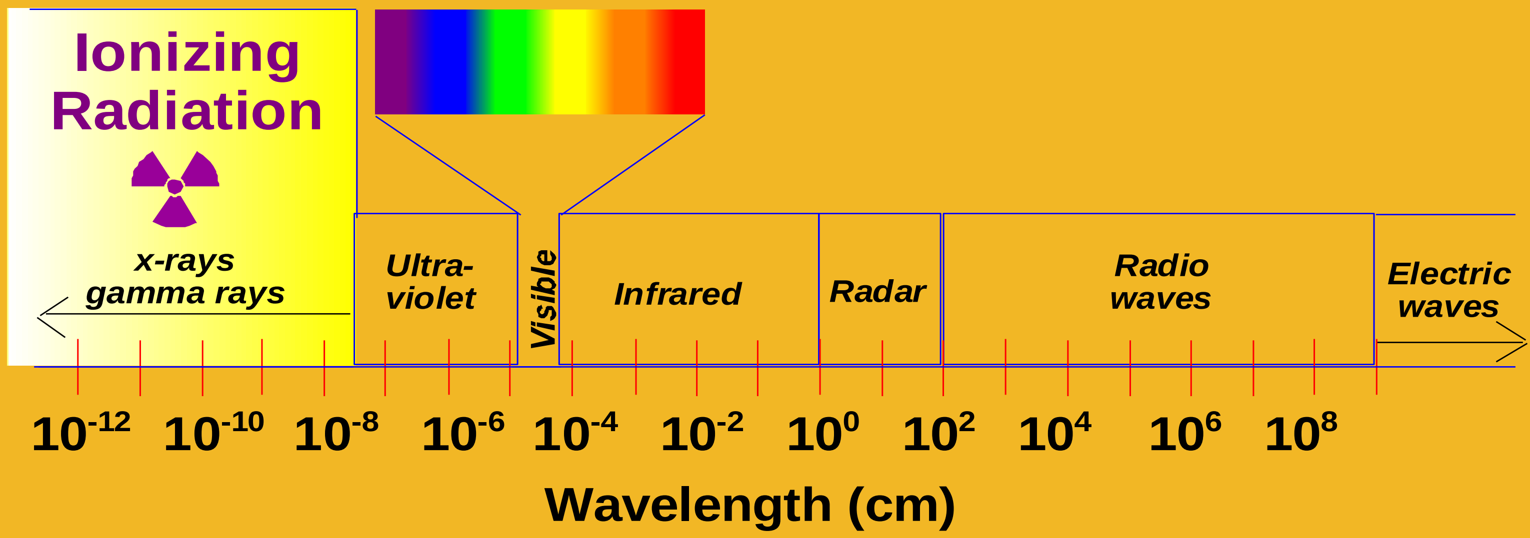




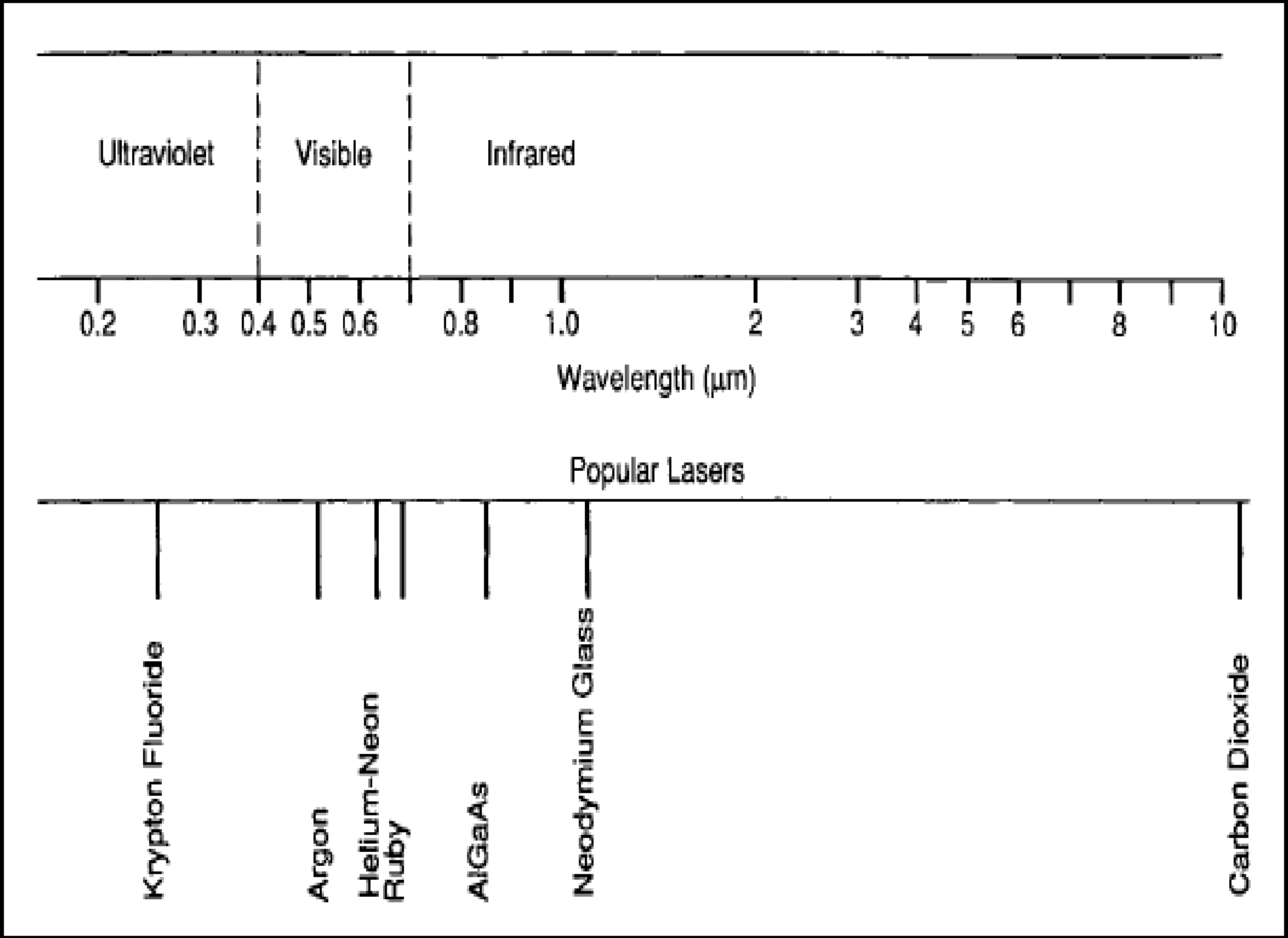
Electromagnetic Spectrum

- Laser wavelengths are usually in the Ultraviolet, Visible or Infrared Regions of the Electromagnetic Spectrum.

