

PLV™ Multi-beam Optical Head for Materials Processing



**SILICON
LIGHT
MACHINES**

EPIC December 6, 2022

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Silicon Light Machines GLV[®] in SCREEN Industrial Tools

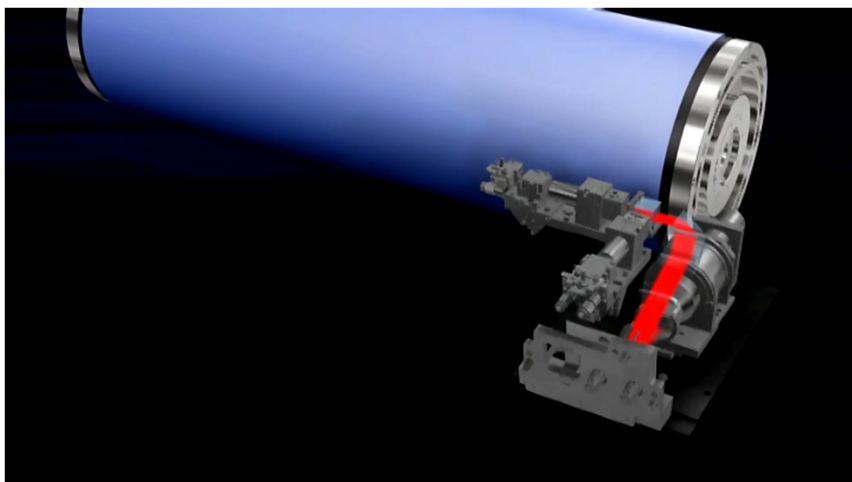


- **1088 channel GLVs used in SCREEN CtP digital systems**
 - 808 nm GLV
 - High resolution: 2400 dpi (10um features)
 - High throughput: >70 meter-scale flexible aluminum substrates per hour
 - High-power: 80-100W infrared per GLV (power densities up to 10kW/cm²)
- **SCREEN has #1 global market share of CtP plate-setters**
 - OEM for AGFA & Fuji and others
 - Thousands of GLV-based systems in use today around the globe

SCREEN

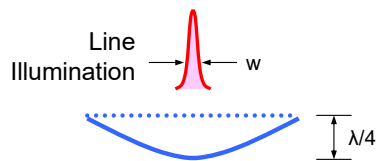
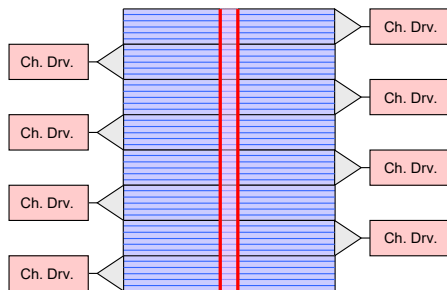
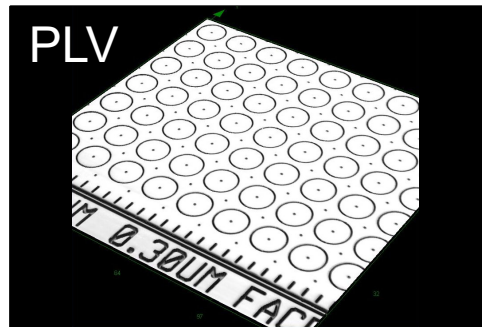
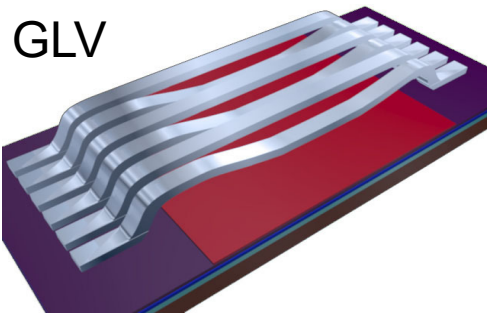


DW-3000
Direct Imaging System



- **SCREEN 355nm direct imaging tool advanced packaging**
 - 8192 channel 355nm GLV
 - 2um minimum features on 0.5um placement grid
 - 65 wafers per hour @ 100mJ/cm² hour

