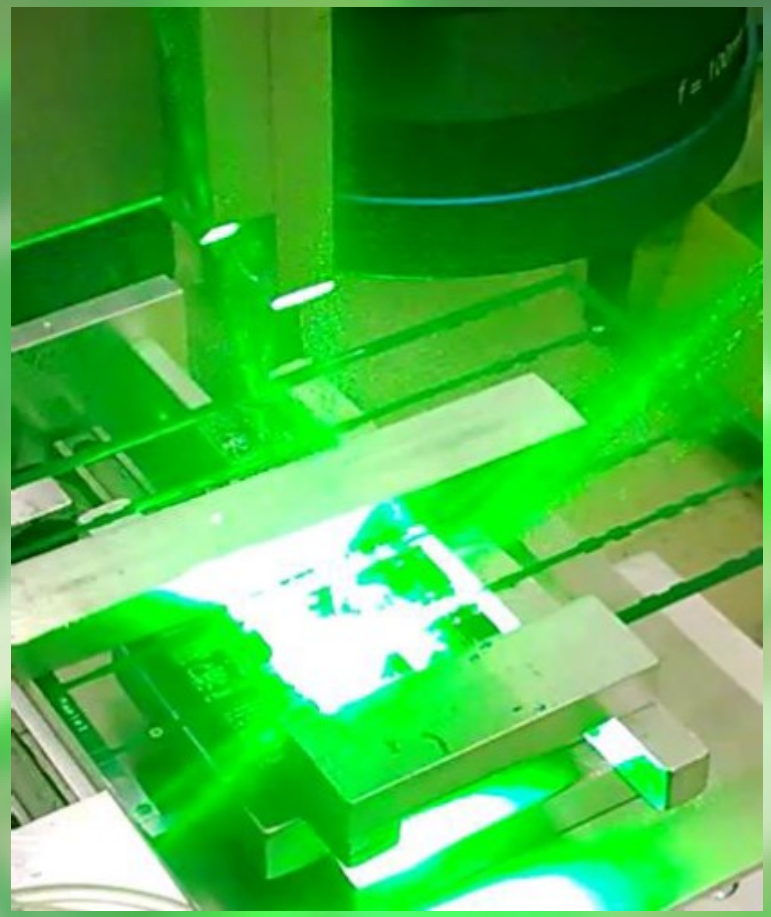
GETECH

"Performance, Value, Integrity"

Introduction to Laser Depaneling



Different PCB **Depaneling Methods**

Contact method

- Breaking by hand
- Pizza cutter
- Punching
- Mechanical routing
- Sawing

Non-contact method

- Laser

  Advantages

  ✓Zero mechanical stress

  ✓Zero tool wear

  ✓Fine cut width

  Disadvantages

  × Not for thick PCBs

  × Not the fastest

  × Not the cheapest

Lasers can be **sorted** by...

Gain medium

- Gas lasers (CO_2)
- Solid state lasers (Nd:YAG)
- Fiber lasers etc.

Wavelengths

- Far IR (CO_2 lasers)
- Near IR (Nd:YAG, fiber)
- Visible
- UV
- Deep UV etc.

Operation modes

- Continuous wave
- Q-switched (ns pulses)
- Mode locked (ps to fs pulses) etc.

Safety class

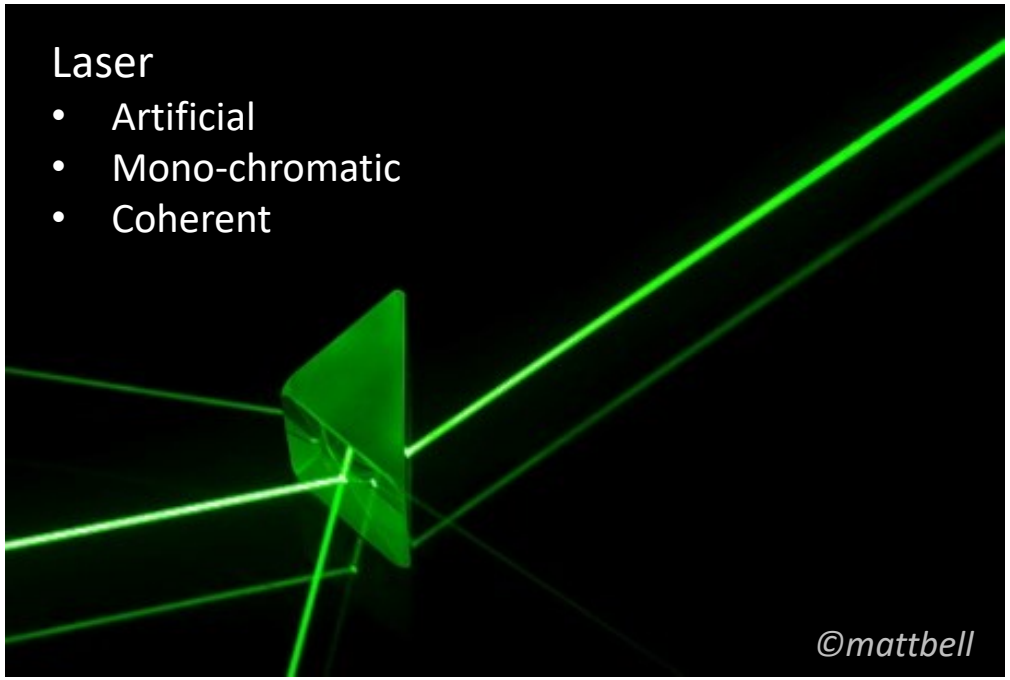
- Class 1
- Class 2
- Class 3
- Class 4 etc.

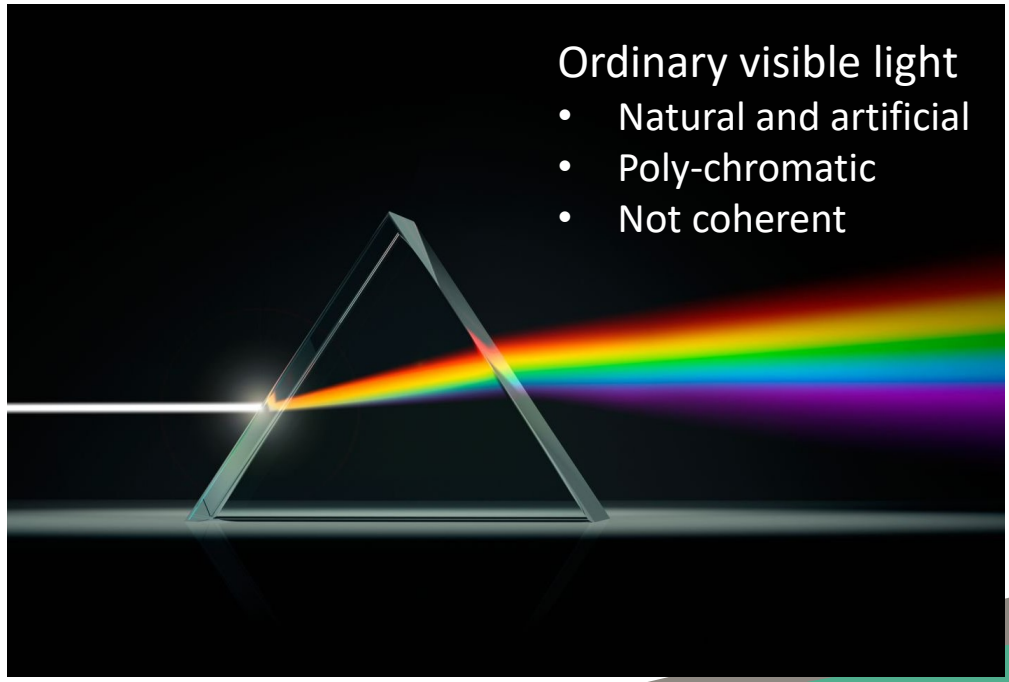
and so on...

What is **laser**?

