

# Safety Issues in a Precision Laser Micromachining Company



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# Outline

- ◆ Introduction
- ◆ Who are we?
- ◆ Capabilities?
- ◆ Safety Issues Related to Equipment
- ◆ Other issues Related to Ongoing Business
- ◆ Conclusion



# I. Introduction: *Who is PhotoMachining?*



Incorporated:  
*September 1997*

Employees:  
*20-30*

Client Base:  
*50% Medical*  
*10% Micro-*  
*Electronics*  
*20% Aerospace*  
*/Defense*  
*10% Solar*  
*10% Other*

# I. Introduction: *Who is PhotoMachining?*

## Products and Services:

*Laser Job Shop*

*Laser Systems Integrator*

*Porous Ceramic Vacuum Chucks*

*Refurbished/Used Laboratory Equipment*

## Location: *Pelham, NH*

*12000 ft<sup>2</sup> (3000 ft<sup>2</sup> Class 10,000 Cleanroom)*

## Technical Experience:

*3- Ph.D.'s (Physics & Technology)*

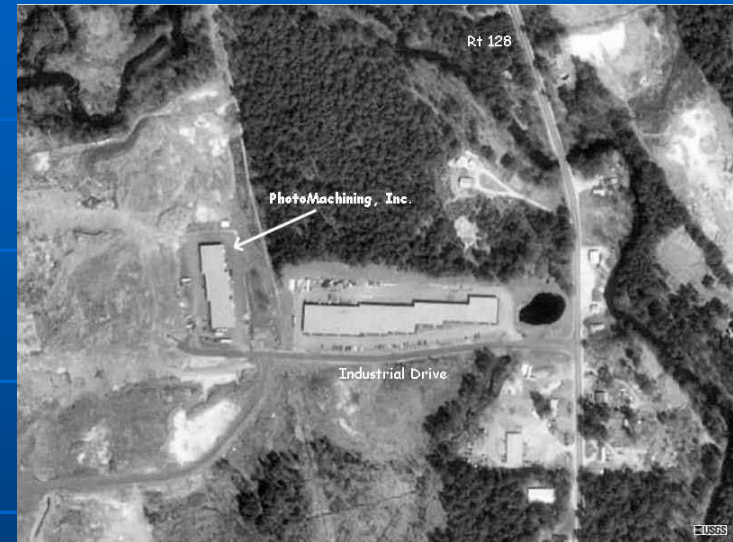
*2- MS-ME,EE*

*4- BS (Technical Fields)*

*Several above with >20 years Experience in Laser Technology*

**\*\* ALL US CITIENS OR GREEN CARD HOLDERS!!**

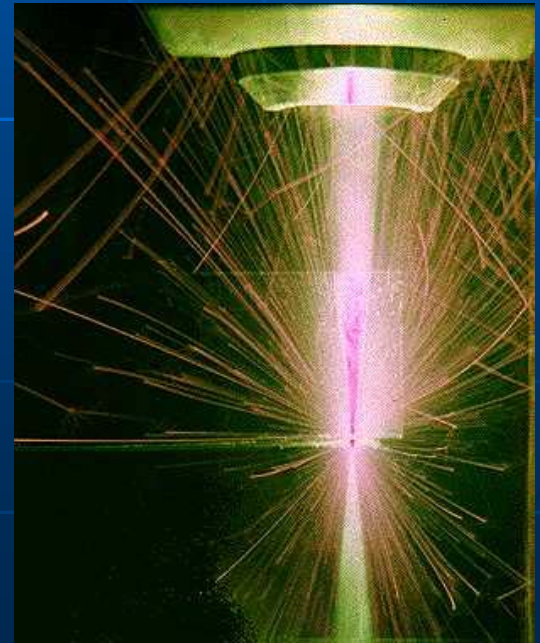
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# I. Introduction: *Laser Micromachining*

- ◆ Feature sizes are less than 1 mm and usually much less.
- ◆ Material thickness is less than 1 mm and usually much less.
- ◆ Does not include additive or joining applications-  
deposition, welding, etc
- ◆ Only specialty marking.
- ◆ Must use lasers (*Duh!*)

◆ *ALL LASERS ARE LOW POWER!*



# What value added do we contribute?

- 1) We understand what happens at the interface of the photons and material.
- 2) We know what hardware to put together to make lasers useful.
- 3) We have our own software to run all the hardware.
- 4) We develop tools to get the material on and off the laser.



