

OPEN HARDWARE FAST HIGH RESOLUTION LASER

Outline

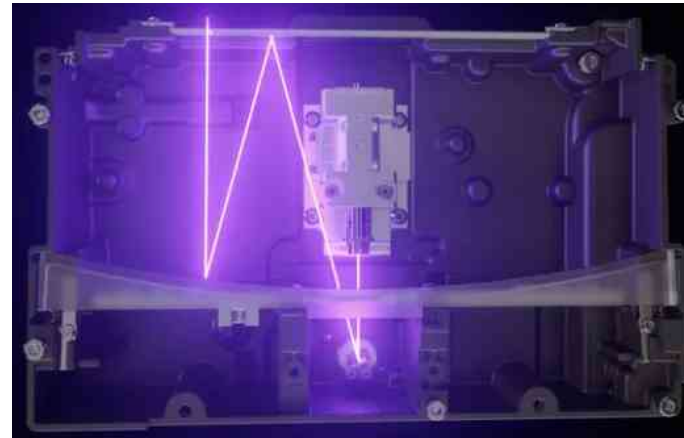
1. Moving mirrors
2. Customer pain
3. Solution
4. Unique Selling Points
5. Beachhead market
6. Competition
7. Possible applications

1. Moving mirrors

formlabs 

Galvo mirror

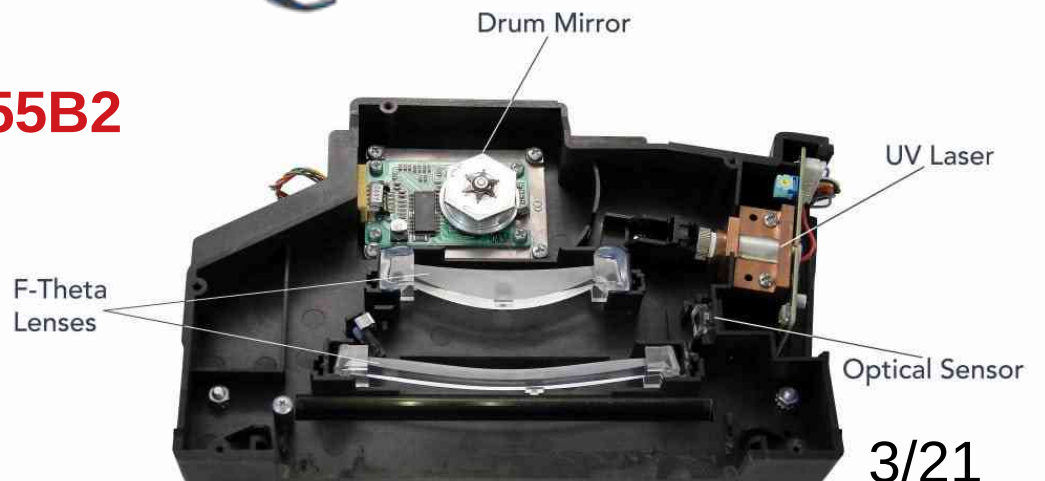
slow



Rotating Mirror

patented US9079355B2

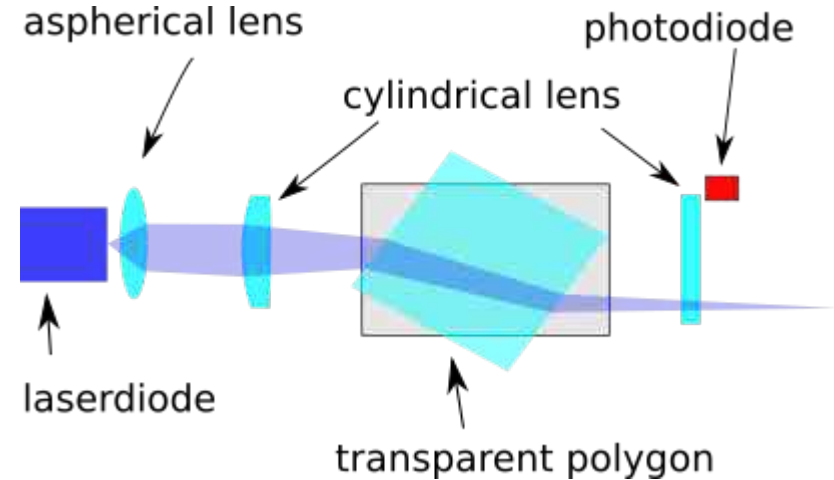
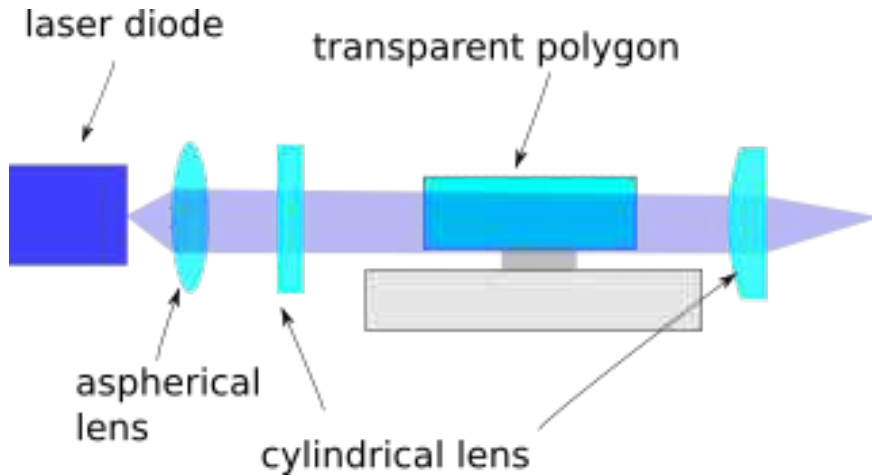
 envisionTEC



2. Customer pain

No open source linear illumination technology

3. Solution



cylinder lenses are optional!

wavelength	405 nm
rotation frequency	2400 rpm*
spot size FWHM	25 micrometers
