



# IPG ultrafast fiber lasers for micromachining

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# IPG By the Numbers



**5000+**  
CUSTOMERS



**42,000**  
DEVICES SHIPPED



**4,800**  
EMPLOYEES

**2/3<sup>rd</sup>s**

**OF FIBER LASERS**  
MANUFACTURED WORLDWIDE

**FOUNDED**  
**1990**



**NASDAQ:**  
**IPGP**



**55M**

Metric Tons LESS CO<sub>2</sub>  
EMISSION WHEN OPERATING  
IPG LASERS COMPARED TO  
OTHERS (2014-2023)



**350 PATENTS**  
430 PENDING



**24 TERAWATT HOURS**  
OF ELECTRICITY SAVINGS SINCE 2011

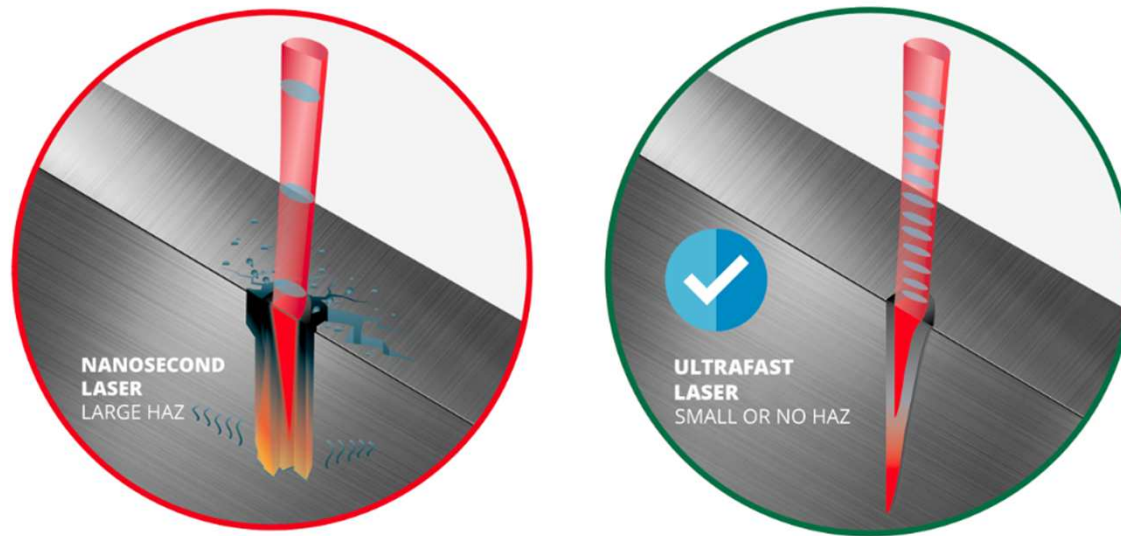
since 2023

# Global Presence



Based on 2023 Data

# Advantages of Ultrafast Lasers

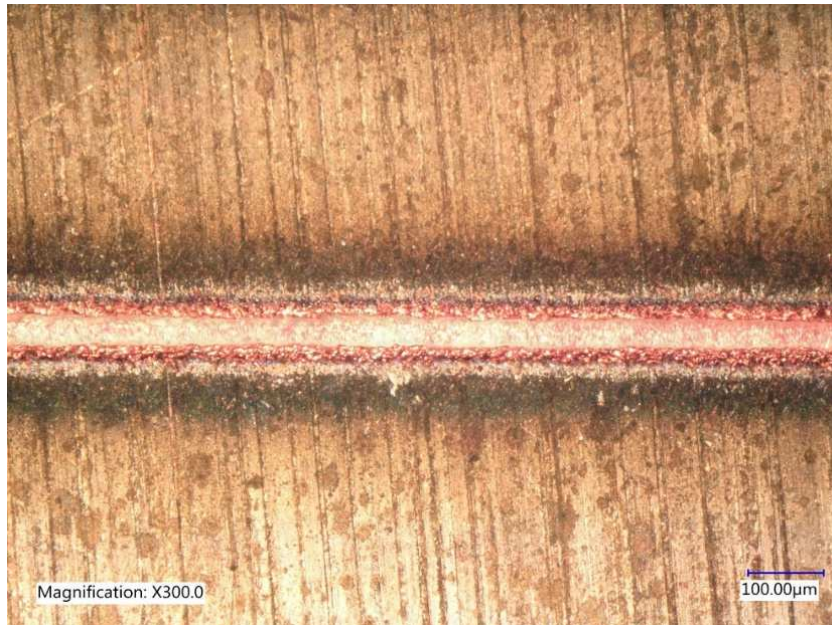


- When ultrafast laser pulses interact with the target material the result is non-thermal absorption of energy.
- This is possible because ultrafast pulse durations are shorter than the characteristic time of vibrational relaxation in the material, allowing energy to be deposited faster than it is dissipated.



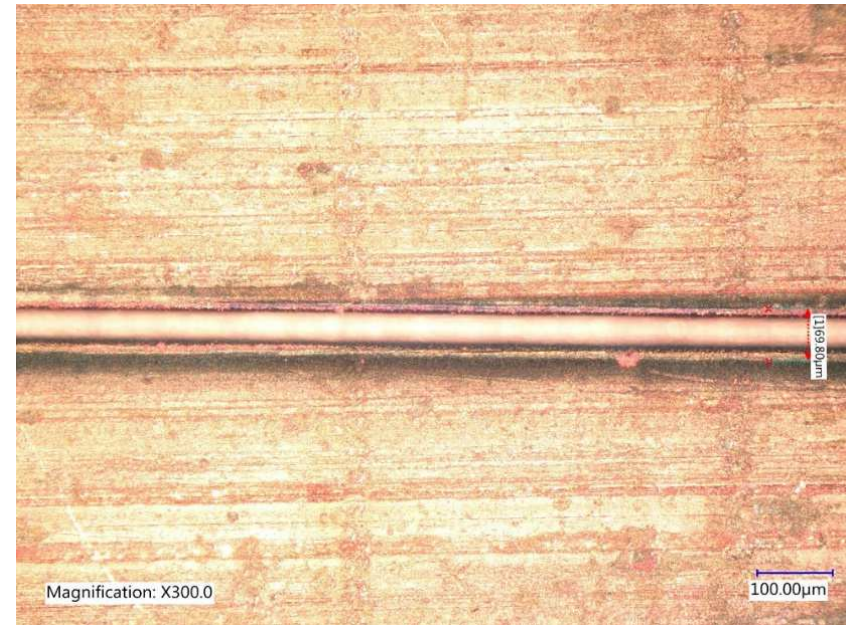
# Nanosecond vs. Picosecond Copper Engraving

## Nanosecond



- Thermal process
- Formation of heat-affected zones and melting around the edges

## Picosecond



- Non-thermal process
- Clean ablation without any heat-affected zones

# IPG Ultrafast Laser

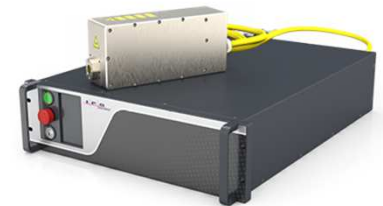
IPG offers unique ultra-compact laser head and fiber delivery