Light **A**mplification by **S**timulated **E**mission of **R**adiation

- It is simply light with some unique properties



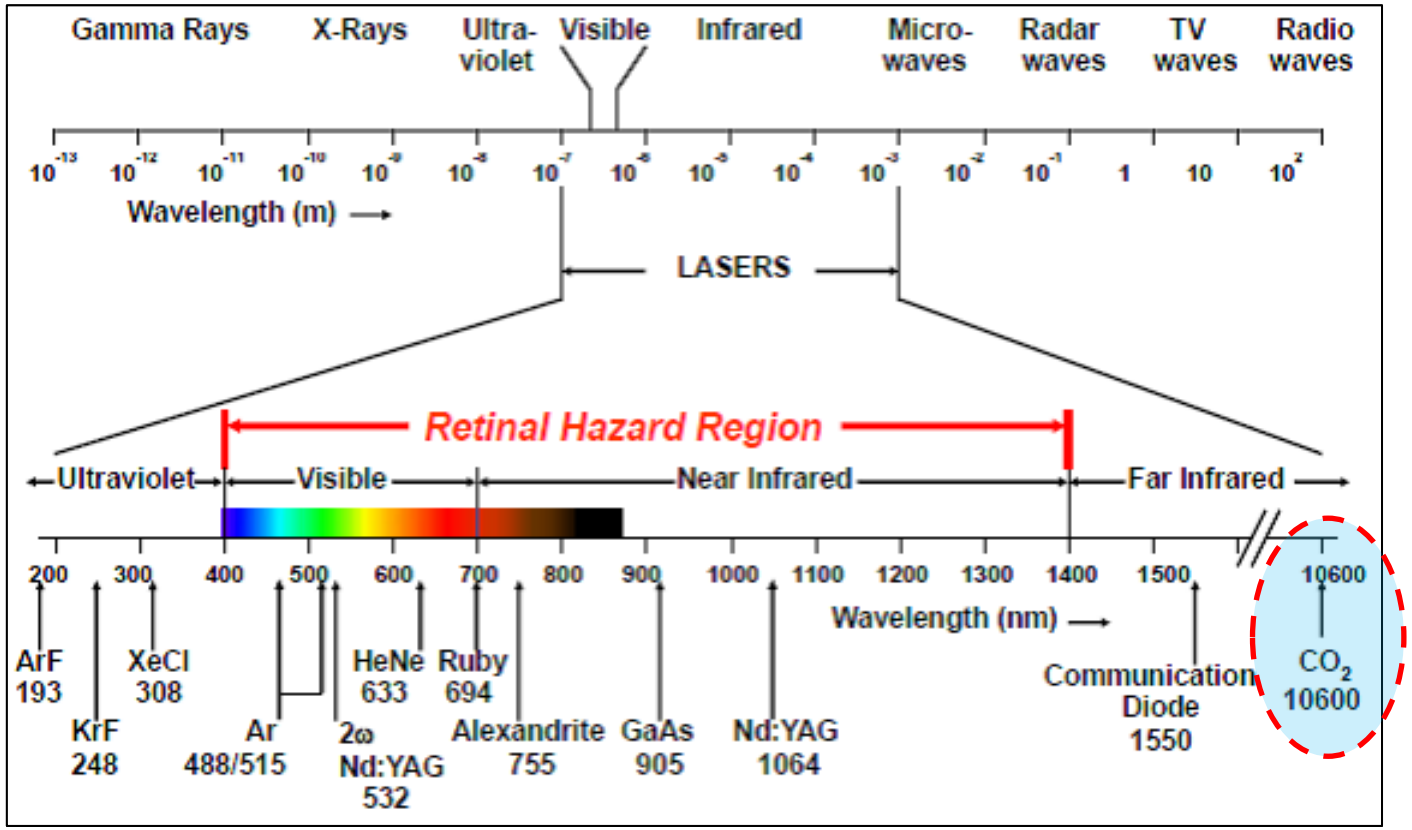


Light is a form of **electro-magnetic radiation**

So are gamma rays, X-rays, UV rays, IR rays, microwaves and radio waves

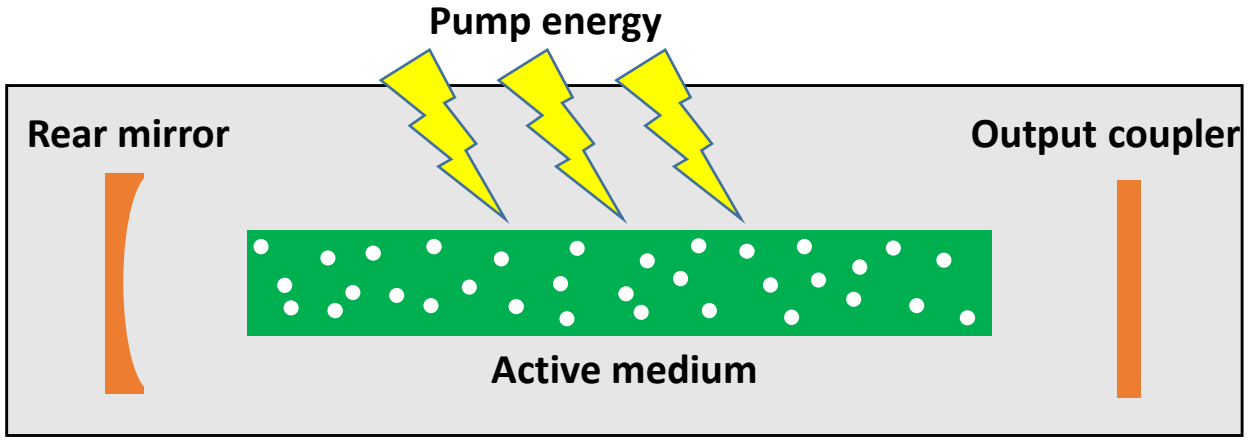
The difference lies in the ***wavelength***

There are many lasers that are not visible by the naked eye

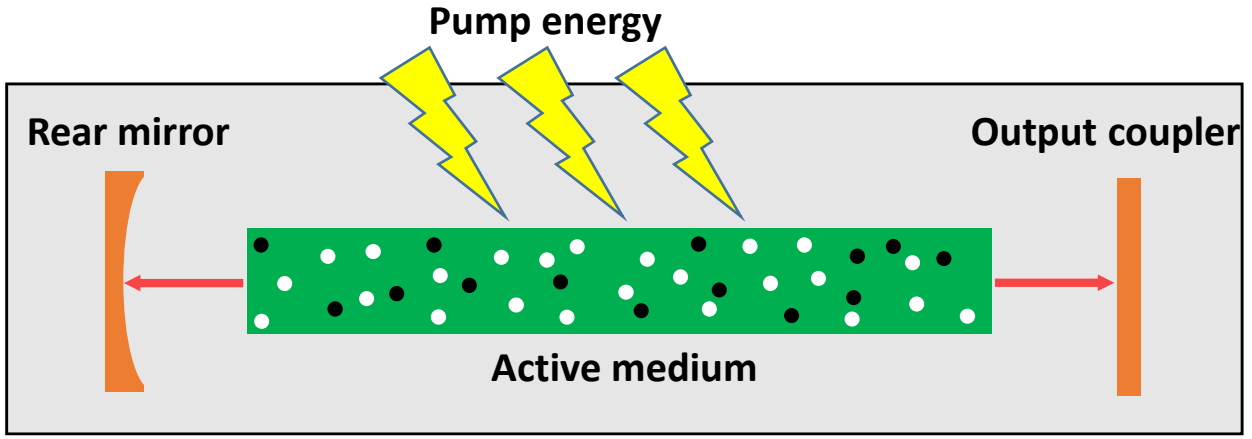


How is laser **generated**? – Basic concept 1

Pumping



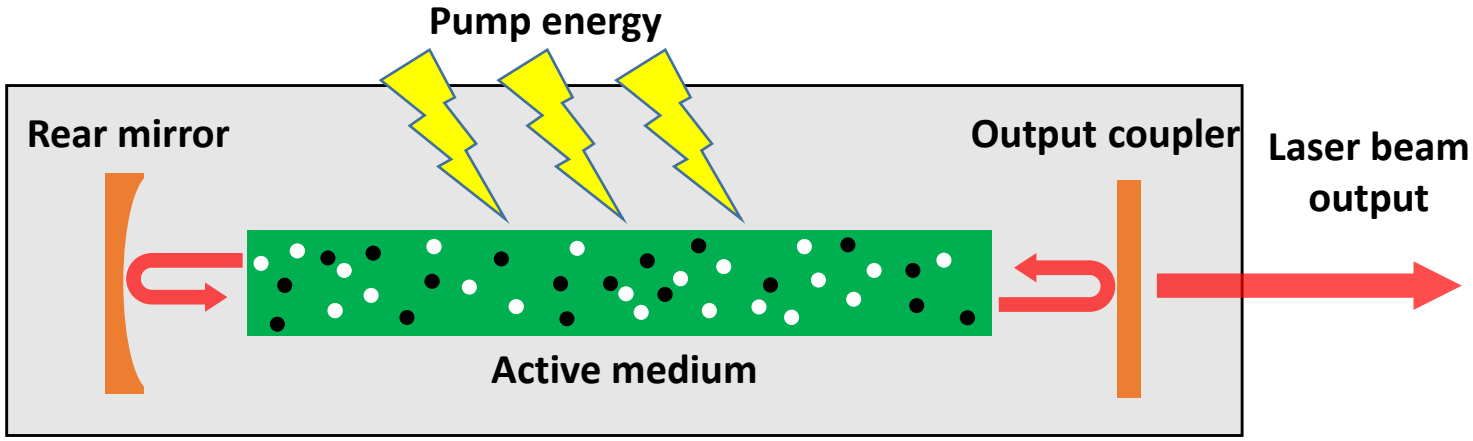
Population inversion



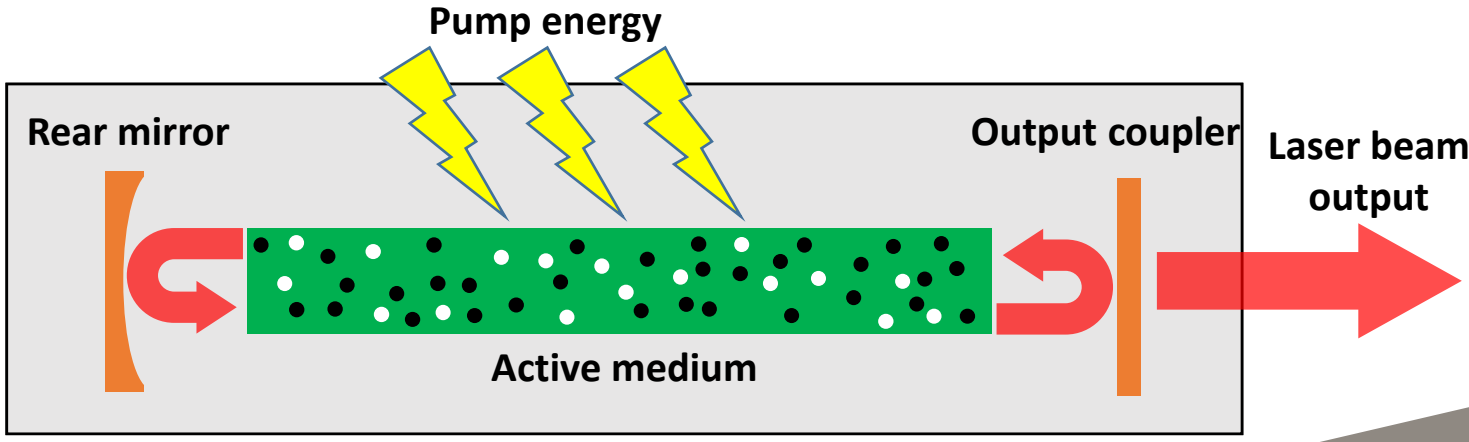
● Excited atom ○ Unexcited atom

How is laser **generated**? – Basic concept 2

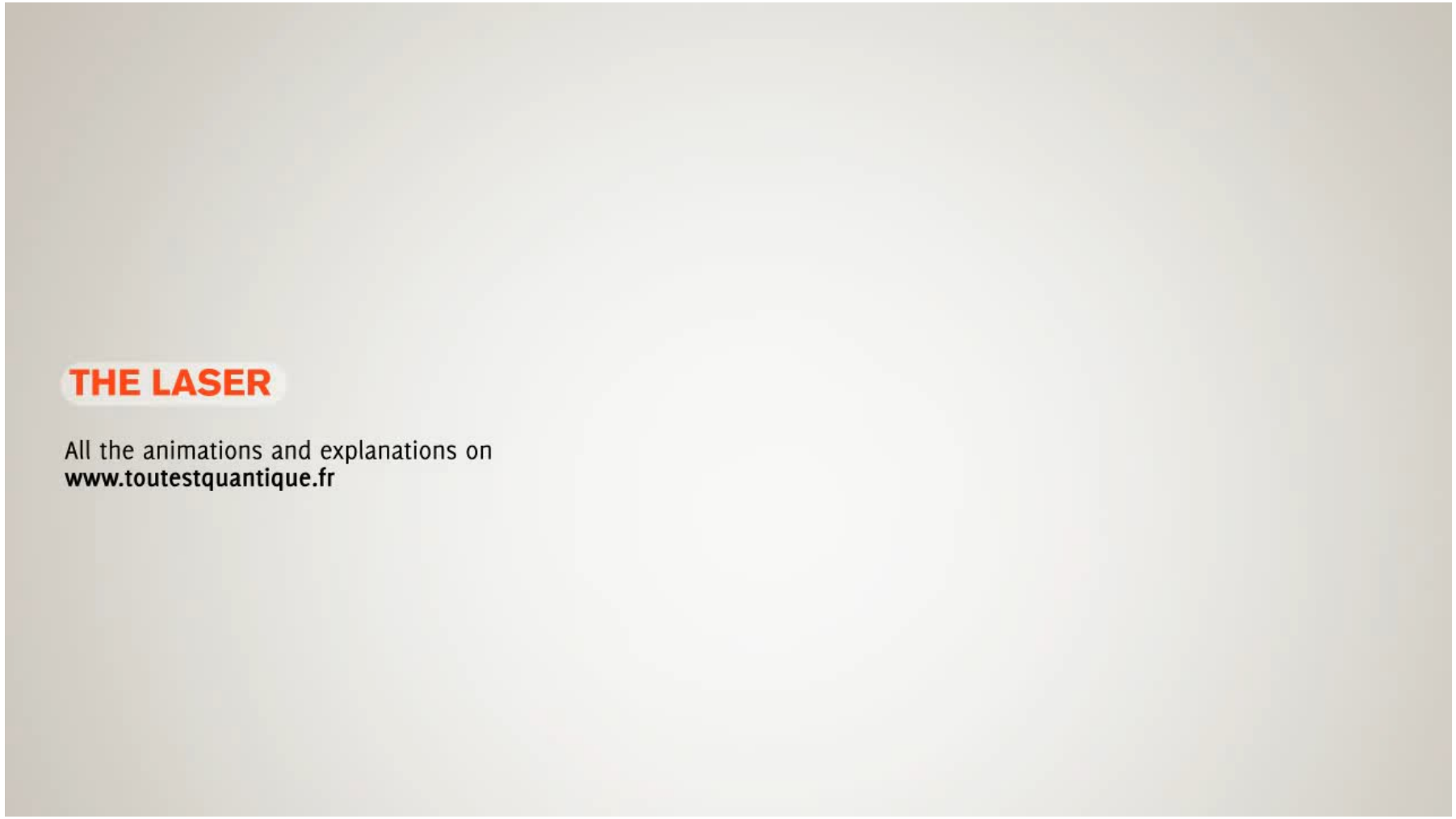
Stimulated emission



Amplification



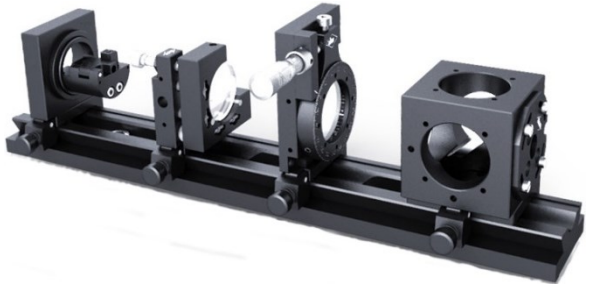
● Excited atom ○ Unexcited atom


THE LASER
All the animations and explanations on
www.toutestquantique.fr

What do you need in order to **cut with laser**?