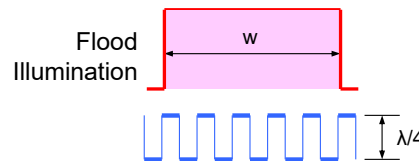
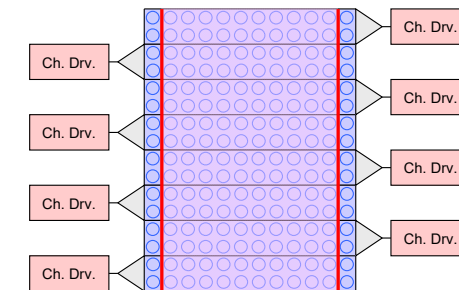
PLV for High Power Modulation



100 W

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Silicon Light Machines



1 kW

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- **Planar Light Valve (PLV) is 2D analog of 1D GLV**
 - Retains desirable properties of GLV
 - Allows new features beyond GLV
- **Optical area of PLV can be made arbitrarily large**
 - GLV → line illumination
 - PLV → flood illumination
- **PLV modulator in linear drive configuration is ideal for high power scanned line systems**
 - Scanning can be done with galvo mirrors or translation of beam with respect to the bed

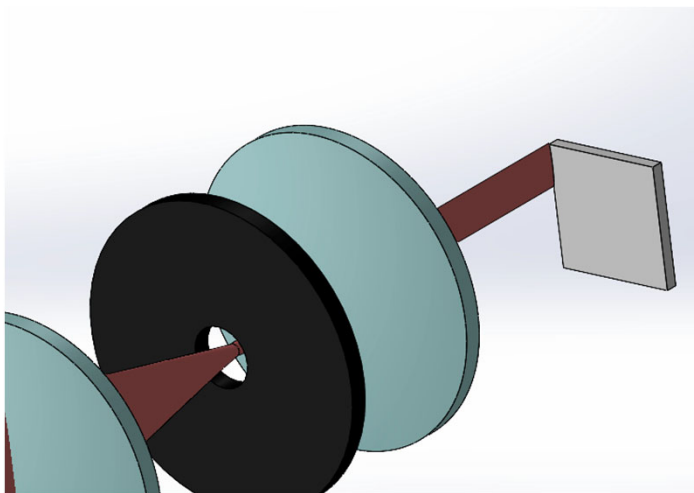
EPIC Members New Product Release December 2022

PLV™ Multi-Beam Scanning



- The Planar Light Valve creates a linear array of beamlets that can be modulated at frequencies up to 200 kHz
- Modulation is synchronized with motion to create a 2D image
- Higher laser pulse energy → larger swath width

Beam scanned across workpiece



Linear array
of beamlets
(swath)

