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laser micromachining systems

Introduction au Microusinage par laser

Optec S.A.
A.Biernaux

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CONTENU

- Introduction Optec
- Objectif de la présentation
- Généralités sur le laser
- Traitement des matériaux par laser
- Tendances du marché
- Point de vue d'un intégrateur
- Quelques ex de machines

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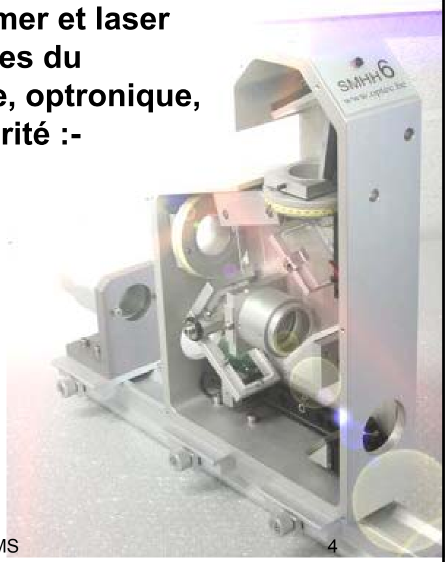
Micro Usinage par laser Excimer et laser Ultra Rapide pour les domaines du semiconducteur, électronique, optronique, médical et marquage de sécurité :-

- Excimer & lasers Ultra Rapides
- Centre d’usinage laser standard
- Solutions spécifiques
- Sous ensembles opto-mécaniques
- Expertise Process
- SAV



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Quelques exemples de systèmes

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Notre expertise dans le domaine du traitement Athermique par laser :

Nous intégrons des sources lasers avec des durées d'impulsions comprises entres fs-ns, des longueurs d'ondes situées dans le spectre UV-IR, en combinaison avec des techniques de projection ou d'usinage au point focal.

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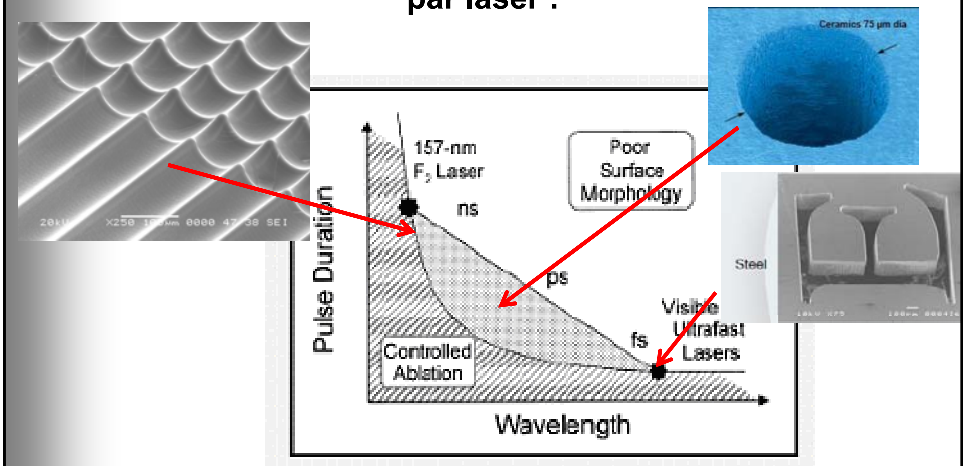
Notre expertise dans le domaine du traitement Athermique par laser :



From P.R. Herman et al. Applied Surface Science 154–155 (2000) 577–586

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Objectifs

- Passer en revue les différents paramètres Laser, les techniques et procédés d'usinage ainsi que leur interaction au regard des besoins du marché et des applications actuelles et à venir.

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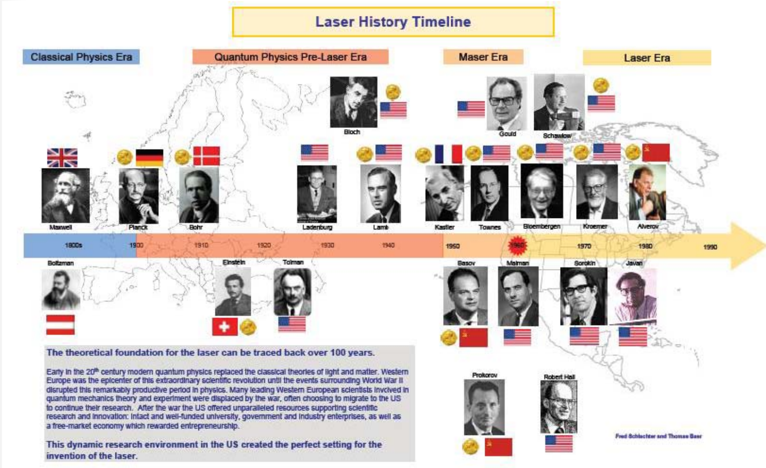
Un peu d'histoire…



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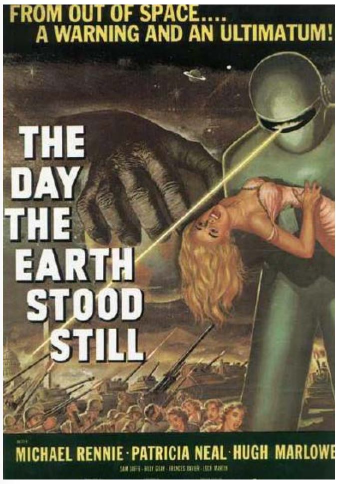
Le laser ce n'est pas…



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Mais c'est aussi…

Un rayon lumineux

Pointeur laser

Spectacle

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Le laser c'est…

Dans l'industrie

Découpe de plaques, tubes, pièces métalliques …

Laser à CO_2

… et aussi de bois, de tissu, de plastique

Le laser est un outil universel

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Le laser c'est…

Dans l'industrie (suite)

Perçage

Laser YAG ou CO_2

Trous de 10 µm dans un film en polymères

Usinage

Supports en céramique pour microélectronique

Soudage

Petites pièces mécaniques

Réservoir de carburant pour fusée

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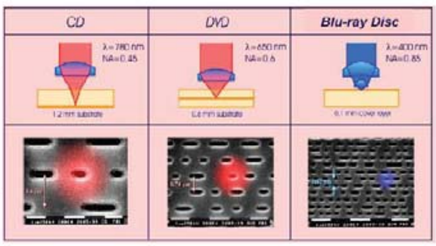
Le laser c'est…

Pour stocker l'information et la lire

Lecture de code-barres

Lasers à semiconducteurs

CD et DVD



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Le laser c'est…

Pour transporter l'information

On peut coupler les lasers avec des fibres optiques qui guident la lumière pendant des milliers de km

Les pertes à grande distance sont plus faibles que celles qu'on a pour un signal électrique dans un conducteur métallique

Le réseau mondial sous-marin de câbles de fibres optiques

80% des communications à longue distance dans le monde le sont grâce au réseau de fibres optiques

Le multiplexage (superposition de signaux de différentes fréquences) permet d'avoir jusqu'à 256 canaux par fibre et d'augmenter le débit

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Le laser c'est…

Au bureau ou à la maison

Imprimante laser

Le toner se colle au tambour au niveau du spot laser

Il est ensuite déposé sur la feuille de papier

Grâce au laser, vitesse et la résolution sont meilleures qu'avec un jet d'encre

Particule de toner

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Le laser c'est…

Dans le bâtiment (suite)

**Nettoyage de la pierre des monuments et des sculptures :
sans eau, sans produit chimique, sans abrasif, sans pression**

Façade de la cathédrale Notre Dame de Paris

Laser YAG pulsé

Restauration du Musée national du Moyen Age

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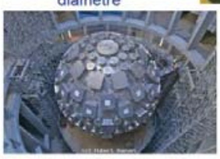
Le laser c'est…

Le laser Mégajoule

En construction par le CEA au CESTA près de Bordeaux,
il sera avec le NIF à Livermore le laser le plus énergétique au monde

Un hall de 320 m de long (40 000 m²)
maquette

La cible : une microbille au centre d'une chambre d'expérience de 10 m de diamètre



240 faisceaux synchronisés entre eux,
durée de l'impulsion 20 ns, YAG 1053 nm amplifiés puis triplés en fréquence → UV
L'énergie produite à chaque impulsion sera de **1,8 MJ**
focalisée sur moins de 1mm²
Puissance crête **550 TW**

Fonctionnement prévu en 2014

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Mais le Laser c'est aussi…

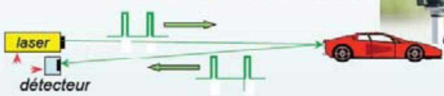
Mesurer des distances ou des vitesses

Télémètre laser

Laser en impulsions

Mesure de distance : temps mis par la lumière pour faire un aller-retour

en plus des radars, les "jumelles laser"



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Et aussi…

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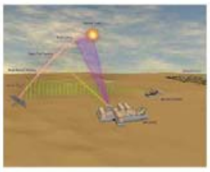
Et Malheureusement aussi…







Rue89

La guerre au laser, c'est pour bientôt

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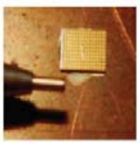
Une grande variété de lasers…

Une grande variété de réalisations et de propriétés

- **Géométries et dimensions**

100 microlasers à semiconducteur



Laser Nova pour la fusion nucléaire

- **Puissances**

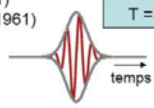
  du microwatt au pétawatt (1PW = 10^{15} watts)

- **Continus ou pulsés**

  Des impulsions de plus en plus courtes :
  - fonctionnement relaxé (le premier laser)
  - fonctionnement déclenché (Q-switch, 1961)
  - blocage de modes

  Impulsions femtosecondes (1fs = 10^{-15} s)

λ = 600 nm
ν = 500 THz
T = 2 fs



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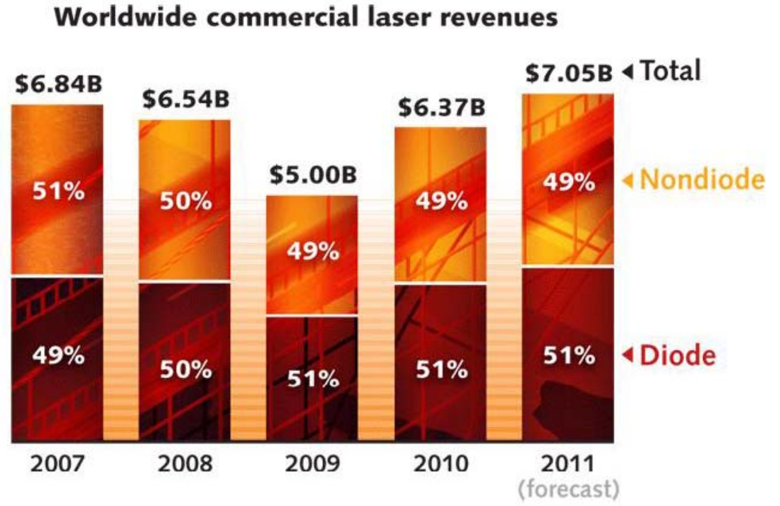
Le laser, quelques données commerciales…



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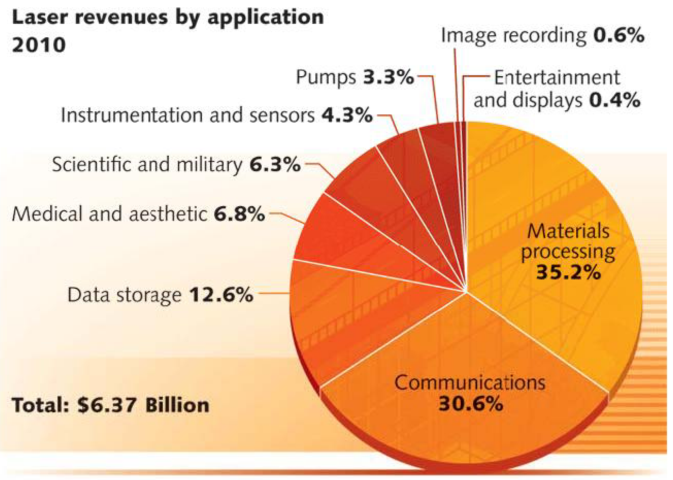
Le laser, quelques données commerciales…



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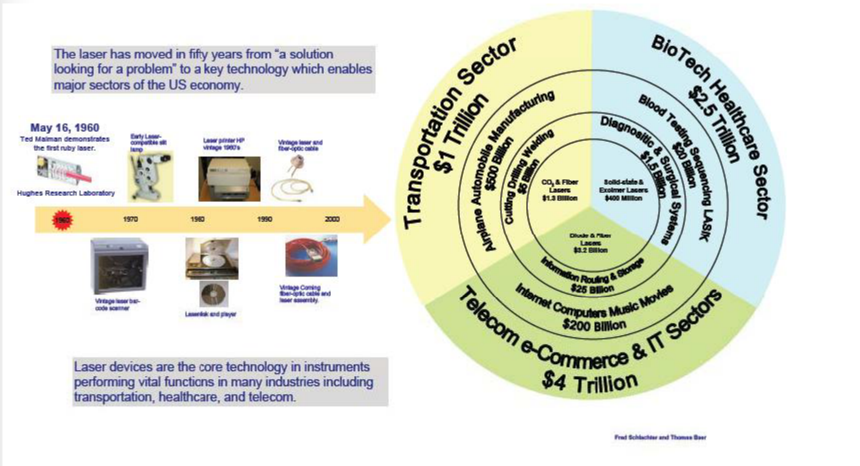
Le laser est un composant dans la chaîne …



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Why use lasers at all?

- **Conventional**
  - EDM
  - Mechanical
  - Chemical milling
  - Water jet
  - Ion milling
  - EB
  - Plasma
  - Punching
  - Others…
- **Laser**
  - Non Contact
  - No Chemicals
  - Selectivity
  - Processing Speed
  - High Resolution
  - Flexibility
  - Compactness
  - Cost effectiveness

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Laser Materials Processing

- **Laser**
  - Type
  - Wavelength
  - Output Power
  - Pulse Energy
  - Rep.Rate
  - Pulse Length
  - Beam Diameter
  - Beam Polarisation
  - Beam Divergence
  - Beam Intensity Profile
    - Spatial
    - Temporal
- **Material**
  - OPTICAL
    - Absorptivity
    - Reflectivity
    - Refractive Index
    - Surface Roughness
  - THERMOPHYSICAL
    - Thermal Conductivity
    - Specific Heat
    - Melting Point
    - Boiling Point
    - Evaporation Enthalpy
    - Surface Tension
    - Vapour Pressure
  - MECHANICAL
    - Density
    - Hardness
    - Poisson Ratio
    - Young's Modulus
- **Processing**
  - Lens NA
  - Spot Size
  - Shot Overlap
  - Gas Assist
  - Focal Plane
  - Processing Speed
  - Drilling Technique

! IMPORTANT:
Most parameters are interrelated and/or depend on temperature, pressure, etc.