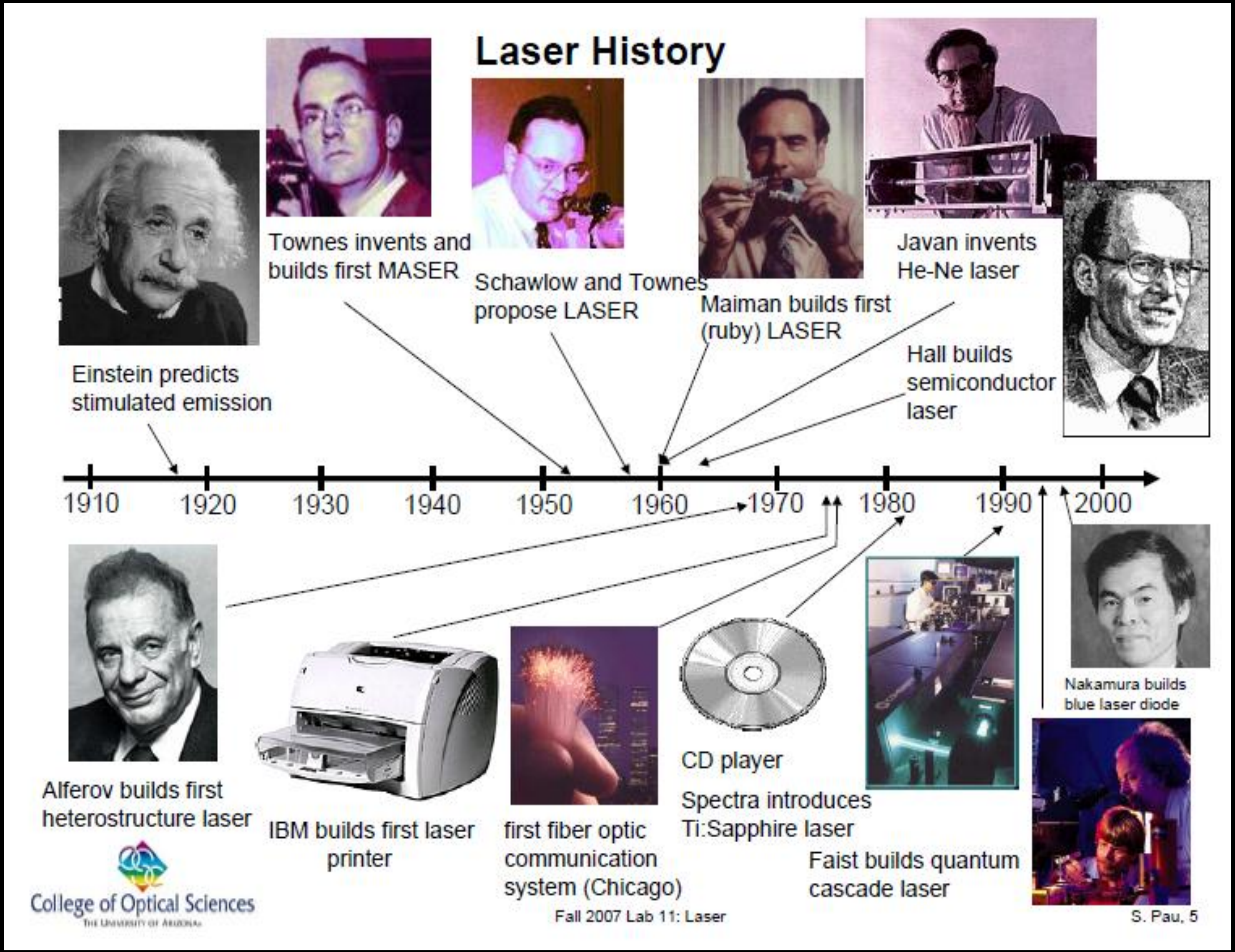
The Electromagnetic Spectrum



Laser wavelengths



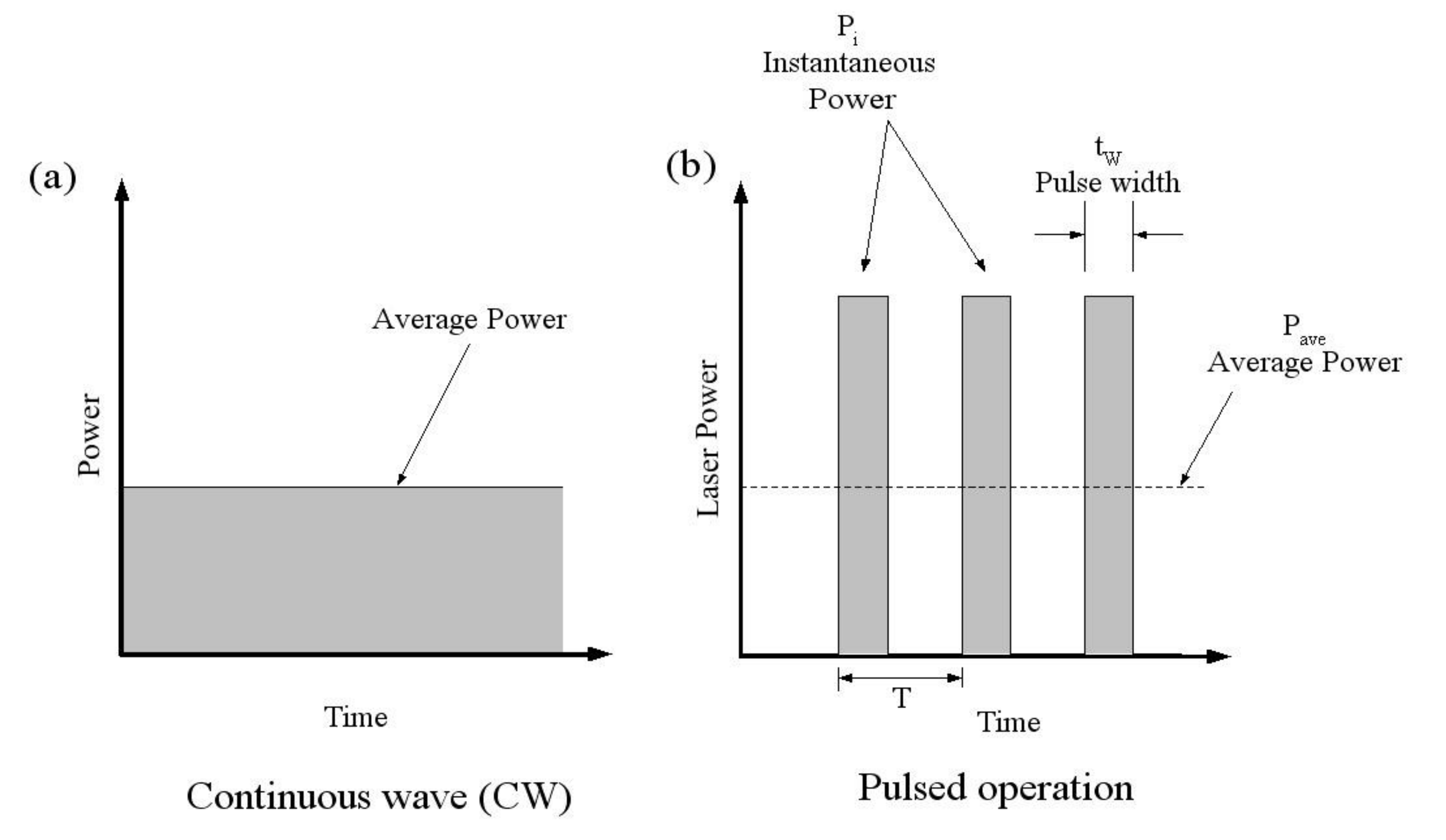
Laser History



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

Laser Metal Interaction

- The laser beam absorbed photon interacts only with the electrons

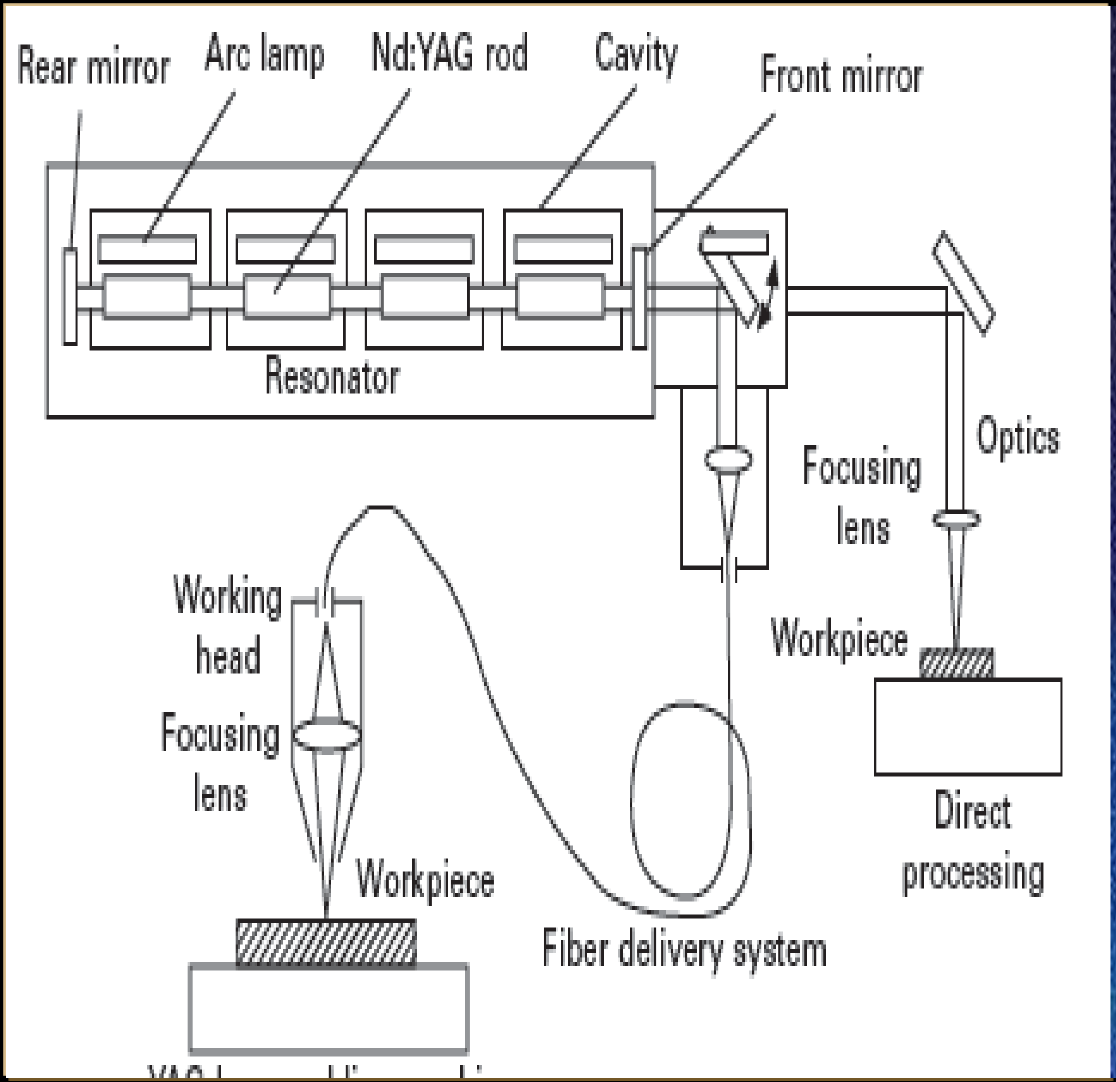
- electrons give up this energy through collisions with other electrons and with lattice phonons.

- If the absorbed photon has large enough energy it will remove the excited electrons from the metal