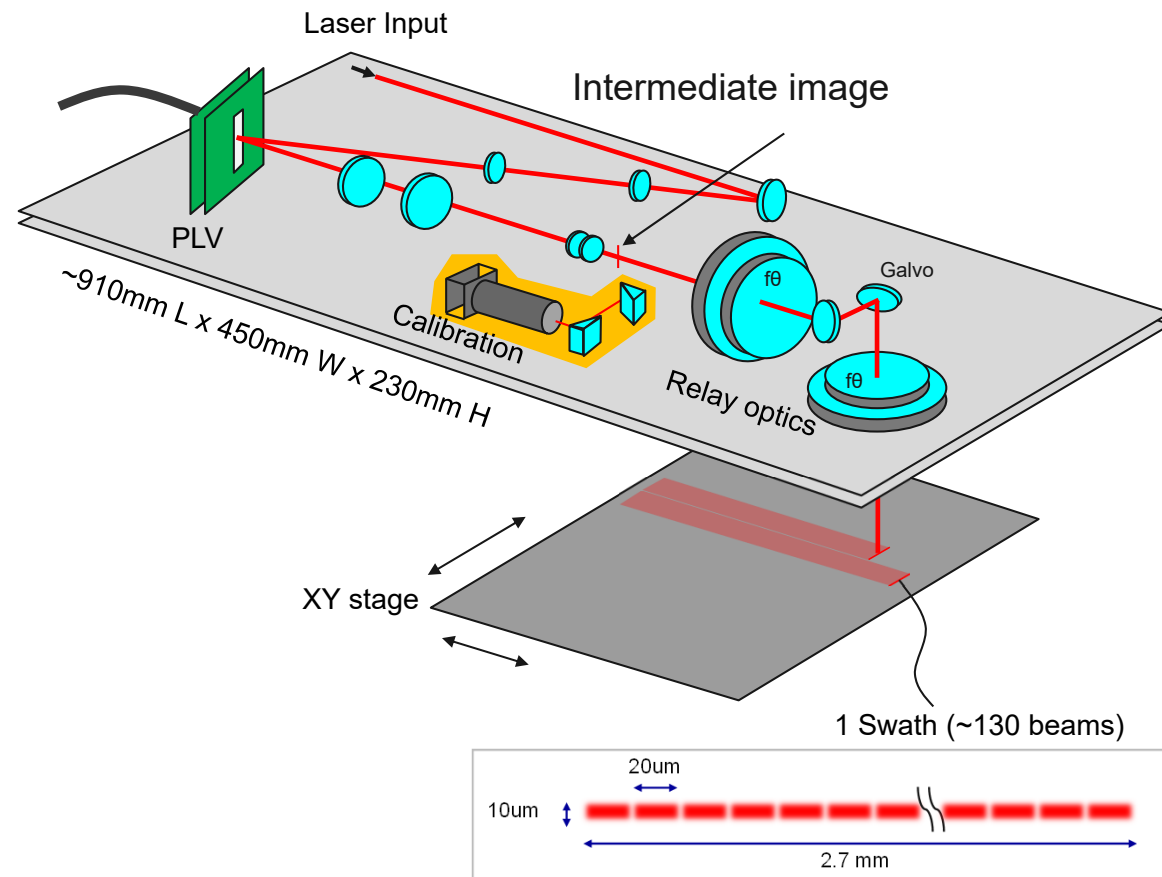
Example image



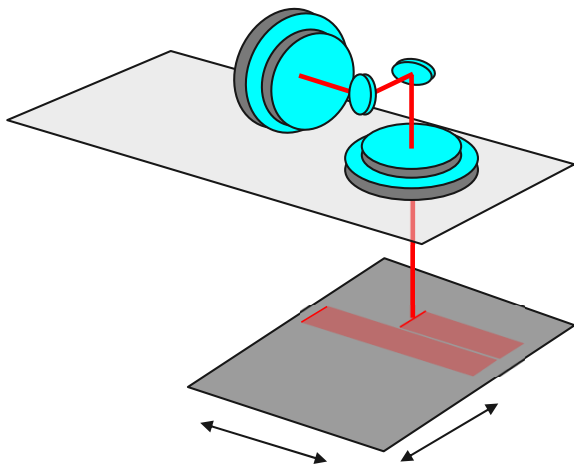
PLV Multi-beam Optical Head



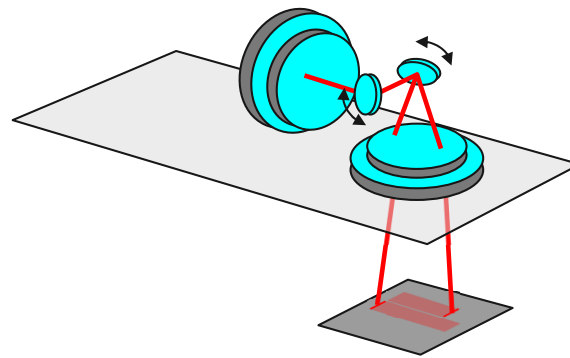
- **>10x higher throughput compared with single beam at 50 um resolution and below**
- **1064 nm picosecond laser now**
- **20 um spot size, 2.5um edge placement**
- **2.7 mm swath length ~ 130 beams**
- **0.6 J/cm² fluence**
- **Internal calibration system**
- **Scanning galvo option**
- **515/532 nm future option**



