

【 Comparison table of lasers 】

4M+S=29

	YAG Laser	Fiber Laser	Femtosecond Laser
Laser source	YAG crystal	Optical fiber	Mode locking laser
Processing method	Heat conducting processing: Laser energy absorbed on the surface conducts into a depth direction.	Key hole processing: Multiple reflection of laser in a key hole, made by evaporation of the laser condensing point, enables to make a deep hole.	Non-heating processing: The laser beam evaporates just a laser condensing spot area instantaneously so that the heat gives minimum effects to the material.
Welding capability	Excellent: Spot welding is available at low cost and high power.	Good: It is suitable for deep and narrow welding at high speed.	Inapplicable: Basically impossible
Subtractive process (cutting, drilling etc.)	Inapplicable: Basically impossible	Good: It can remove a large volume of a work at one time, but the finished quality is sometimes poor.	Excellent: It removes a small volume of a work at one time in a high quality, requiring a longer time for removing a volume of work.
Pulse width	Microseconds to milliseconds	Microseconds to continuous wave	Femtoseconds to picoseconds
Total output power	Middle: High peak power	High: Continuous processing with a high power is available.	Low: Ultrashort pulse with a high peak power
Dross or deposited	(Only welding is available)	Dross adhesion: Finishing work is required for removing dross.	Dross-free: (Dusts can be easily washed out.)
Productivity	Middle	High	Low

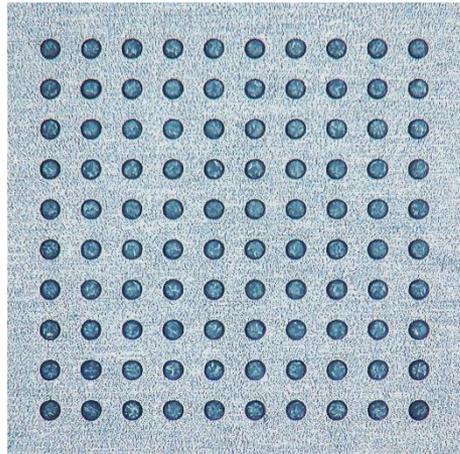
【Features of Femtosecond Laser】

Ultrashort pulse laser	One femtosecond is one quadrillionth of a second (10 ⁻¹⁵ second). (Light can travel only 0.3 μm in one femtosecond.)
Minimum thermal effect to materials	Much smaller denaturalized areas is provided to the vicinity of a processed point due to the less heat effects. Resins can be processed as well as metals. Materials weak to heat, e.g. one having a low melting point, are especially suitable to be processed.
High precision work (Transparent materials can be processed, even the inside.)	Transparent materials, even only inner parts of them, can be processed. Ultrashort pulse laser beam, having a strong electric field with compressed energy in time and space, causes non-linear interactions, such as multiphoton absorption and multiphoton ionization, only on a beam condensing spot.
Less damages to vicinity	Less chippings or cracks are given. Femtosecond laser process can be well employed for hard-to-cut materials, such as ceramics and composite materials, because it minimizes the damages to the vicinity of the processed area.
Processing capability to high-band-gap materials	Femtosecond laser process can be well employed for high-band-gap materials, e.g. glass or particular polymers, because the ultrashort pulse laser absorbs a large number of multiphotons. Transparent materials are processed from the bottom side, and the higher transparency gives higher productivity.

【Hole making samples in thin plate of SUS304】

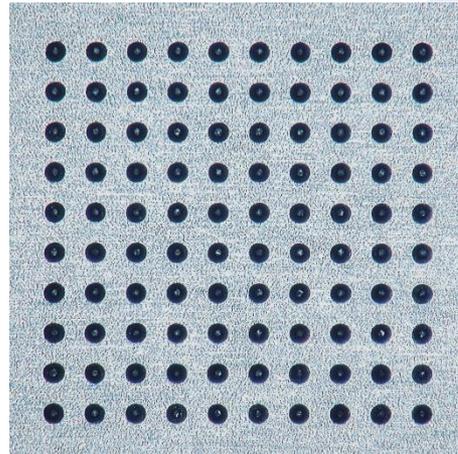
4M+S=29

Straight holes with 90 μm in dia.

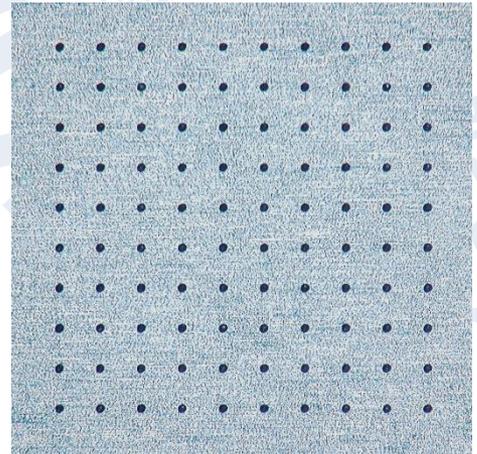


Front side
(Irradiated side)
Microscopic image

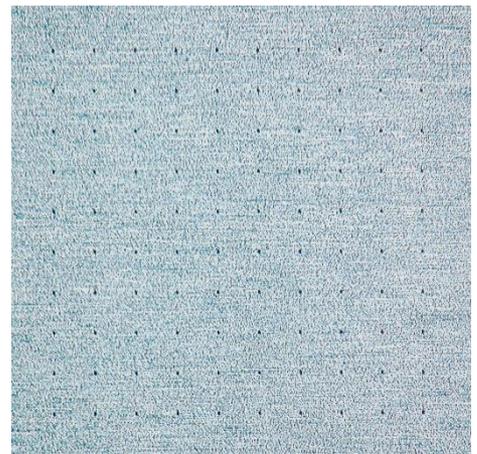
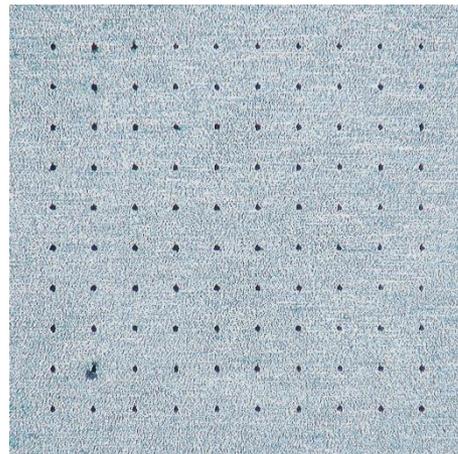
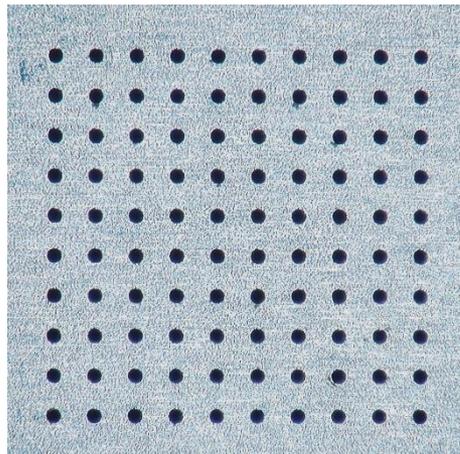
Tapered holes with the diameters of 90 μm on the front and 30 μm on the back side



Straight holes with 30 μm in dia.



Back side
Microscopic image



300 holes in a square sheet with 10 mm sides and 50 μm thick
100 holes for each sheet (10 by 10 with 200 μm intervals)