**IPG's Unique Ultrafast Platform addresses the shortcomings of current Ultrafast products in the market:**

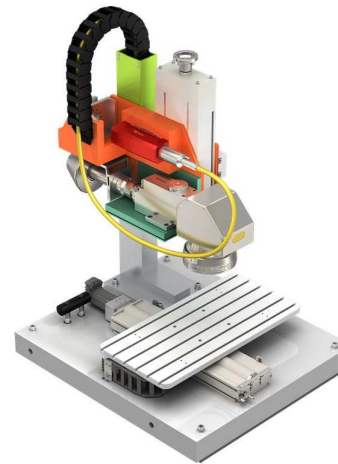
- Ultra compact and light weight
- Fiber delivery for easy integration
- Maintenance/alignment free
- No warm-up time (alternative lasers: 30-45 min)
- High reliability
- Low cost



All-fiber platform 50W IR picosecond laser



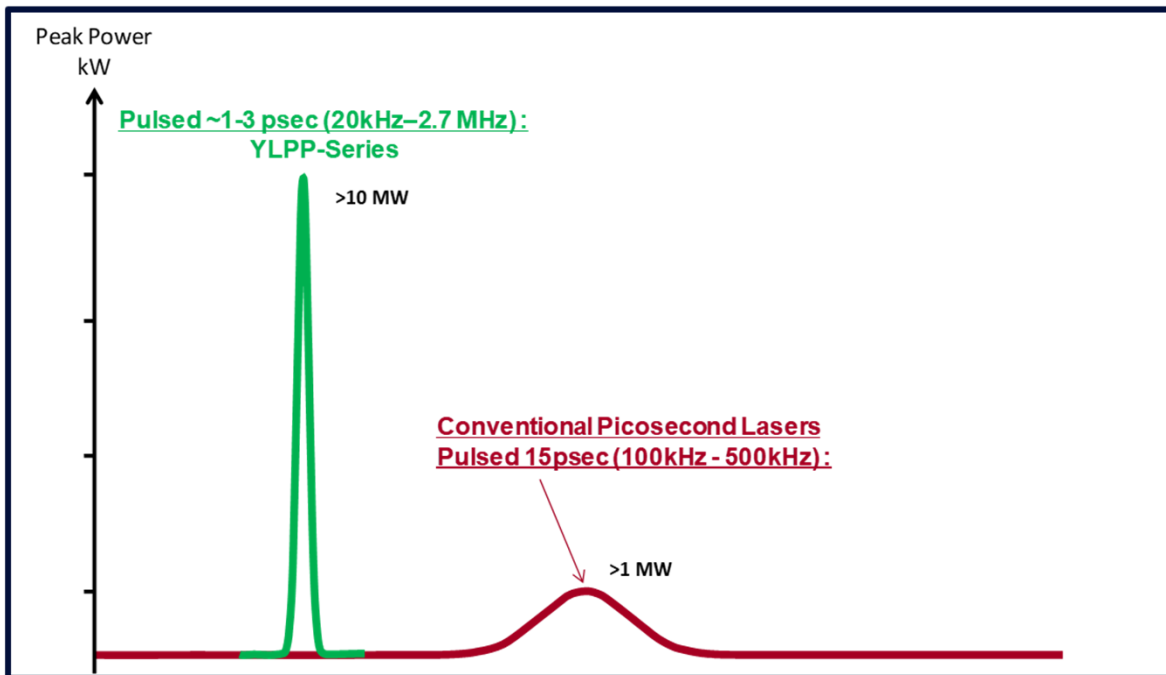
Hybrid platform IR pico/femtosecond laser



Size: 1/20<sup>th</sup> in volume compared with a similar USP lase.

# IPG's Unique Picosecond Laser

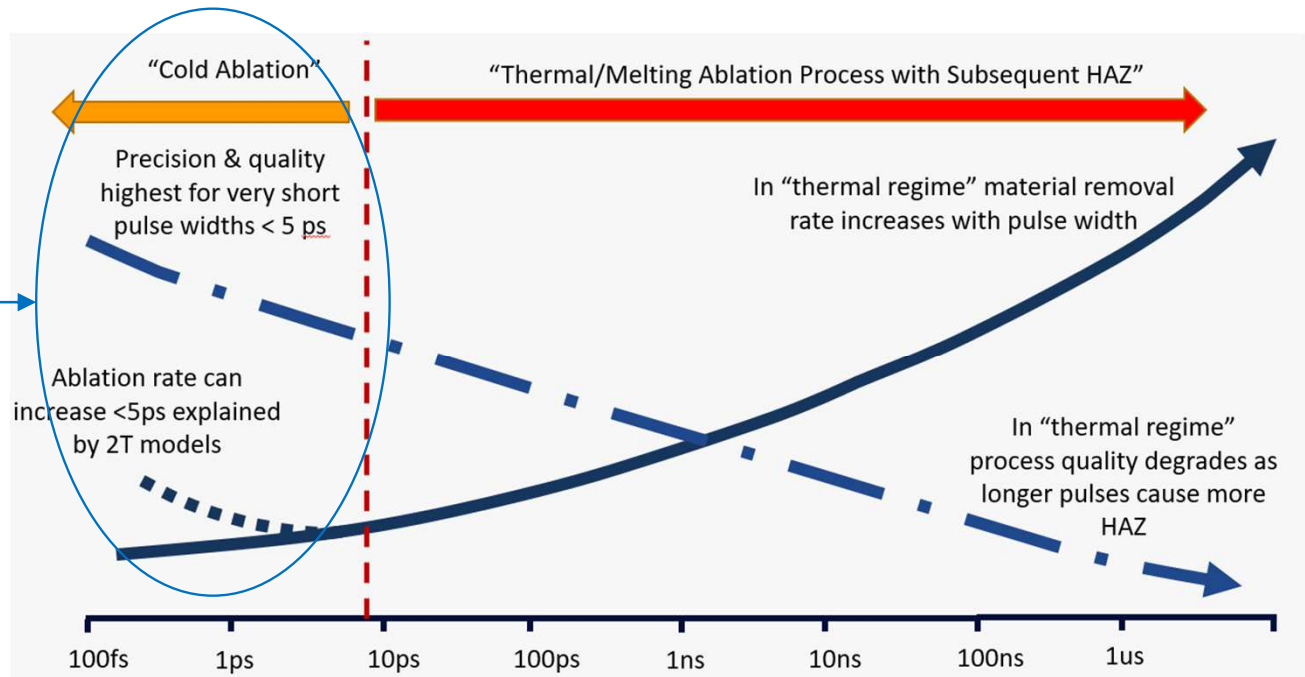
- IPG's picosecond pulse duration (1-3ps) about ~10x shorter than typical solid-state lasers
- ~10x higher peak power than traditional solid-state laser



# Effect of Pulse Width on Process Quality and Speed

## Choice of Laser Pulse Width is a Trade-Off Between Process Quality and Process Speed

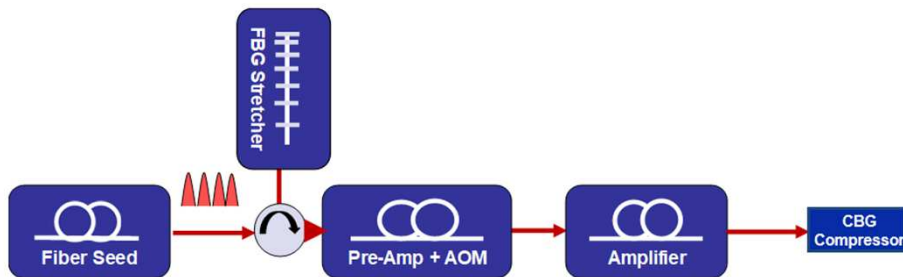
- IPG's short picosecond (1-3ps) laser works in the '**Cold Ablation**' regime.
- Enables high precision & quality, and increased ablation rate