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Laser
- Type
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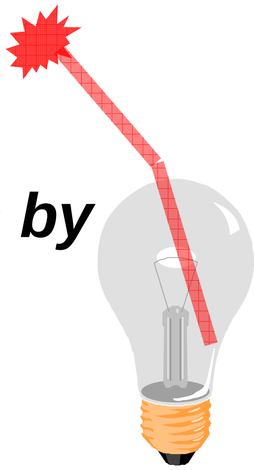
  - Temporal

***L**ight*
***A**mplification by*
***S**timulated*
***E**mission of*
***R**adiations*



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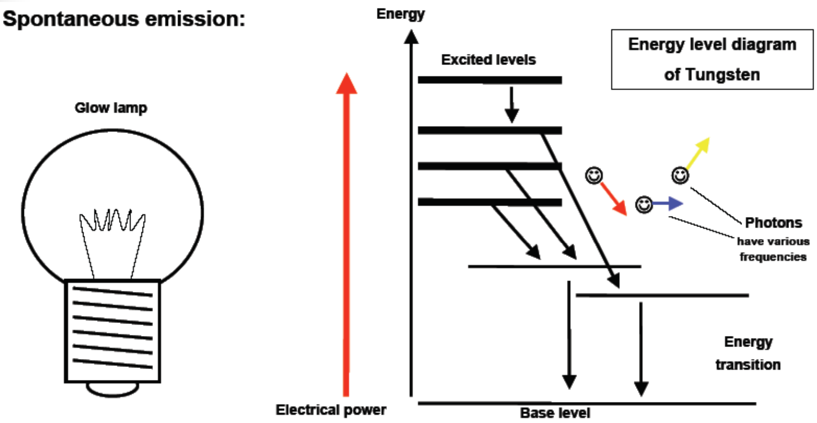
Lamp / Laser

Spontaneous emission:



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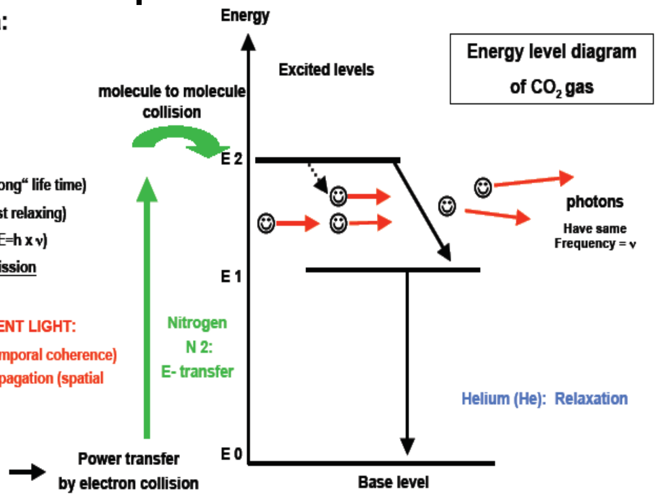
Lamp / Laser

The laser media:

- E2 = upper laser level, („long“ life time)
- E1 = lower laser level, (fast relaxing)
- Very narrow band width (E=h x ν)
- ⇒ Enables stimulated emission

LASER LIGHT = COHERENT LIGHT:

- Very small bandwidth (temporal coherence)
- almost parallel beam propagation (spatial coherence)



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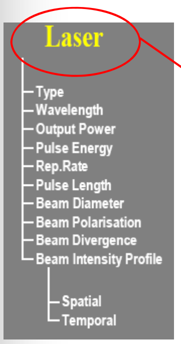
What is a LASER ?



- A LASER is a device which generates or amplifies light.
- Properties of laser beams:
  - Monochromatic
  - Directional
  - Coherent
  - Intense

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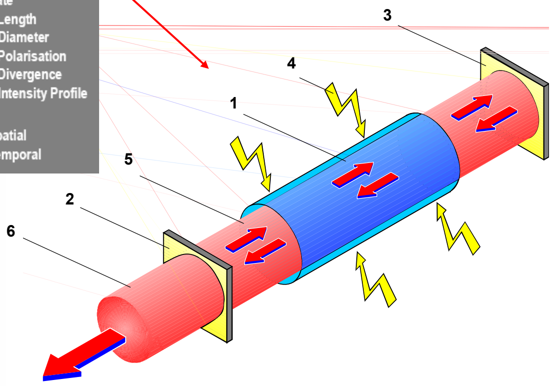
Laser

- Type
- Wavelength
- Output Power
- Pulse Energy
- Rep.Rate
- Pulse Length
- Beam Diameter
- Beam Polarisation
- Beam Divergence
- Beam Intensity Profile
  - Spatial
  - Temporal



1. **Laser Medium**
2. **Front Mirror**
3. **Rear Mirror**
4. **Pumping Process**
5. **Stimulated Emission**
6. **Laser Beam**

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Laser

- Type
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- Beam Diameter
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  - Spatial
  - Temporal

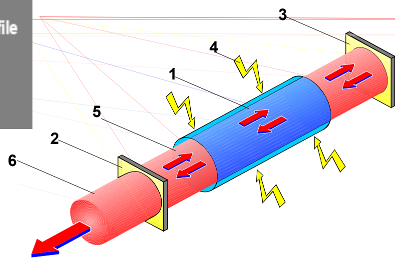
1. Laser Medium

SOLID : ROD, DISK

GAS

SEMI CONDUCTOR

FIBER



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Laser

- Type
- Wavelength
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- Pulse Energy
- Rep.Rate
- Pulse Length
- Beam Diameter
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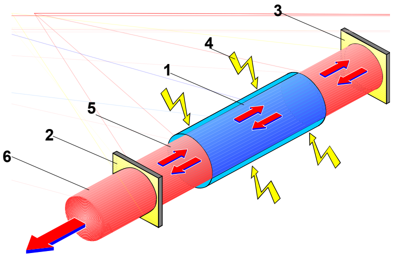
- Beam Divergence
- Beam Intensity Profile
  - Spatial
  - Temporal

4. Pumping Process

Electrical Discharge

Flash Lamp

Diode Laser



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Laser

- Type
- Wavelength
- Output Power
- Pulse Energy
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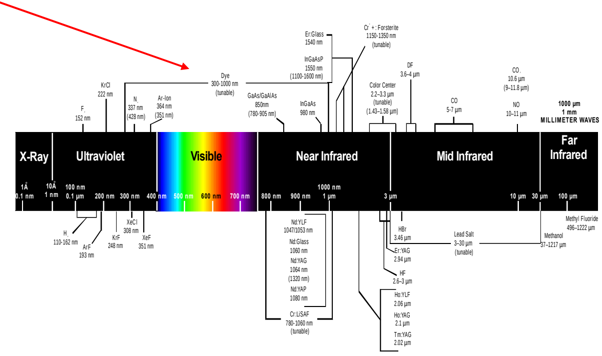
- Pulse Length
- Beam Diameter
- Beam Polarisation
- Beam Divergence
- Beam Intensity Profile
  - Spatial
  - Temporal

Laser Parameters



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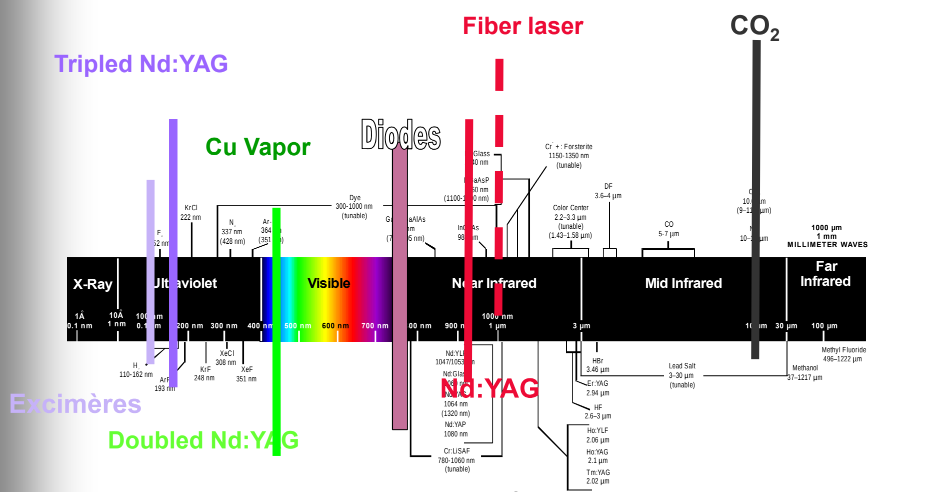
Laser Parameters



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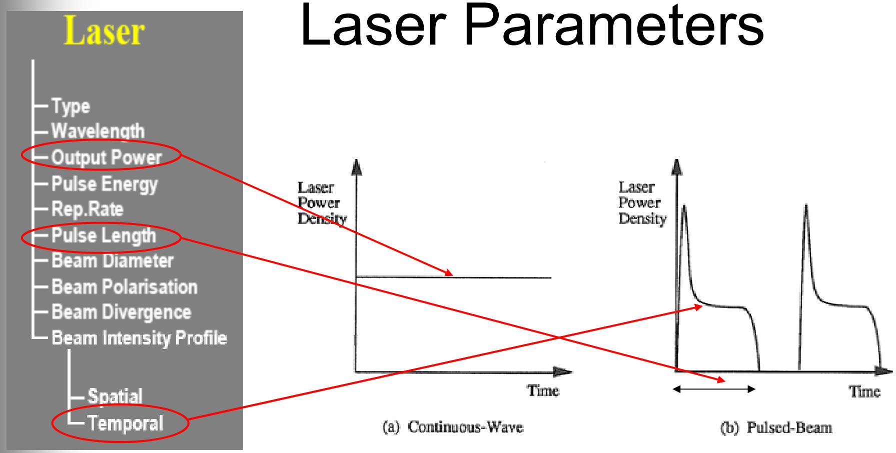
Laser Parameters



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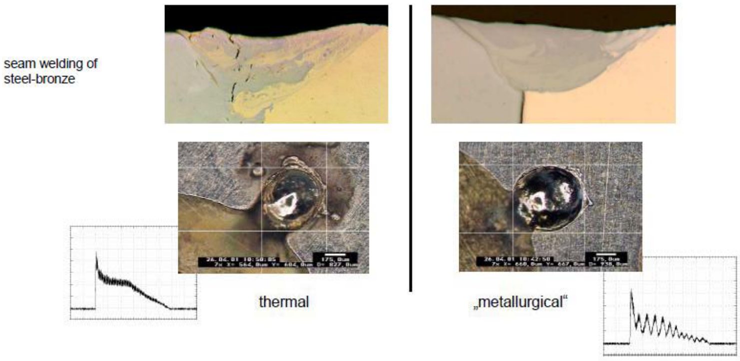
Laser Parameters

„metallurgical“ adaption of the laser pulse



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Laser Parameters

Laser
- Type
- Wavelength
- Output Power
- Pulse Energy
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- Pulse Length
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  - Temporal

- Pulse length (*):
  - Millisecond (ms)
  - Microsecond (μs)
  - Nanosecond (ns)
  - Picosecond (ps)
  - Femtosecond (fs)

(*): **time scale considered for μmachining**

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Paramètres Laser

Laser

- Type
- Wavelength
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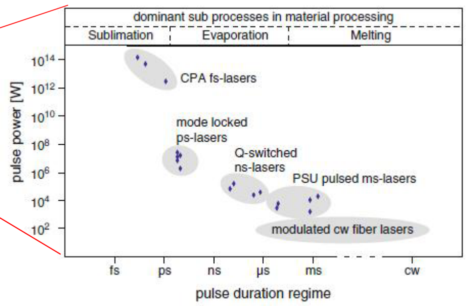

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Laser Processes versus Laser Parameters

Laser

- Type
- Wavelength
- Output Power
- Pulse Energy
- Rep.Rate
- Pulse Length
- Beam Diameter
- Beam Polarisation
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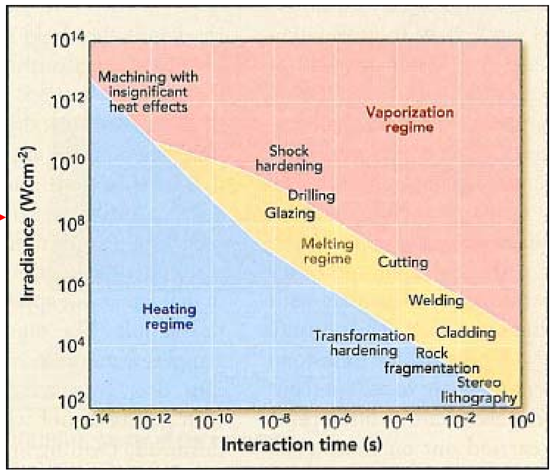
  - Spatial
  - Temporal



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Laser Parameters

Laser
- Type
- Wavelength
- Output Power
- Pulse Energy
- Rep.Rate
- Pulse Length
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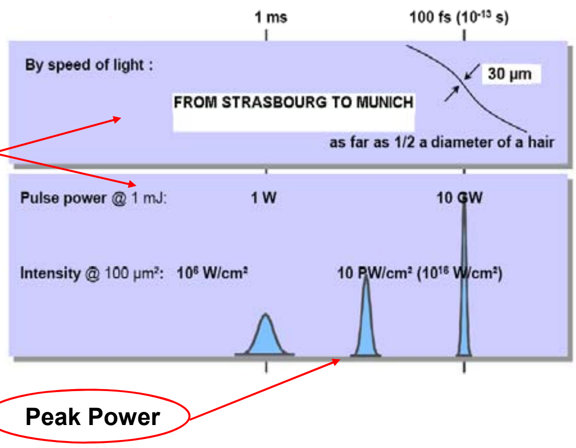

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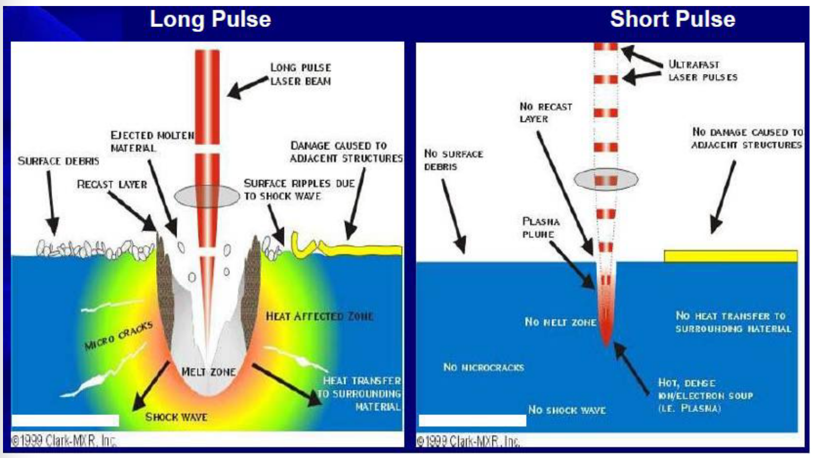
Laser Parameters