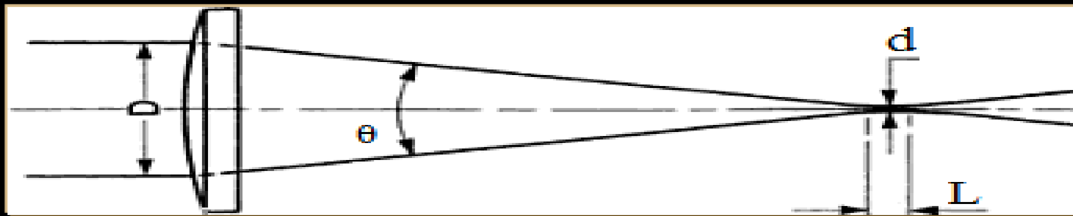
Laser Metal Interaction

- 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

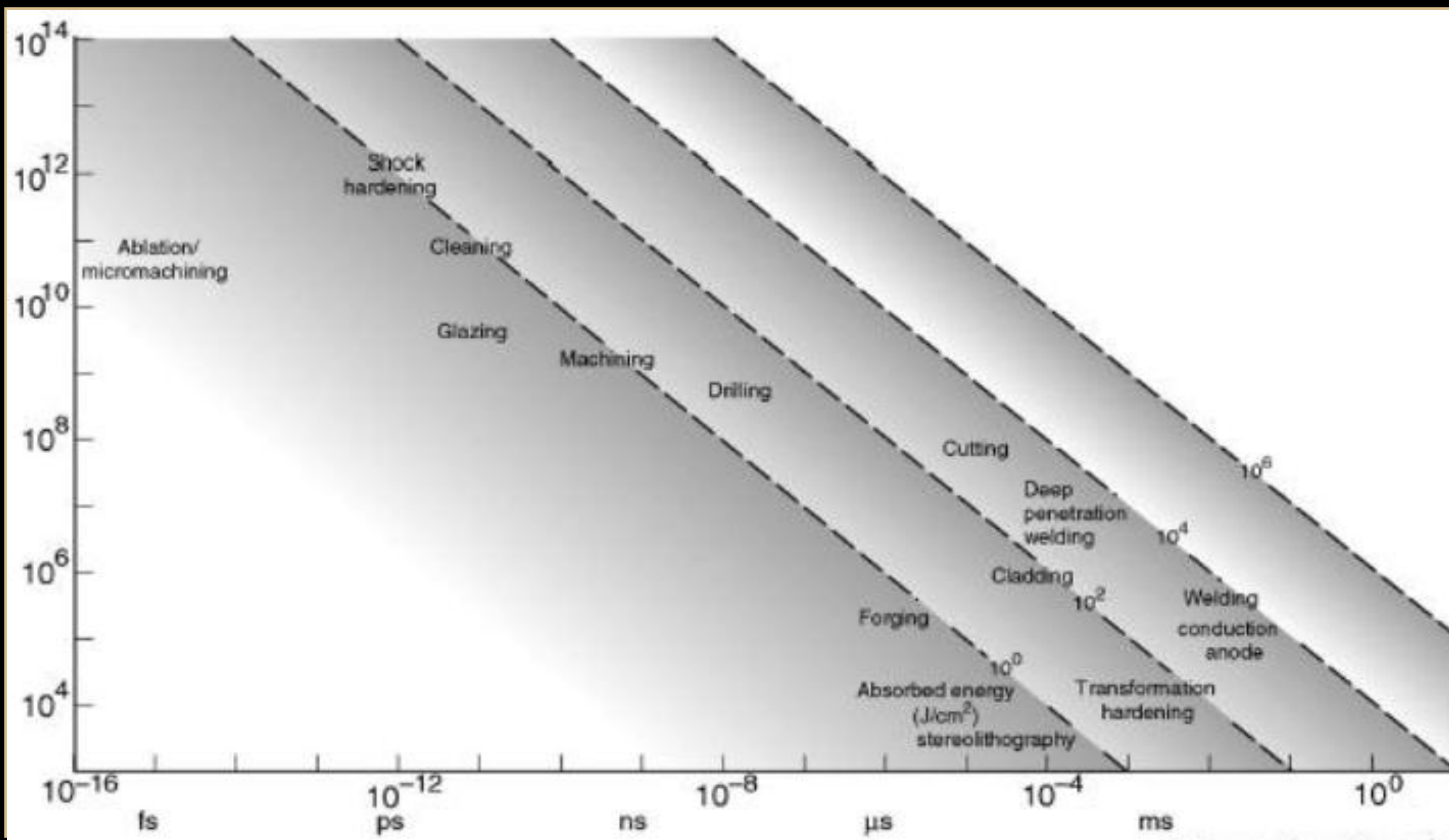
Transferring of the Beam



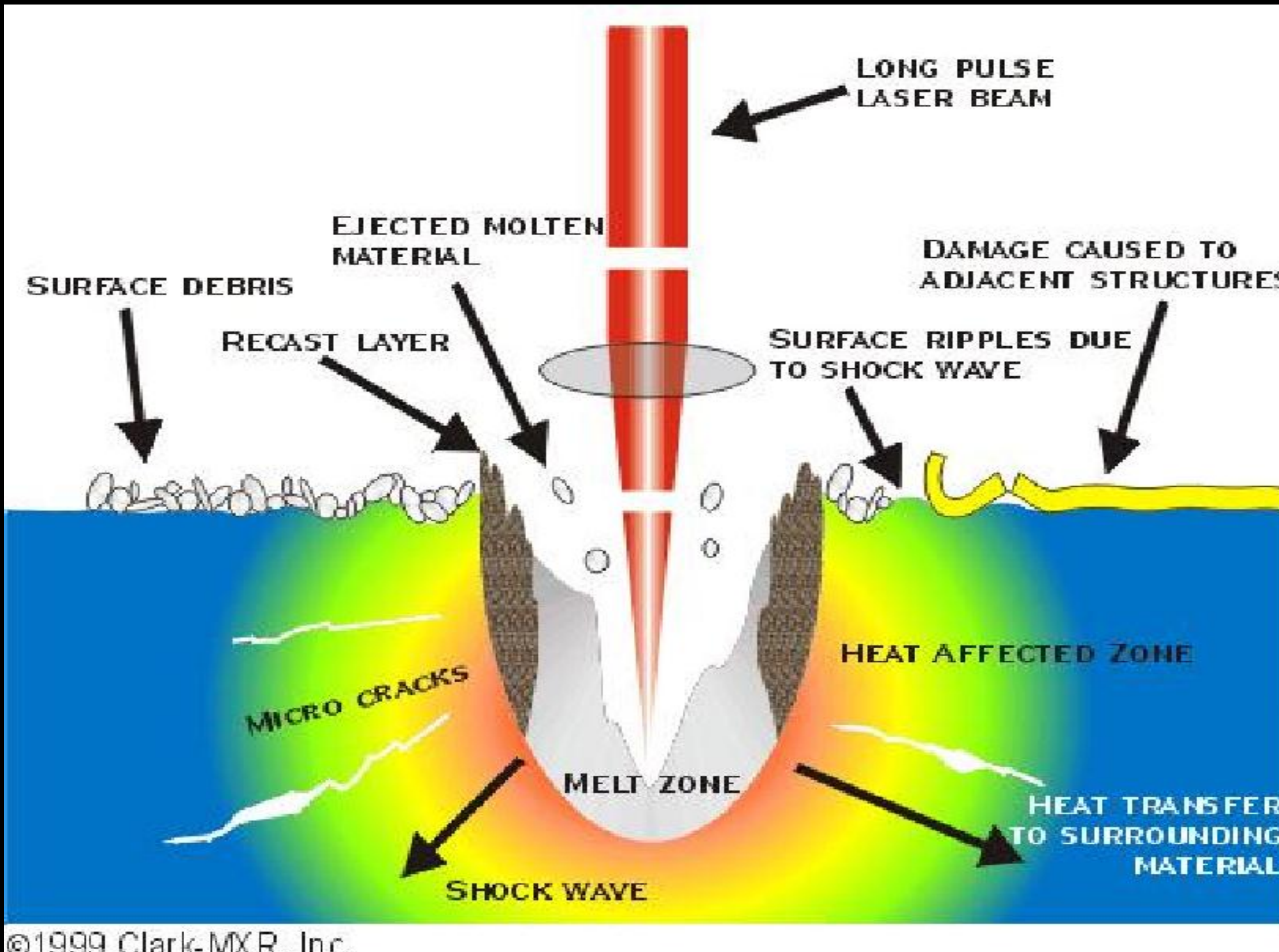
Laser Metal Processing Range



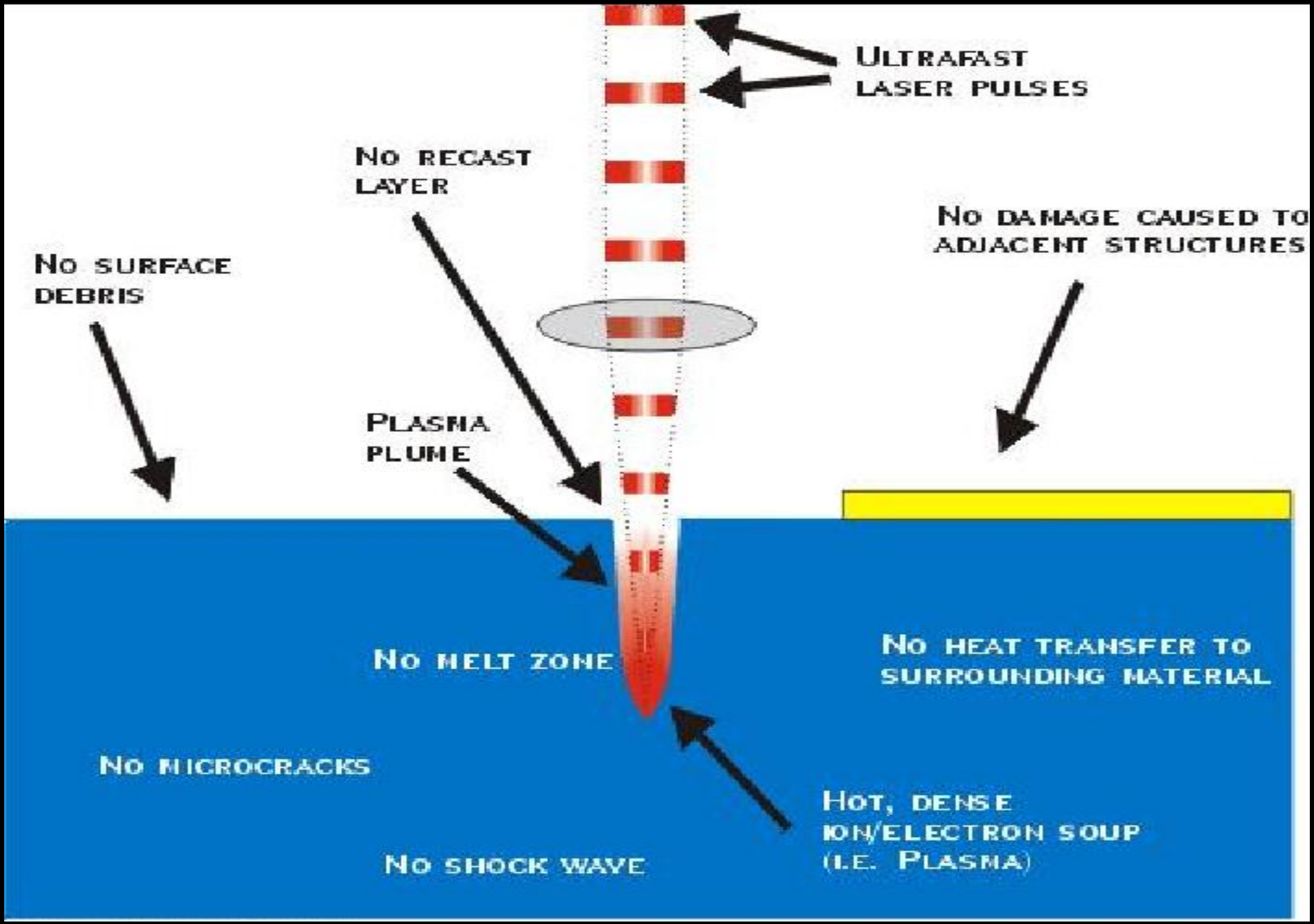
$$I = \frac{P_P}{\pi \omega^2} \quad , \quad P_P = \frac{E_{pulse}}{\tau}$$