# IPG Compact All-Fiber Ultrafast Laser

Complete all-fiber architecture for highly reliable, alignment free performance



## IR, 1030nm

- Up to 200 W
- Up to 50  $\mu$ J pulse energy
- Up to 250  $\mu$ J with burst mode option
- 250-350 fs, 1-3 ps

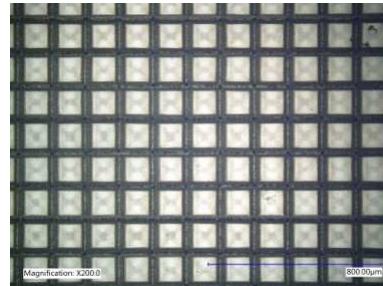
## Green, 515nm

- 20 W, 10  $\mu$ J, 300 fs

Proven performance and reliability for the most-demanding applications



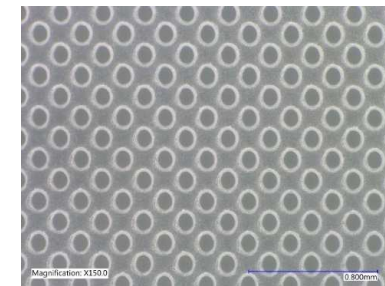
Marking / Texturing of Luxury Goods



Texturing silicon wafer

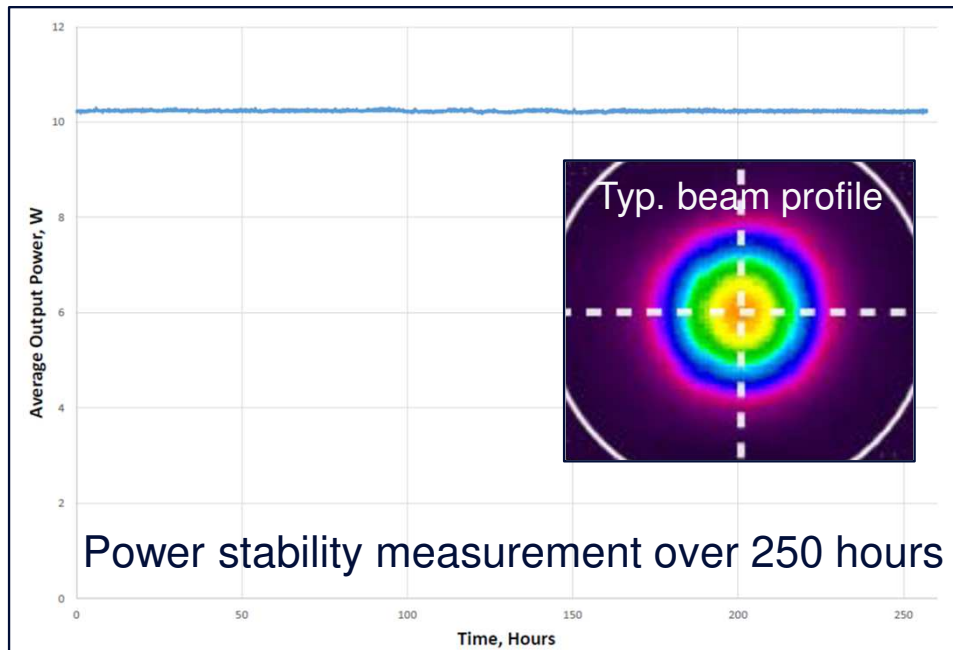


Black marking

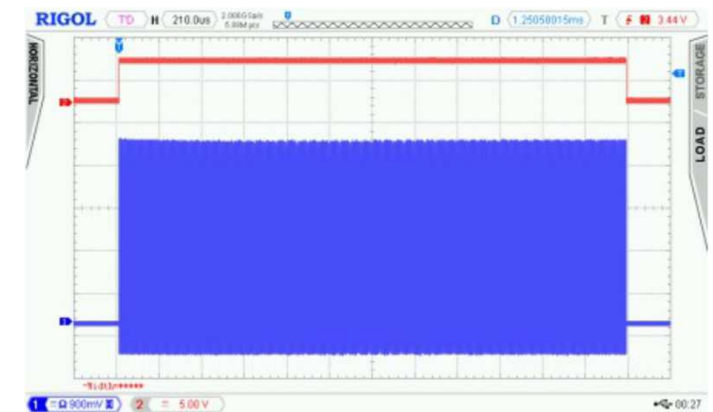
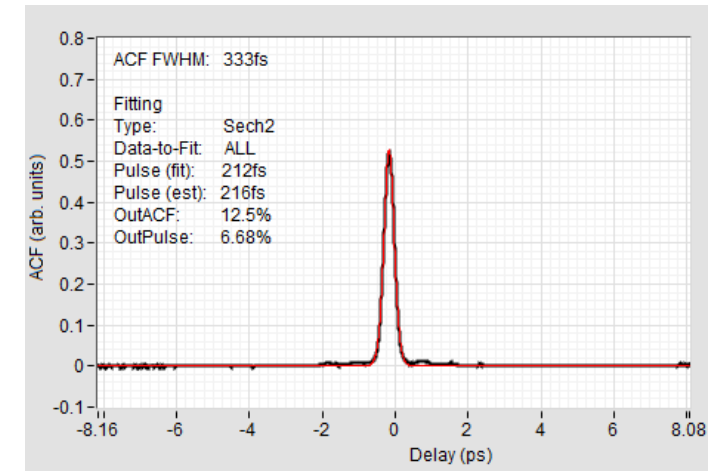


Plastics drilling

# Compact All-Fiber Ultrafast Laser



**IPG world-class ultrafast laser with robust and reliable performance**



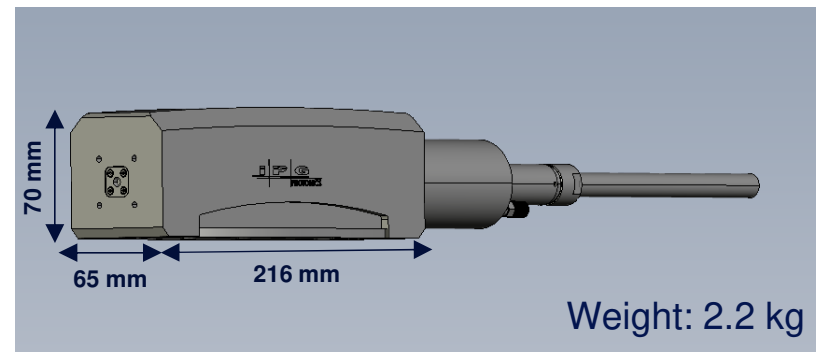
Sharp pulse train rise without ramp-up time