Laser source

This is where the laser comes from



Beam manipulation optics

This is what makes the laser ‘bend’ to our will

Focusing optics
(including positioning)

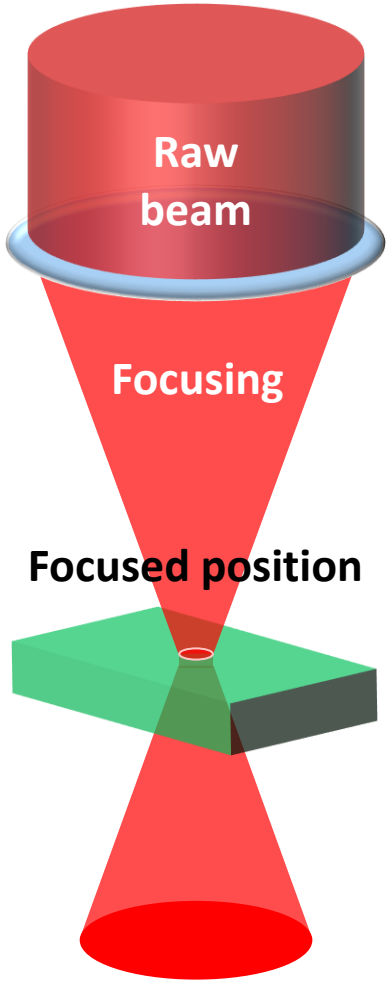
This is what cuts your PCBs

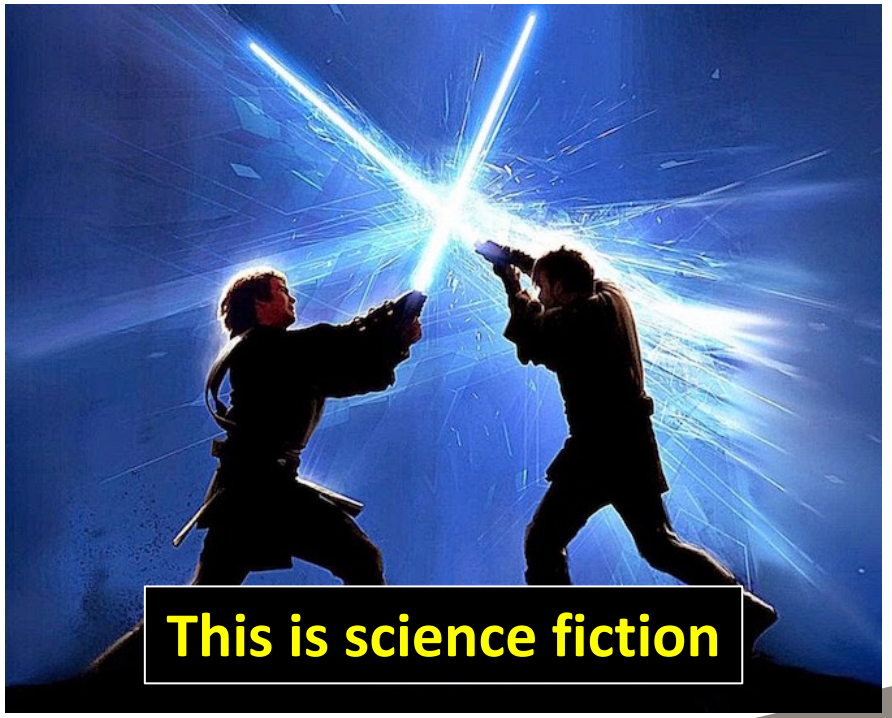
**Note: Getech does not manufacture laser sources and optics*

How does **laser cut** PCB? – Basic 1

Focusing the laser to a very small spot to intensify the power

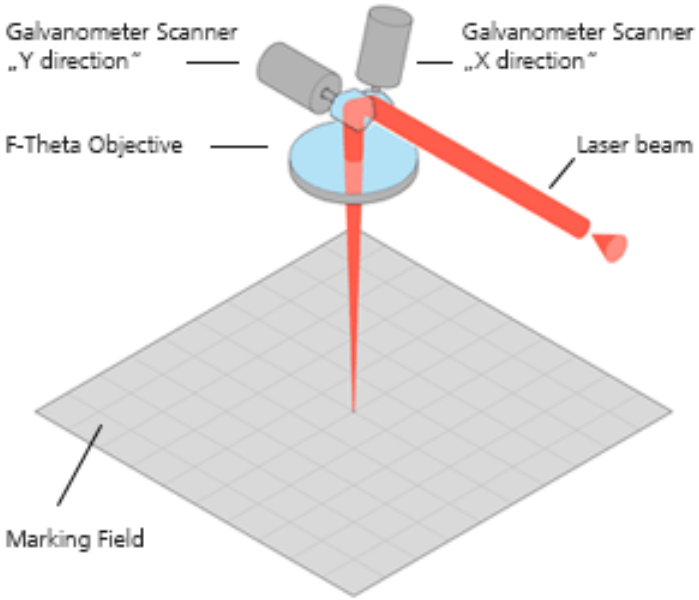
Cutting is only possible at the focused position where intensity is the highest



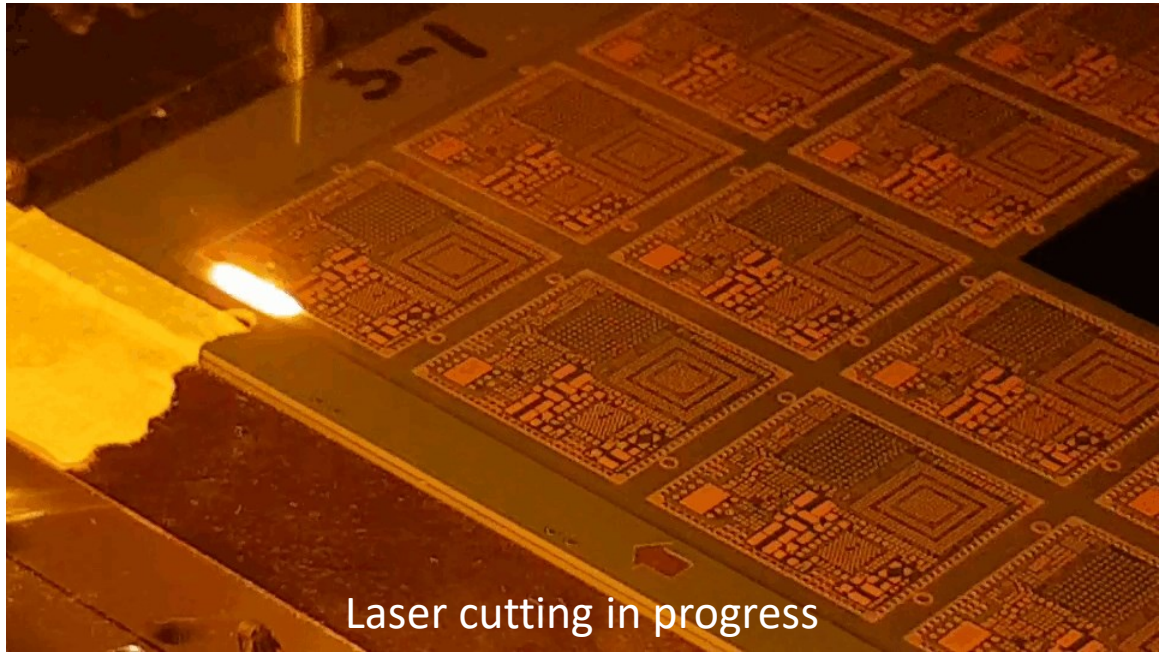


How does **laser cut** PCB? – Basic 2

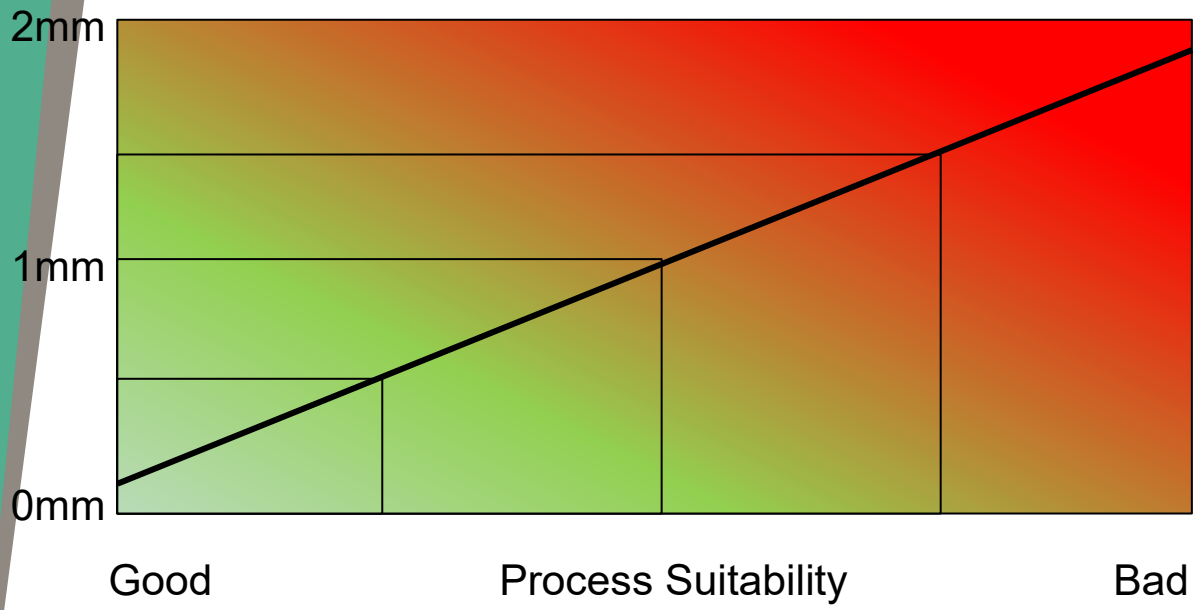
Galvanometric scanner runs the laser beam across the panel



Mirrors deflect laser to cut at desired spot
https://www.raylase.de/en/products/2-axis-deflection-unit.html