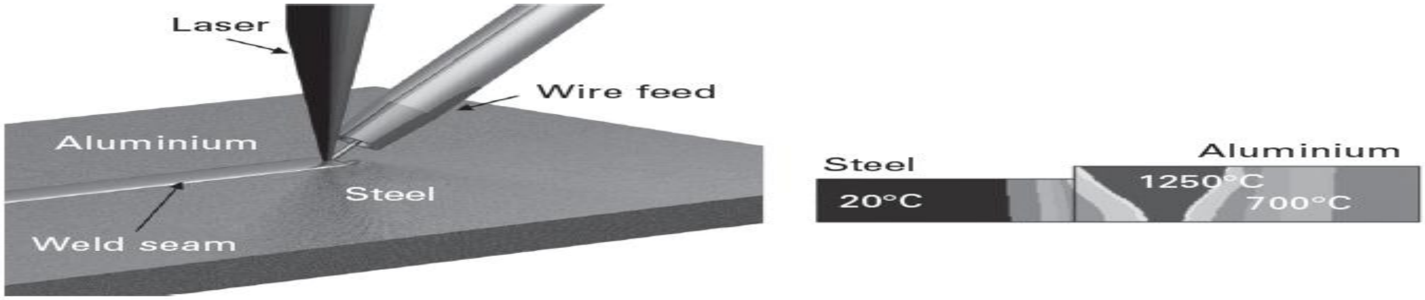
Long Pulse Interaction



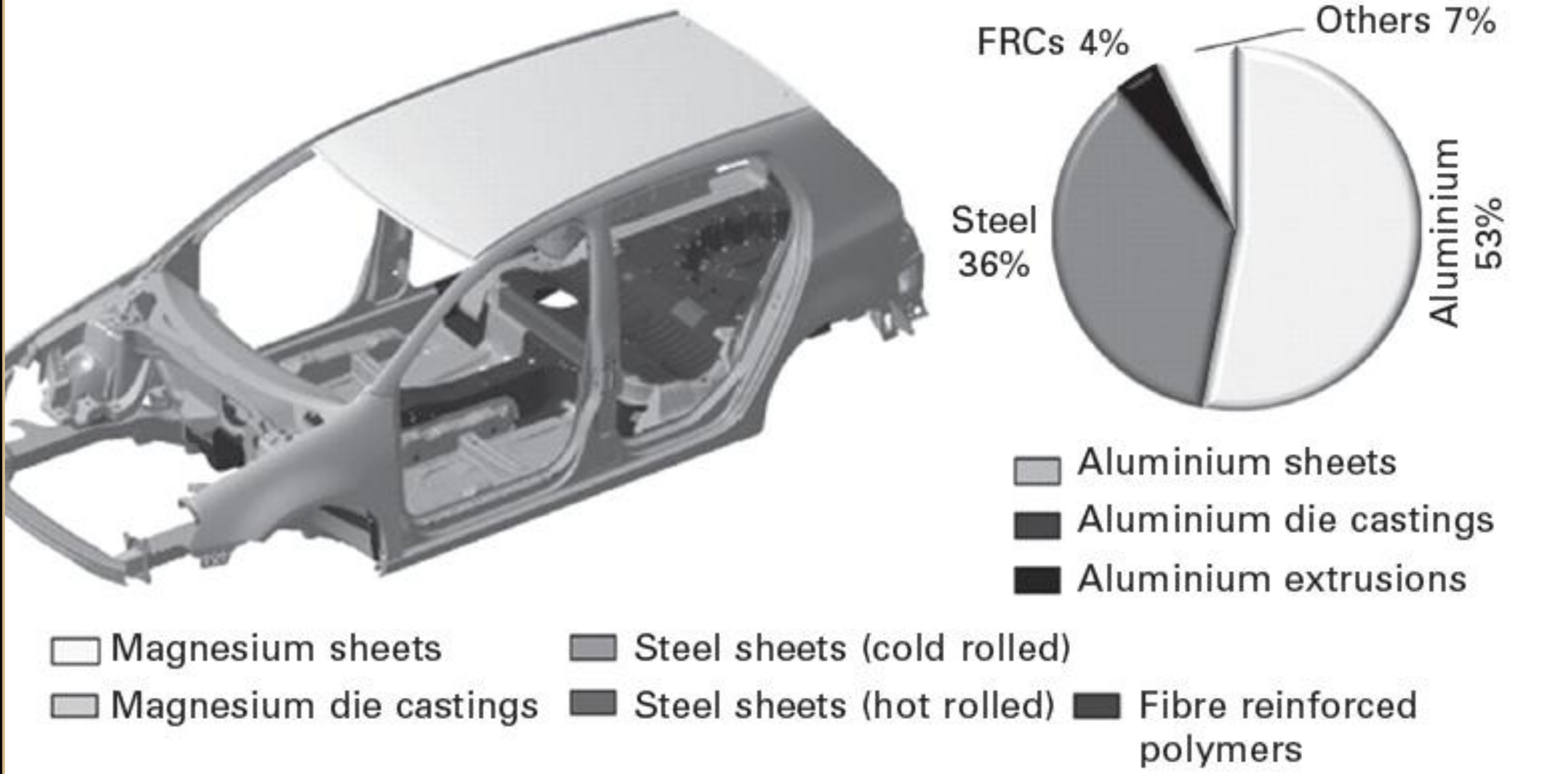
Ultra Short Pulse Interaction



Welding ,Brazing and Soldering of Dissimilar Materials



9.2 Laser welding of aluminium to steel.

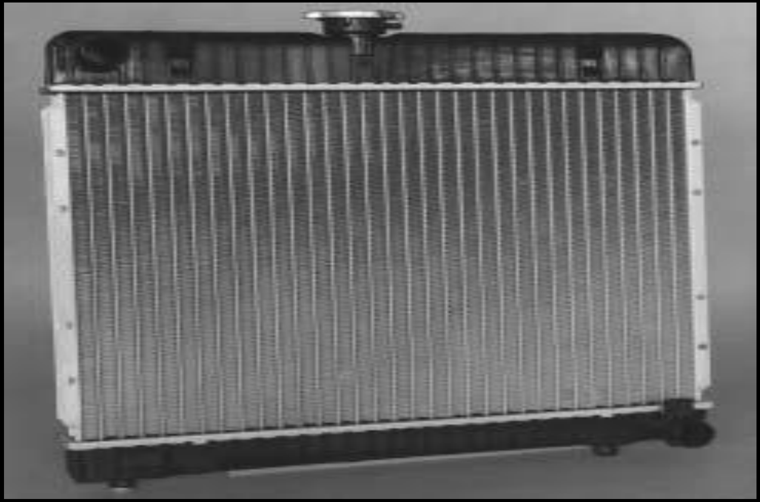


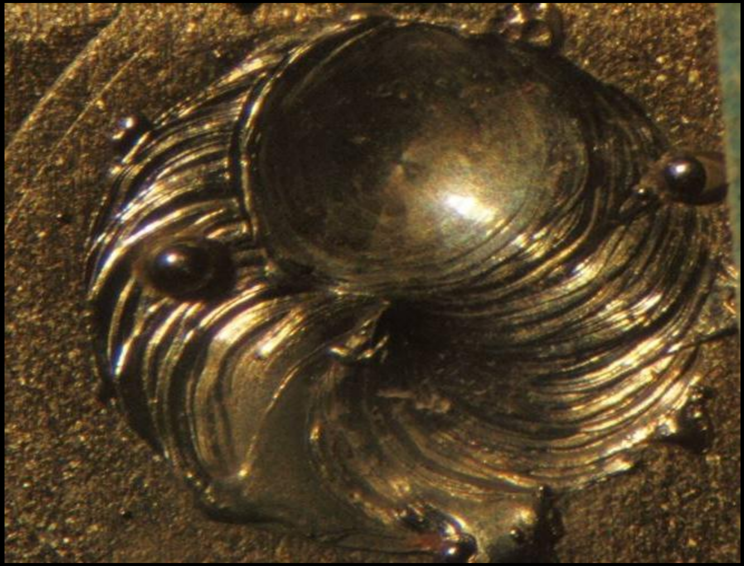
Welding, Brazing and Soldering of Dissimilar Materials

Butt joint: SS and bronze for spring inside a watch

Welding ,Brazing and Soldering of Dissimilar Materials Applications

- Airplane cabin cooling systems,





Welding of Ti to Al: Problem Description

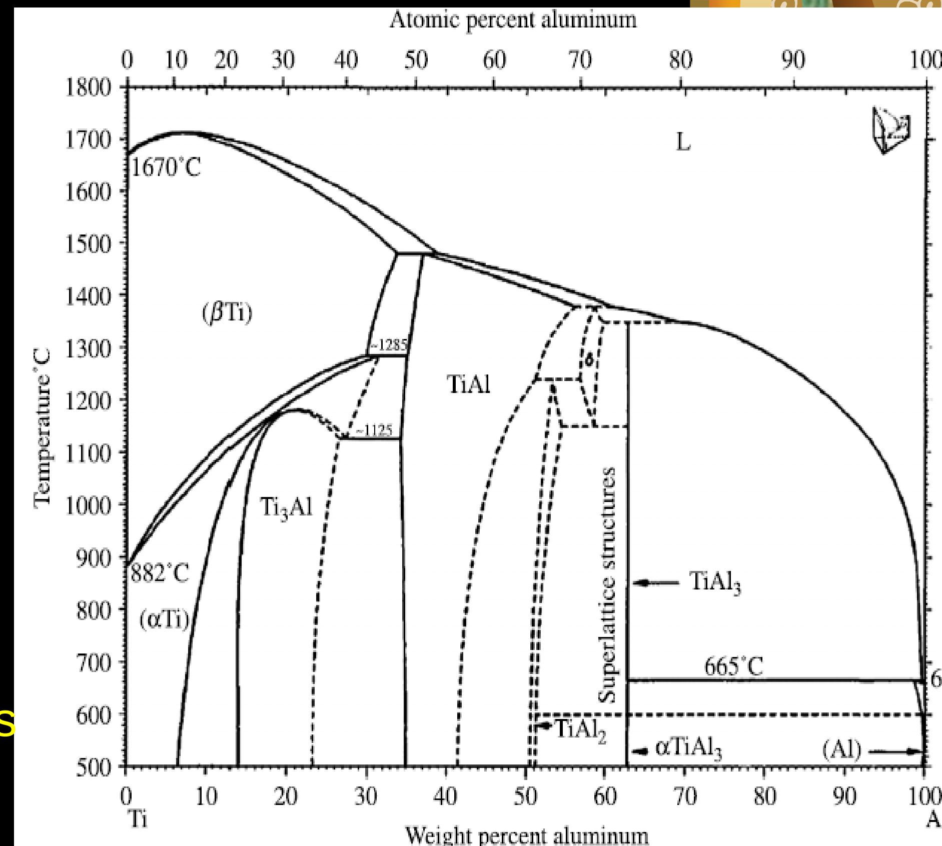
Elem .wt. %	Fe	Cu	Mn	Mg	Zn	C	Ball
Al	0.6	.09	0.5	0.5	0.06	-	Al
Ti	0.06	-	-	-	-	0.0 8	Ti

Property	Ti	Al
Yield Stress (MPa)	275	55
Ultimate Stress (MPa)	344	115
Shear Strength (Mpa)	-	83
Elongation (%)	20	24
Modules of Elasticity (GPa)	105	69

Metals	Coef. of thermal Expansion X10-6 K-1	Latent heat fusion Jg-1	Specific heat JK-1 kg-	Thermal conductivity Wm-1 K-1	Melting point °C	Boiling point °C	Thermal diffusivity (cm^2/sec),
Al	23.5 @ 0-100C	388	900 @25C	173 @ 0-100C	660	2467	0.91
Ti	8.9@ 0-100C	365	523 @25C	21.9@ 0-100C	1660	3287	0.092

Welding of Ti to Al: Problem Description

- Lattice structure Al FCC, Ti   HCC
- Al to dissolve in Ti is 13at.% from Ti rich side
- Ti to dissolve in Al is 2 at.% from Al rich side
- Any additional amount of Al above 13% in Ti or Ti above 2at.% in Al form IMP (Ti_3Al, TiAl, $TiAl_2$ $TiAl_3$
- Reducing of Al below 20at.% in the F.Z. is impossible via playing by any of laser parameters