# Ultrafast All-Fiber Platform

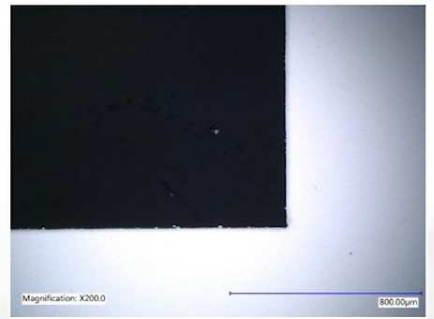


- Ultra compact optical head
- Fiber delivery for easy integration
- Rack mountable power supply
- No warm-up time

Laser Parameter	Typical Spec
Emission Wavelength	1030 and 515 nm
Max Power	50 W
Max Pulse Energy	50 $\mu$ J
Max Burst Energy	250 $\mu$ J
Number of Pulses per Burst	1 – 10
Repetition Rate	50 kHz – 5.5 MHz
Short Picosecond Version	1 – 3 ps
Femtosecond Version	250 – 350 fs
Typ. Beam Quality	M2 = 1.2



# High Power Ultrafast All-Fiber Platform



High-speed battery foil and separator cutting

Laser Parameter	Typical Spec
Emission Wavelength	1030 nm
Max Power	Up to 300 W
Max Pulse Energy	75 $\mu$ J
Max Burst Energy	200 $\mu$ J
Number of Pulses per Burst	1 – 10
Tunable Repetition Rate	Single pulse – 5.5 MHz
Fixed Repetition Rate	11 - 44 MHz
Short Picosecond Version	1 – 3 ps
Typ. Beam Quality	M2 = 1.3

## Options:

- Extended fiber delivery up to 5m
- Burst mode (up to 200  $\mu$ J)
- Integrated pulse picker



# IPG Hybrid Ultrafast Lasers

Best of both worlds enables high-pulse energy with the compactness and stability of fiber lasers

- Compact optical head
- Fiber delivery for easy integration
- Rack mountable power supply

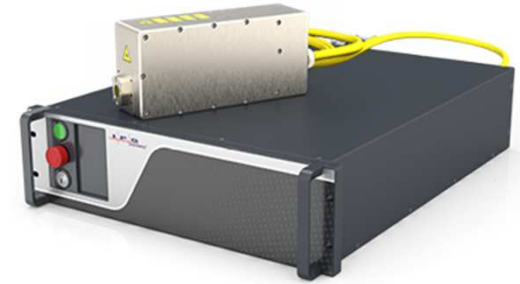
<b>IR:</b>	100 W, 100 $\mu$ J
1030nm	50W, 200 $\mu$ J
	750 fs and ~1.5 ps

<b>Green:</b>	25 W, 100 $\mu$ J
515nm	50 W, 50 $\mu$ J
	750 fs and ~1.5 ps

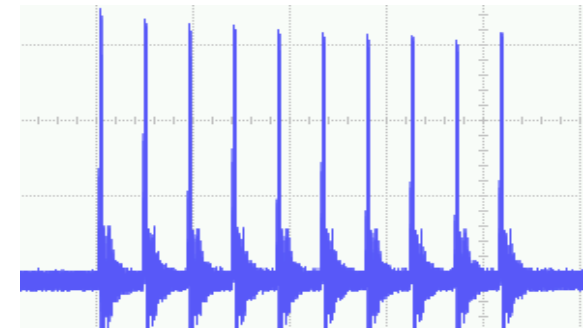
<b>UV:</b>	20 W, 150 $\mu$ J
343nm	30 W, 50 $\mu$ J,
	750 fs and ~1.5 ps

Options:

- Burst mode (up to 500  $\mu$ J)
- Integrated Pulse picker



Up to 200  $\mu$ J (IR), 100  $\mu$ J (Green), 150  $\mu$ J (UV)  
Up to 500  $\mu$ J (IR) with burst

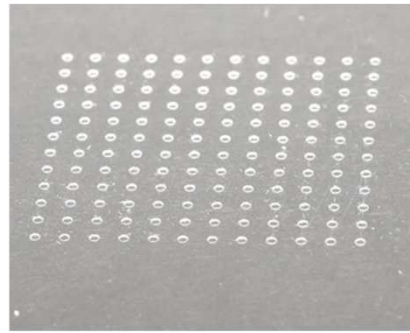


500  $\mu$ J 10-pulse burst

# Ultrafast Hybrid Platform

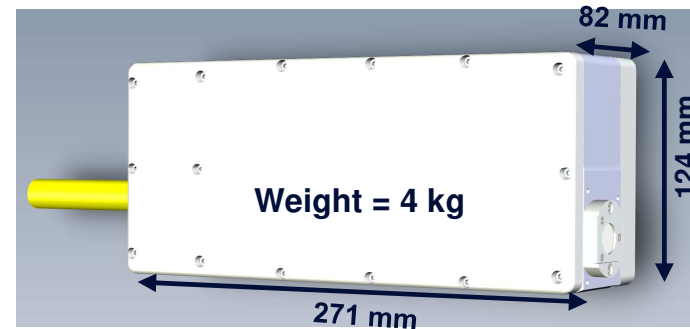


**Ablation/cutting of  
ultra-hard materials**



**Glass cutting and  
drilling**

Laser Parameter	Typical Spec
Emission Wavelength	1030nm, 515 nm, 343nm
Max Power	100 W
Max Pulse Energy	200 µJ
Max Burst Energy	500 µJ
Number of Pulses per Burst	1 - 10
Repetition Rate	Single pulse – 5.5 MHz
Short Picosecond Version	1 - 3 ps
Femtosecond Version	600 -900 fs
Typ. Beam Quality	M2 = 1.2



# IPG Ultrafast Lasers | Portfolio

## Picosecond

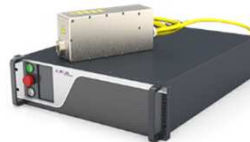
### IR 1030nm All Fiber

- 50W, 25uJ, 1-3ps
- 50W, 50uJ, 1-3ps
- 200W, 200uJ burst, 1-3ps



### IR 1030nm Hybrid

- 50W, 200uJ, 1-3ps
- 100W, 100uJ, 1-3ps



### Green 515nm All Fiber

- 20W, 10uJ, 300fs



### Green 515nm Hybrid

- 25W, 100uJ, 1-3ps
- 50W, 50uJ, 1-3ps



### UV 343nm Hybrid

- 20W, 150uJ, 1-3ps
- 30W, 50uJ, 1-3ps

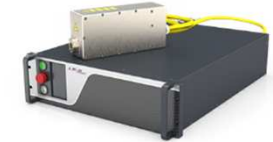


## Femtosecond

- 10W, 20uJ, 250fs
- 10W, 40uJ, 250fs
- 20W, 40uJ, 350fs



- 50W, 200uJ, 600-900fs
- 100W, 100uJ, 600-900fs



- 25W, 100uJ, 600-900fs
- 50W, 50uJ, 600-900fs



- 20W, 150uJ, 600-900fs
- 30W, 50uJ, 600-900fs





# IPG Ultrafast Laser Applications



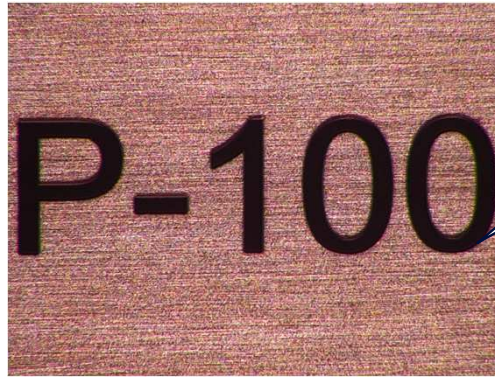
# Permanent Black Marking



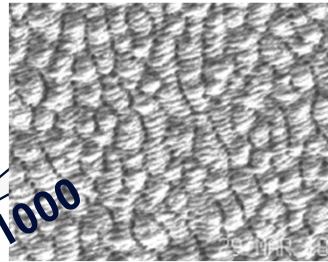
- Creating a durable, black mark on various metal surfaces.
- The marking process doesn't cause any material removal or damage on the surface.
- Various metal substrates: stainless steel, aluminum, copper, etc.