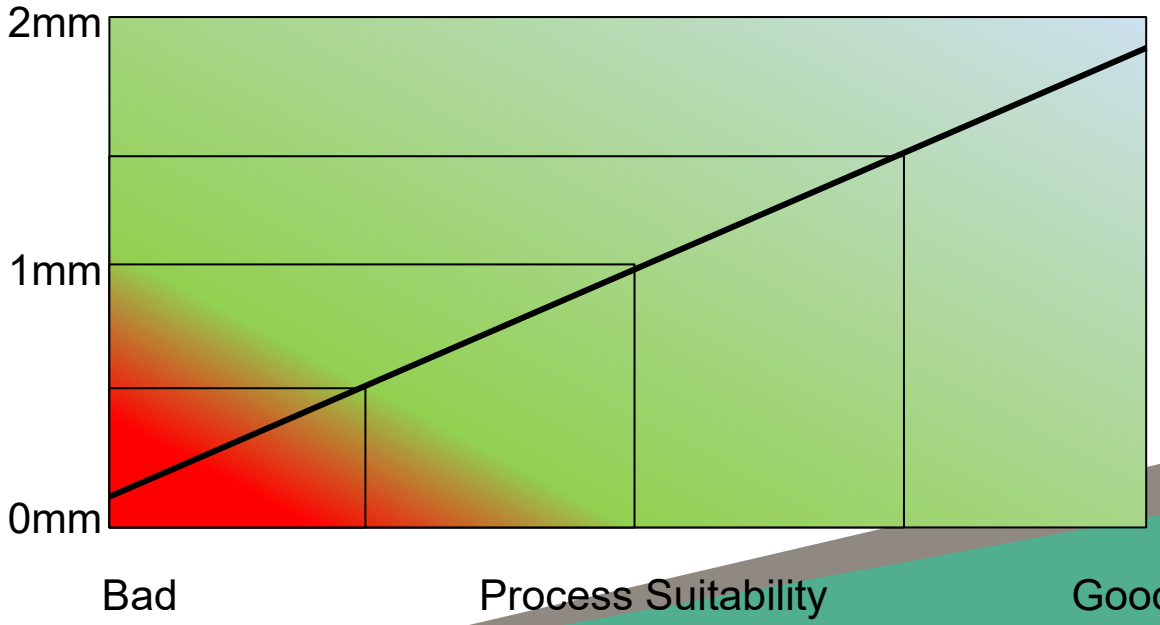


PCB Thickness Limitations



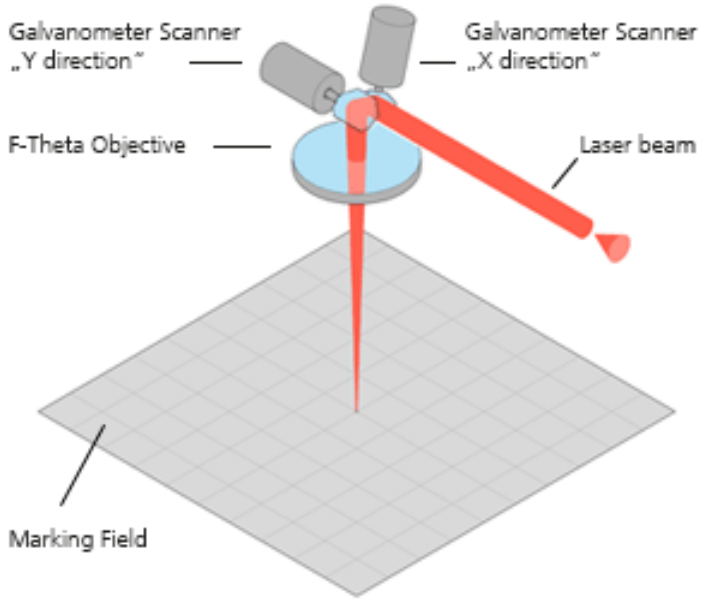
Laser routers

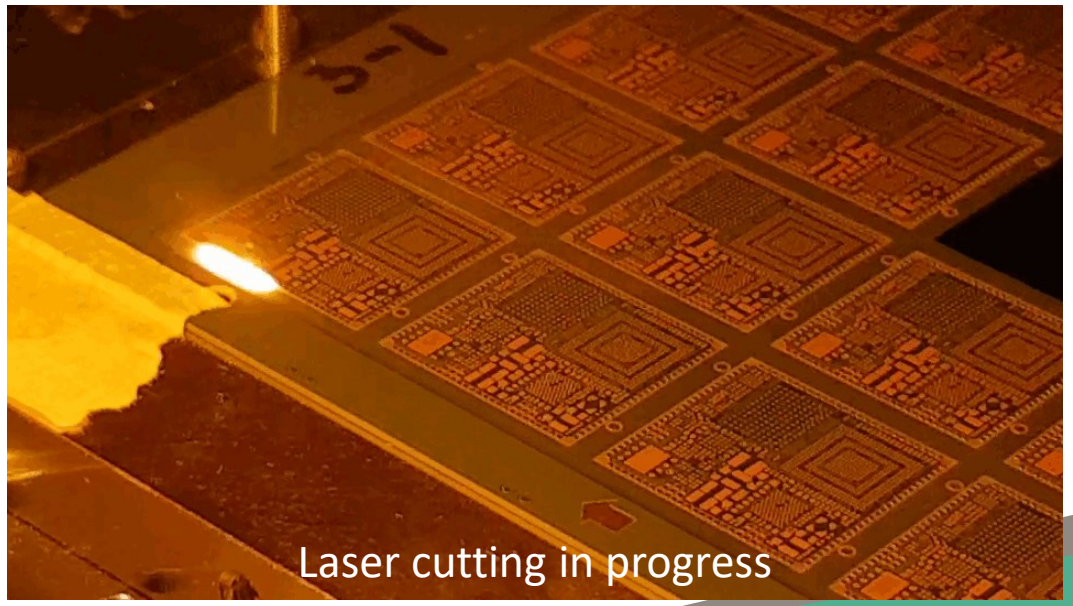
Mechanical routers



Lasers for **PCB Depaneling**

Type	Wavelength nm	Pulse duration sec	Power W
Nanosecond green	≈ 532	≈ 10 to 20 (x 10^{-9})	20 to 40
Nanosecond UV	≈ 355	≈ 10 to 20 (x 10^{-9})	5 to 20
Picosecond IR	≈ 1064	≈ 2 to 15 (x 10^{-12})	60 to 100