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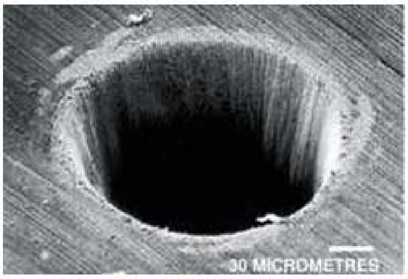
Laser Parameters



t = 200 femtosecondes

t = 3.2 nanosecondes

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LASERS…

LASER	MEDIUM	Wavelength (nm)	Pulse width	PRF
DPSS	Solid	213 - 1064	ns - µs	1 Hz – 200 kHz
CVL	Gas	255, 511	ns	kHz
Excimer	Gas	157 - 351	ns	1 Hz – 1 kHz
Ultrafast	Solid	390 – 1048	fs – ps	1Hz – 10 MHz
Fiber	Fiber	1057	ps – ns	1Hz – 100 kHz
CO2	Gas	9000 - 11000	ns - µs	1 Hz – 100 kHz

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Laser Parameters

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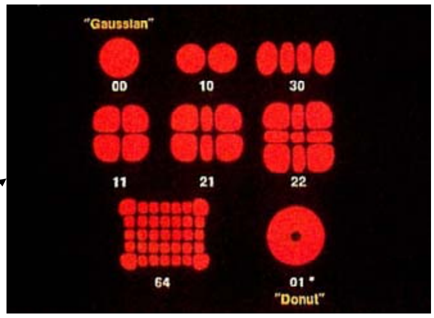

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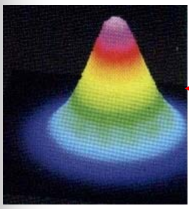
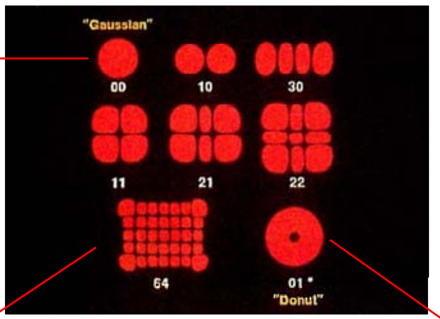
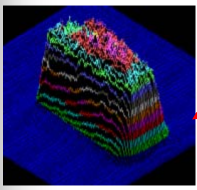
Laser Parameters

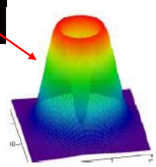


Gaussian





Multimode



Donut

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Laser Parameters

Laser

- Type
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- Rep.Rate
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- Beam Diameter
- Beam Polarisation
- Beam Divergence
- Beam Intensity Profile
  - Spatial
  - Temporal

Tailored PulsesTrains

A new Process?

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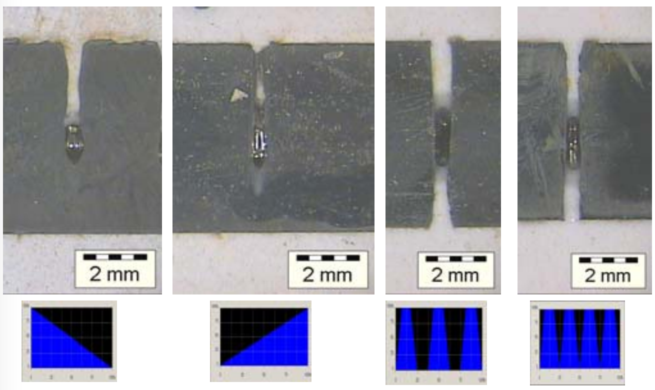
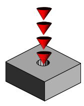
Special laser solutions for super alloy hole drilling

R&D: Drilling with pulse shaping technique





Pulse length: 2.8ms
Peak power: 8.5 kW
20 pulses (5Hz, 12.9J)

thickness: 6mm
Fiber core diameter: 0.4mm
Material: 1.4301

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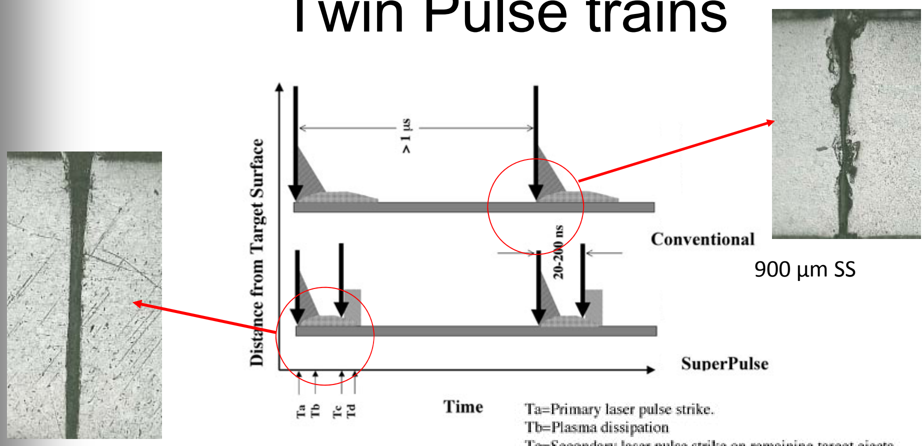
OPTEC
laser micromachining systems

Twin Pulse trains



OPTEC
laser micromachining systems

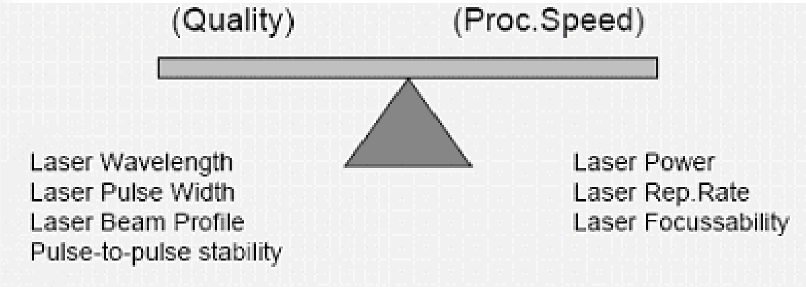
Laser Parameters / Processing Parameters

Laser Parameters		Processing Parameters
Power (W)	→	Process Throughput
Wavelength (nm)	→	A,R,T & Resolution
Pulse Width (sec)	→	Interaction Time
Peak Power (W)	→	Damage
Stability (%)	→	Process Latitude
Efficiency (%)	→	Cost
Reliability	→	Cost

OPTEC
laser micromachining systems

Laser Parameters / Processing Parameters

The Balance



BUT WHAT ABOUT COST?

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OPTEC
laser micromachining systems

Material Optical Properties

OPTICAL
- Absorptivity
- Reflectivity
- Refractive Index
- Surface Roughness

- A + R + T = 100 %
  - A : Absorption
  - R : Reflectivity
  - T : Transmission

  - **Depends on Temperature**

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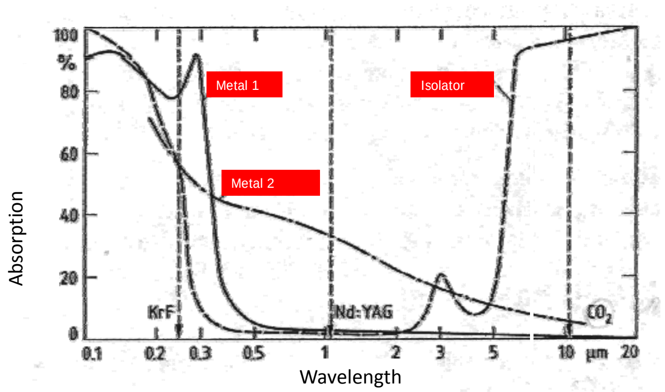
OPTEC laser micromachining systems

Material Optical Properties…



Metal 1: Au, Ag, Cu…, Metal 2: Fe, Ni, Cr…,
Isolator: glass, Polymer

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OPTEC laser micromachining systems

OPTICAL
- Absorptivity
- Reflectivity
- Refractive Index
- Surface Roughness

Laser
- Type
- Wavelength

Metal	At 10.6 µm	At 1.06 µm	At 0.25 µm
Aluminum	2	10	18
Iron	4	35	60
Copper	1	8	70
Molybdenum	4	42	60
Nickel	5	25	58
Silver	1	3	77

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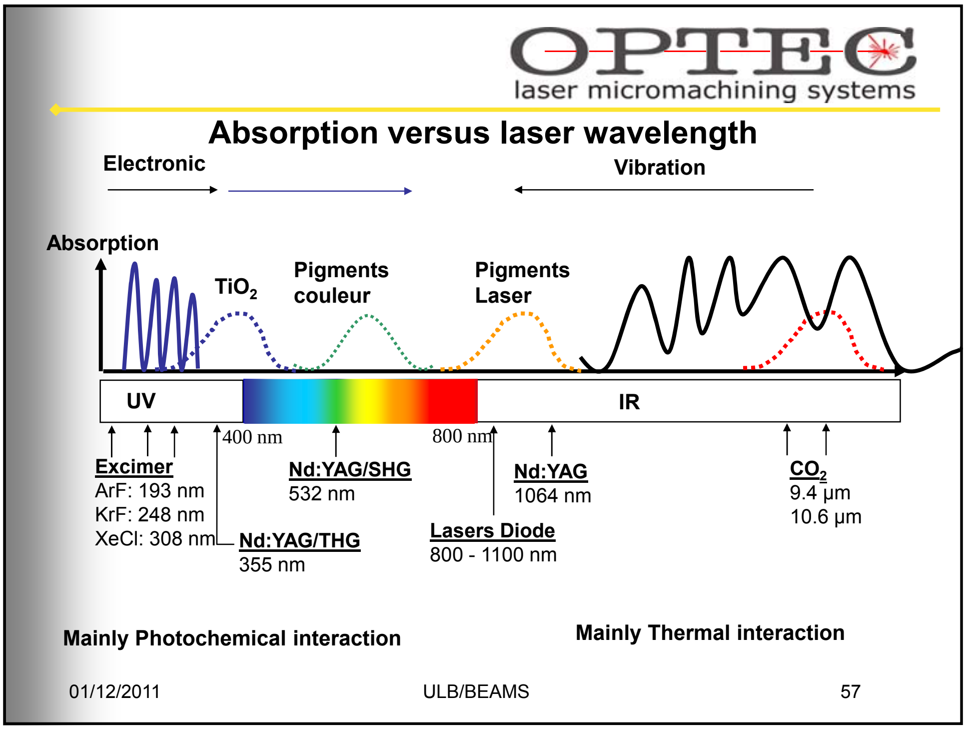
OPTEC
laser micromachining systems
Absorption versus laser wavelength
Electronic
Vibration
Absorption
TiO2
Pigments couleur
Pigments Laser
UV
IR
400 nm
800 nm
Excimer
ArF: 193 nm
KrF: 248 nm
XeCl: 308 nm
Nd:YAG/SHG
532 nm
Nd:YAG/THG
355 nm
Lasers Diode
800 - 1100 nm
Nd:YAG
1064 nm
CO2
9.4 µm
10.6 µm
Mainly Photochemical interaction
Mainly Thermal interaction
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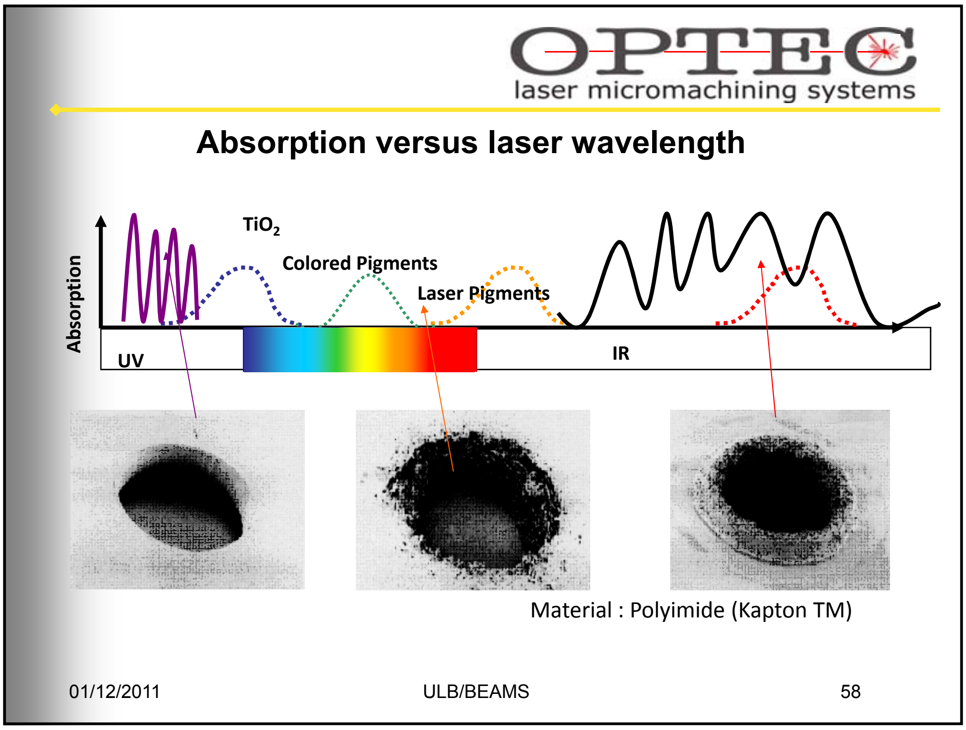
OPTEC
laser micromachining systems
Absorption versus laser wavelength
Absorption
TiO2
Colored Pigments
Laser Pigments
UV
IR
Material : Polyimide (Kapton TM)
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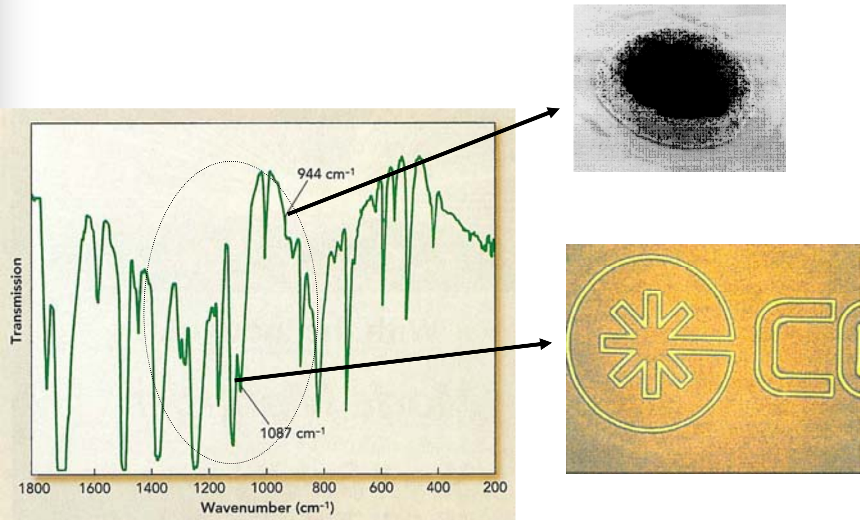
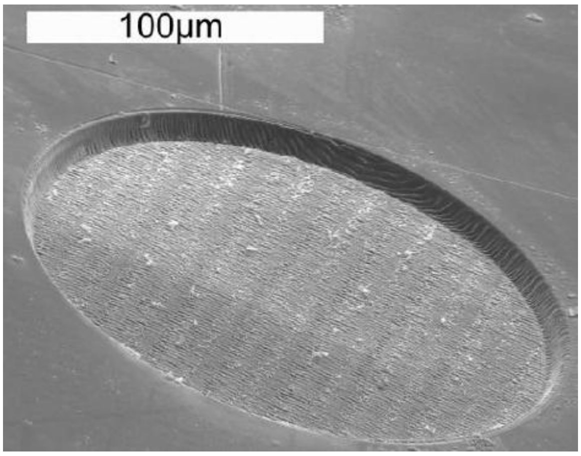
OPTEC
laser micromachining systems