# IN HOUSE LASER TOOLS



- 248 nm excimer lasers
- 266 nm DPSS lasers (Avia)
- 355 nm DPSS lasers (1.5W, 3W, 7W, 10W, 20W Avia lasers, 20W Pulseo laser, 2W Matrix laser)
- 1064 nm q-switched fiber lasers (20W SPI and IPG)
- 1064 nm pulsed YAG lasers (Trumpf HL101P)
- CO<sub>2</sub> lasers (Impact TEA, 20W DEOS, 100W Diamond, 10 W Synrad, 250 W K250)
- Lumera Super Rapid, short pulse 12ps laser with three wavelengths including 532 nm!
- What's next ? More short pulse lasers! 193 nm excimer??

# Why Should We Use UV Lasers?



- ◆ Short ( $\lambda$ ) wavelength light:  $<400$  nm
- ◆ Short Pulse Duration:  $<100$  ns
- ◆ High Peak Power (Pulse Energy per Pulse Duration):  $>1$  kW



# Short ( $\lambda$ ) wavelength allows for:

- ◆ Photon/Material Interaction within shallow absorption depth
- ◆ Small feature sizes
- ◆ Clean or "Cold" Ablation - UV bond breaking, rather than thermal material removal



# Why Should We Use IR Lasers?



- ◆ Long ( $\lambda$ ) wavelength light:  $>1 \mu\text{m}$
- ◆ Long Pulse Duration:  $\text{CO}_2$
- ◆ High Powers commercially available (kW)

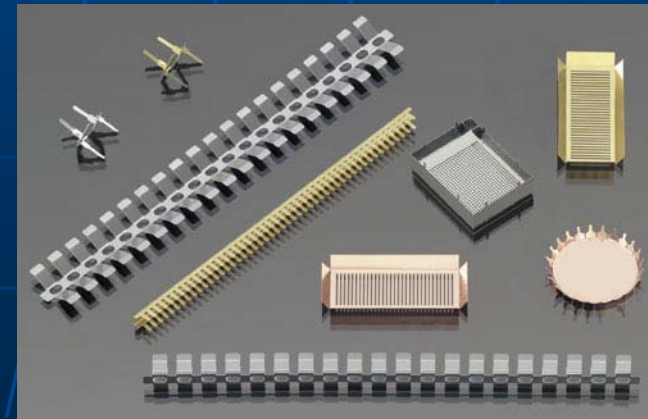
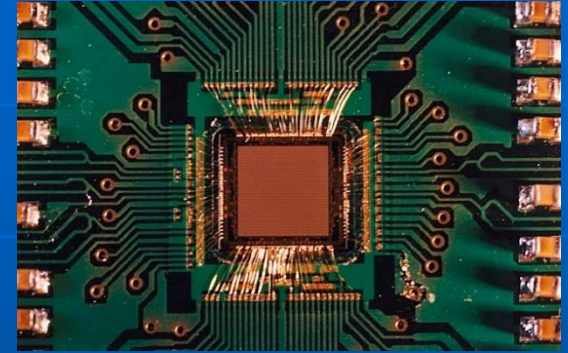
# Long Wavelength Allows For:

- ◆ Photon/Material Interaction with high absorption depth
- ◆ Large Feature Sizes
- ◆ Thermal material removal



# Review of Applications

- ◆ Medical
- ◆ Microelectronics
- ◆ Aerospace
- ◆ Renewable Energy
- ◆ Other

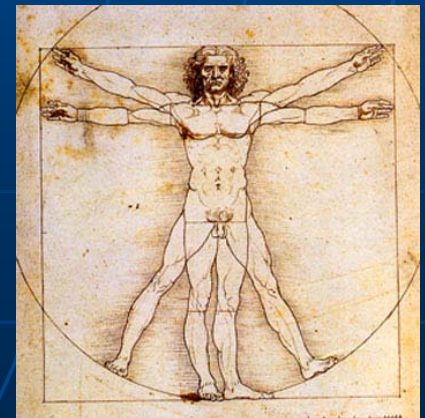


# Typical Medical Applications: Cutting, Drilling, Marking

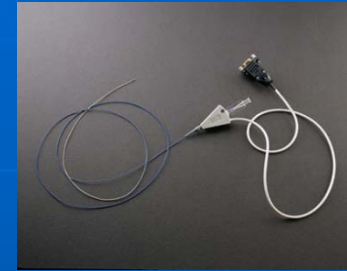


50% of all medical devices sold worldwide are manufactured in US!

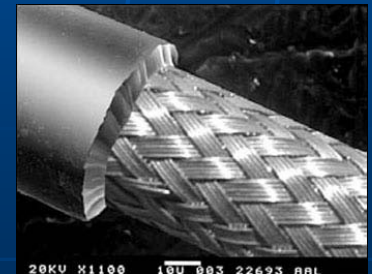
50% of the Medical Device manufacturing process is currently outsourced!