cross scan error	40 micrometers
jitter	35 micrometers**
optical power	500 mW
duty cycle	47 % @ 4 facets
scan line length	8 mm

*max is 24000 rpm

**jitter can be reduced further with correction table

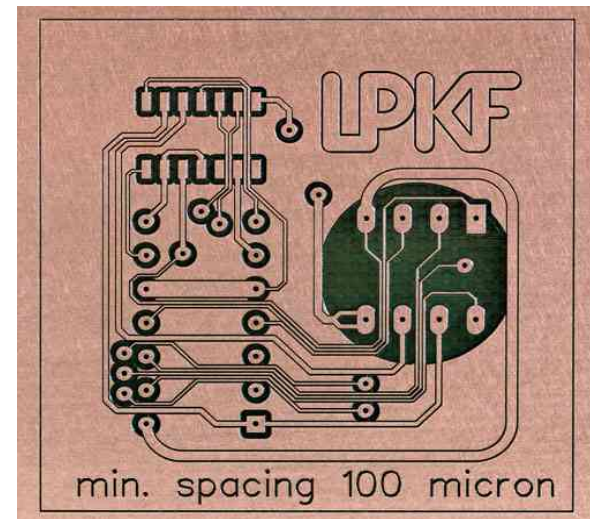
4. Unique Selling Points

- short scan line
- less sensitive to facet imperfections
- 90 degrees of incidence
- extensive freedom of use

5. Beachhead Market: PCB prototyping

- **Buyer:** machine builders and electronic designers
- **Market size:** 30K printing systems (EU and USA)*
- **Sales model:** hardware / software
- **USP:**

curved substrates
small feature size



*Source: Edison report on NanoDimension [2017](#)