OPTEC
laser micromachining systems

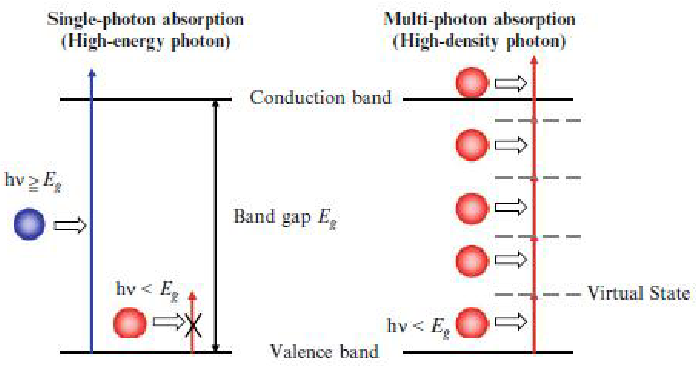
Non Linear Absorption



Ablation de Polyimide avec un laser ultra court; L.O. : 1064 nm

OPTEC
laser micromachining systems

Non Linear Absorption: Multiphoton effect



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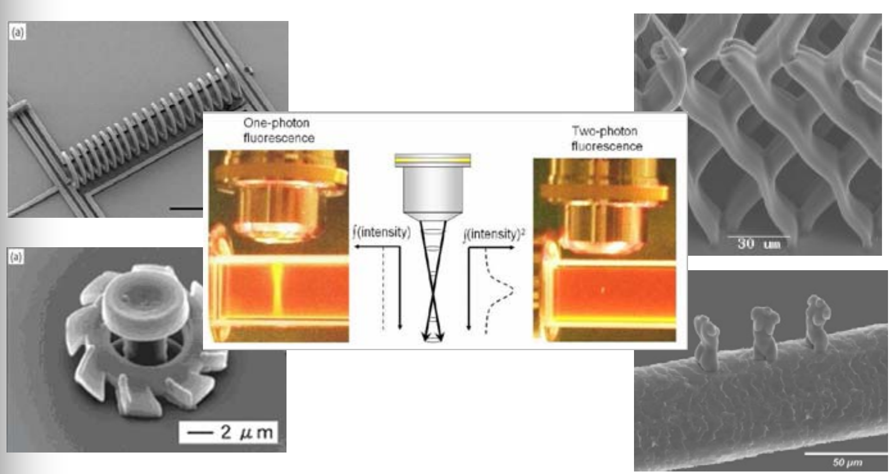
OPTEC
laser micromachining systems



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laser micromachining systems

Materials Properties

THERMOPHYSICAL
- Thermal Conductivity
- Specific Heat
- Melting Point
- Boiling Point
- Evaporation Enthalpy
- Surface Tension
- Vapour Pressure

→

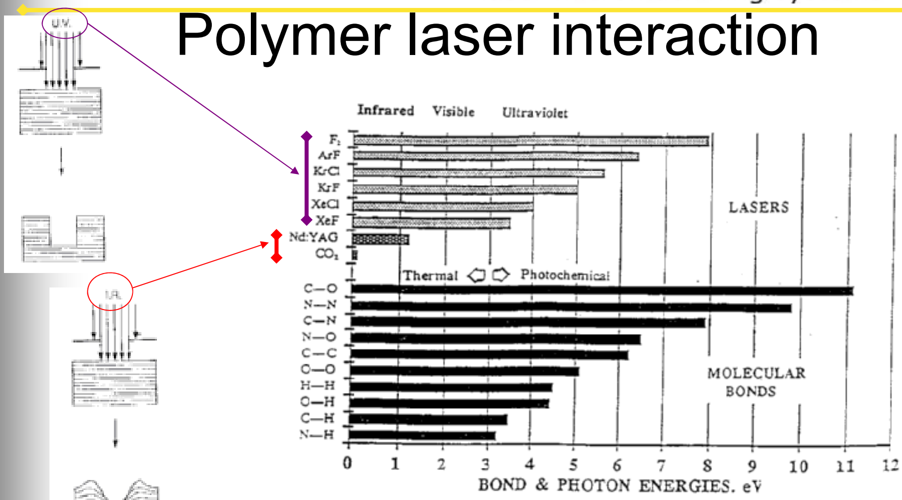
- Metals
- Ceramics
- Polymers
- Glass
- Composites

laser micromachining systems

POLYMER LASER INTERACTION

OPTEC
laser micromachining systems

Polymer laser interaction



E (ev) =hv or E (ev) = hc/λ

OPTEC
laser micromachining systems

UV + Short pulse = Precision micromachining:-

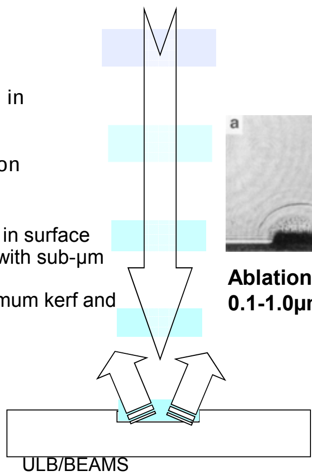
CHARACTERISTICS

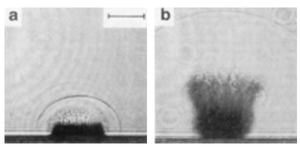
- UV radiation (248nm or 193nm) strongly absorbed in nearly all materials
- Short (4-6ns) pulse duration

RESULT

➢ High energy density absorbed in surface layers, - efficient vaporisation with sub-µm depth precision

➢ Precision machining with minimum kerf and absence of thermal effects

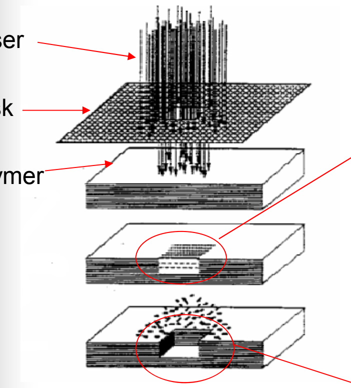


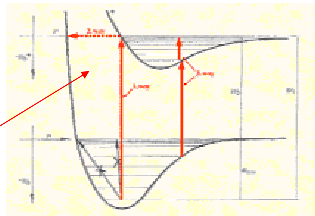


Ablation
0.1-1.0µm/shot

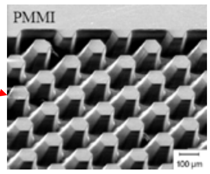
OPTEC laser micromachining systems

Polymer laser interaction





Etching of polymers by non thermal cracking of bounds due to valence transitions induced by UV photons



OPTEC laser micromachining systems

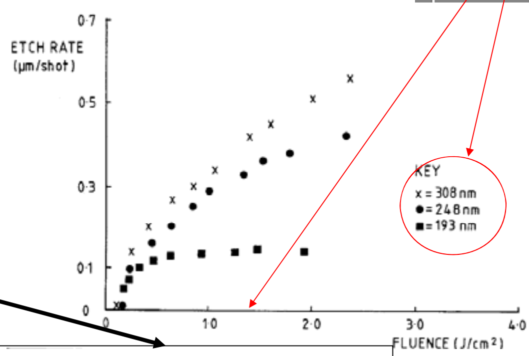
OPTICAL

- Absorptivity
- Reflectivity
- Refractive Index
- Surface Roughness

Laser

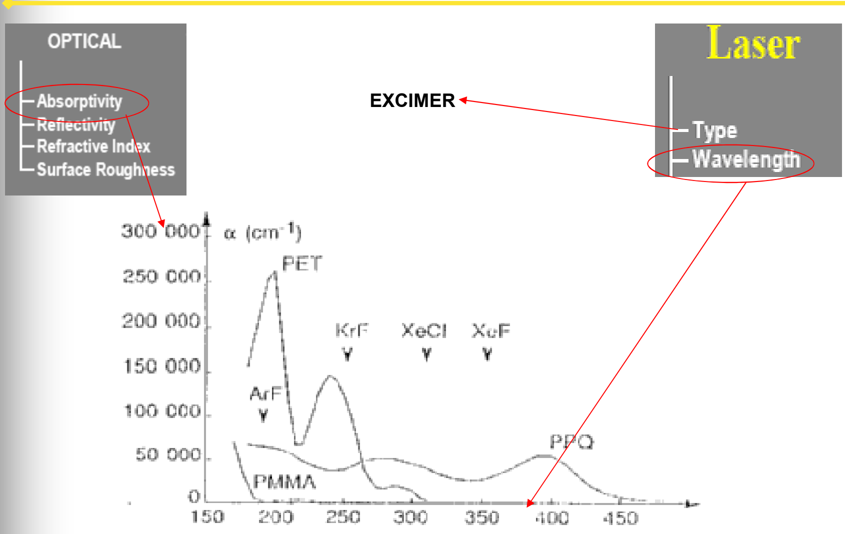
- Type
- Wavelength
- Output Power
- Pulse Energy

$$I(x) = I_0(1-R)e^{-\alpha x}$$



Ablation follows Beer Lambert's Law

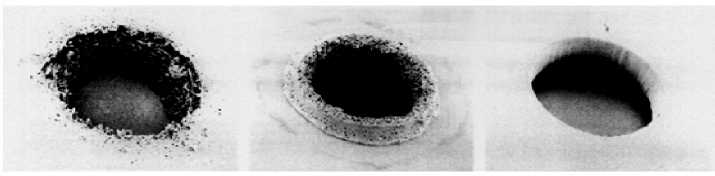
OPTEC
laser micromachining systems



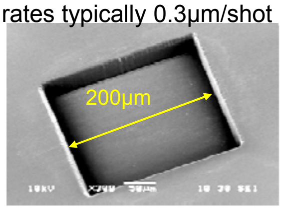
OPTEC
laser micromachining systems

Photoablative decomposition in polymers:-

Nd-YAG (1.06 µm) CO_2 (10.6 µm) Excimer (0.248 µm)

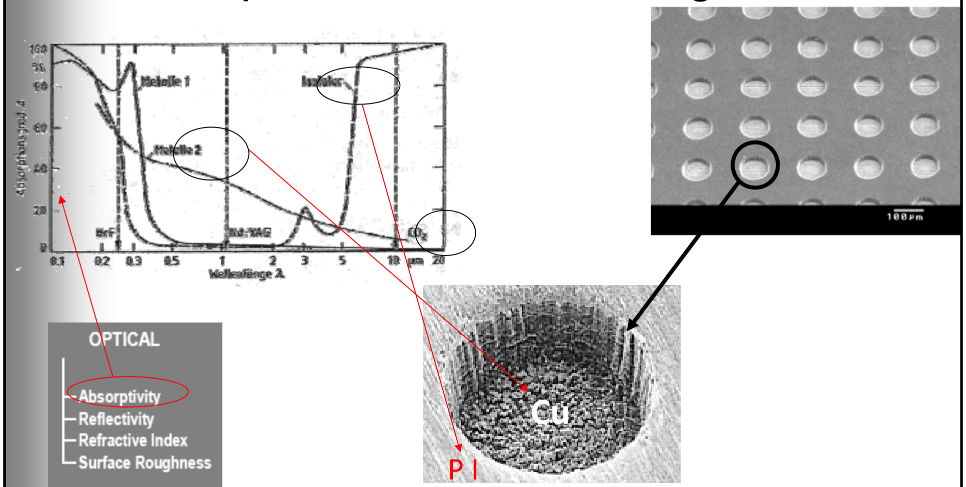


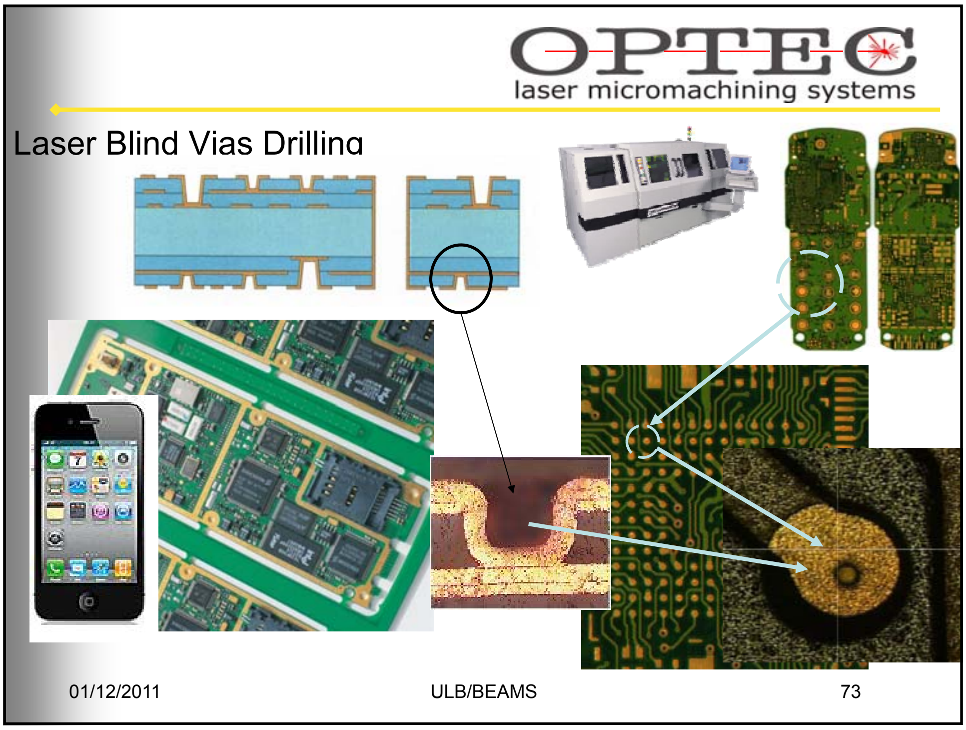
Unlike Nd-YAG or CO2 lasers, excimer laser ablation of most polymers occurs by photo-ablative decomposition, with little excess heat and removal rates typically 0.3µm/shot