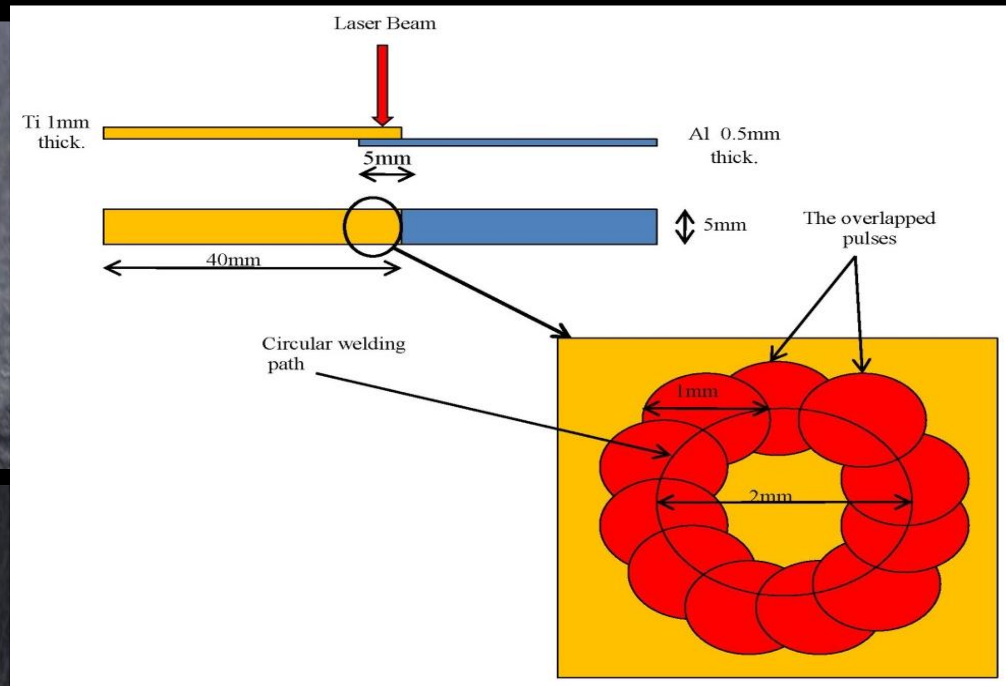


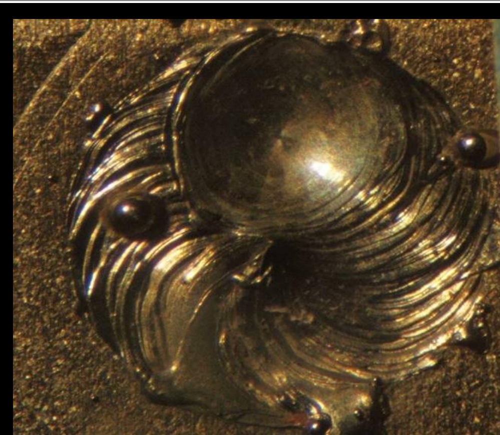
Phase diagram of Ti-Al binary alloy

Experimental Set Up

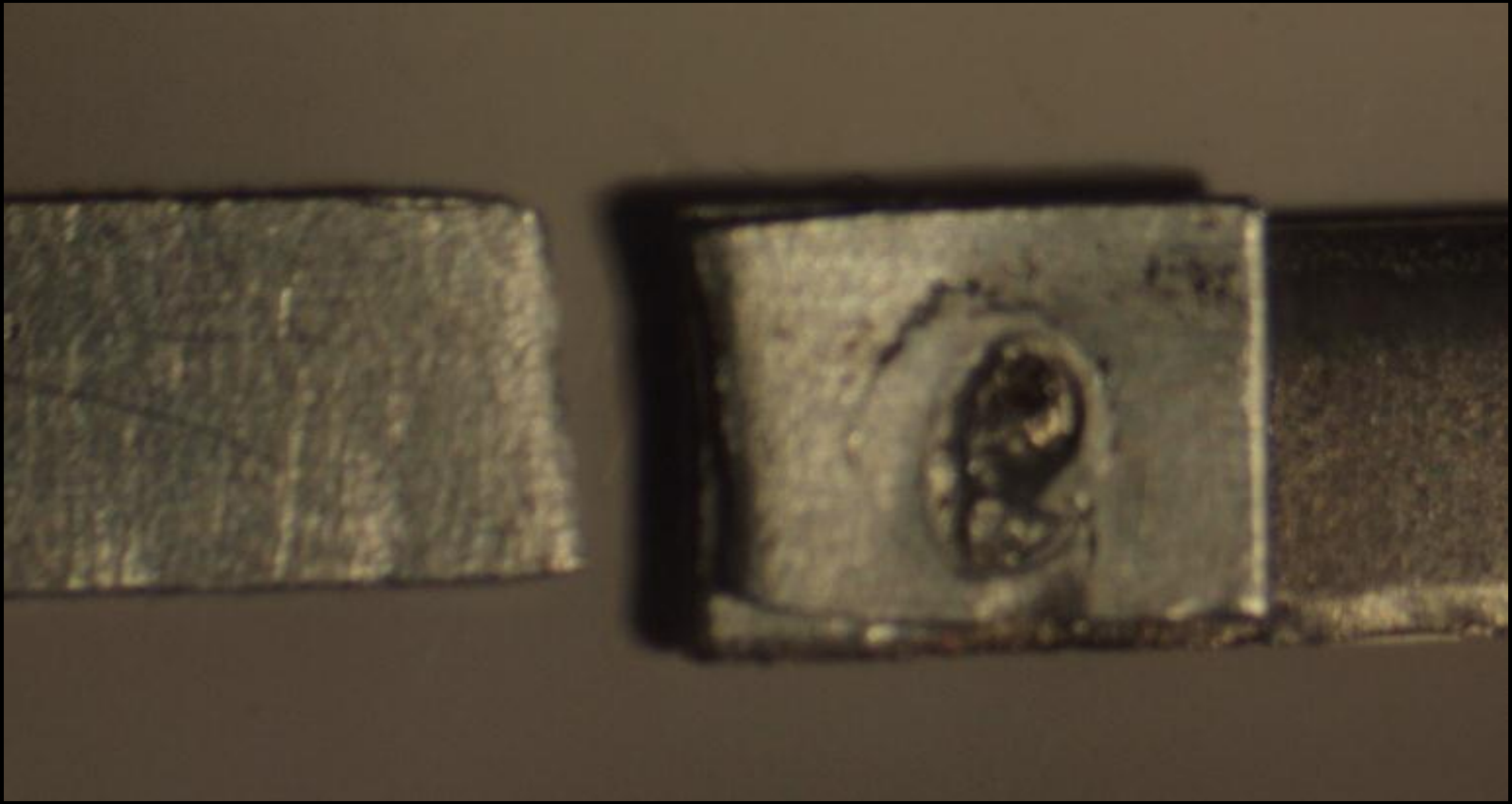
Laser Inlet

The designed clamping device

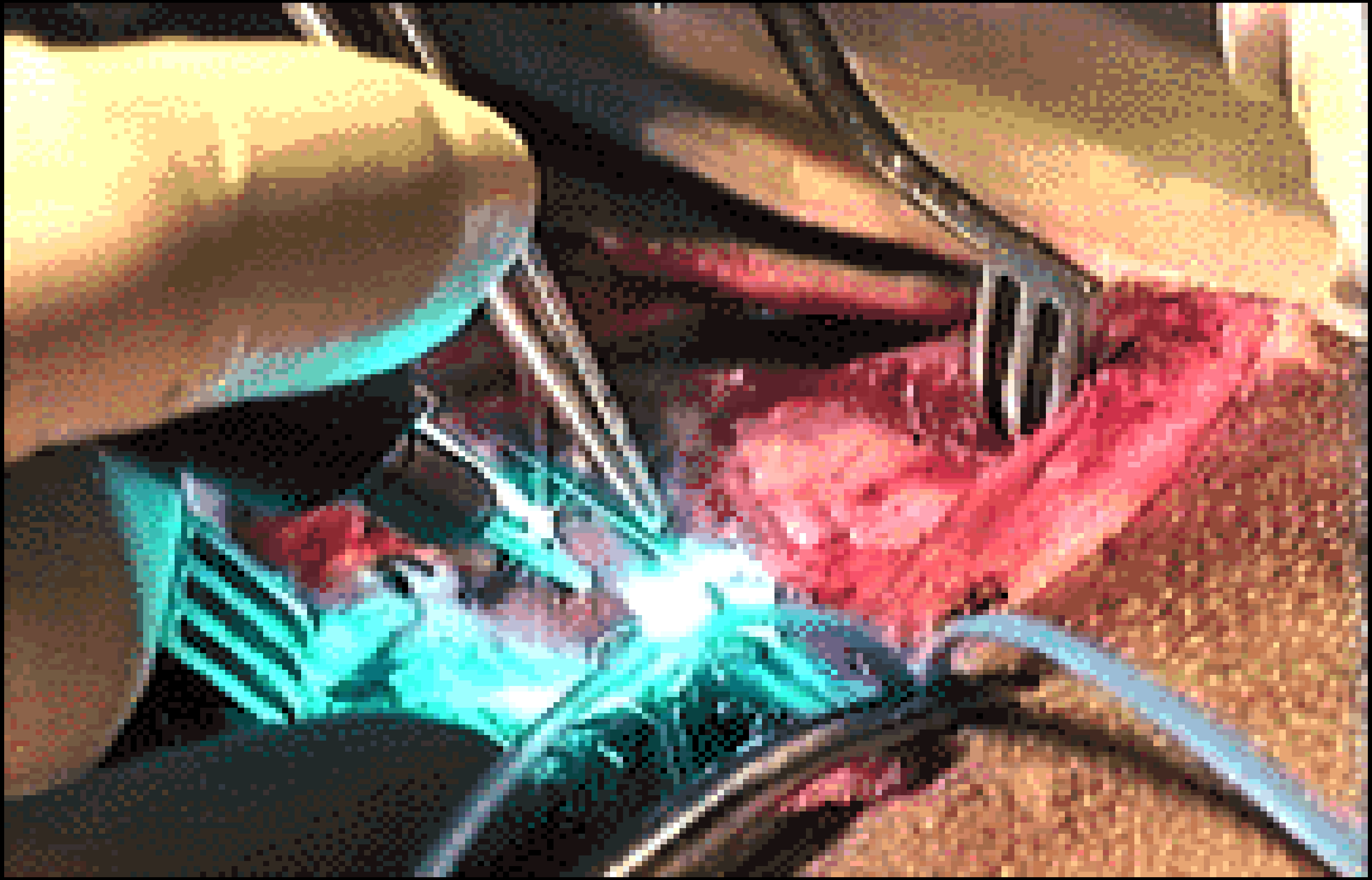




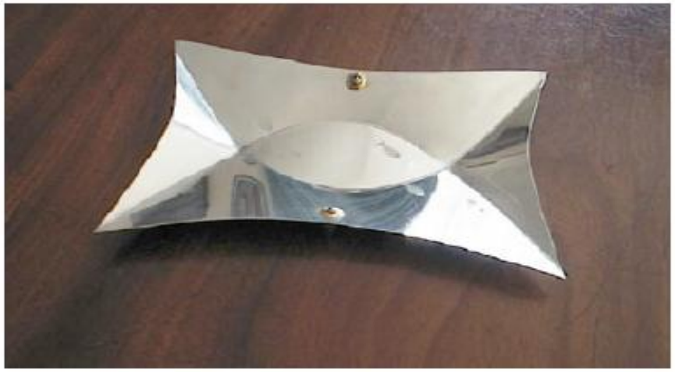
The Result



Laser Tissue Welding

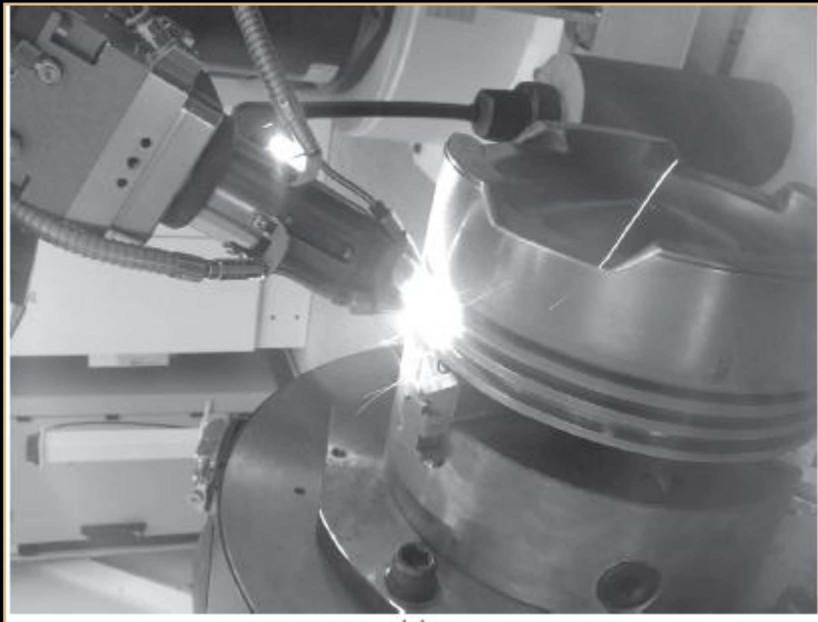


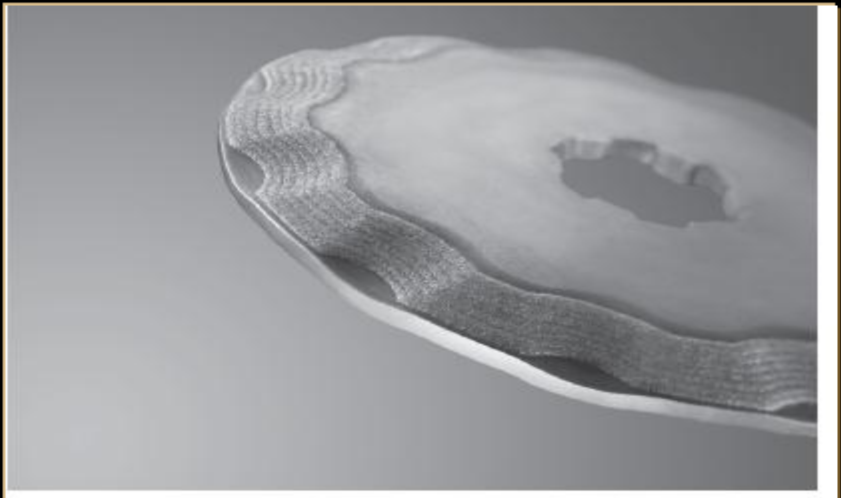
Laser Cutting



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

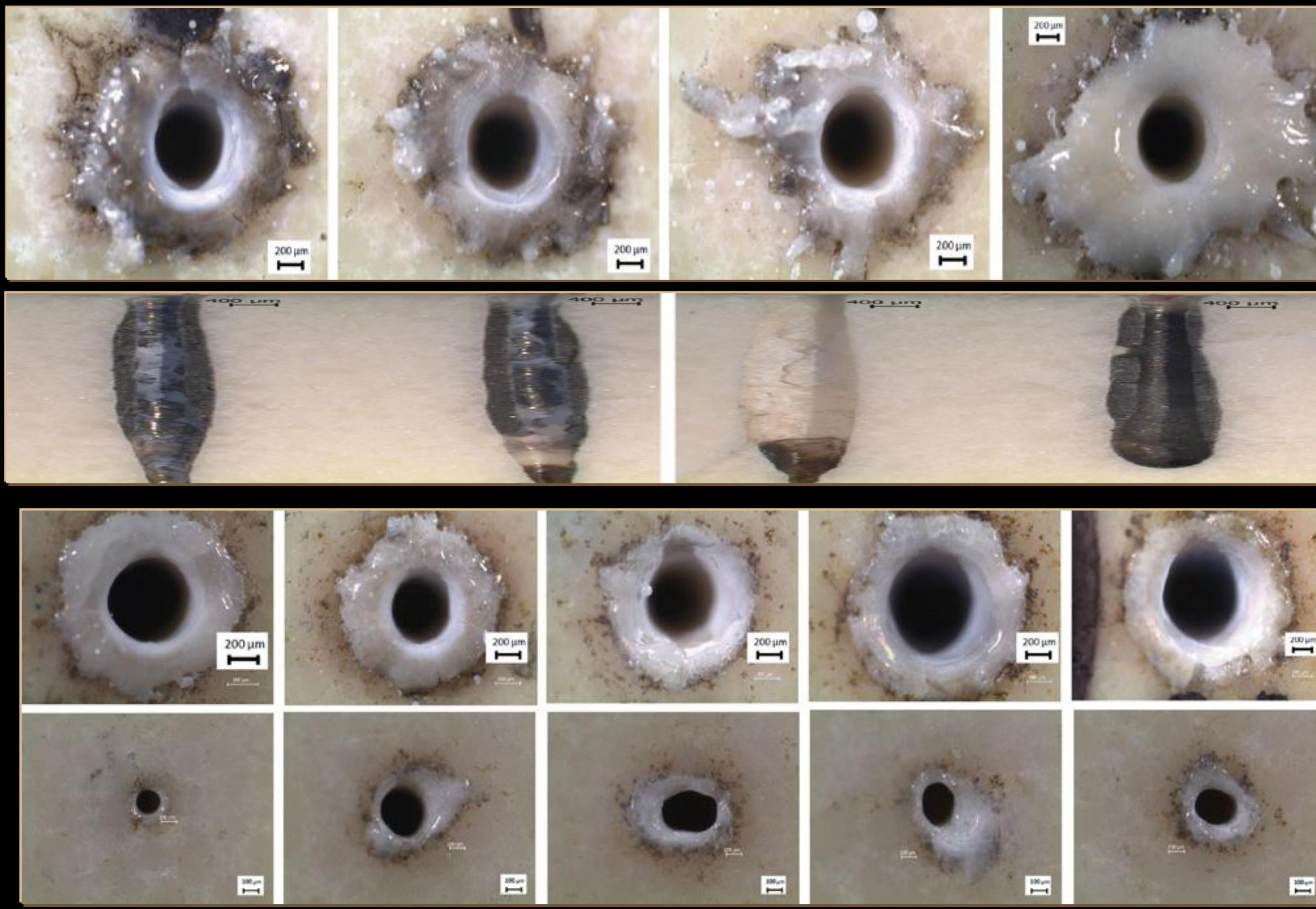