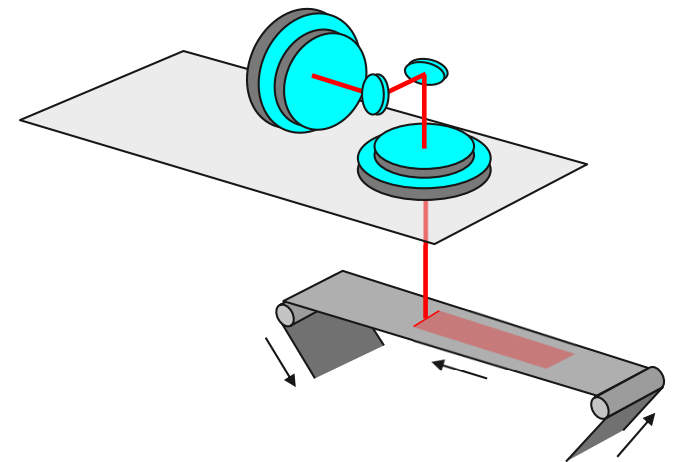
Scanning Methods



XY Stage



Galvo Mirrors

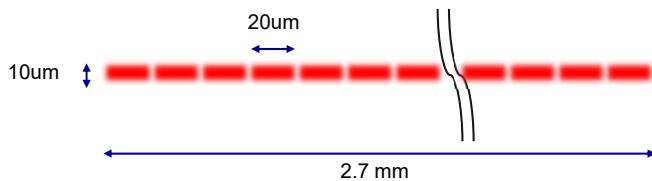


Roll to Roll
(Next gen)

PLV Advantage



- PLV provides higher throughput at higher resolution
 - 4x resolution
 - >>10x throughput
- The average power per beam can be less than a single spot system which is gentler for heat sensitive materials
- Head configuration:
 - 130 beams, 20um x 10um each
 - 2.7mm swath length
 - 13.8x faster than 50um single-spot system



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Silicon Light Machines

		PLV multi-spot line beam system				Single-spot System			
LPLV Length	mm	27.74							
LPLV Width	mm	1.00							
Demag - Long Axis		10.2x							
Demag - Short Axis		100x							
Number of Pixels		1088							
Pixel Grouping		20	12	8	4				
Number of Spots		54.4	90.7	136.0	272.0				
Swath Length - Long Axis	mm	2.72							
Spot Size - Long Axis	um	50	30	20	10	50	30	20	10
Spot Size - Short Axis	um	10				50	30	20	10
Pulse Separation Distance	um	0.1				0.5	0.3	0.2	0.1
Scanning Speed	mm/s	49				1000	600	400	200
Laser Rep Rate	kHz	490				2000			
Target Fluence	J/cm ²	0.6				0.6			
Pulse Energy from Laser	uJ	204				5.89	2.12	0.94	0.24
Average Power	W	100				11.8	4.2	1.9	0.5
Image Size (Square)	mm	15				15			
Time per Swath	s	0.31				0.100	0.167	0.250	0.500
Number of Swaths		5.5				3000	5000	7500	15000
Time per Jump	s	0.60				-			
Time per Image	s	4.4				61	169	380	1520
How much faster than Single-spot?		13.8x	38.4x	86.5x	345.8x	1.0x			

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Additive Manufacturing Demo System

SCREEN

2nd f-theta lens
(f=163.5mm, telecentric)

galvo mirror(XY)

1st f-theta lens
(f=163.5mm, telecentric)