Black marking on  
anodized aluminum.



Black marking on  
copper.



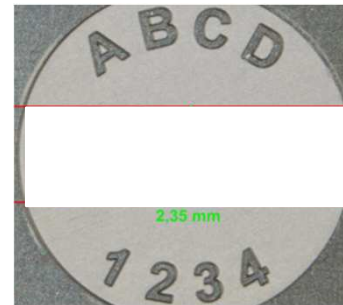
Permanent black marking on  
Stainless Steel

# Metal Engraving and Texturing

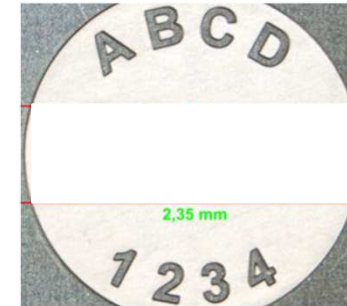


- High quality marking and texturing on Jewelries and Watches
- Burst mode further improves quality and speed in metal engraving for luxury goods

**Luxury goods marking/engraving**, burst mode improves quality and speed in metal engraving



No burst

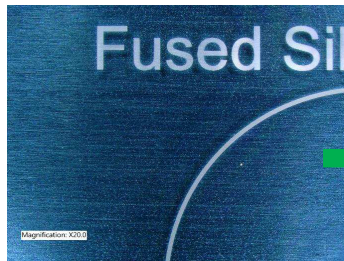
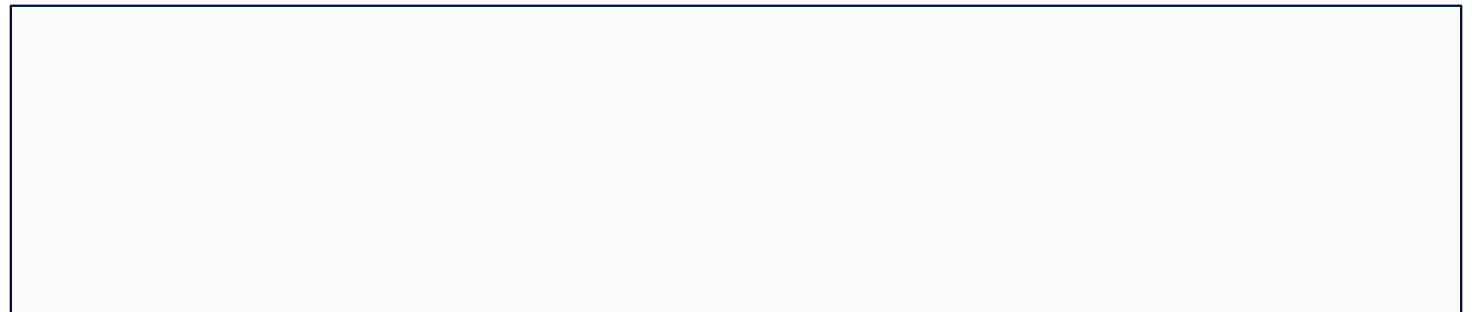


With burst

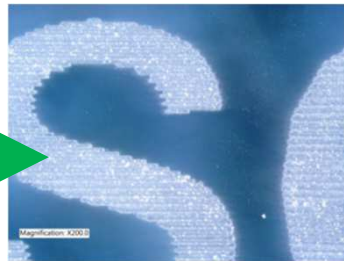
# High-Contrast Glass and Sapphire Marking



- Marking text, serial numbers and decorative elements on various types of glass substrates (fused silica, aluminosilicate)
- The marking cause no chipping or micro cracking



200X



Fused Silica Marking

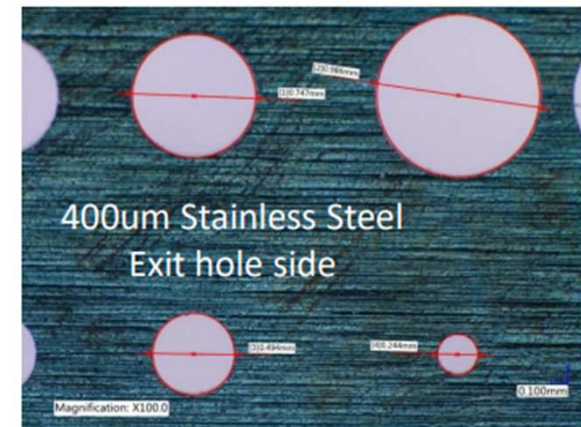
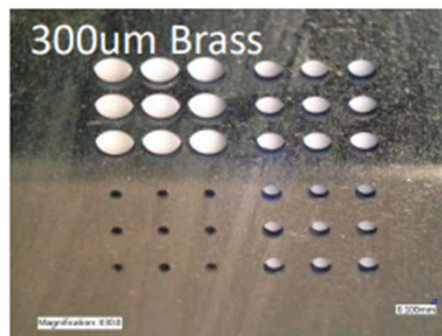
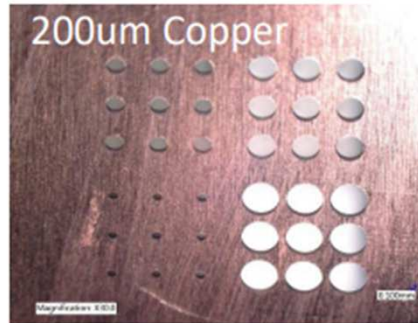
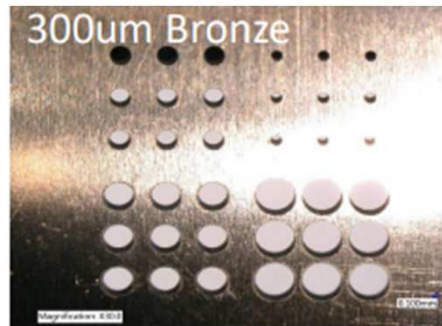