6. Competition

	Number of layers	Minimum Line Width	Cost
Nano Dimension DragonFly 2020	<17 layer PCB	90 micron	\$150K
BotFactory Squink	2* layer PCB	254 micron	\$4k
Optomec Aerosol Jet	3D object with embedded wiring	254 micron	\$400k
Xerox	3D object with embedded wiring	N/A	unknown
LPKF mechanical milling	<8 layer PCB	100 micron	\$6-17K
LPKF laser milling	<8 layer PCB	50 micron	\$100K
LPKF laser transfer printing	Individual layers	unknown	unknown
Volterra V-One	2* layer PCB	200 micron	\$4.2K
Bungard	2* layer PCB	50 micron	unknown
Hexastorm	2* layer PCB	25 micron	700\$ per module

Hexastorm offers smallest feature size

7. Possible applications

**Prism scanning was overlooked industry wide.
There are a lot more applications.**

photopolymer printing
selective laser sintering
enterprise PCB
virtual reality displays
etcetera...



Small Medium Enterprise photopolymer printing

	Formlabs	Prusa Research
Machine Name	Form 3	Prusa SL1
Speed [m/s]	2	6 seconds per layer
Resolution [μm]	90 (spot)	47 (pixel)
Layer Thickness [μm]	25 - 150	25 - 100
Wavelength [nm]	405	405
Power at surface per source [Watt]	0.25	
Exposure Technology	galvo mirror + parabolic lens	LCD
Light source	Laser diode	LED
Platform size [mm]	145 x 145 x 175	120x68x150
Coating	Bottom-Up	Bottom-Up
Price [\$]	3500	1700



Hexastorm can be 10x faster and 4x more accurate than Formlabs

Enterprise photopolymer printing



	Prodways	3D Systems	Envisiontec
Machine name:	ProMakerL7000D	ProX 950	XEDE 3SP
Exposure Technology	Moving beamer + mirror	Galvo mirrors + f-theta	Rotating mirror + f-theta
Light source	LED	SSL	laser diode
Resolution [μm]	40	130	100
Coating	Applicator	Applicator	Applicator
Layer thickness [μm]	25-150	25-150	50-100
Wavelength [nm]	365/405	355	405
Power at surface per source [Watt]	<4	1	0.5
Platform size [mm]	800 x 330 x 200	1500 x 750 x 550	457 x 457 x 457
Price [\$]	350000	500000	100000-250000

Prism easier to combine due to short scan line

Special photopolymer printing



	Carbon 3D	Admatec	Nanoscribe
Machine Name:	L1 Printer	AdmaFlex 130	GT2
Exposure Technology	DMD	DMD	Polygon mirror + f-theta
Light source	LED @ 405 nm	LED @ 405 nm	Femto-second @ 750 nm
Resolution [μm]	40	50	0.2
Coating	Bottom Up	Foil	In fluid
Specialty	production speed flexible parts no stair stepping	metal ceramics	high resolution dual photon
Customer need Price [\$]	100000 per year*	100000	450000
Customer need	US7892474B2 circumvention	needs lasers for precise cure	move laser fast with prism

* source [Fabbaloo](#)

**All these companies have a need
which Hexastorm can provide.**

Small Medium Enterprise selective laser sintering



	Formlabs	Sintratec
Machine name	Fuse 1	S2
Speed [m/s]	2	2
Resolution [μm]	90 (spot)	90 (spot)
Layer Thickness [μm]	25 - 150	25 - 150
Wavelength [nm]	950	950
Power at surface per source [Watt]	7-8	7-8
Light source	Laser diode	Laser diode
Exposure Technology	Galvo mirror	Galvo mirror
Platform size [mm]	165 x 165 x 320	160 x 160 x 400
Coating	Counter rotating roller	Counter rotating roller
Price [\$]	9999	30000 (includes peripherals)