PLV optical head

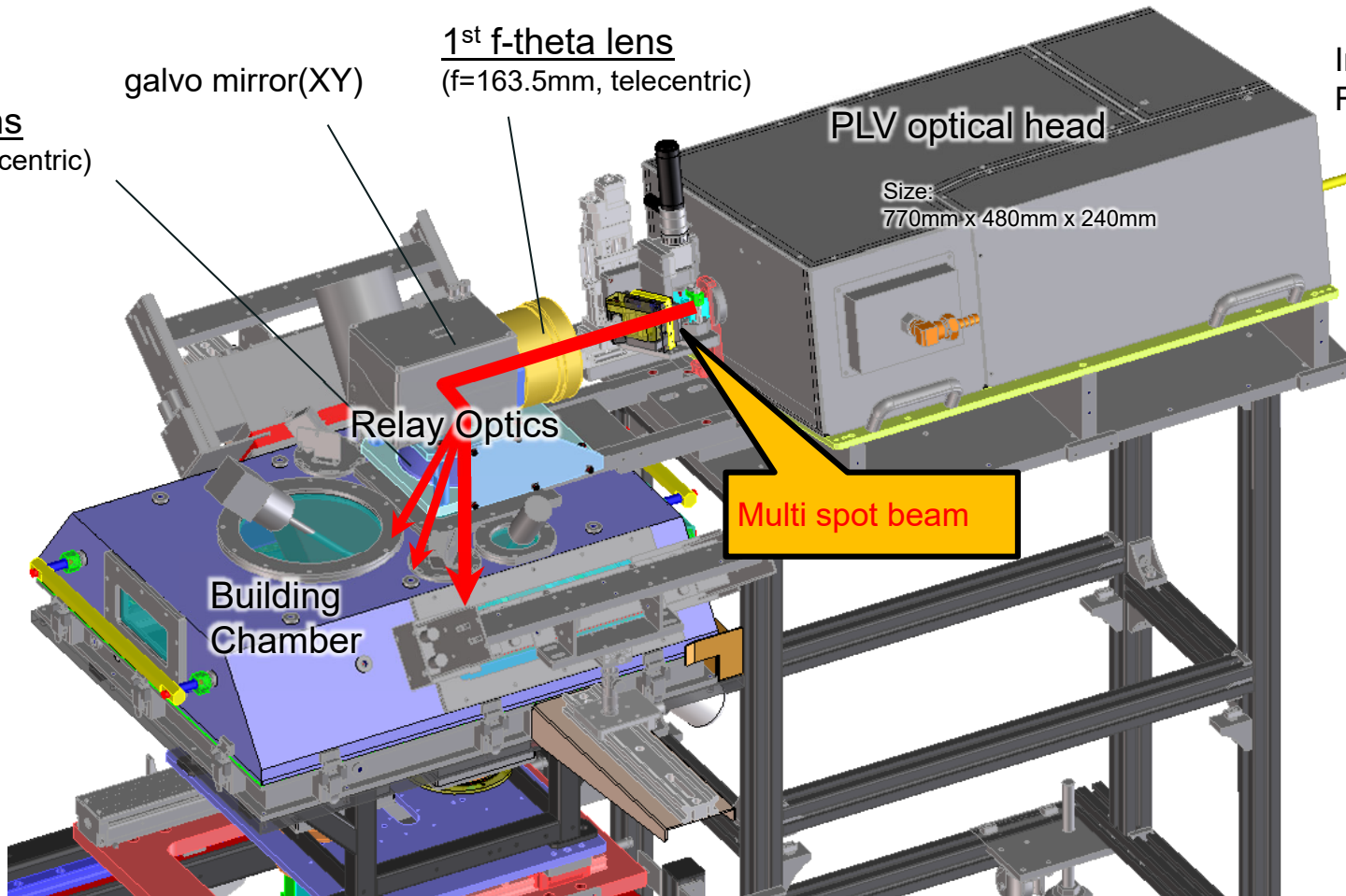
Input:
Fiber laser 1070nm
500W

Size:
770mm x 480mm x 240mm