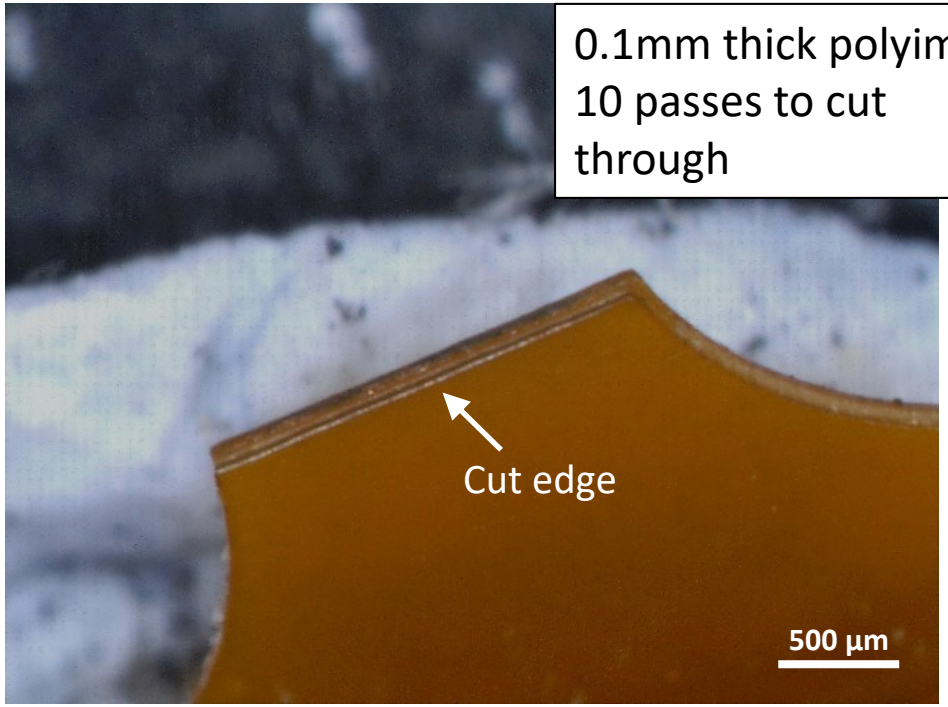


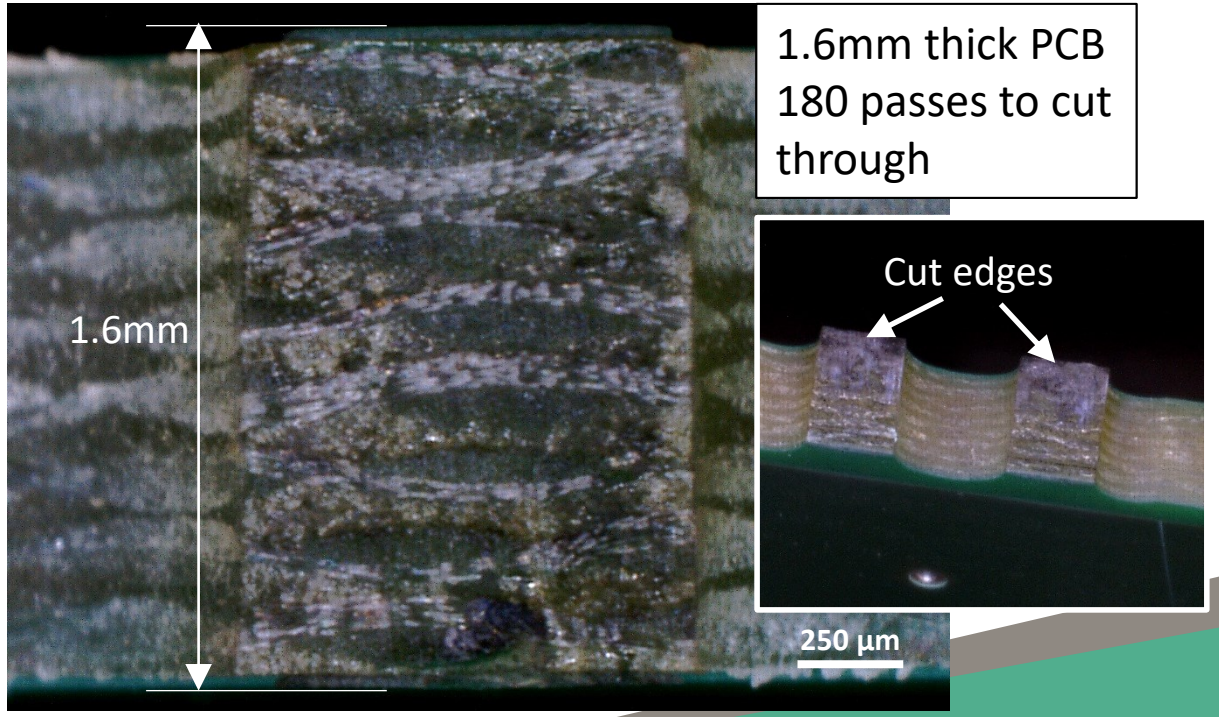


How does **laser cut** PCB? – Basic 3

Ablates a few microns to tens of microns ***deep*** per pass

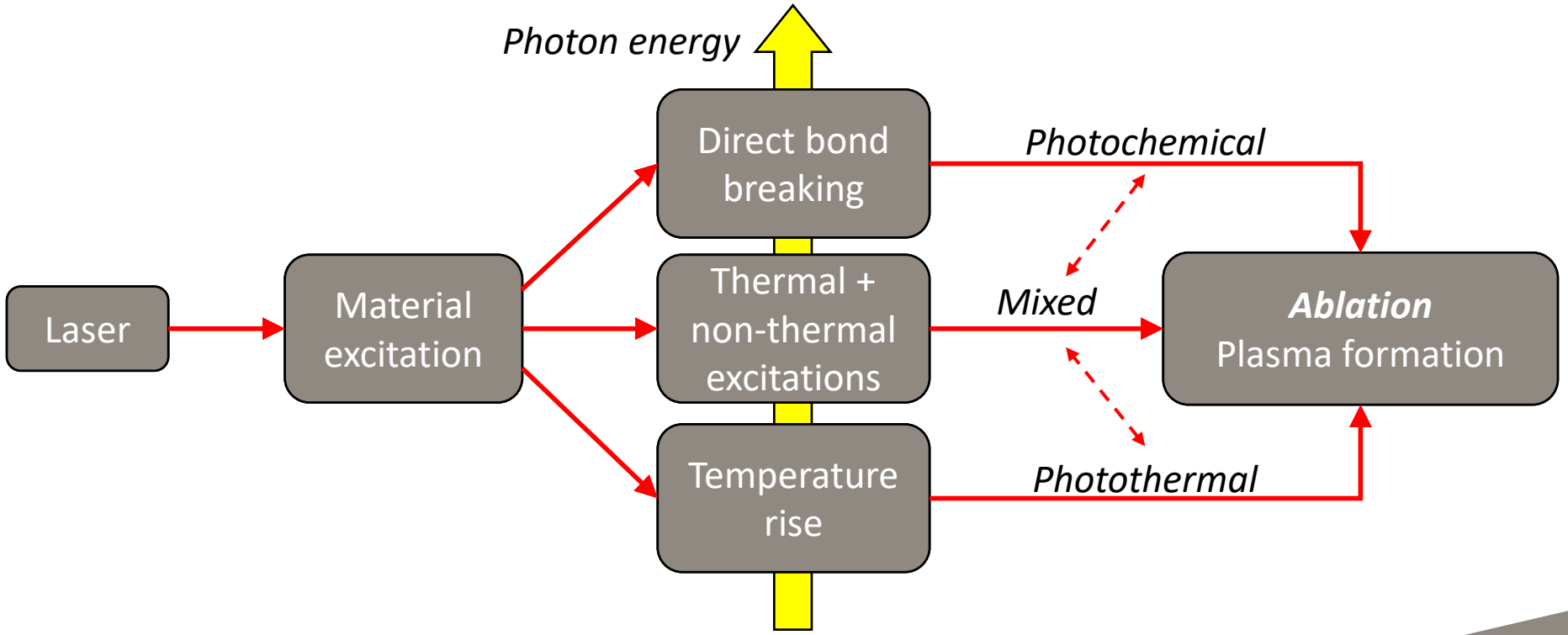
- The thicker the panel, the more passes it takes





What is **ablation**?

The process of ***removing material*** from a substrate using a laser beam



Bäuerle. (2000). *Laser Processing and Chemistry.* Berlin, Heidelberg: Springer-Verlag

Photo**thermal** or photo**chemical**?

Green laser photon

2.33eV (≈3.73x10^{-19} J)

More photochemical

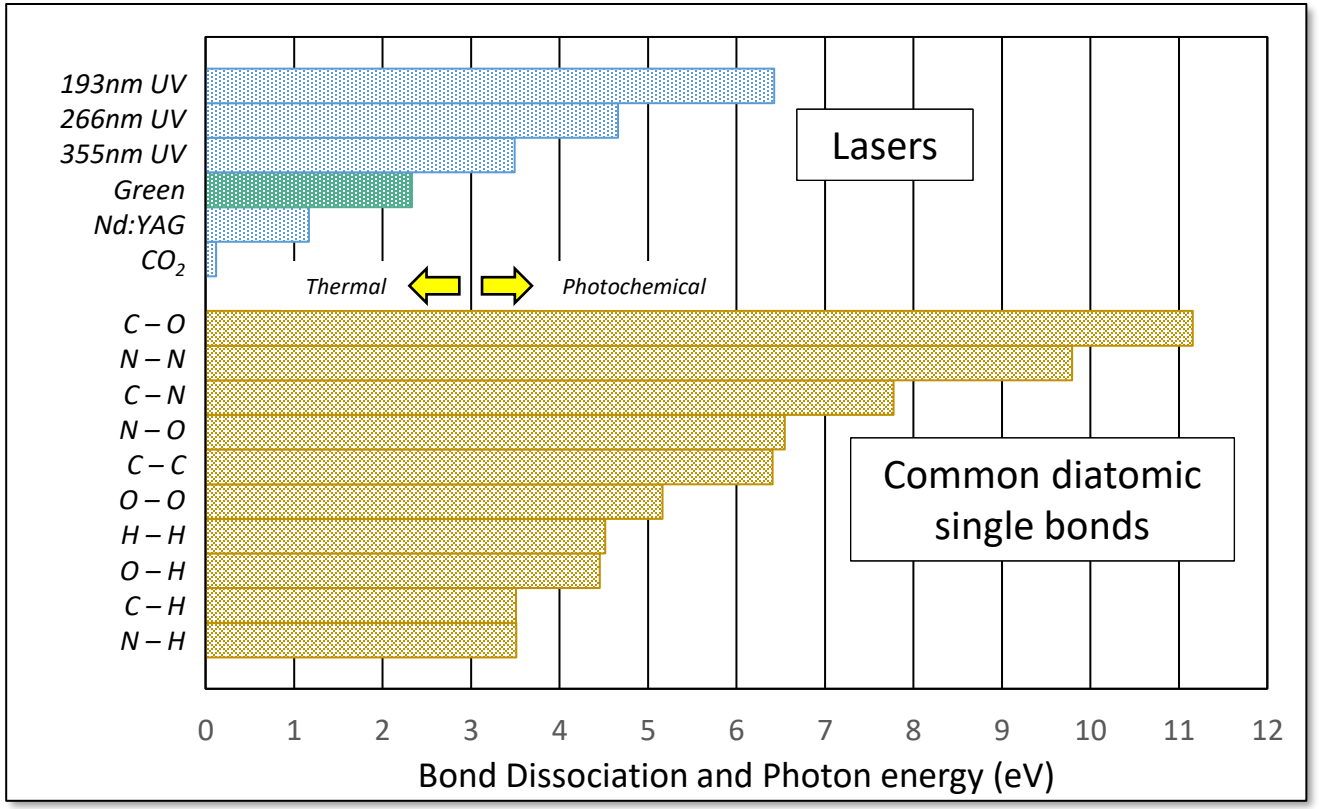
Less photothermal

CO_2 laser photon

0.12eV (≈1.87x10^{-20} J)

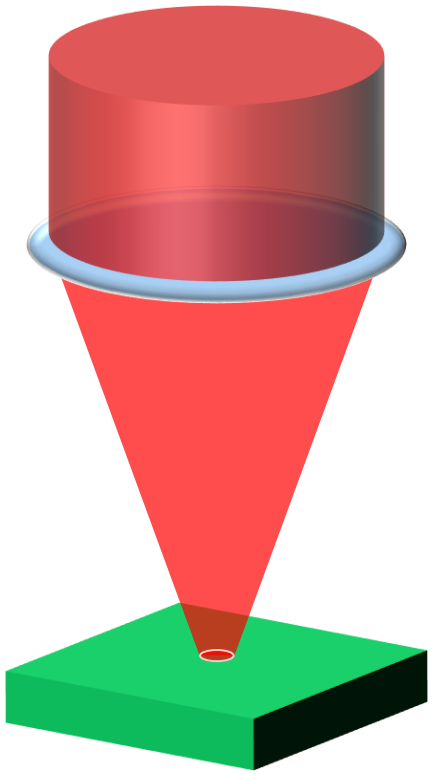
More photothermal

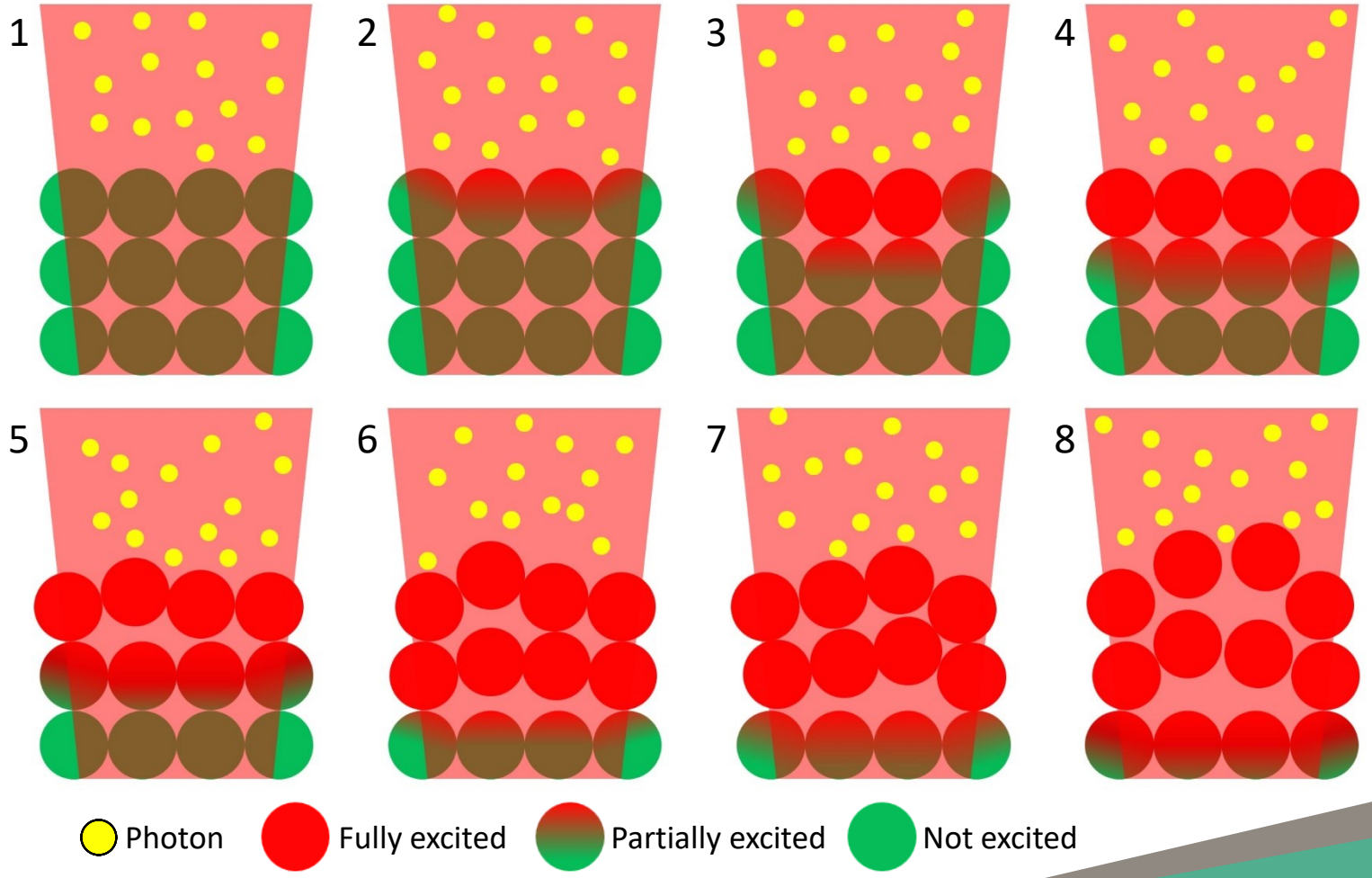
Less photochemical



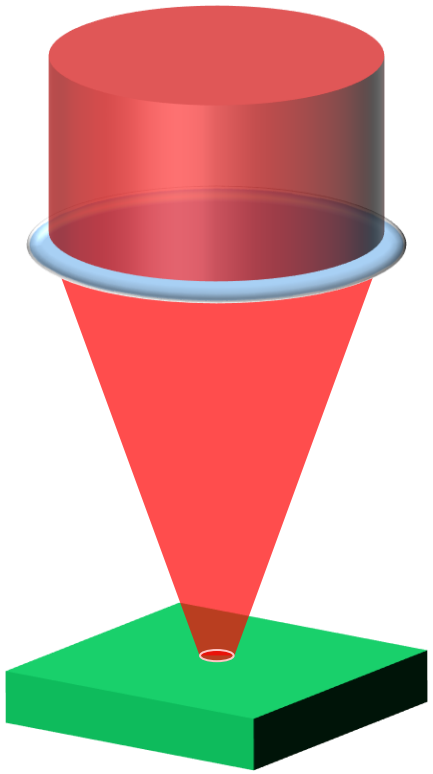
Yu-Ran, Luo. (2007). *Comprehensive Handbook of Chemical Bond Energies.* Boca Raton, FL: Taylor & Francis Group