COMBINED MATERIALS LASER INTERACTION

Absorption versus wavelength




OPTEC
laser micromachining systems
Laser Blind Vias Drilling
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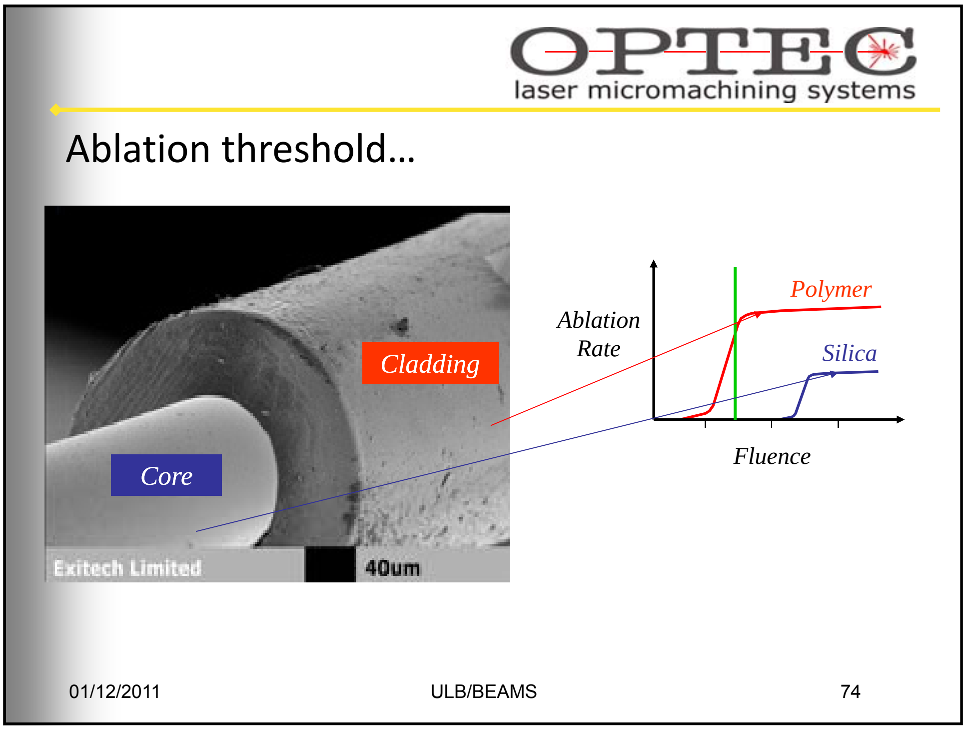
OPTEC
laser micromachining systems
Ablation threshold…
Cladding
Core
Exitech Limited
40um
Polymer
Silica
Ablation
Rate
Fluence
01/12/2011
ULB/BEAMS
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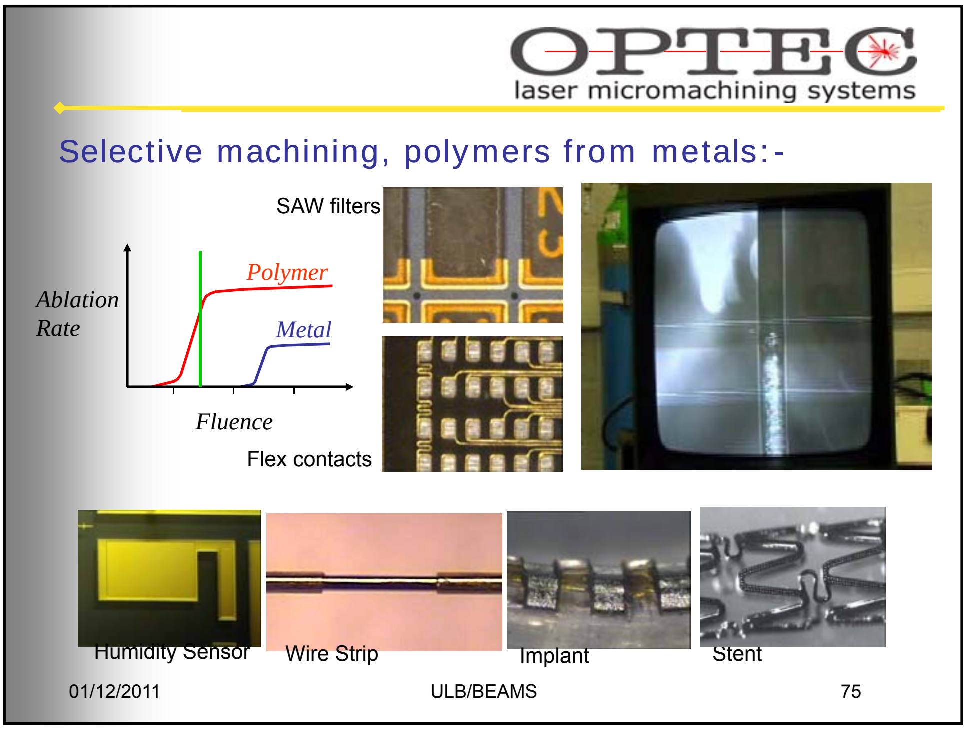
OPTEC
laser micromachining systems
Selective machining, polymers from metals:-
SAW filters
Ablation Rate
Polymer
Metal
Fluence
Flex contacts
Humidity Sensor
Wire Strip
Implant
Stent
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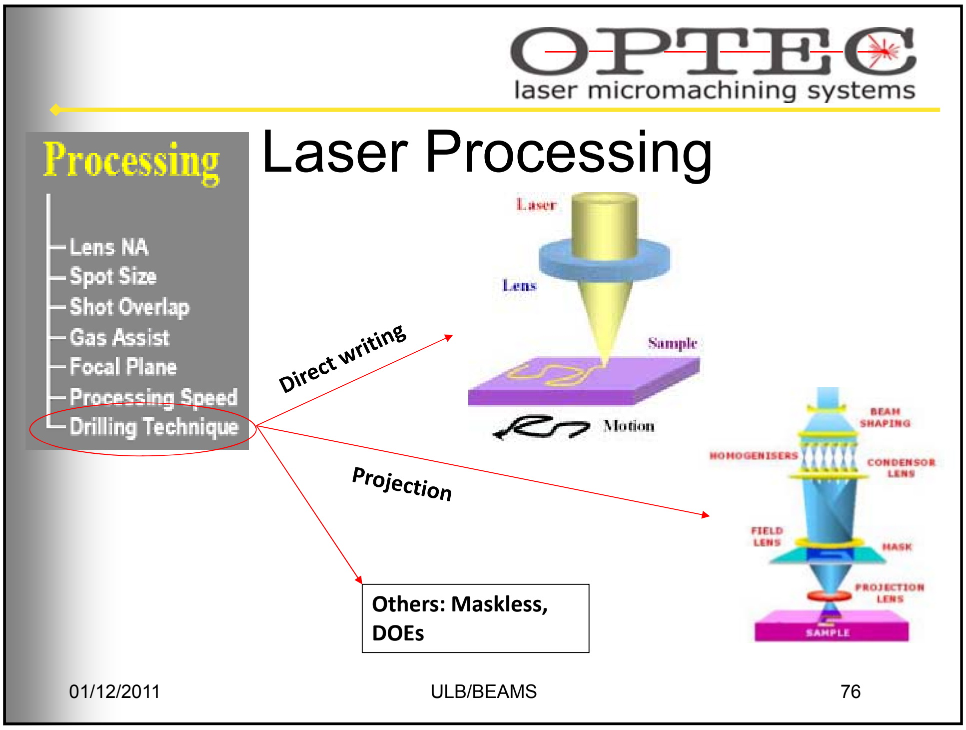
OPTEC
laser micromachining systems
Processing
Lens NA
Spot Size
Shot Overlap
Gas Assist
Focal Plane
Processing Speed
Drilling Technique
Laser Processing
Laser
Lens
Sample
Motion
Direct writing
Projection
Others: Maskless, DOEs
BEAM SHAPING
HOMOGENISERS
CONDENSOR LENS
FIELD LENS
MASK
PROJECTION LENS
SAMPLE
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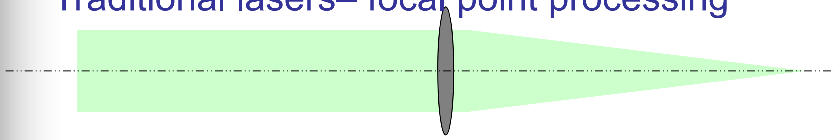
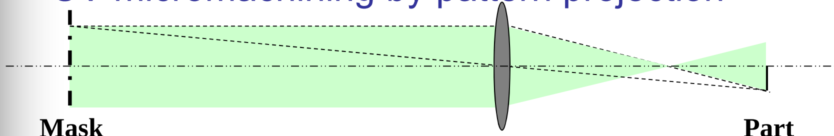
OPTEC
laser micromachining systems

Traditional lasers– focal point processing



Poor definition of focal point, low flexibility.

UV micromachining by pattern projection



Precise definition on machined area by optical projection of mask image, many motif shapes possible.

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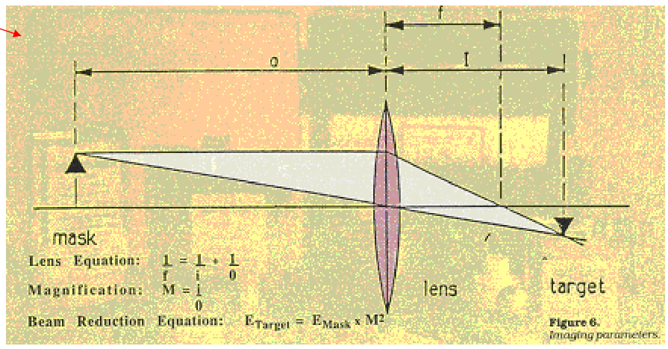
OPTEC
laser micromachining systems

Drilling Techniques / Projection

Processing
- Lens NA
- Spot Size
- Shot Overlap
- Gas Assist
- Focal Plane
- Processing Speed
- Drilling Technique



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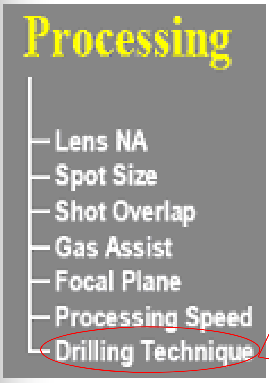
OPTEC
laser micromachining systems

Drilling Techniques / Projection



- Static Mask and workpiece
- Moving Mask
- Moving Workpiece
- Synchronised Scanning
- Synchronised overlay scanning
- Bow Tie scanning
- Half Tone & Gray Scale Mask

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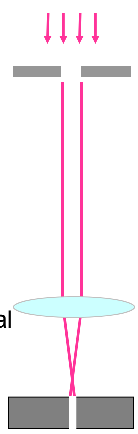
OPTEC
laser micromachining systems

Processing using simple motifs:-

...particularly suitable for small lasers!

Laser illumination, generally around 50mJ/cm²

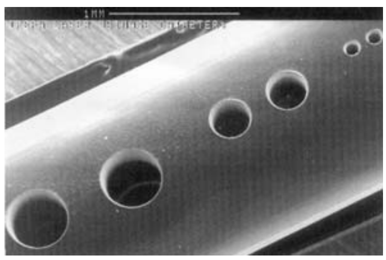
Mask, in this case with a single hole



Process lens to project mask image with typical demag. 4-20X

1-20J/cm² on the part

- Drill/mill simple holes or shapes
- Drill many holes sequentially using X,Y part motion
- Use mask selector to change motifs, incl. alphanumeric
- For small features, energy requirements modest, but high rep. rate useful.