Relay Optics

Multi spot beam

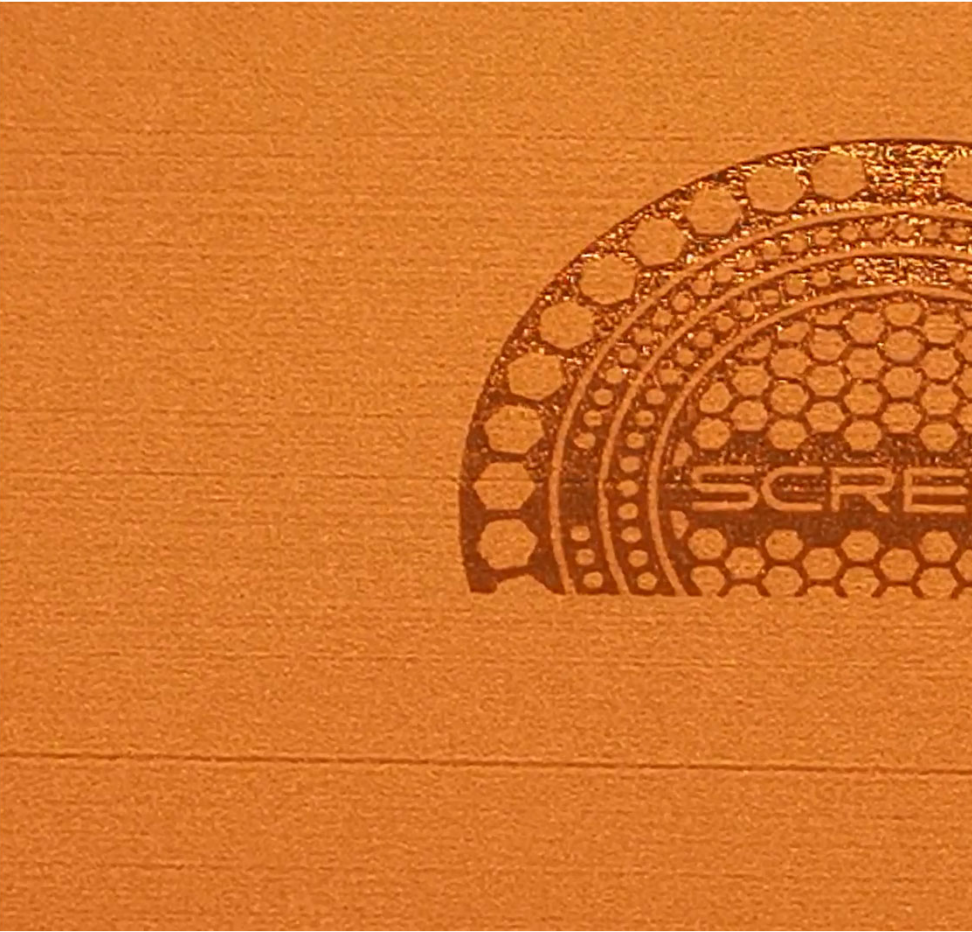
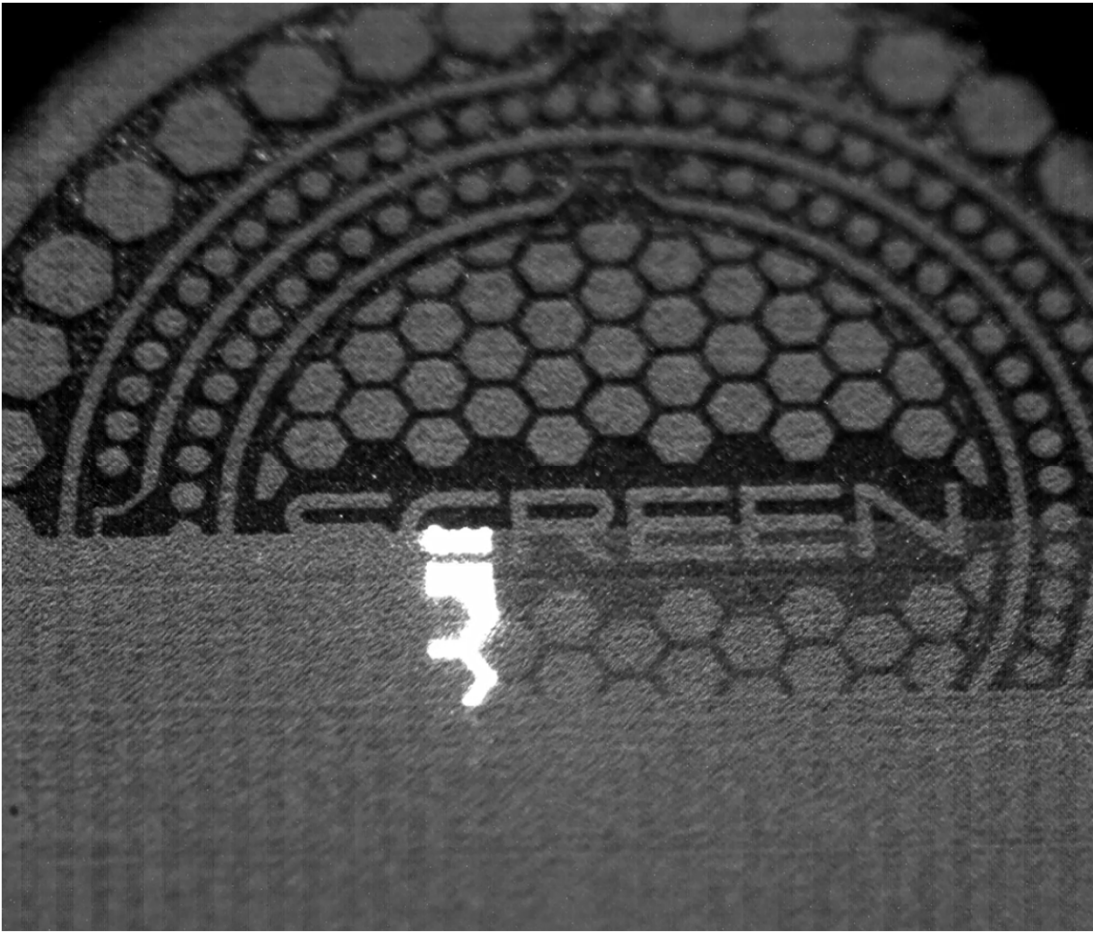
Building
Chamber