Laser Deposition





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

Laser Drilling



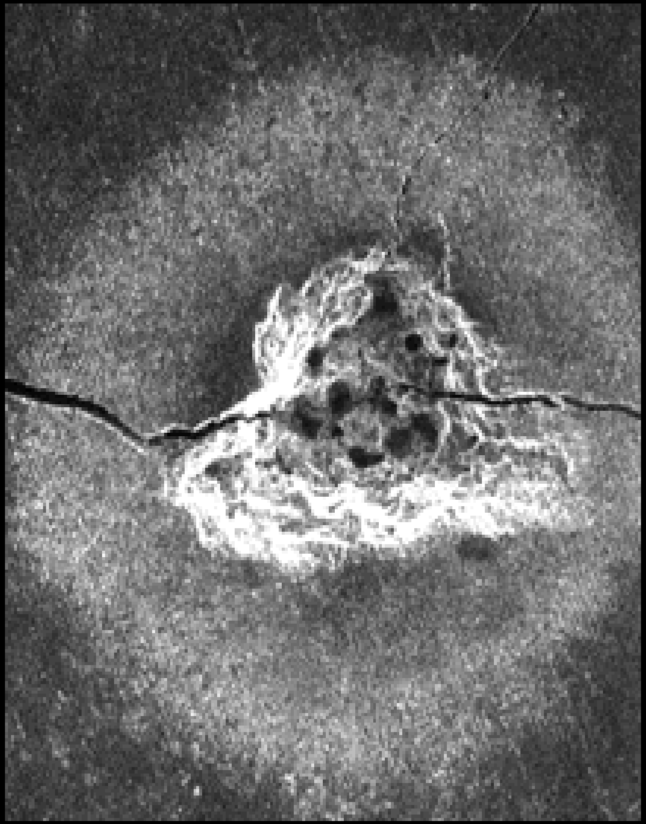
Effects of pulse repetition rate (at 8kW peak power, 2ms pulse duration and -2 mm fpp. Effects of the focal position 10 Hz repetition rate. 0,-1,-2,-3,-4

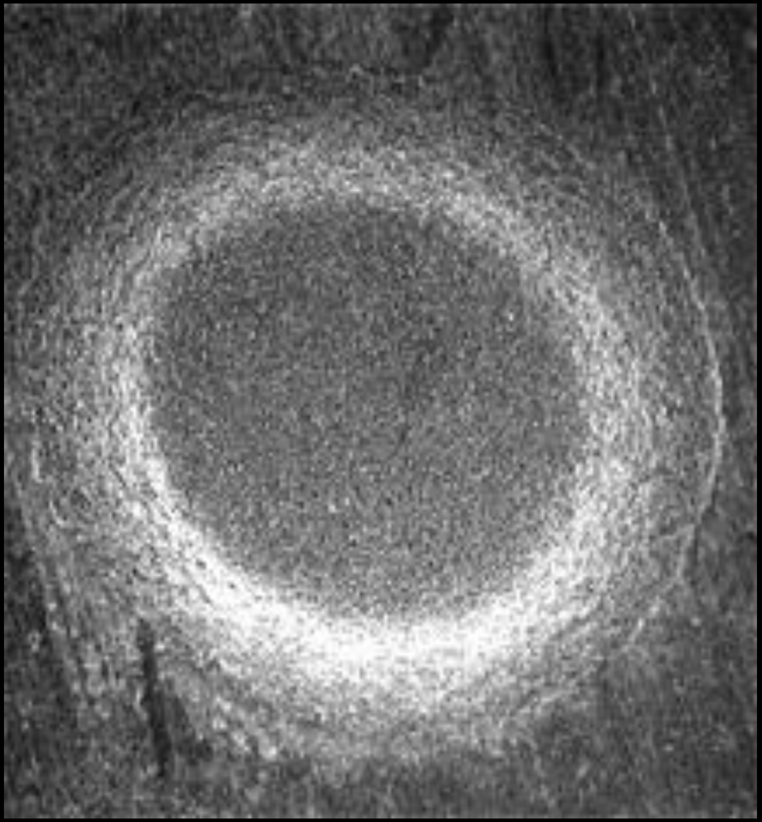
Laser Drilling of Enamel

Laser Drilling of Enamel

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

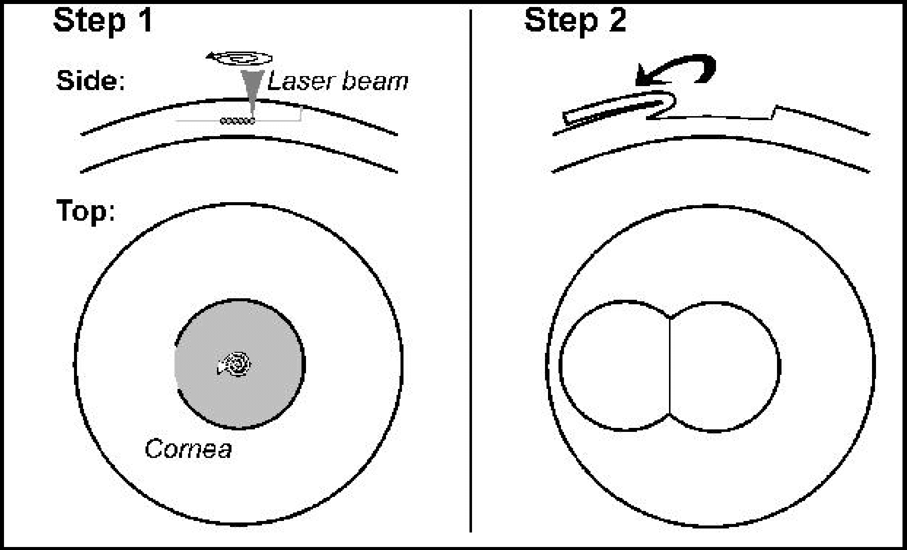
Smooth hole with no thermal damage after drilling with a USPL.