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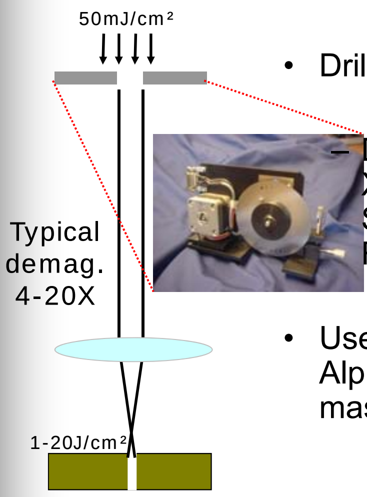
OPTEC laser micromachining systems

Static Mask & Workpiece

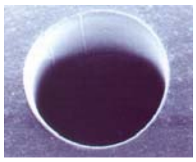


- Drill simple holes or shapes
  - Drill many holes sequentially using X,Y part motion or X,Y Galvo Scanners (also known as step & Repeat)
- Use mask selector to change motifs, incl. Alphanumeric (also known as indexed mask projection)

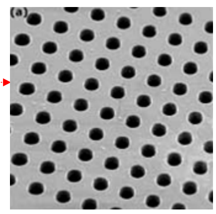
OPTEC laser micromachining systems

Static Mask & Workpiece

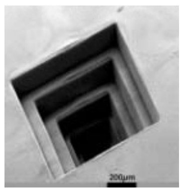
- Drill simple holes or shapes



  - Drill many holes sequentially using X,Y part motion or X,Y Galvo Scanners (also known as step & Repeat)



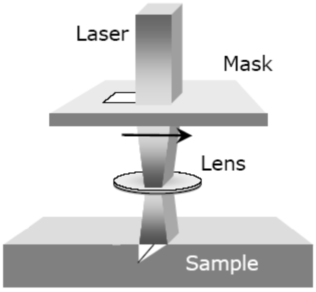
- Use mask selector to change motifs, incl. Alphanumeric (also known as indexed mask projection)

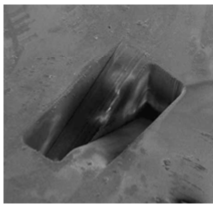


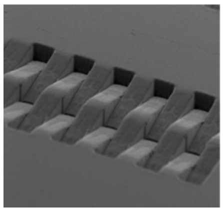
OPTEC
laser micromachining systems

Drilling Techniques / Projection

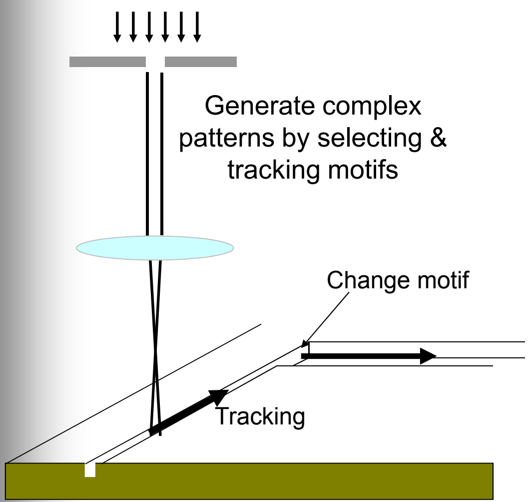
Moving Mask







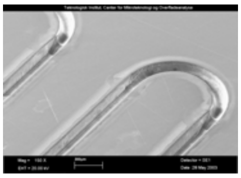
OPTEC
laser micromachining systems

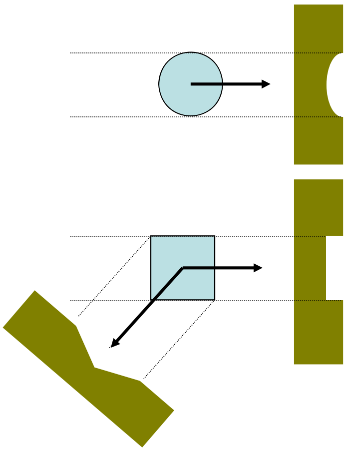


- **Laser firing + motion generates a groove, or cuts through the part.**
- **For a given material, groove depth depends mainly on average shot dose(rep. rate x motif size/tracking speed)**
- **Use different motifs to generate complex patterns**

OPTEC
laser micromachining systems

- **tracked circle always makes elliptical-shaped profile, independently of direction**





- **For other shapes, profile depends on tracking direction**

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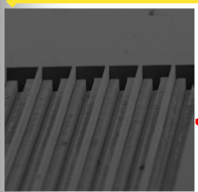
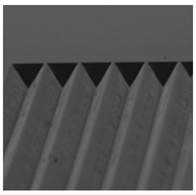
OPTEC
laser micromachining systems

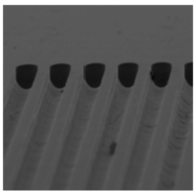
Moving Workpiece…more



- Mask Shape:
  - T Mask



  - Triangle Mask



  - Round Mask

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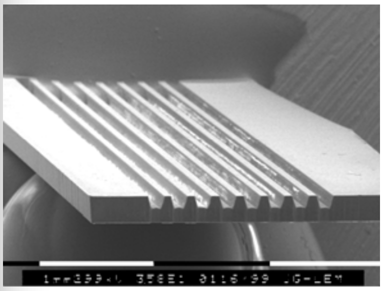
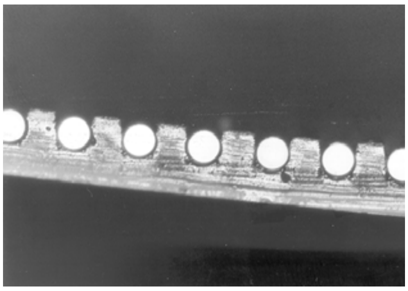
OPTEC
laser micromachining systems

Moving Workpiece

Microgrooving:some examples



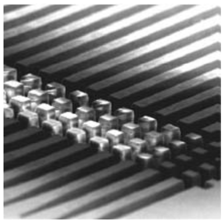


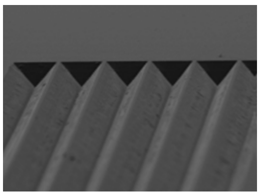
(INTEC - Ghent University - B)

OPTEC
laser micromachining systems

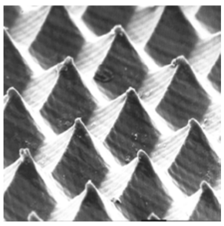
Moving Workpiece…more

Turn by 90°



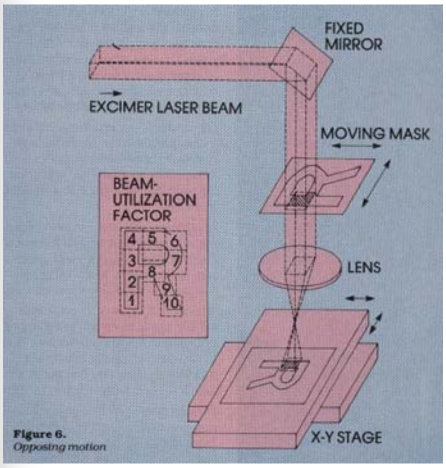


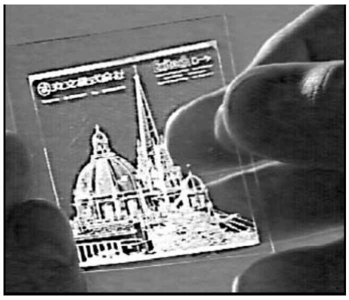
Turn by 90°



OPTEC
laser micromachining systems

Synchronised Scanning





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OPTEC
laser micromachining systems

Laser Processing

Processing

- Lens NA
- Spot Size
- Shot Overlap
- Gas Assist
- Focal Plane
- Processing Speed
- Drilling Technique

DIRECT WRITING

01/12/2011 ULB/BEAMS 90

OPTEC
laser micromachining systems

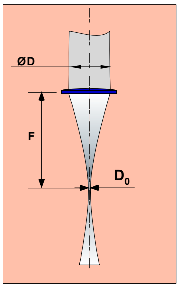
Drilling Techniques / Direct Writing

Processing

- Lens NA
- Spot Size
- Shot Overlap
- Gas Assist
- Focal Plane
- Processing Speed
- Drilling Technique

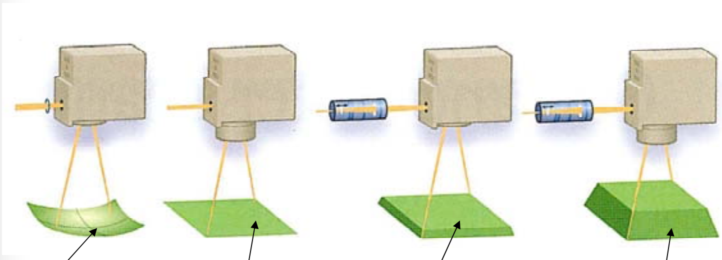
$$K = \frac{1}{M^2} = \frac{4\lambda F}{\pi D_0 D} = \frac{4\lambda}{\pi D_0 \theta}$$

$$D_0 = M^2 \times \frac{4\lambda}{\pi} \times \frac{F}{D}$$



OPTEC
laser micromachining systems

XY Galvo Mirrors



Pre-focus lens

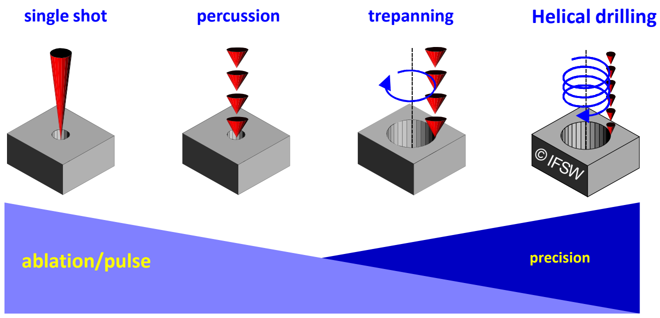
Dynamic pre-focussing

F-Theta objective

F-Theta & Dynamic pre-focussing

laser micromachining systems

Drilling Strategies...Contd



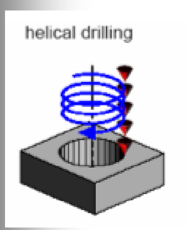
Source: FGSW Stuttgart

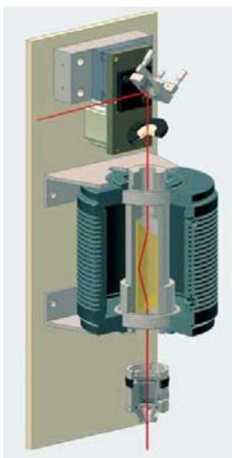
Aspect (d/T)	max. 1:15	max. 1:100	open	open
Tolerance %	5-10	5	5	<3

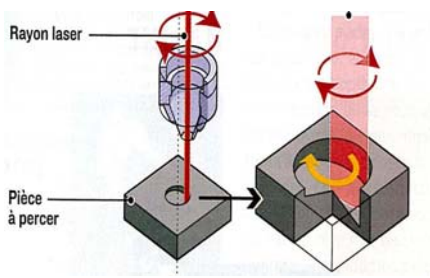
Pulsed Laser

laser micromachining systems

Drilling Techniques / Direct Writing



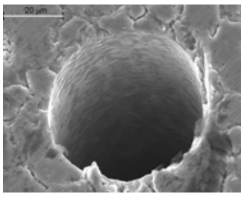




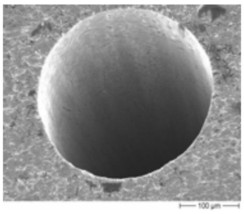
laser micromachining systems

Process Results

Material:	**stainless steel**
Thickness:	**1.2 mm**
Diameter:	**50 µm ± 2 µm**
Time:	**10 s**



Material:	**stainless steel**
Thickness:	**1 mm**
Diameter:	**200 µm ± 3 µm**
Time:	**20 s**



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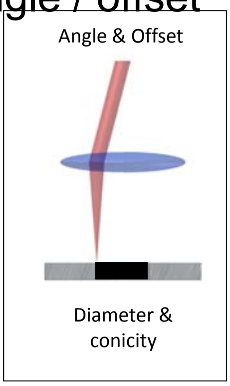
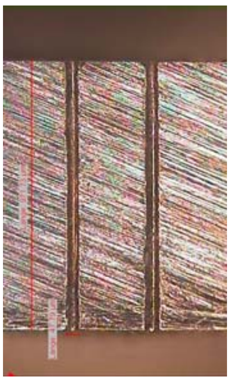
laser micromachining systems

Process Parameters...Contd

- Angle / offset





stainless steel
d=50 µm
depth=1 mm, t=8 s

stainless steel
d=100/250 µm
depth 1 mm, t=20 s

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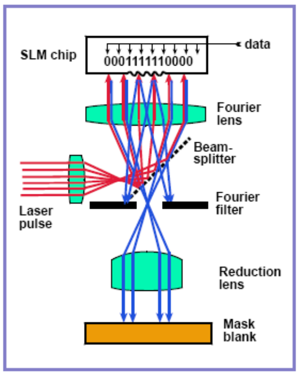
laser micromachining systems

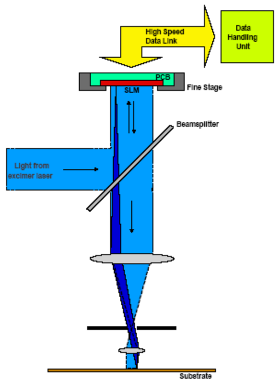
Drilling Techniques / Others

Processing

- Lens NA
- Spot Size
- Shot Overlap
- Gas Assist
- Focal Plane
- Processing Speed
- Drilling Technique

Maskless / Digital Mask





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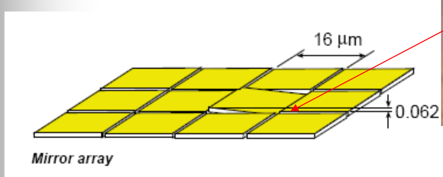
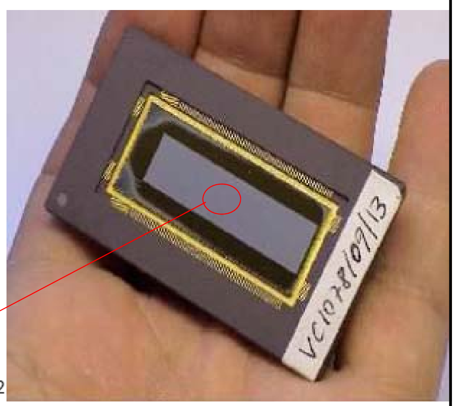
laser micromachining systems

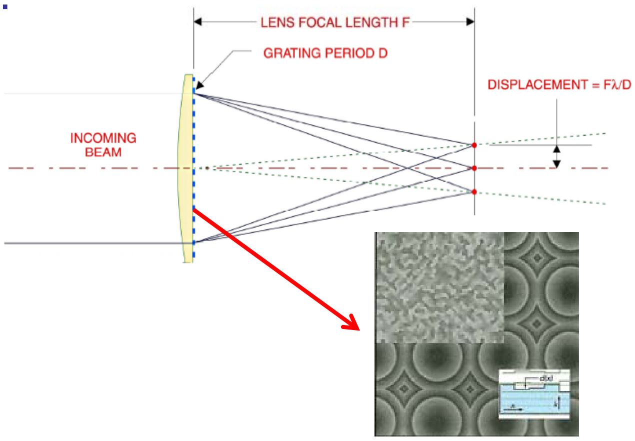
Digital Masks:-





OPTEC laser micromachining systems

Drilling Techniques
DOE's:-



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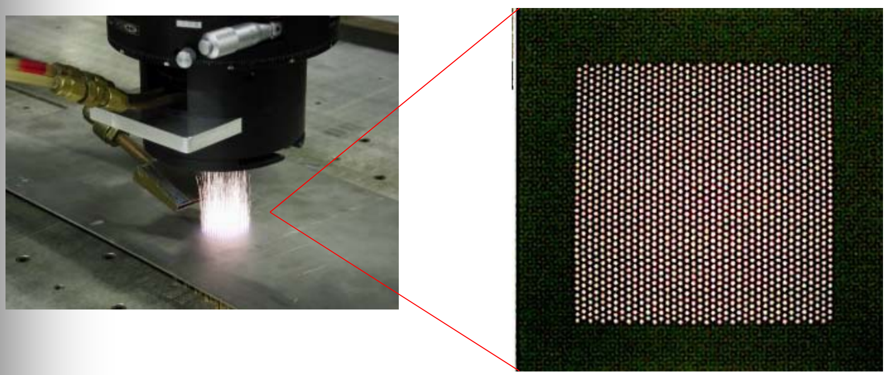
OPTEC laser micromachining systems