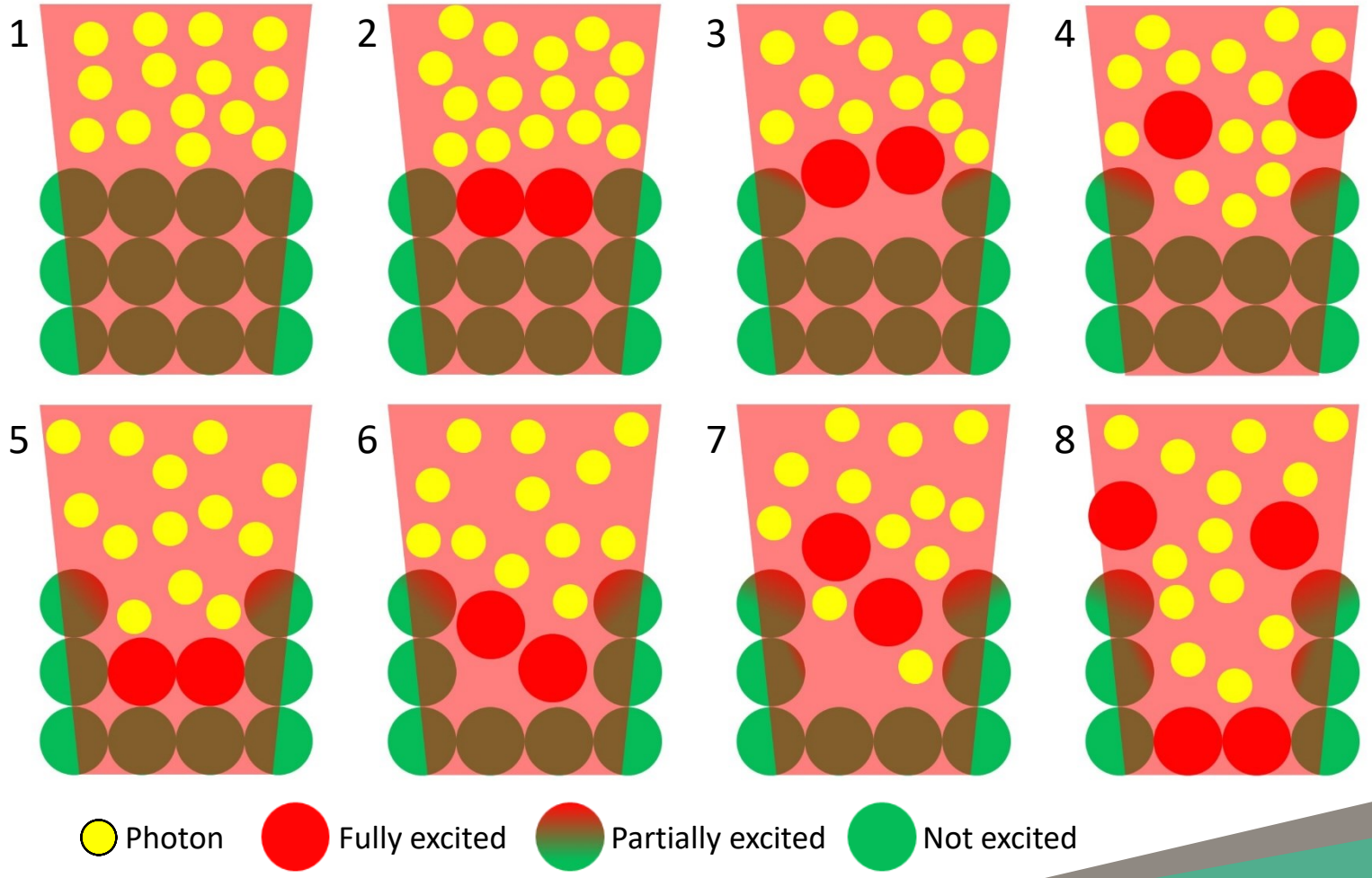
Photo**thermal** excitation





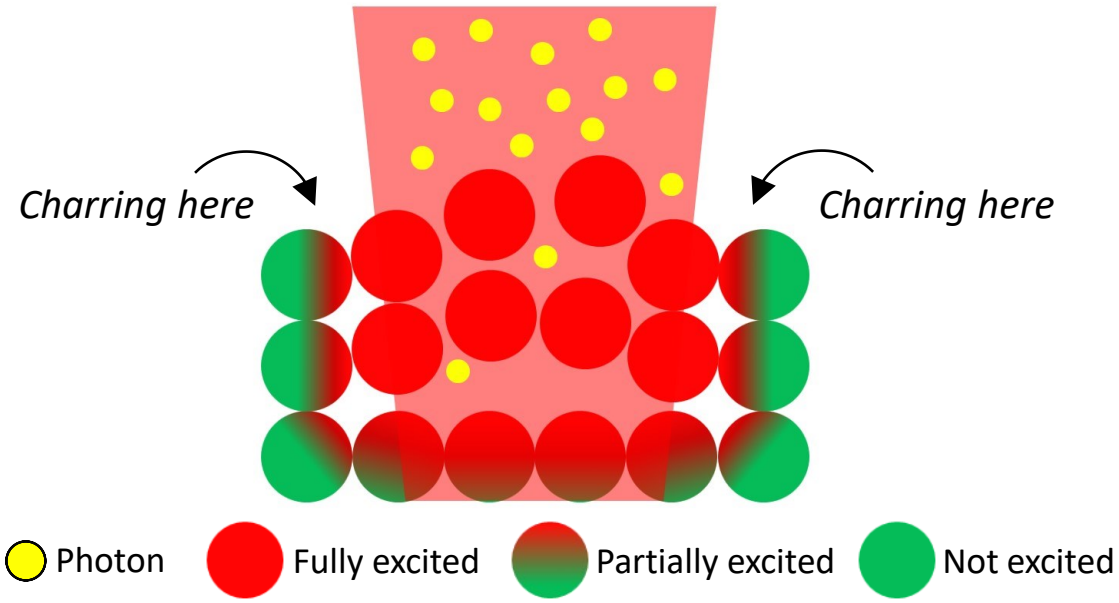
Photo**chemical** excitation

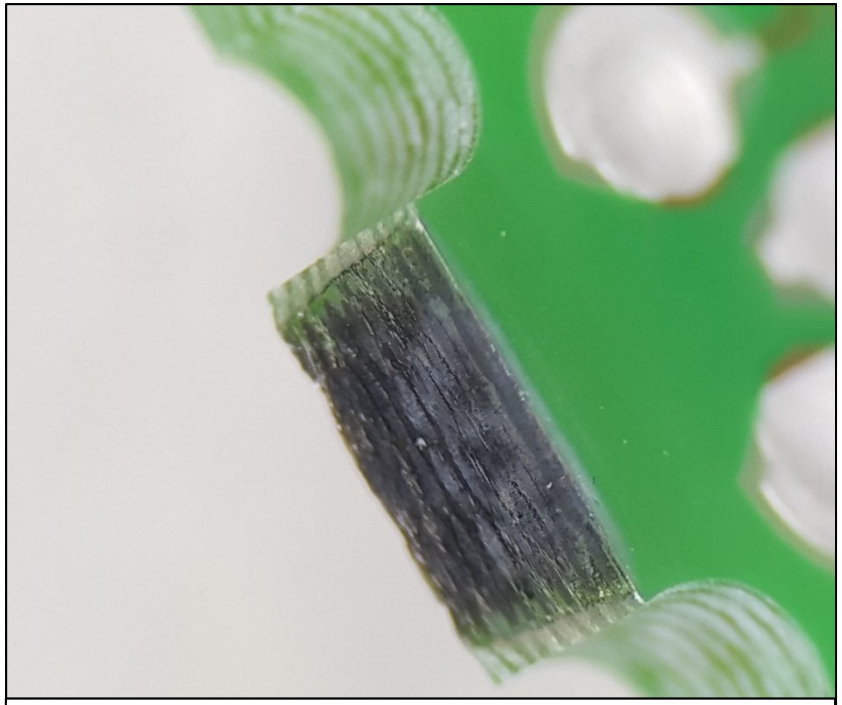




What about **charring**?

It is a result of ***heat accumulation*** in the material that is ***directly beside*** those being ablated

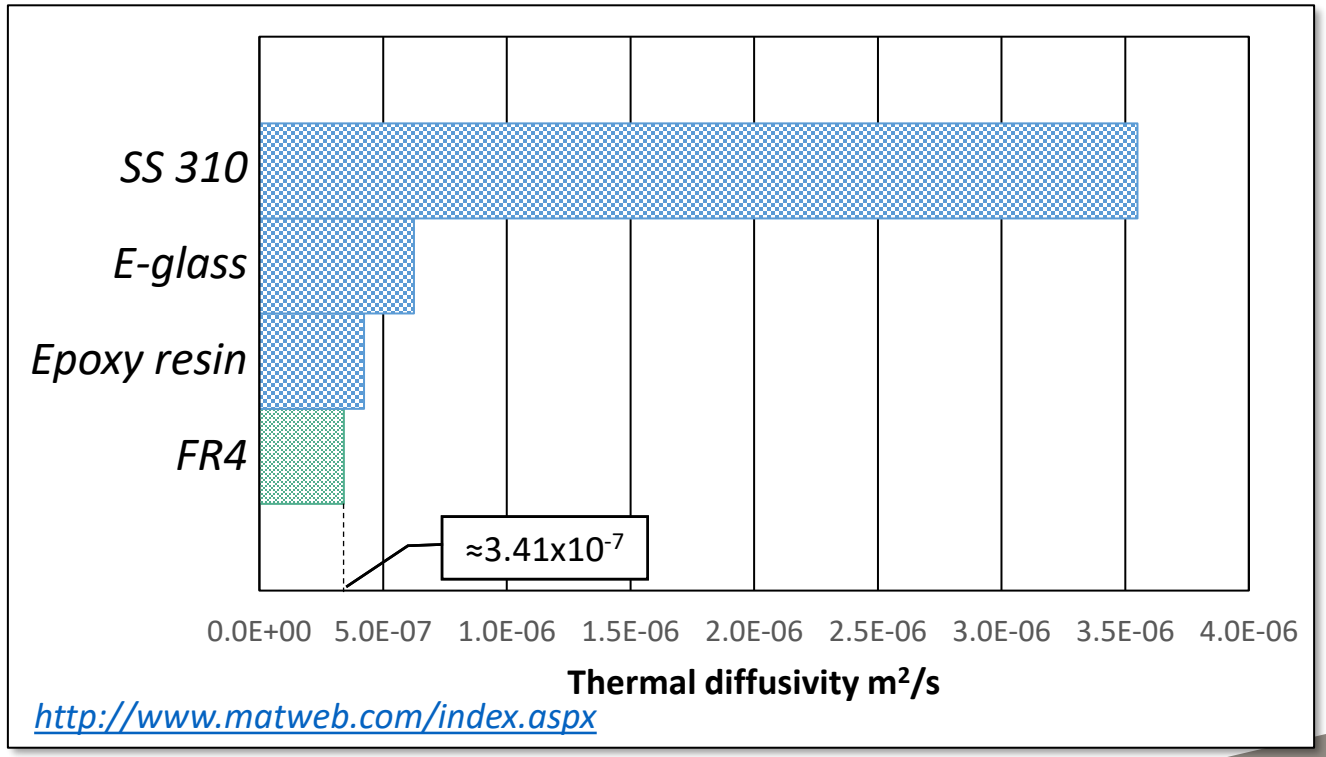




Char residue is left on the surface of the side that is not cut

Why does it happen?