Prism is more accurate and easier to scale

Enterprise PCB

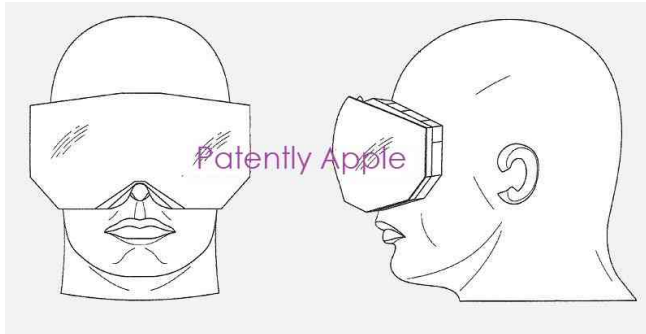


	Orbotech	Kleo	Screen	Ucamco	Next Scan Technologies
Machine name	Nuvogo Fine10	Speedlight 2D	DT-3000	Ledia 3WL	LSE170A
Light source	DPSS Paladin	Laser diode	YAG laser i-line	LED	various
Wavelength	355	405	355	405/385/365	various
Exposure Technology	Rotating mirror + refractive F-theta	9 Thick rotating mirrors	Grating light valve	Multiple beamers	Rotating Mirror + reflective F-theta
Track [μm]	10	15	3	15	5
Gap [μm]	15	15	3	15	5
Throughput [sides/hour]	240	360	65	405	
Depth of Focus [μm]	300	300		?	
Number of light sources	1	288	1	? but >1	1

Hexastorm can disrupt this market by introducing rotating prism



Virtual Reality Displays



	Apple	Magic Leap
Exposure Technology	Scanning mirror	Fiber Scanning display* / Liquid Crystal on Silicon
Light source	Laser diode	Laser diode / LED
Pattern	square	circle / square
Patents	20190265486	US20150178939A1 US20180052277A1

*Fiber scanning display is also used in endoscopes



Apple believes scanning mirrors can be used in augmented reality. Hexastorm claims it should be prisms...

Etcetera



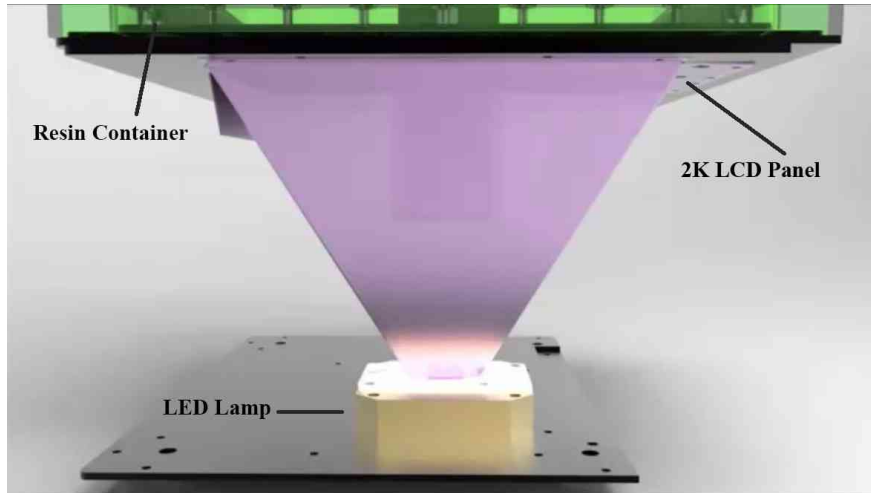
Company Name	Technology	Application
HP Cylite	Galvo mirror	Ophthalmology
Carl Zeiss Meditech	Galvo mirror	Ophthalmology & Optometry
TTP labtech	Galvo mirror	Laser scanning cytometry
Horiba	Galvo mirror	Laser Scattering Particle Size Distribution Analyzer
Bea Sensors	Rotating mirror	Security, Movement sensor industrial doors
Video Jet	Galvo mirror	Marking of medicine
Mirada	Rotating mirror	LiDAR for self-driving cars
Discover Aether	XY laser	Cure liquids during printing
Poeitis	Scanning mirror	Laser induced forward transfer in bioprinting
Keyence	Scanning mirror	Confocal Laser microscope
LAP Laser	Rotating mirror	Tube diameter inspection

There are many more applications still!