Outline Marking in Glass and Sapphire



# Low-Taper Hole Drilling in Various Metals

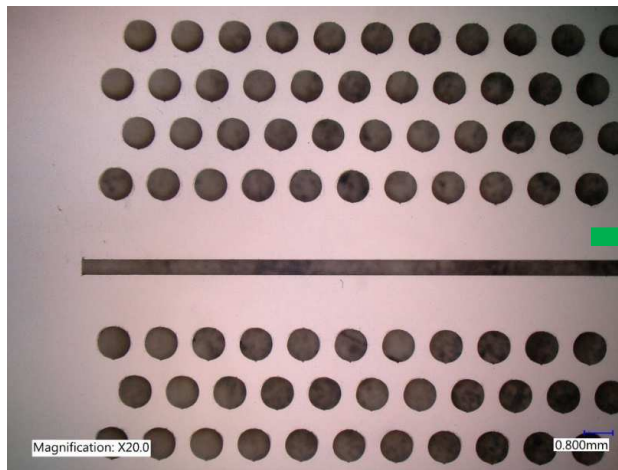
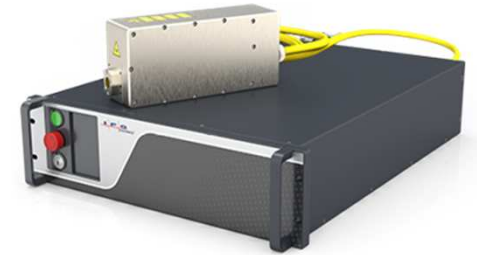
- Femtosecond pulses were used to drill holes with 3-5° kerf angle in Steel, Copper, Brass, and Bronze
- Low Taper and no HAZ



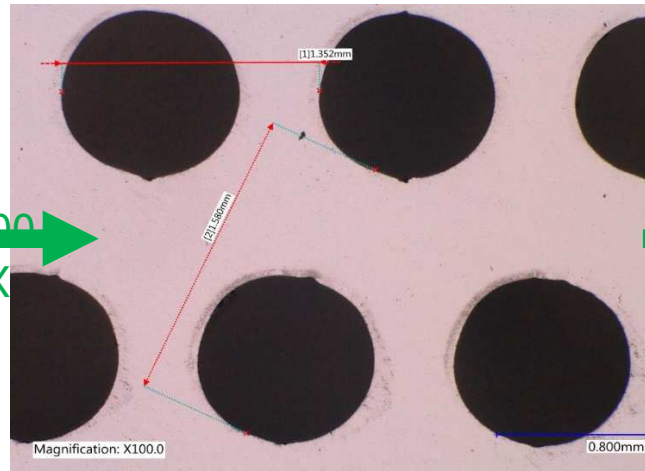


# Cutting and Drilling in Silicon Wafers

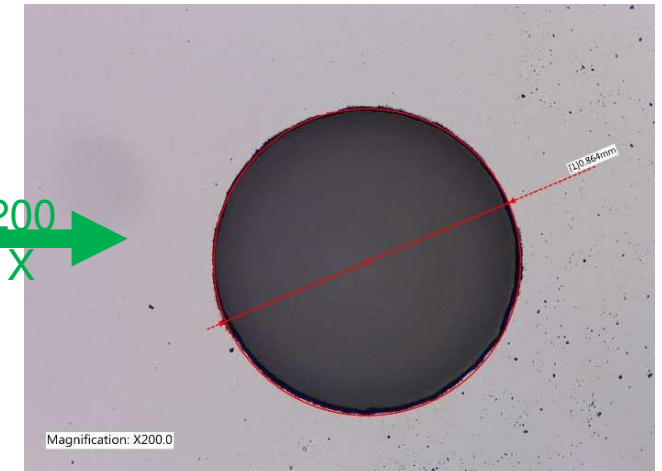
- Cutting and drilling polished and unpolished silicon wafers
- Ultrafast pulses were used to drill holes in 1.5 mm silicon wafer
- Various sized cut outs and drilled holes, from 10 mm to 30  $\mu\text{m}$  exit holes



100  
X



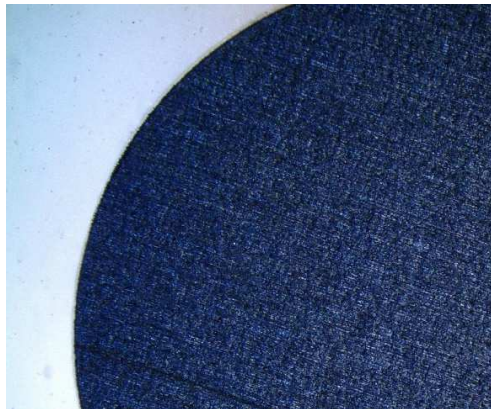
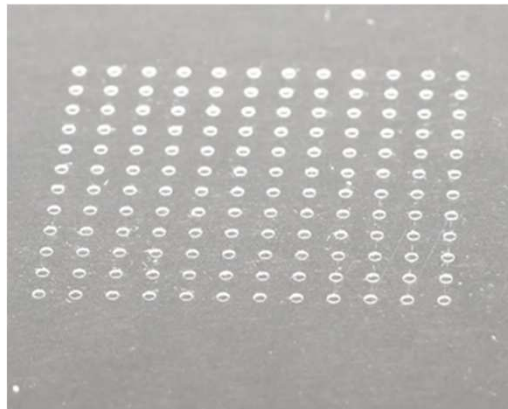
200  
X



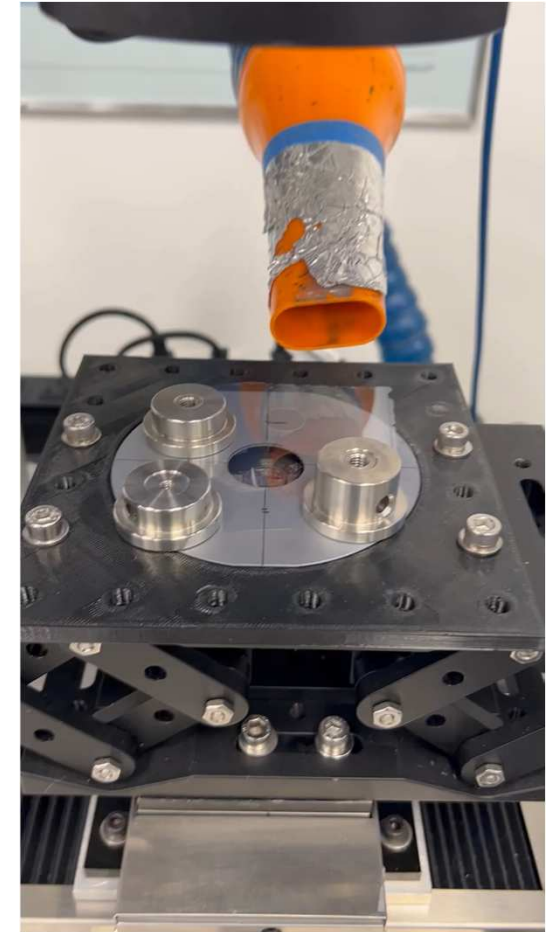
Cutting and Drilling of silicon wafers with a 1030 nm ultrafast laser

# Cutting and Drilling in Glass

- Excellent thru cut excised disc edge quality with minimum heat affected zone
- No microcracking or discoloration