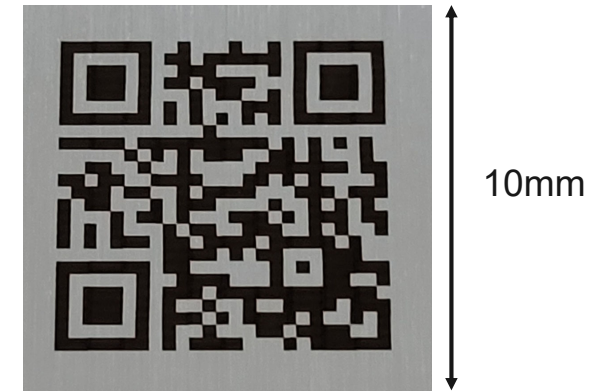
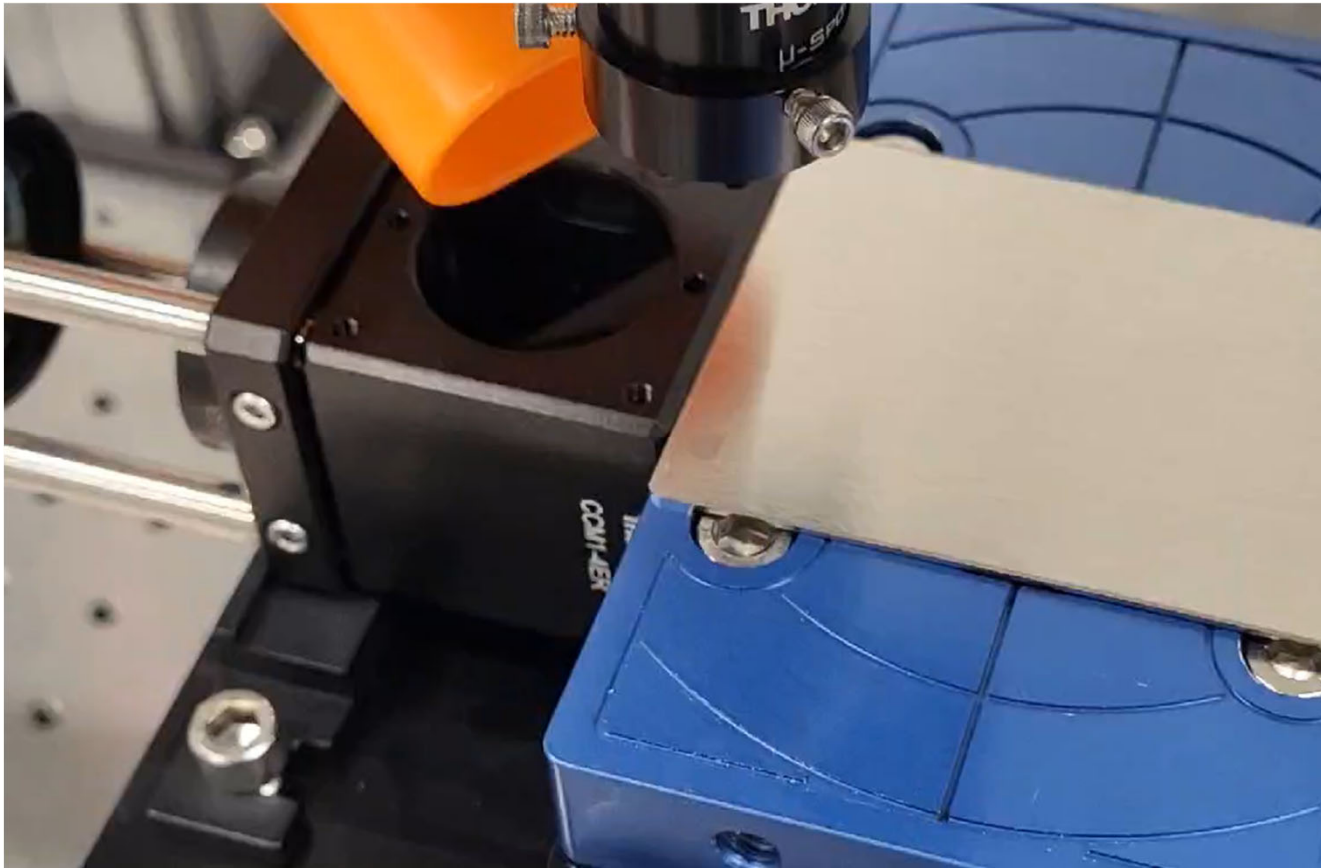
Demo: 3D Printing Video