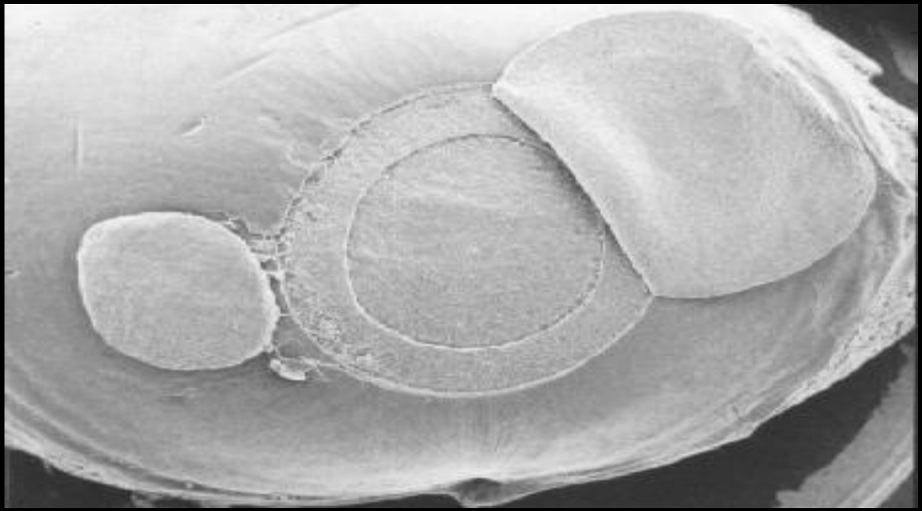


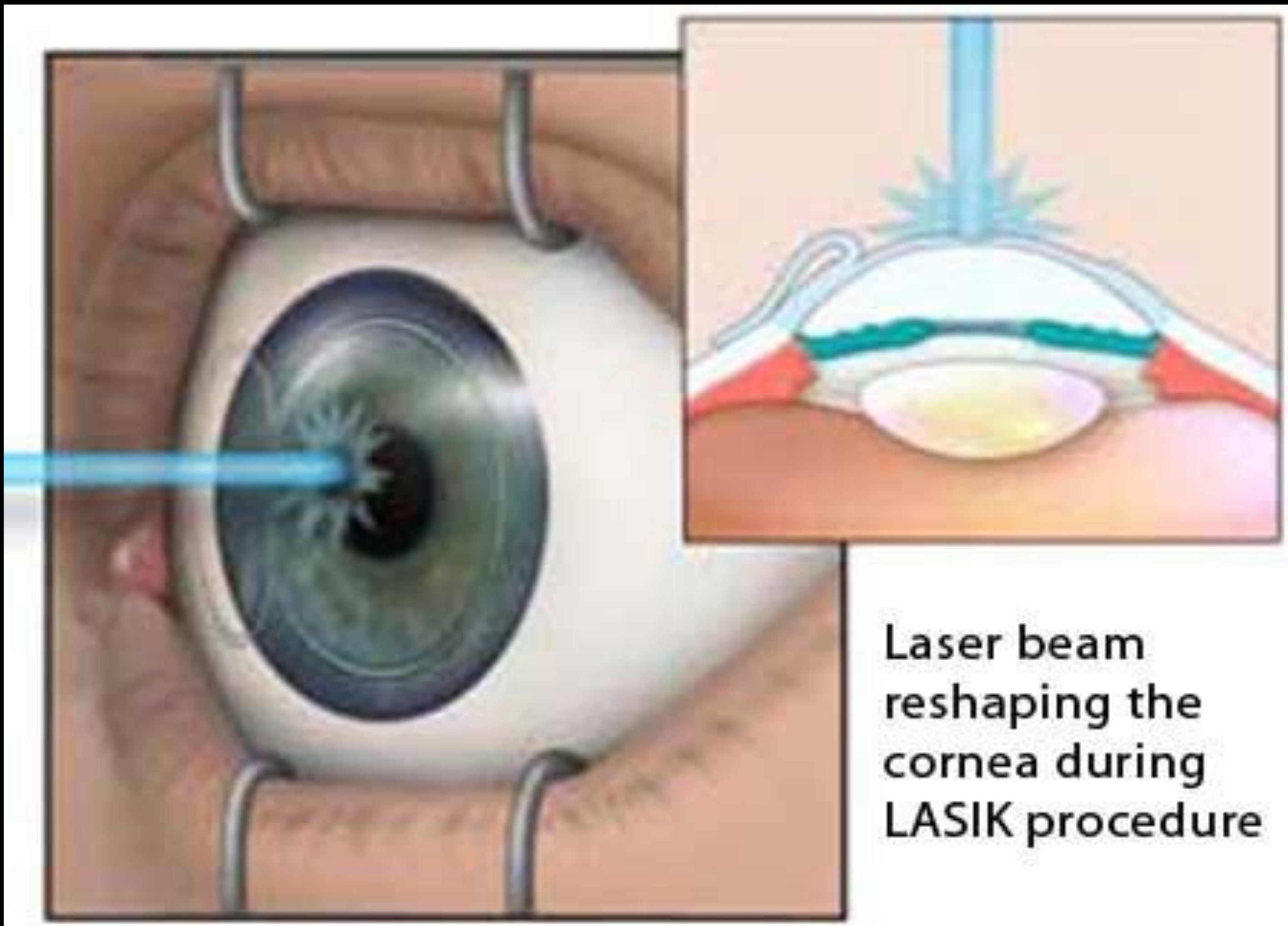


Femtosecond Laser Surgery of Cornea

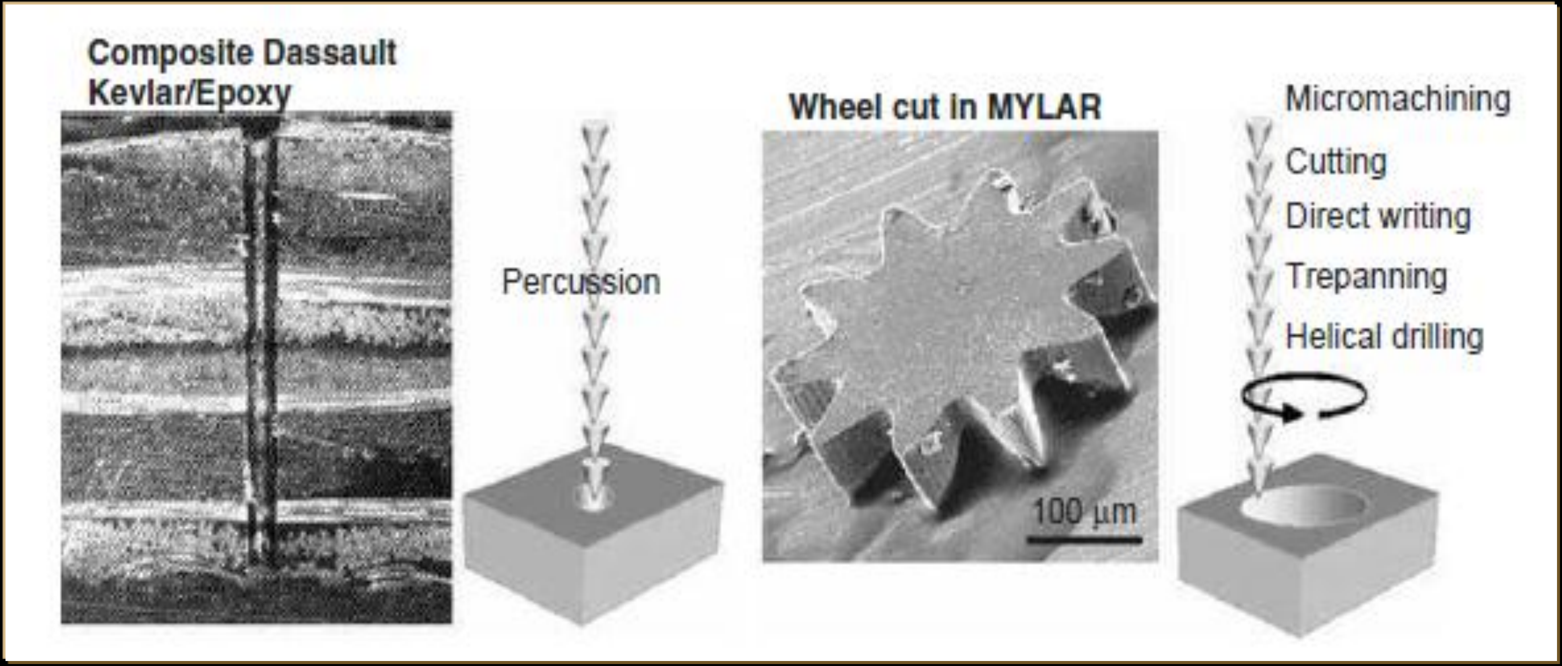
Femtosecond LASIK

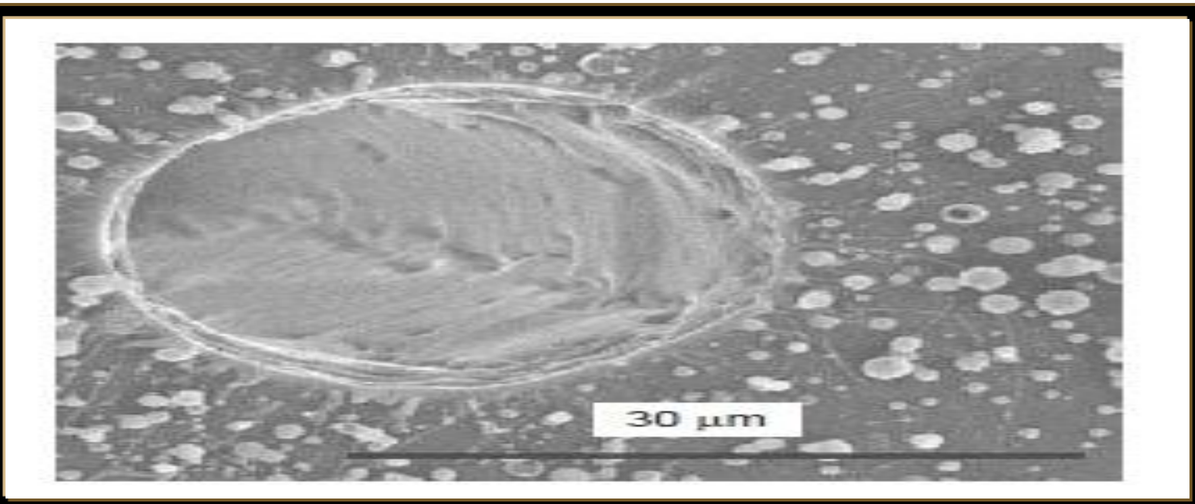





Laser beam
reshaping the
cornea during
LASIK procedure

Micromachinating





Micromachinating

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

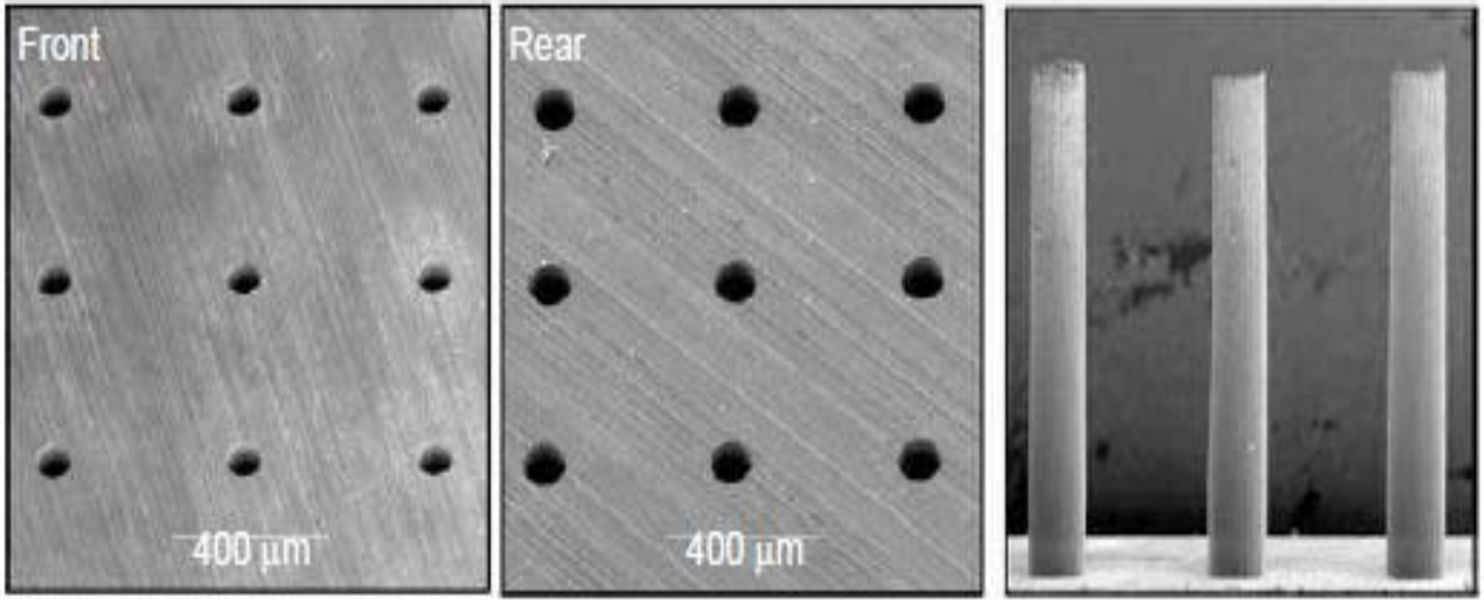
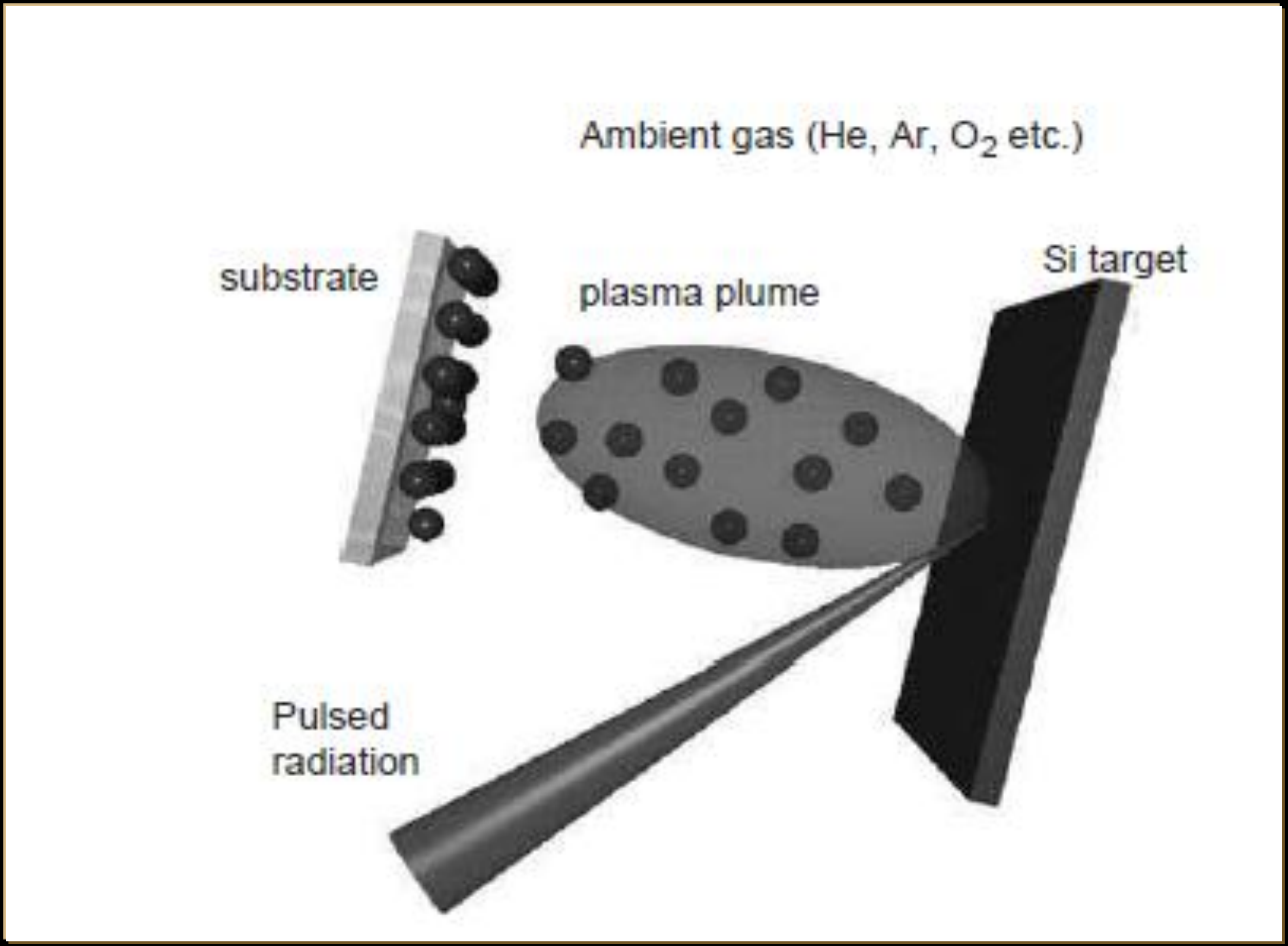