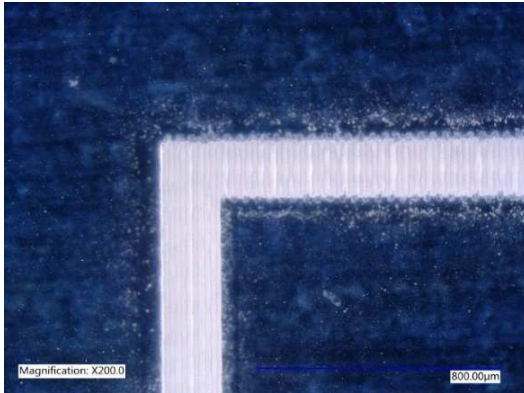


Glass drilling with minimum HAZ

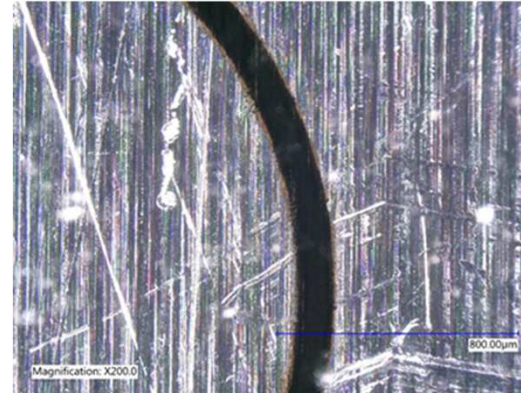


# Glass Welding

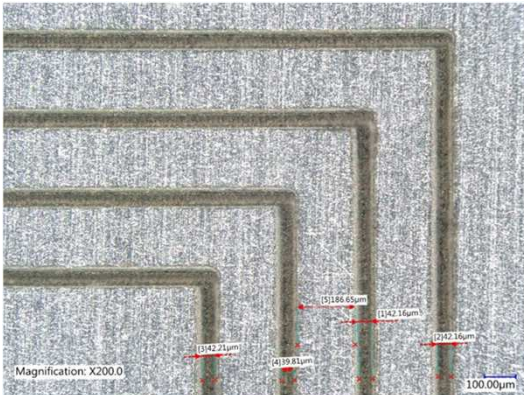
- Ultrafast laser pulses are used to weld transparent or dissimilar materials



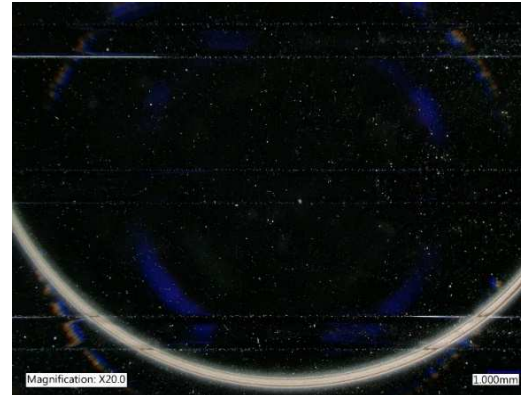
Welding  
sapphire to  
sapphire



Welding  
sapphire to  
aluminum



Welding  
borosilicate to  
aluminum



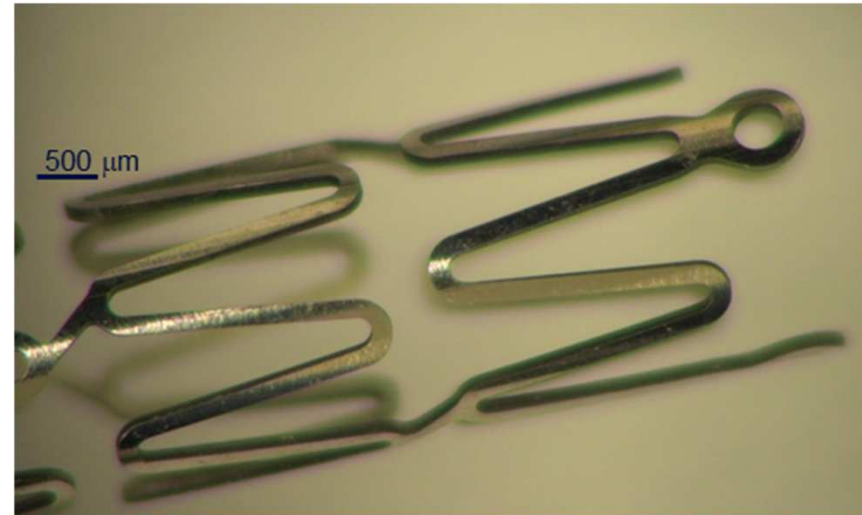
Welding  
borosilicate to  
silicon

# Cutting Metal Stents

- Cutting components for medical applications: the cutting edge should be free of dross and the heat affected zone (HAZ) should be minimal
- Desired kerf width  $> 10\text{ }\mu\text{m}$



Stent cutting with  
ultrafast laser

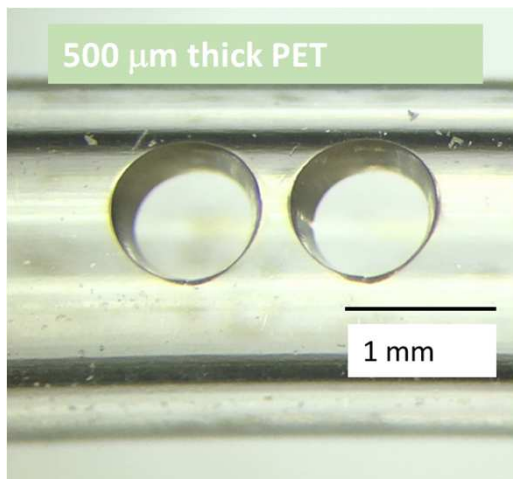


Close-up image of  
Nitinol stent

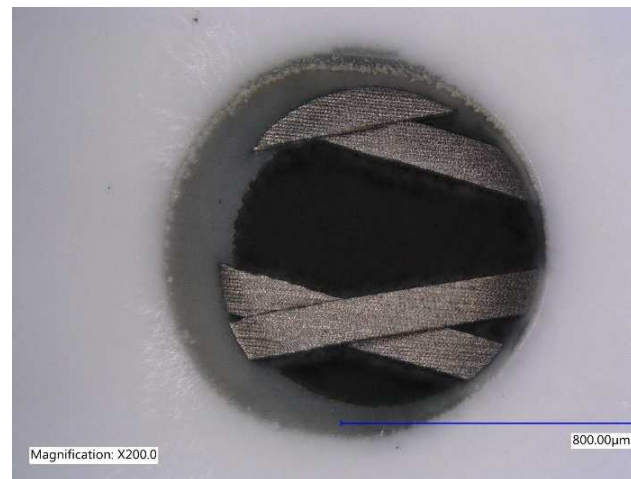


# Cutting and Drilling Polymer

- Green and UV ultrafast lasers are used in drilling and cutting polymers, such as polyethylene, silicone, and Pebax-tubing
- Ultrafast lasers significantly reduce melting and HAZ. No charring, discoloration or swelling of the material.