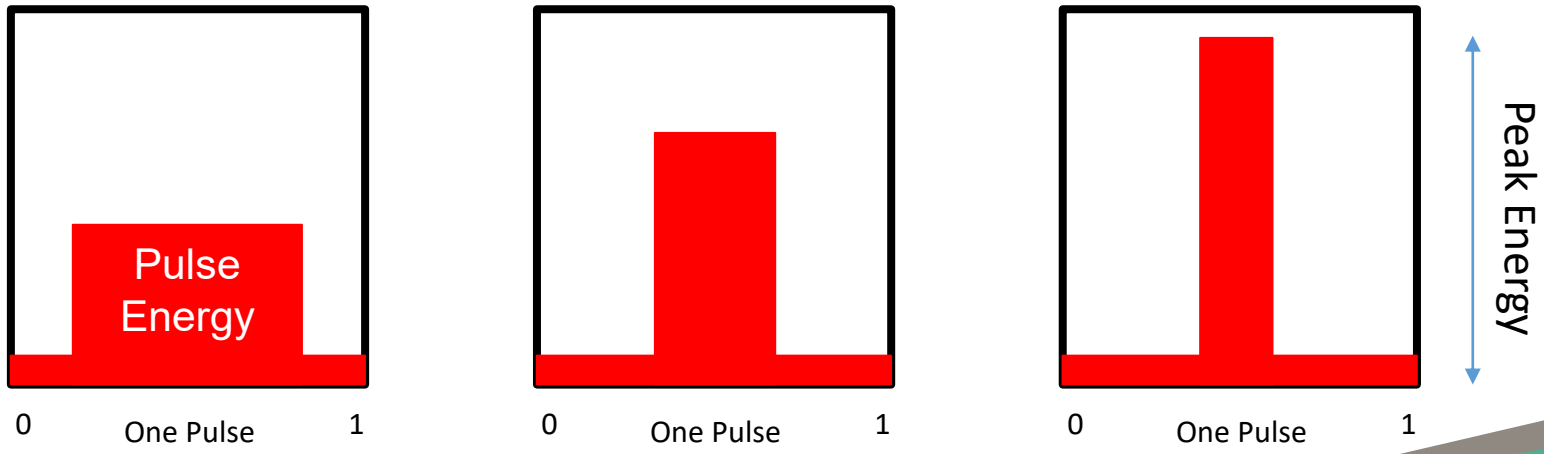
Heat accumulates because the material is ***unable to conduct the heat away from the cutting site*** faster than it receives



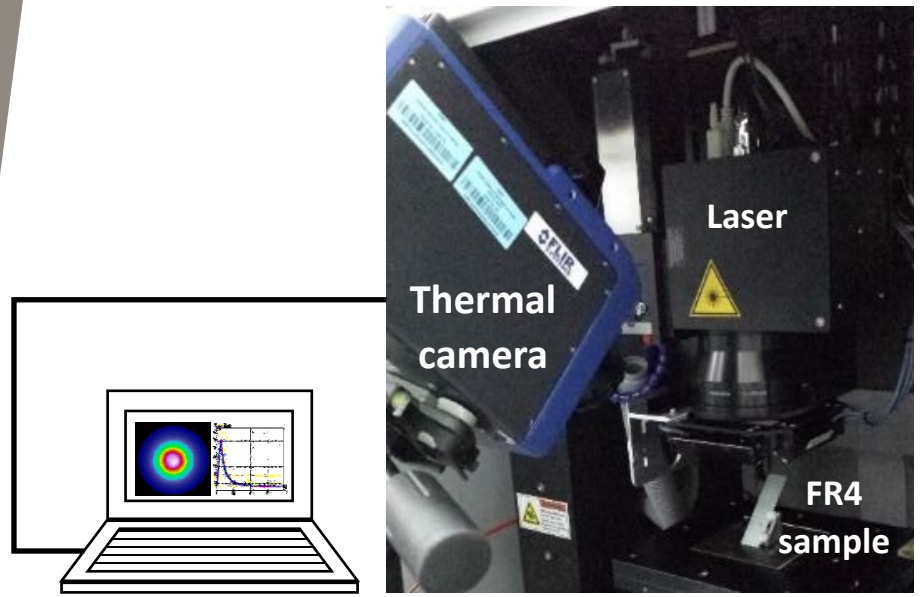
The Old, Current and Future

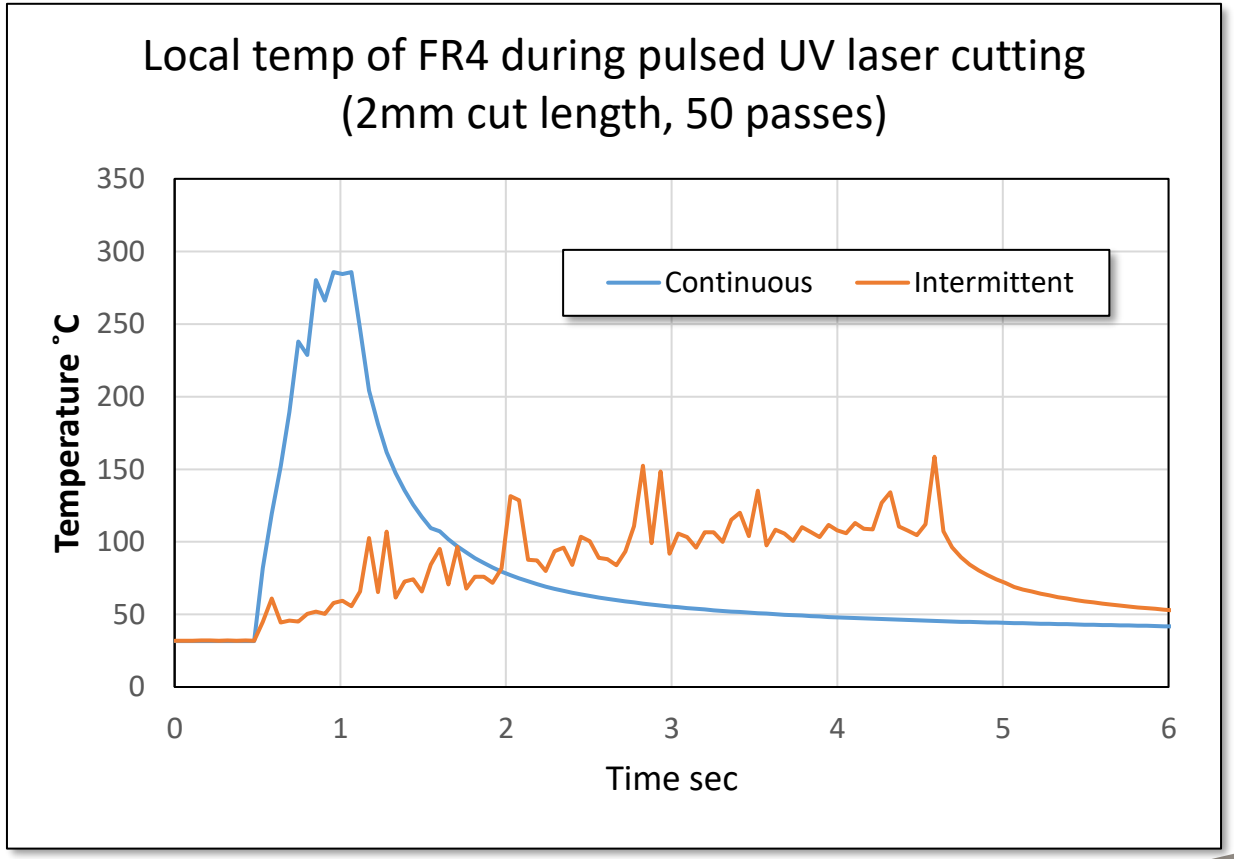
Type	Wavelength nm	Pulse duration sec	Power W
CO2	≈ 10,000	Continuous Wave	High
Nanosecond green	≈ 532	≈ 10 to 20 (x 10^{-9})	20 to 40
Nanosecond UV	≈ 355	≈ 10 to 20 (x 10^{-9})	5 to 20
Picosecond IR	≈ 1064	≈ 2 to 15 (x 10^{-12})	60 to 100

To Pulse or Not to Pulse?



How do we **reduce** heat accumulation?