High-Speed Camera Image

Smart phone image



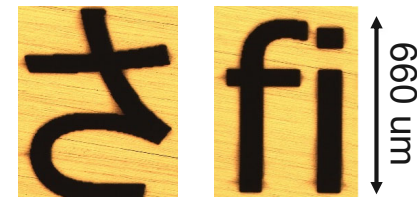
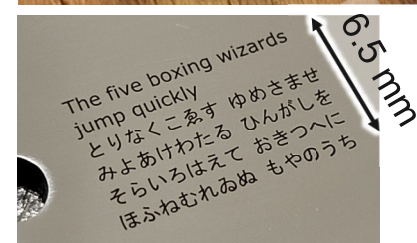
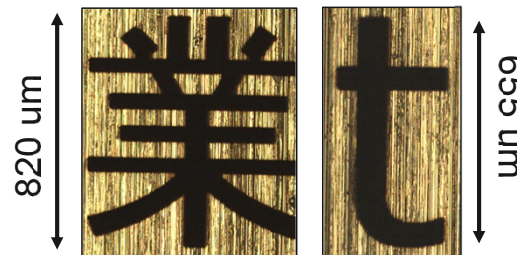
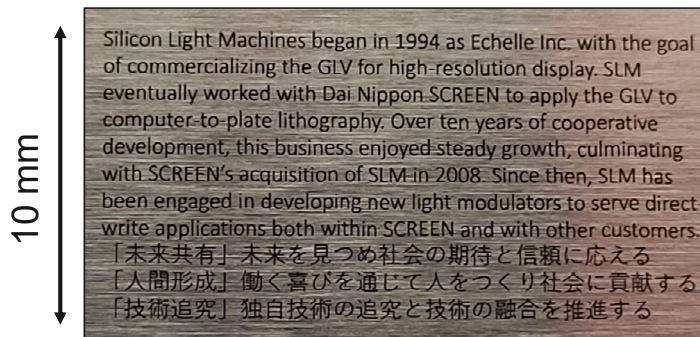
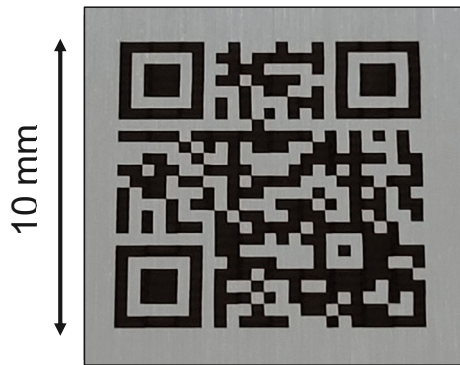
Laser Black Marking Demo



Finished mark on stainless steel

	Demo	Product	
Laser power:	20	>100	W
Laser Energy:	100	200	uJ
# of beams:	50	130	
Swath width:	1.0	2.7	mm

Black Marking Demo Results



Summary



• SLM is building a high throughput multi-beam optical head suitable for laser materials processing

- Outstanding image quality
- High resolution
- Superior throughput

• The optical head can be customized to support stainless steel, plastics, and other materials

- Wavelength (355nm → 1064nm)
- Pulse width (ps, fs, ns, CW)
- Includes calibration unit
- With or without galvo scanner, roll-roll, xy-stage

• Product release: July 2023

• For more info

- Photonics West 2023, Feb 2 paper 12414-29 “High Throughput Spatial Light Modulator Based Multibeam Laser Marking System”
- SLM Technology overview: PW 2021 <https://youtu.be/yaHKy7toJSk>
- Email: larseng@siliconlight.com