# Medical Applications of Laser Processing

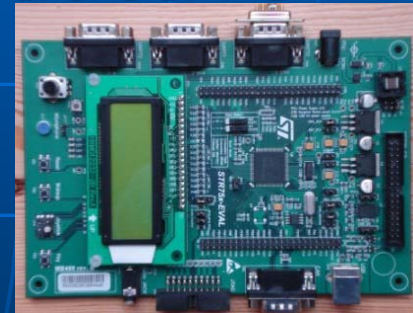


- ◆ Drug Delivery Orifices in Plastic Parts - Tubing and Injection Molded
- ◆ Thin Film Plastic Parts
- ◆ Micro-mechanical Parts
- ◆ Thin Film Patterning on Plastic Substrates
- ◆ Laminates and ceramics
- ◆ SS, Nitinol and other metals, tubing, etc.



# Microelectronic Applications of Laser Processing

- ◆ Microvia Drilling of Cu and Dielectric
- ◆ Profile Cutting - Through and Kiss Cut
- ◆ Dielectric Removal to Expose Conductive Leads
- ◆ Short Repair
- ◆ Solder Mask Removal
- ◆ Fine Line Generation by Patterning Resist Films
- ◆ Fine Line Generation by Direct Copper Patterning



# Defense/ Aerospace Applications

- ◆ Prototyping for High Value, Low Yield Parts-JPL

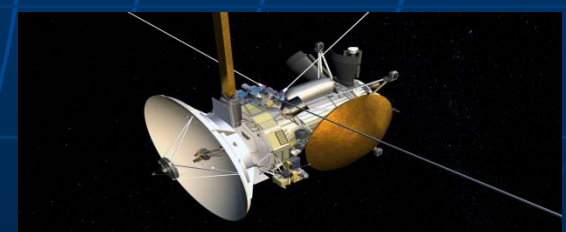


- ◆ Marking of Aircraft Wire

- ◆ High Resolution Wire Stripping



- ◆ Aircraft Flight Panels - Thin Film Patterning





# Lasers and Renewable Energy

- LED's



- Solar



## Batteries



# What can WE do for our Customers?

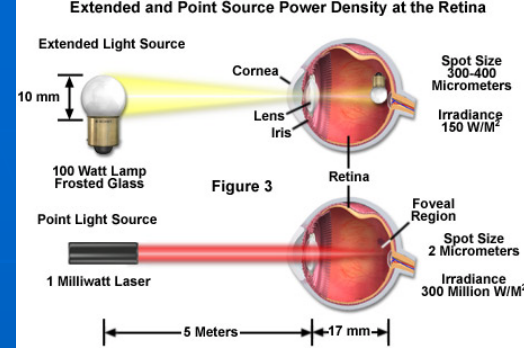


- Most lasers (and laser tools) cost a lot of money, SO ....
- We provide a place for customers to prototype before committing to a large purchase. **We have lots of visitors!**
- We provide short run manufacturing for customers that cannot afford in house tools.
- We provide the expertise gained after years of laser processing experience.
- We provide 'second source' or overflow for customers in production.
- We promote laser technology to 'make the pie bigger' so everyone in the industry benefits.

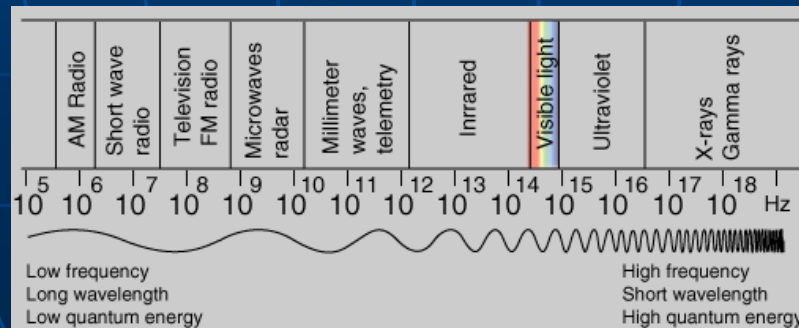
# Safety Issues Related to Laser Tools

- 1) Light - Eye Safety – the first thing everyone thinks about when the work LASER is spoken!
- 2) Gases -
- 3) Electrical –
- 4) Mechanical –
- 5) Materials -