Drilling Techniques
Many holes at once:-



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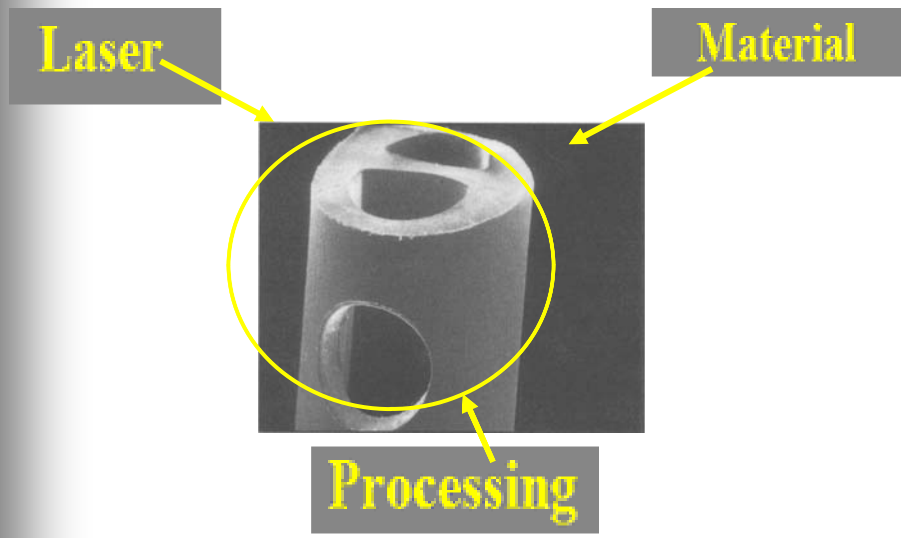
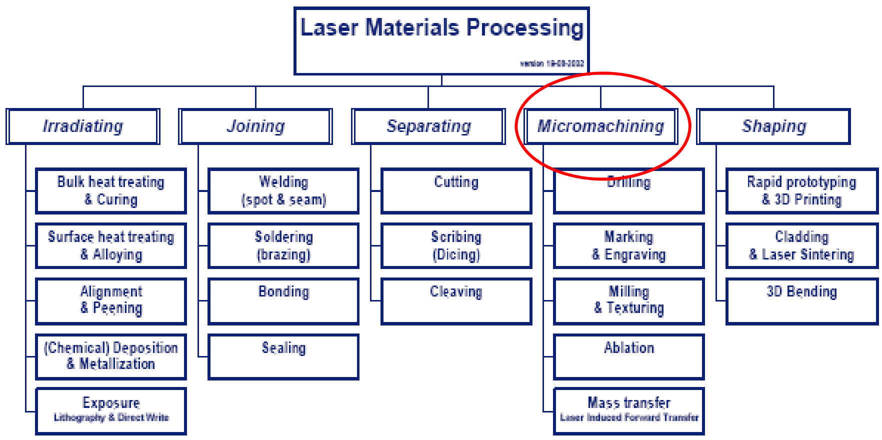
OPTEC laser micromachining systems



OPTEC laser micromachining systems



OPTEC laser micromachining systems

Methodologie

Tendances

↓

Produits actuels et à venir

↓

Sélection de l'outil laser

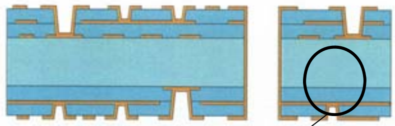
OPTEC laser micromachining systems

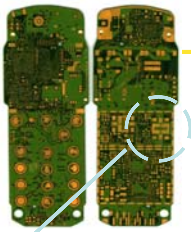
Tendances du marché

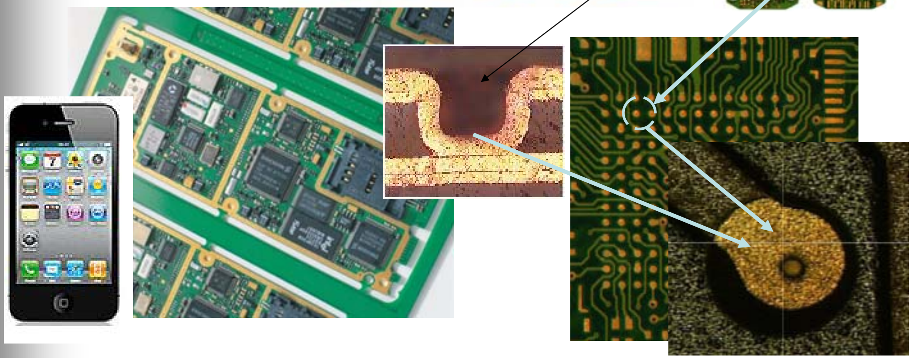
- Miniaturisation
- Fonctionnalisation
- Efficience
- Biomimétisme
- Convergence
- Personnalisation et circuit court (Rapid Proto)
- Réduction des coûts

OPTEC laser micromachi...

Miniaturisation: Perçage laser de micro-via...

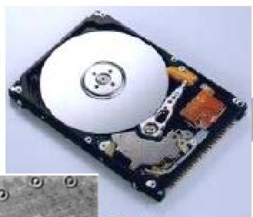


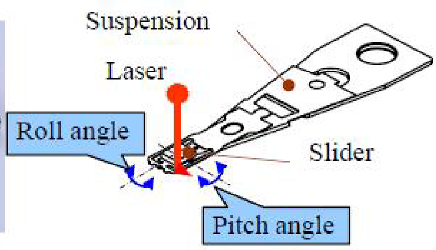


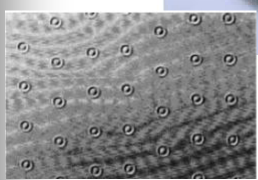


OPTEC laser micromachining systems

Miniaturisation…suite







HDD

Structure of suspension in HDD

OPTEC laser micromachining systems

Fonctionnalisation

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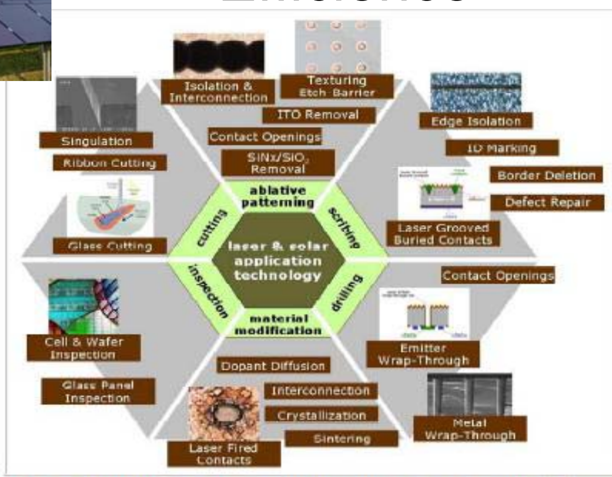
OPTEC laser micromachining systems

Efficience



Classification of the different laser applications in solar by laser / material interaction process

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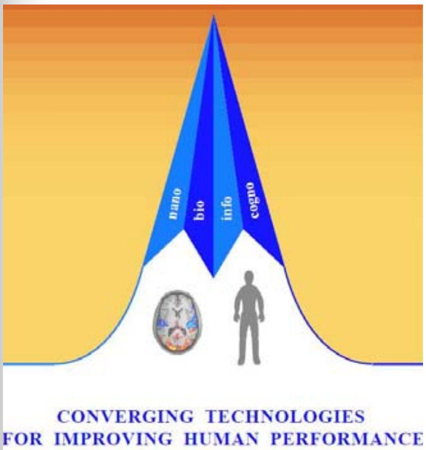
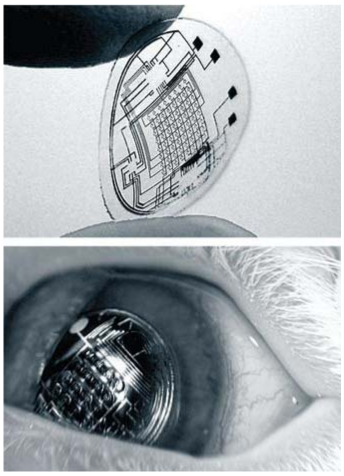
laser micromachining systems

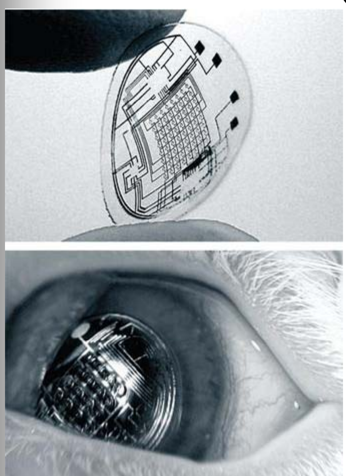
Convergence

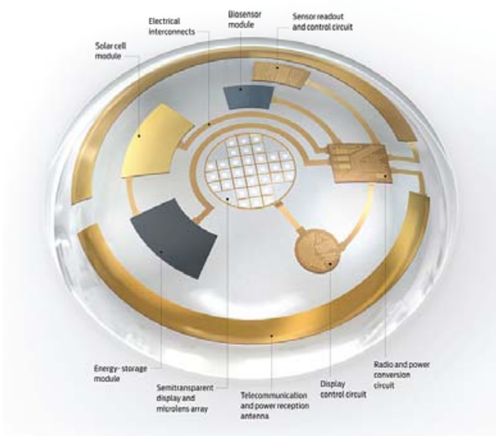




OPTEC
laser micromachining systems

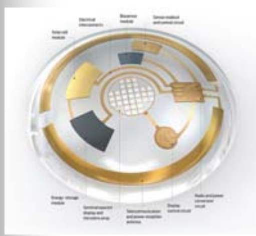
Convergence…suite

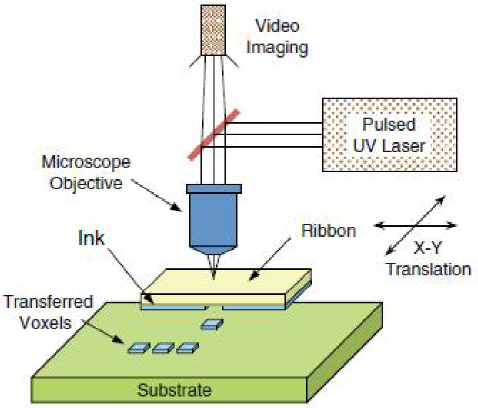




OPTEC
laser micromachining systems

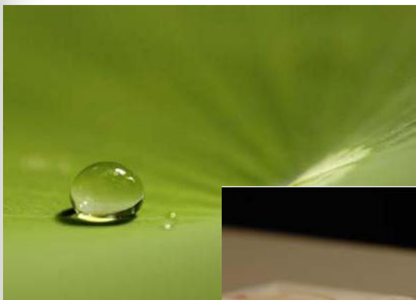
Convergence…suite

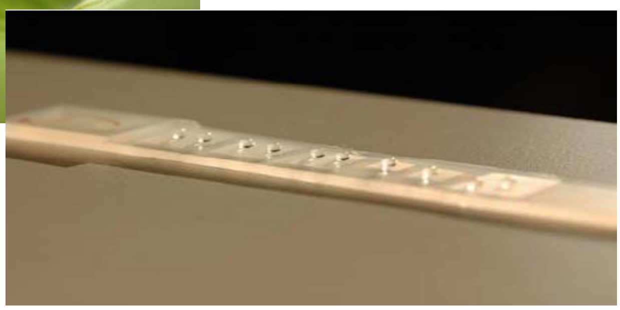




OPTEC
laser micromachining systems

Biomimétisme





OPTEC
laser micromachining systems

Biomimétisme…suite

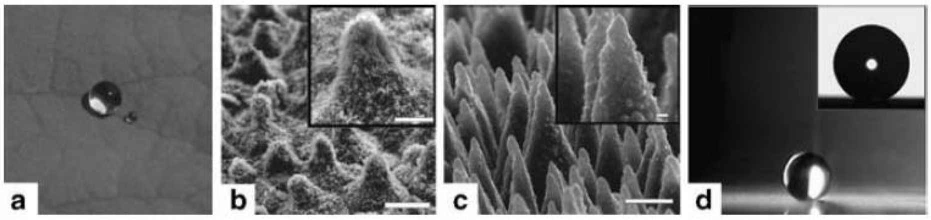


Fig. 4.5 (**a**) A bead of water on a lotus leaf [55]. (**b**) SEM image of the microscale (scale bar 10 µm) and *inset*: nanoscale structures (scale bar 5 µm) on the surface of a lotus leaf [56]. (**c**) SEM images of femtosecond laser textured Si surface showing microscale (scale bar 5 µm) and *inset*: nanoscale (scale bar 1 µm) structures [56]. (**d**) Image of a water droplet on a laser-structured, silane-coated, Si surface with a static contact angle of $\theta = 154 \pm 1°$ [57]

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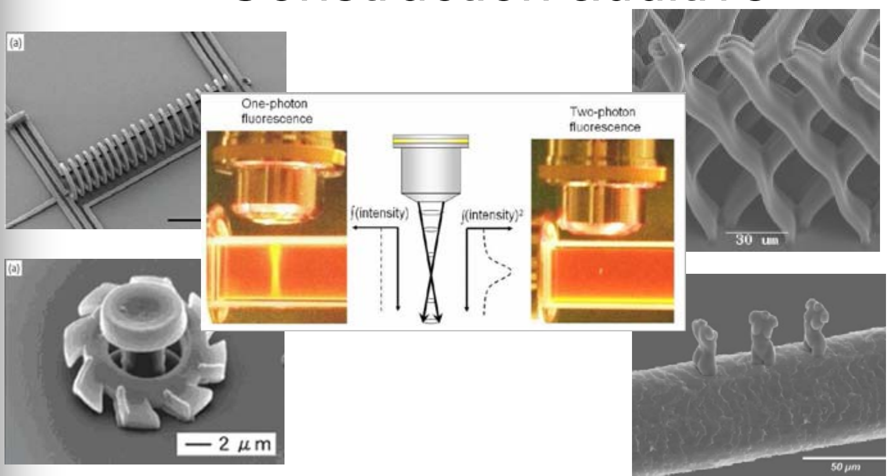
laser micromachining systems