Drilling of PET tubes



Thru hole ablated in  
polymer exposing  
stainless steel



Cutting of PE tube

# Applications

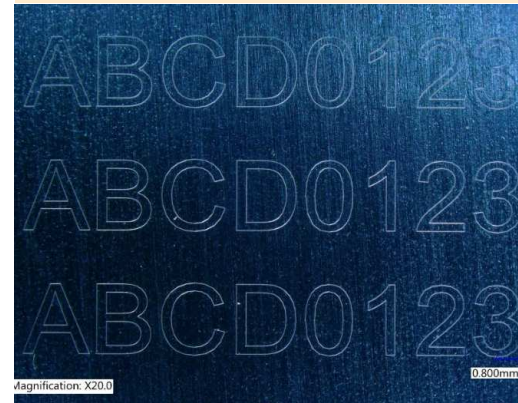
Black marking



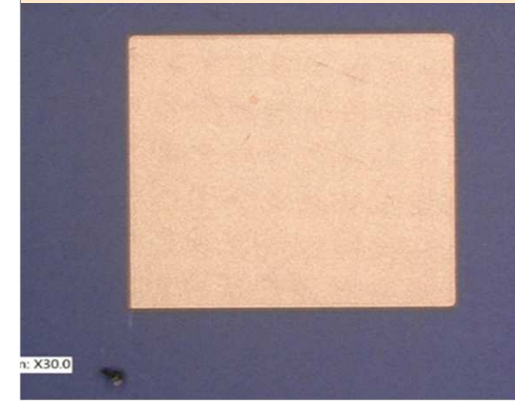
High-contrast glass marking



Outline marking inside glass



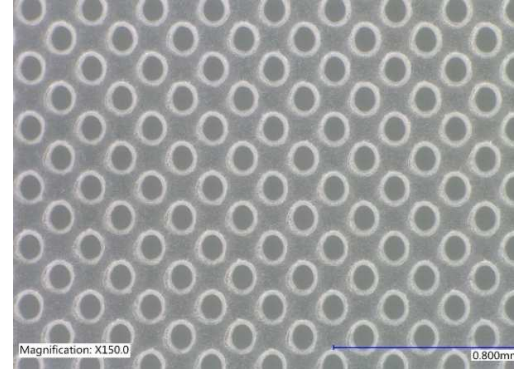
Photoresist coating ablation



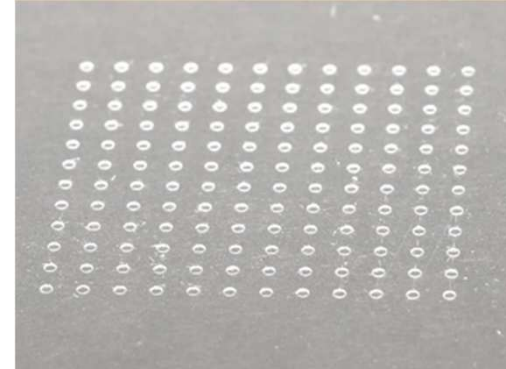
Polymer cutting



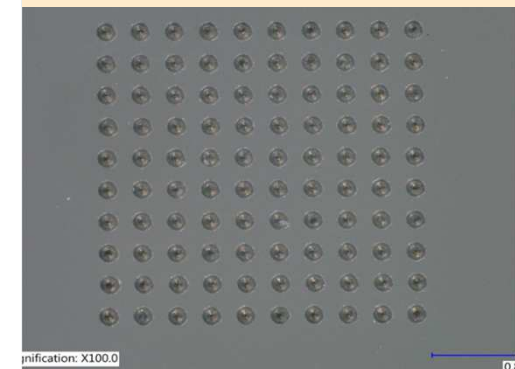
Holes drilled in polymer



Holes drilled in glass

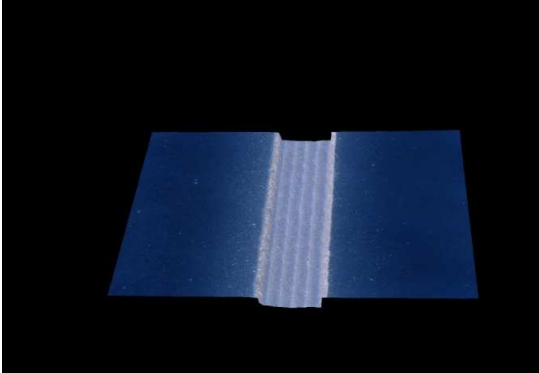


Via drilling in glass



# Applications

Trench Cutting in glass



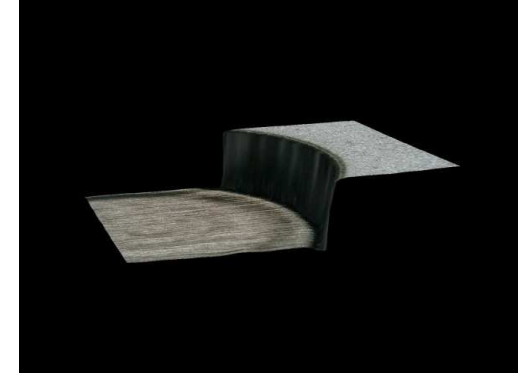
SiC engraving and edging



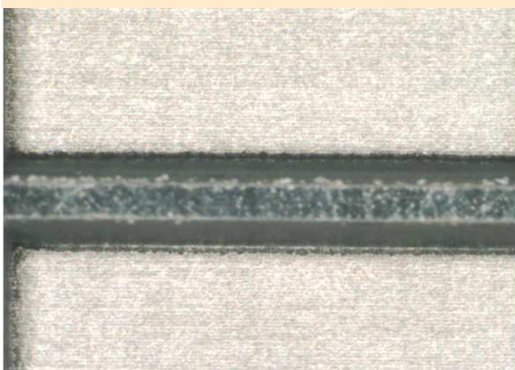
Machining and engraving of SS



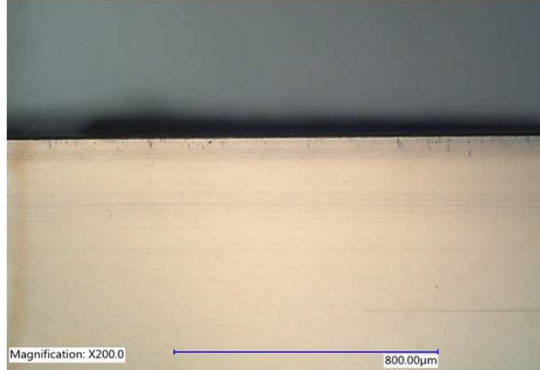
PCD machining



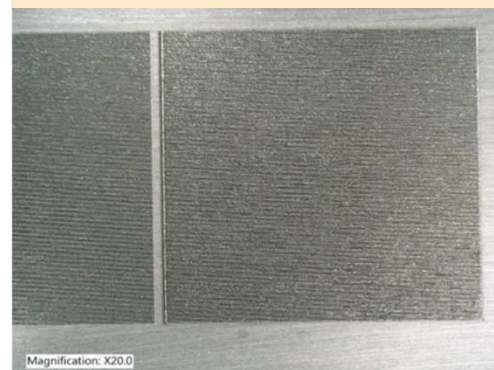
Trench ablation in titanium



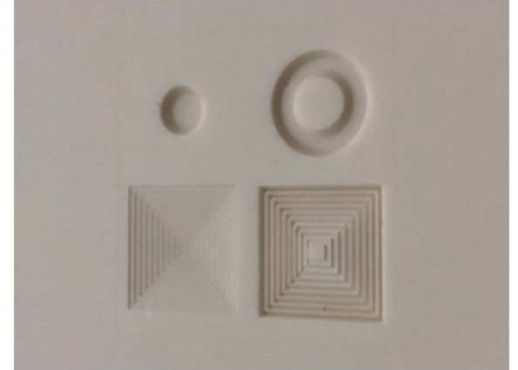
SiC wafer cutting



Surface polishing



Ceramics micromachining





**THANK YOU**