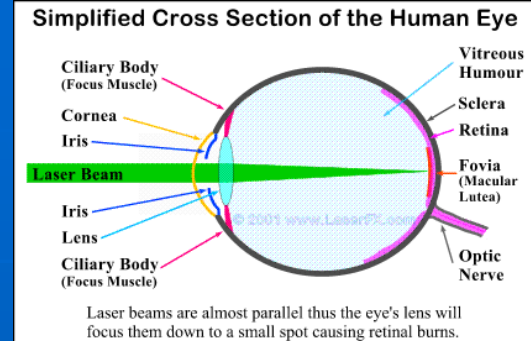
# Eye Considerations



- UV light is absorbed in the cornea within fractions of a micron from the surface and can 'break bonds'
- IR light can penetrate much further and interacts via a thermal mechanism
- Visible light (532 nm) is highly dangerous as it transmits through the cornea and burns the retina (permanently)



# Eye Considerations



- UV light - Energy per pulse on DPSS lasers is low (microJoules). Energy per pulse on excimer lasers is high (hundreds of mJ)
- IR light – high pulse energy even for low power lasers
- Most lasers (not excimer!) have high repetition rates – tens to hundreds of kHz



# Skin



- IR lasers will burn you if you get in the way of the beam.
- Even UV lasers can burn you with direct exposure, however you can get 'sunburn' from stray UV light.
- Always use shields, wear long sleeved shirts, and use sun block for exposed areas.



# Gases

- Excimer lasers use high pressure gases (Ne, He, HCl, F<sub>2</sub>, Ar, Xe Kr)
- Fluorine and HCl gases are used in a 5% mixture in the bottle and then diluted to about 0.1% in the laser head.
- F<sub>2</sub> and HCl both have distinctive odors even at low c. HCl will destroy metals in the lab.



# Gases

- Other gases are inert, but under high pressure so proper handling procedures must be in place.
- Cylinders can become missiles if the neck is broken.
- Oxygen can be depleted if lots of gas is released into a small confined space.



Also known as a bottle rocket!





# Gases

- Some CO<sub>2</sub> lasers require flowing gases – this mix contains CO<sub>2</sub>, He and N<sub>2</sub>.
- At times other gases are used as assist gases like O<sub>2</sub>, liquid N<sub>2</sub> blow off or compressed air.
- All of the gases used must therefore be dissipated or trapped (for instance used excimer gases are trapped in a halogen filter).

# Electrical



- Lethal voltages are present in the AC distribution box and in the laser head!
- 110 – 120 V for most small items, 208V, single or three phase with 30A per leg typical ... up to 480V in some cases.
- Only qualified service people should have access.

# Electrical

- Interlocks – shutter the laser output when interrupted – key switch can choose between operator and service mode.



- EMO – cuts power to the AC distribution box.



# Mechanical

- Large motion systems, conveyors, moving parts may pose mechanical hazards to people.
- Mechanical guards should be used with labels at 'pinch points'.
- Closed toed shoes should be worn in the lab!!!!

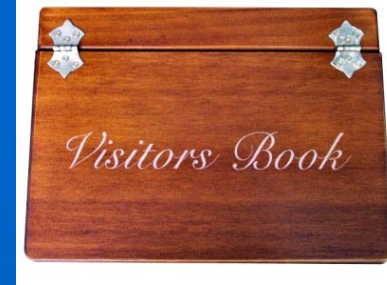


# Materials



- Toxic materials from effluent can be hazardous:
- Polymers can create toxic carbon compounds
- BeCu, Ni, etc. .... Many metals and ceramics are also toxic – fortunately we remove very little material in micromachining, but we still need to be aware!

# Other Considerations



- Visitors – must adhere to policies AND sign a document saying so!
- Pinch points, hazardous points, light exposure points, etc. must be properly labeled.
- CLASS I systems are typical for installed laser tools – Class IV systems are typical in Job Shops.
- Inspection and record keeping are key!

# Visit from our Friendly NH Safety Folks



- Random visit !
- Never left conference room
- Wrote us up for:
  - 1) Not having 3 days of food on hand
  - 2) Not having in place a policy of dealing with gun carrying psychos
  - 3) A few other minute things ....
    - \* More concerned with no workman's comp. claims than in real safety!

# PhotoMachining Class 10,000 Clean Room







# X. Conclusion



- ◆ Lasers provide a valuable and unique capability in high precision materials processing
- ◆ Several new and different kinds of lasers are now available – expanding our processing capabilities but requiring safety considerations
- ◆ Not only the light, but other factors are involved in keeping a Safe Workplace
- ◆ Safety is an ongoing process and a workplace mentality, not just a one-off thing!

# Thank You.



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