Construction additive



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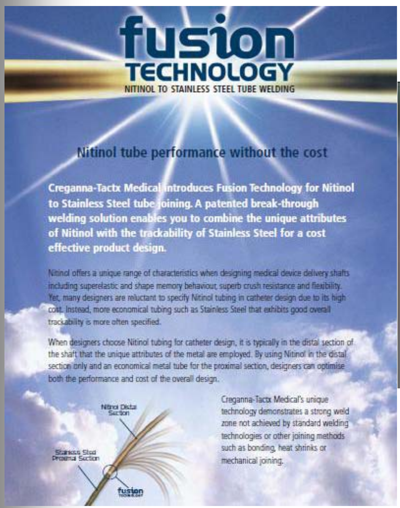
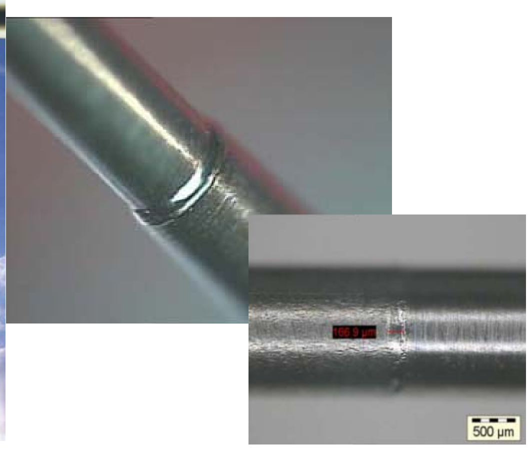
Réduction des coûts





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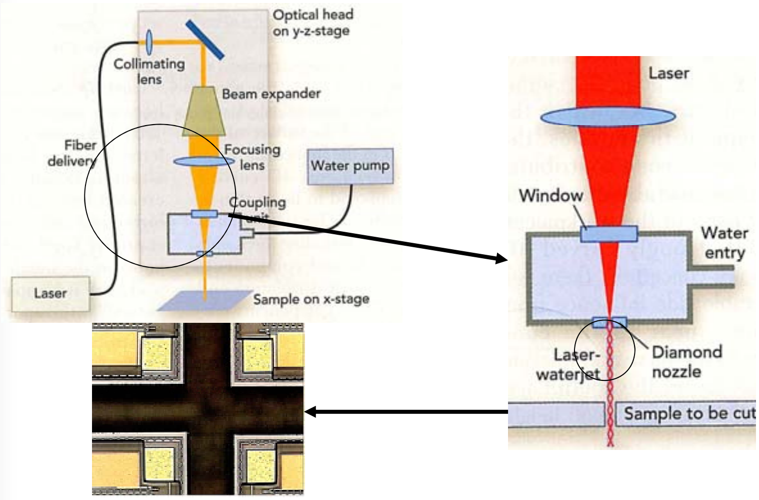
Procédés Laser Hybride

01/12/2011 ULB/BEAMS 116

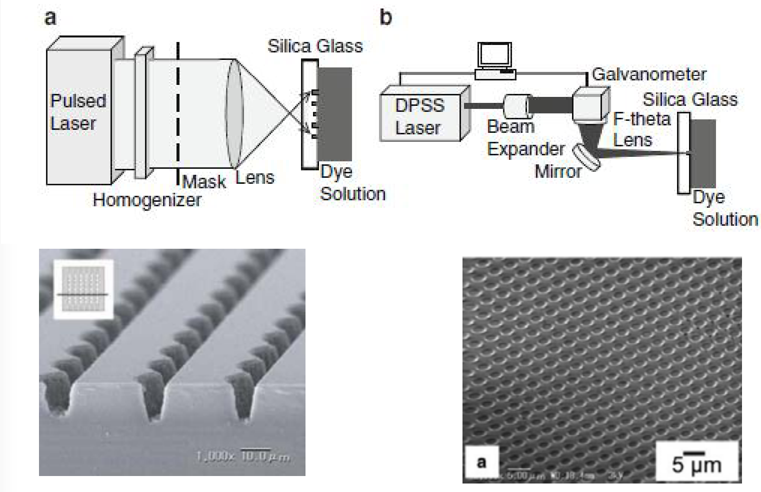
laser micromachining systems

Procédés Hybrides/ Synova



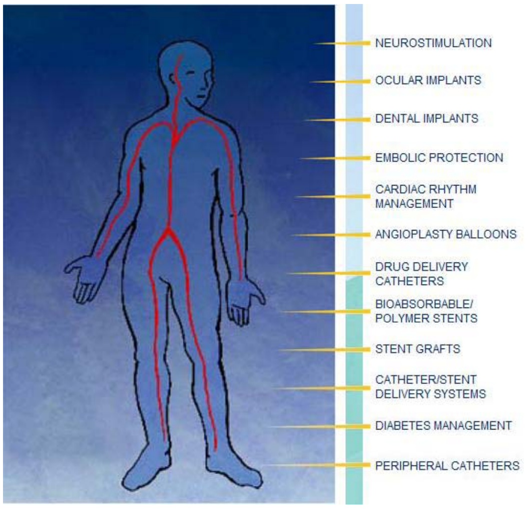
laser micromachining systems

Procédés Hybrides/ LIBWE



OPTEC
laser micromachining systems

Typical Laser Tasks for MDM:



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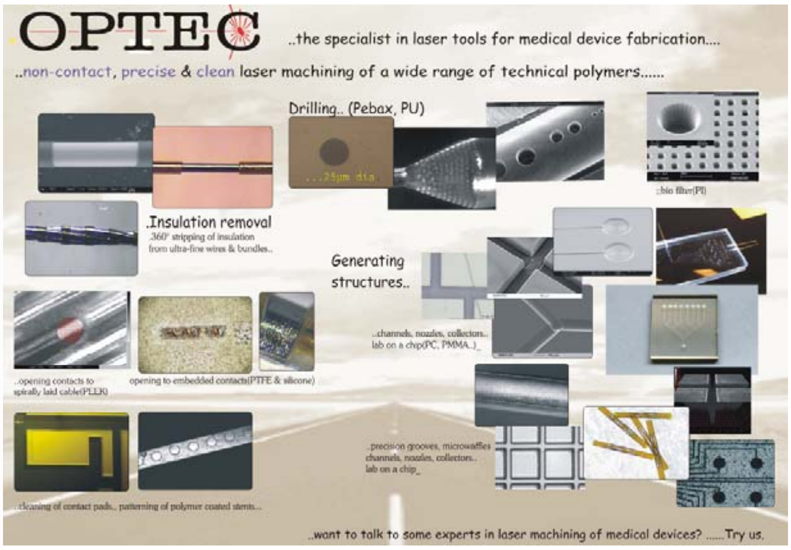
OPTEC
laser micromachining systems



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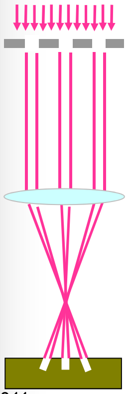
laser micromachining systems

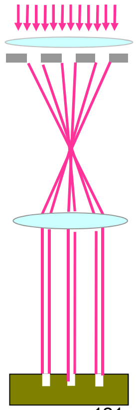
Processing using Complex Motifs:-

…parallel patterning, generally suitable for big lasers

Illumination of a complex mask



Telecentric imaging using a field lens



- The complete pattern is projected in a single operation using a complex mask
- Inflexible but inherently suitable for mass production
- Stencil-type masks are limited to simply-connected motifs
- Metal/FS masks – any feature possible, & more precise, but costlier and lower damage threshold

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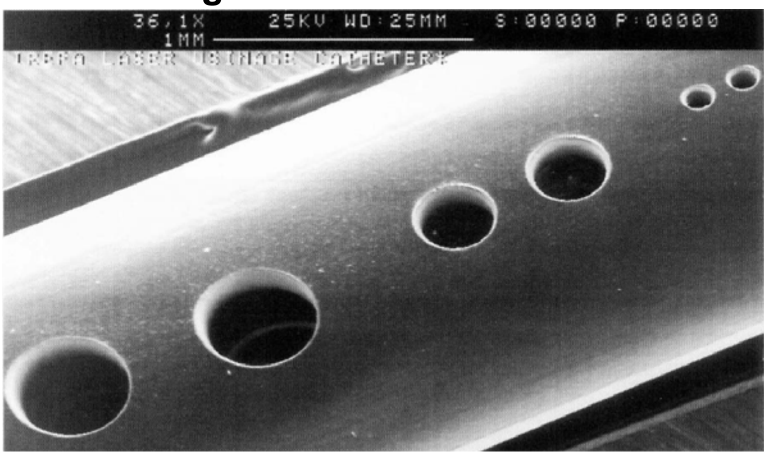
laser micromachining systems

Catheters machining



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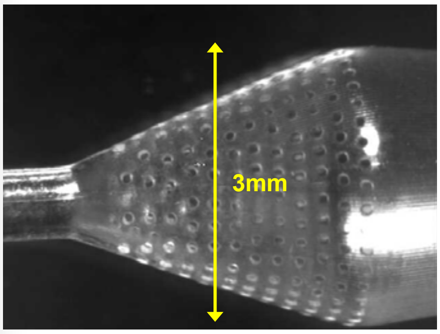
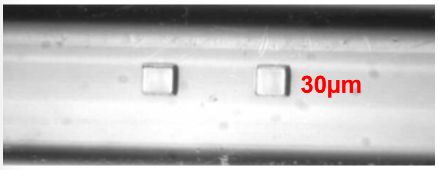
laser micromachining systems



Filter device(medical)



Catheter wall

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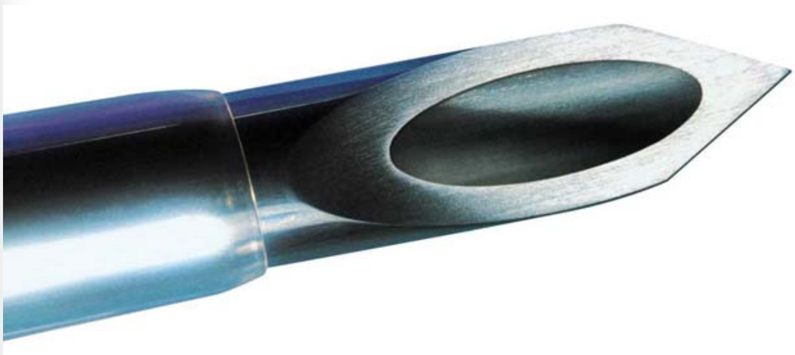
laser micromachining systems

Laser catheter chamfering



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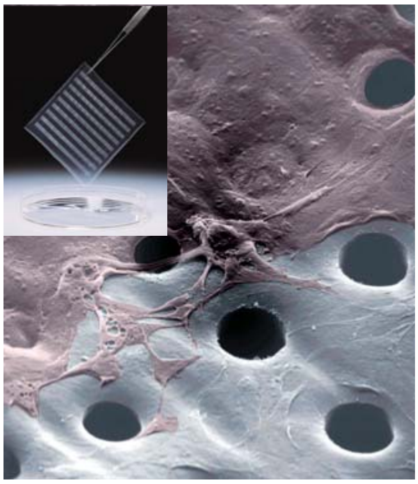
Laser drilling of artificial skins



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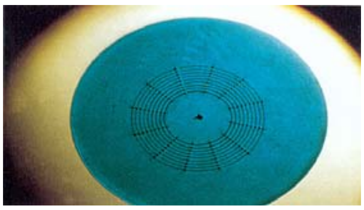
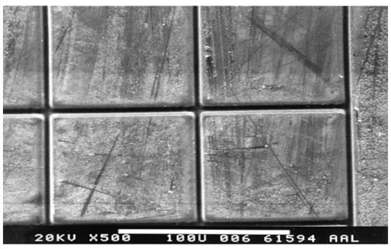
Laser machining of medical components





- Machining of glass substrates
- Machining of counting grids

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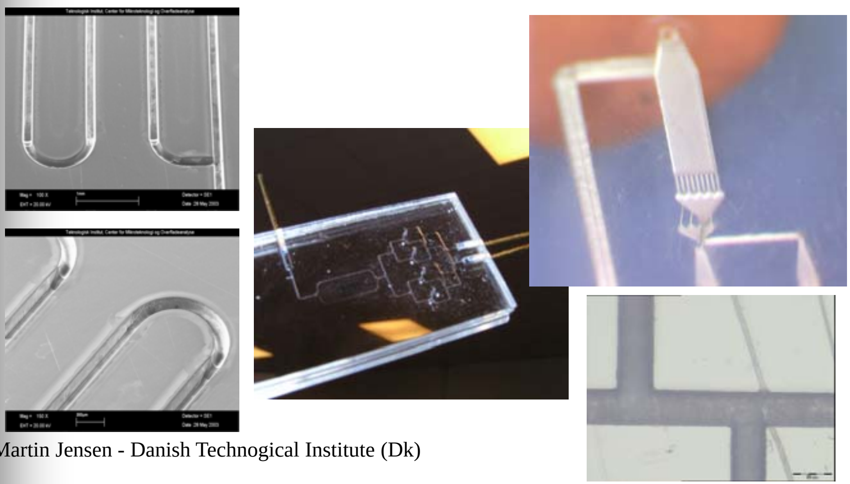
laser micromachining systems

Laser machining of microfluidics:lab on a chip



Nigel Kent – NCSR (Irl)

Martin Jensen - Danish Technogical Institute (Dk)

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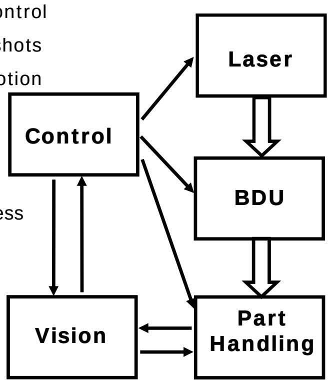
OPTEC
laser micromachining systems

- Mask motif selection/control
- Laser firing, energy & shots
- Focus control & part motion
- Process monitoring
- Vision software
- Hardware maintenance
- Operator interface/access
- Data logging



- Gas Supplies(fuel)
- Performance monitoring

- Energy Control
- Illumination optics
- Mask motif, (incl. Dynamic)
- Projection optics
- Demag. a Focus

- Motion, incl. multi-axis
- Environment Control

- Vision
- Lighting
- Measurement

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laser micromachining systems

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laser micromachining systems

Remerciements

Crédit Photos: ALPHANOV, Clark-MXR, Coherent, Creganna, Fuji, General Atomics, FGSW,GSIG, IREPA LASER, Lasag, Lightmotif, LPKF, LZH, Optec, Oxford Laser, Rofin, Synova, TI

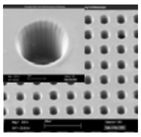
laser micromachining systems

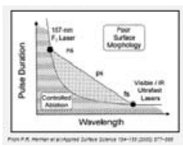
Merci pour votre attention

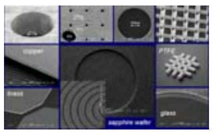
QUESTIONS….

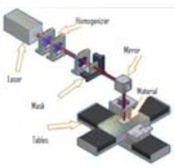
laser micromachining systems

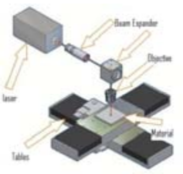
Notre expertise dans le domaine du traitement Athermique par laser :











OPTEC
laser micromachining systems

Typical Micromachining Tasks:-