Figure 24: Drilling in 1 mm stainless steel; details of nozzle in- and outlet as well as replica of the channel geometry.

Nanomachaining



PLD experiment for deposition of Si-based nanostructured films

Nanomachaining

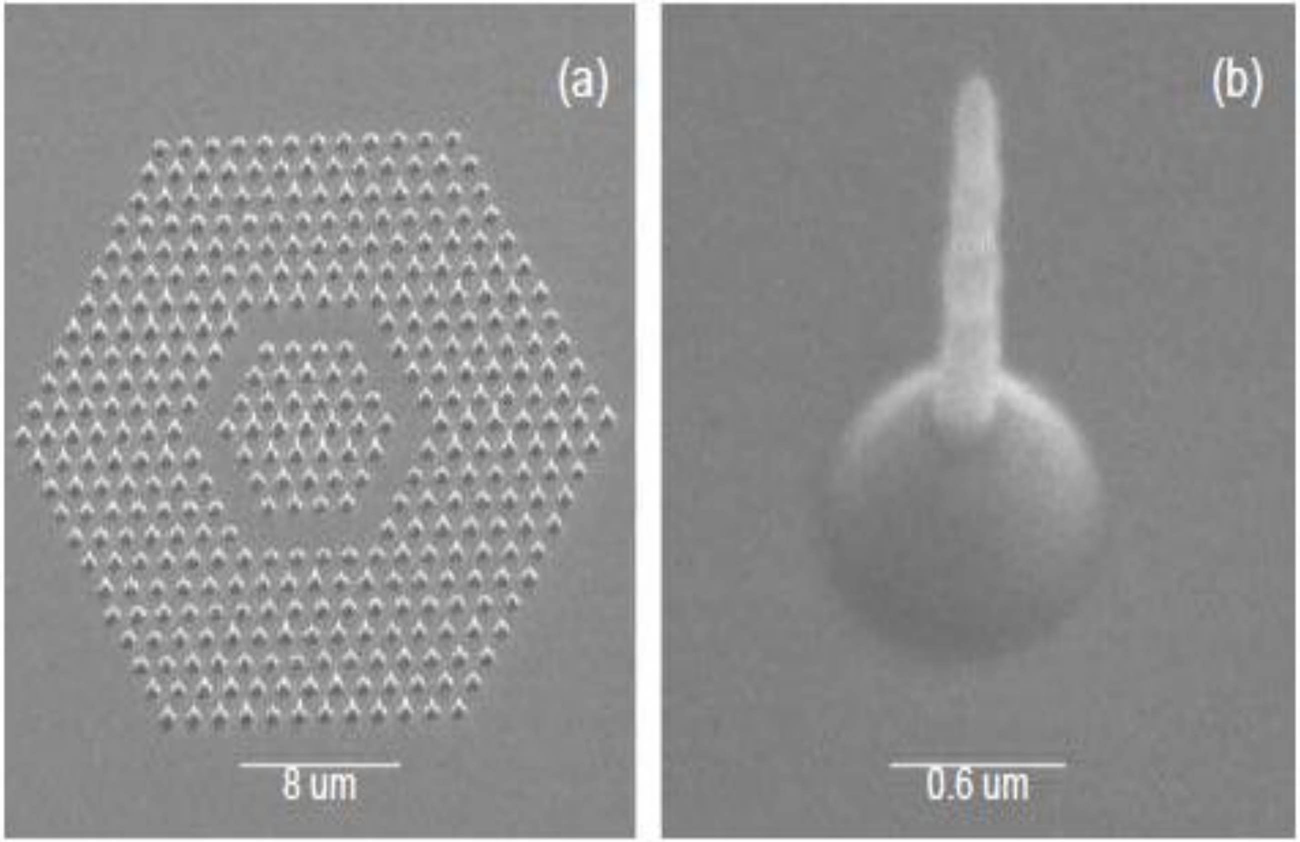
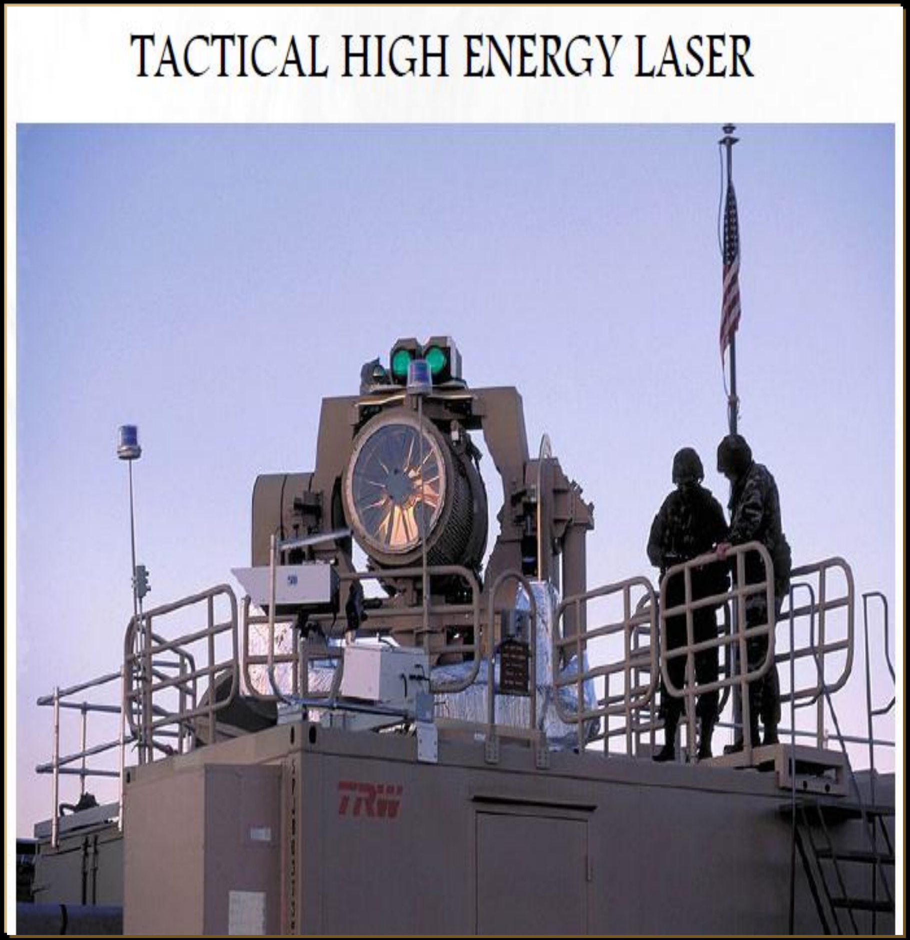


Figure 14: SEM images of an array of nanojets fabricated in a 60 nm thick gold film with femtosecond laser pulses (a) and a single nanojet in detail (b).

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

Thank You for Patient Hearing