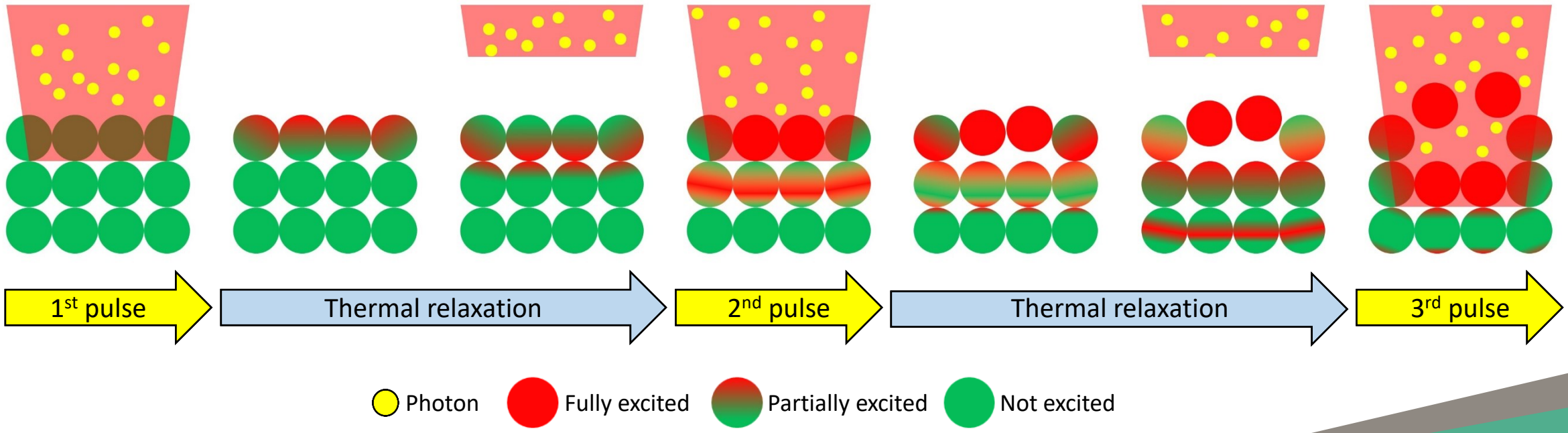


Temperature data collection and analysis courtesy of SIMTech

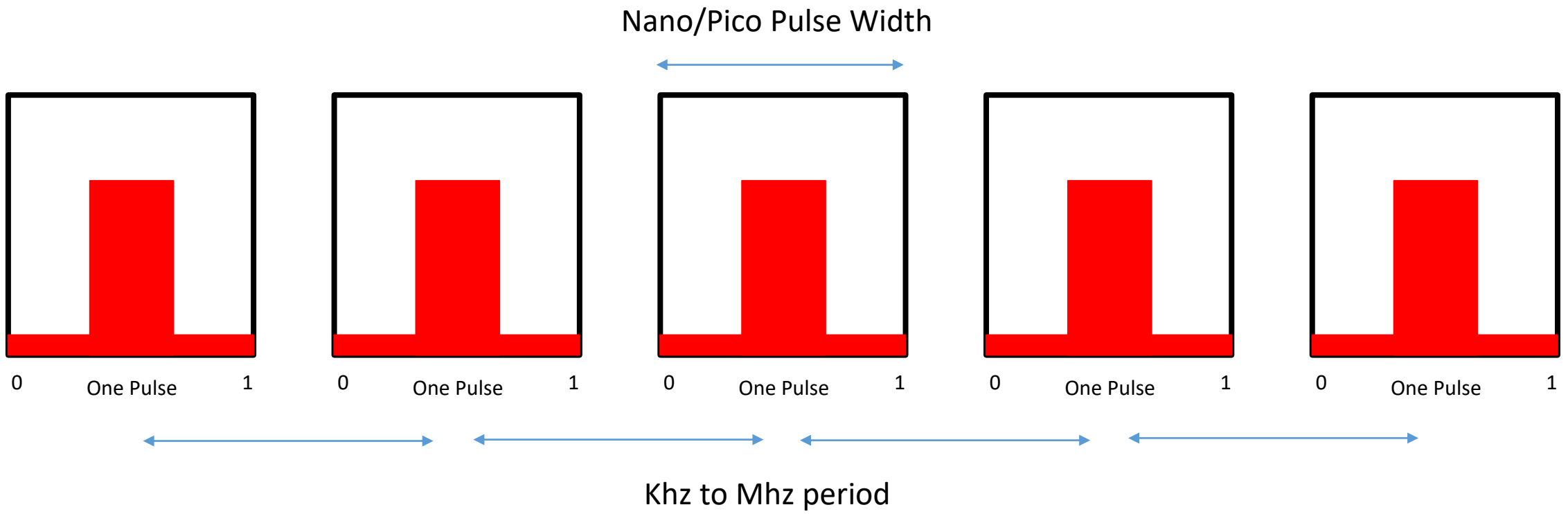
Reduce the **laser-material interaction time** – 1

Short-pulse lasers allow 'thermal relaxation' time between laser pulses

- ***Nanosecond*** or shorter pulse durations



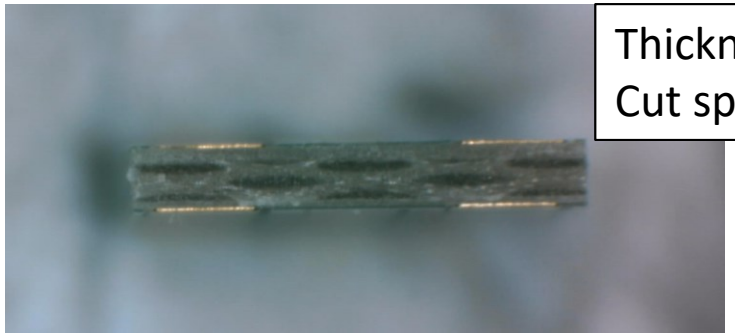
Pulse rates V Repetition rate



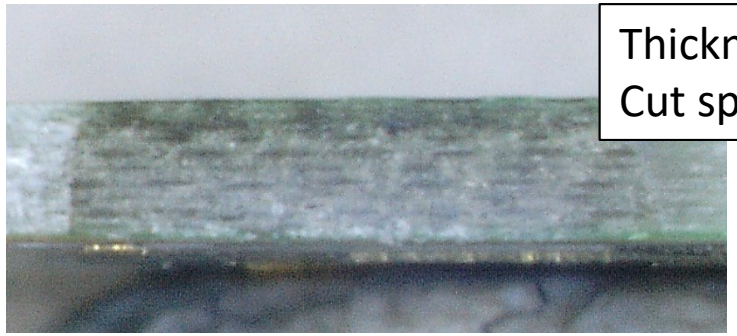
Reduce the **laser-material interaction time** – 2

Reduce thickness of the tabs being cut, ***preferably 0.6mm or less***

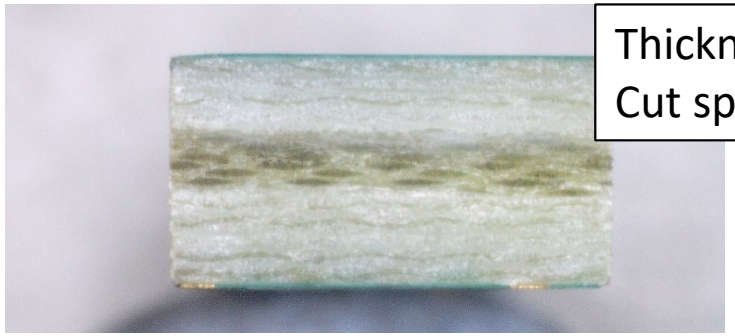
- Consider complementary V-scoring if it is thicker than 1mm



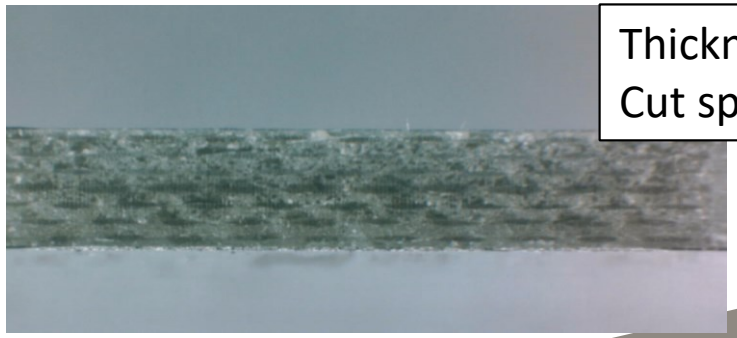
Thickness: 0.455 mm
Cut speed: 5.48 mm/s



Thickness: 0.7 mm
Cut speed: 0.94 mm/s



Thickness: 0.445 mm
Cut speed: 4.33 mm/s

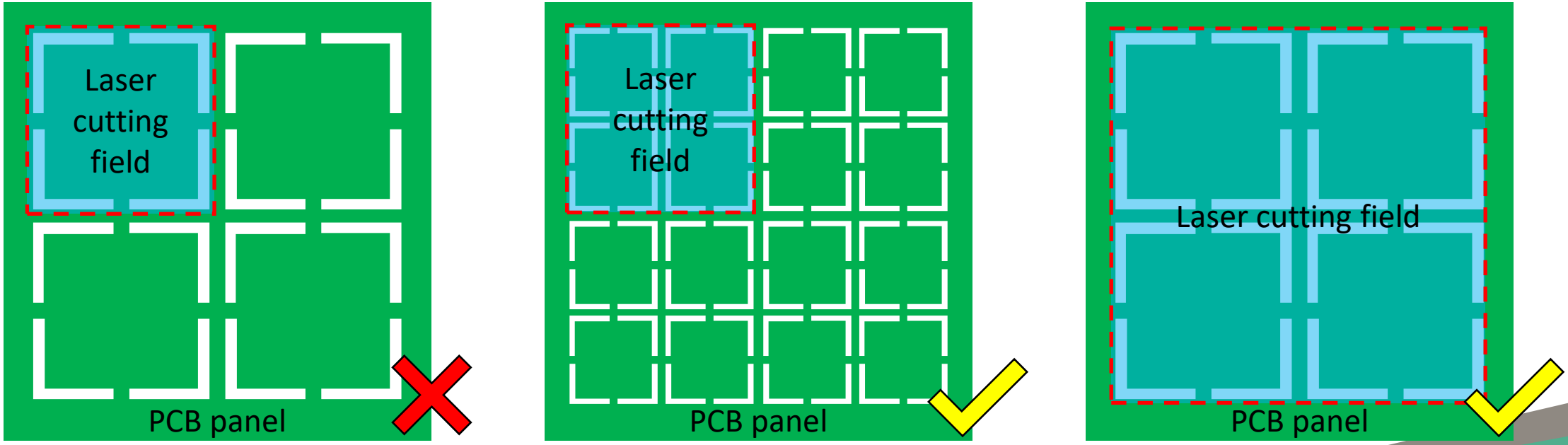


Thickness: 0.75 mm
Cut speed: 0.85 mm/s

Reduce the **laser-material interaction time** – 3

Have more tabs to cut within a cutting field, ***preferably 5 tabs or more***

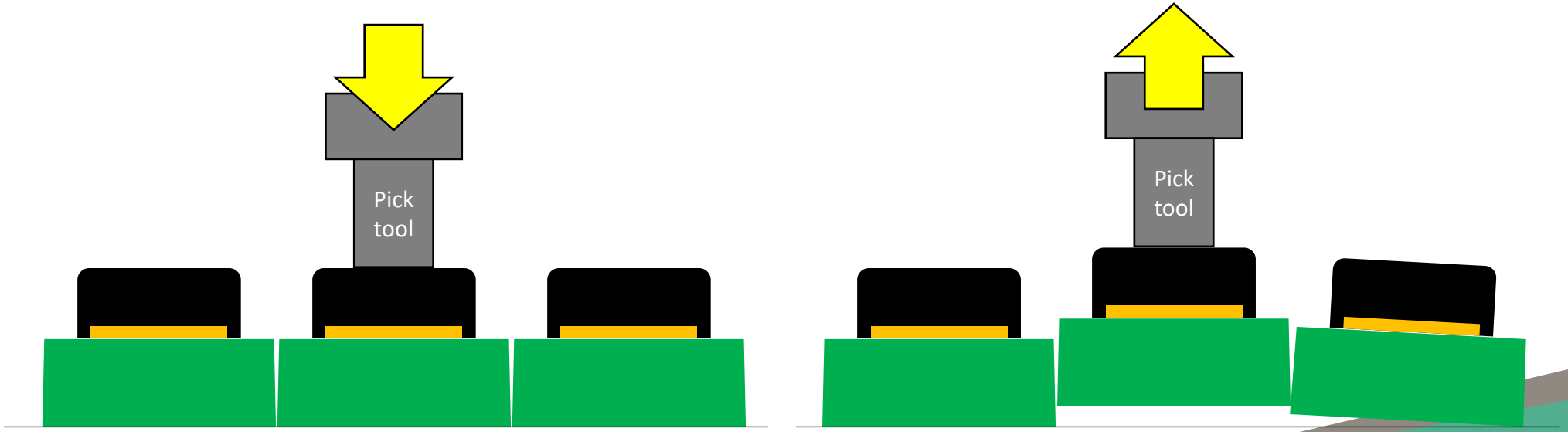
- Typical field sizes: 50mm x 50mm, 100mm x 100mm



What else do I have to consider?

Is ***automatic pick-and-place*** required?

- Although the laser can produce ***cut width smaller than 0.05mm***, this amount of clearance is ***not conducive*** for automatic pick-and-place
- It is preferred to have cut widths bigger than 0.1mm



Is it the Future?

- Yes – where the strain, vibration and general sensitivity are high; And in products were the PCB spacing simply cannot accommodate pre-route gaps such as sensor products with very small footprints.
- No – for standard applications that have PCB thicknesses in excess of 1.2mm and a cost profile that is sensitive to capital cost of the equipment used in its production.
- Lasers are more versatile than they were and progress is being made in both power, delivery and cost – but today the production output/$ spent is far more attractive with standard mechanical systems.

Common questions – 1

Why do I need a fixture to secure my PCB? I thought it is a contact-less cutting process.

Although there is no mechanical cutting force imparted by the laser, there is a natural 'recoil' action upon breakage. The force holding the PCBs together via the tabs is suddenly gone, therefore the PCBs and tabs may move a little after being cut through. This will affect the cutting of the subsequent tabs.

Also, a top press is usually required if the panel warpage is bad.

Common questions – 2

Will the process generate dust or debris?

Yes, it will. Laser cutting processes typically generate fine dust particles ranging between a few hundred microns to under a micron in diameter. PCBs, being fibre composites, will also generate debris consisting of fibre strands up to 1 to 2mm long from the cutting.