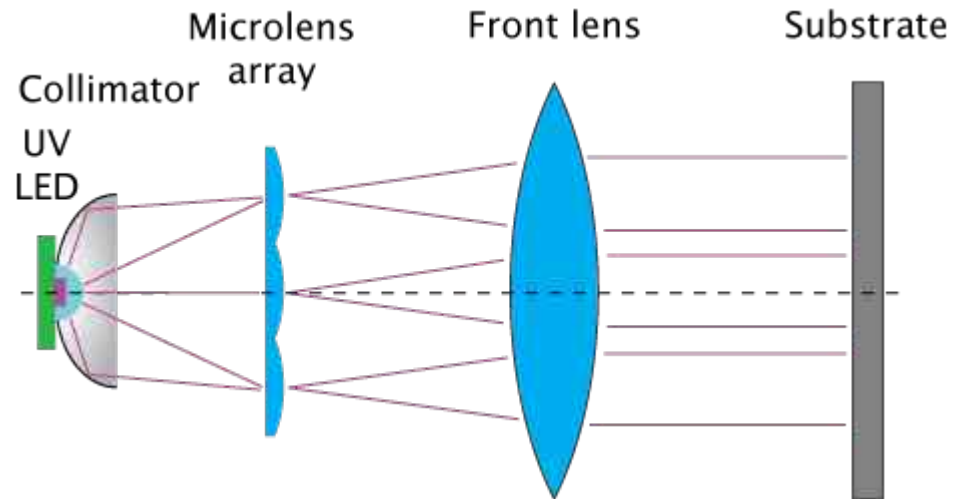
Thank you for your attention & Happy hacking!

Back Up Slides

Mask Exposure



inaccurate



accurate

**Prusa SL1 does not use lenses;
illumination is not uniform
light exits under angle**

Microfluidics

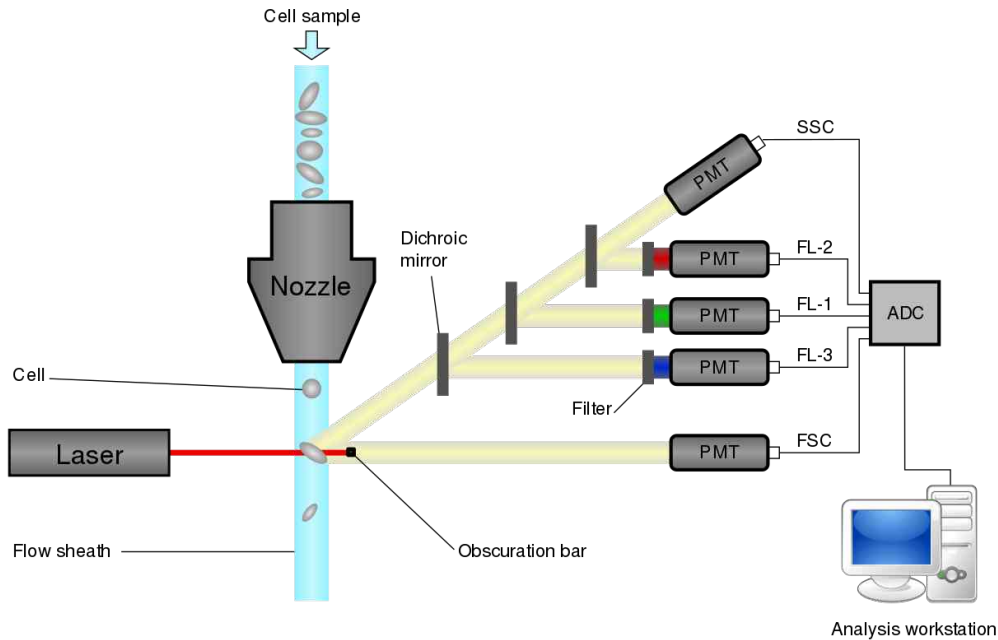


	Kloe	4PICO
Machine name	Dilase 3D	PicoMaster200
Speed [mm/s]	50	405
Technology	XY gantry	XY gantry
Resolution [μm]	5 (spot)	0.300
Wavelength [nm]	375/405	375
Power at surface per source [Watt]	0.3	0.3
Light source	laser diode	laser diode
Platform size [mm]	100 x 100 x50	
Coating	Top-down	Top-down

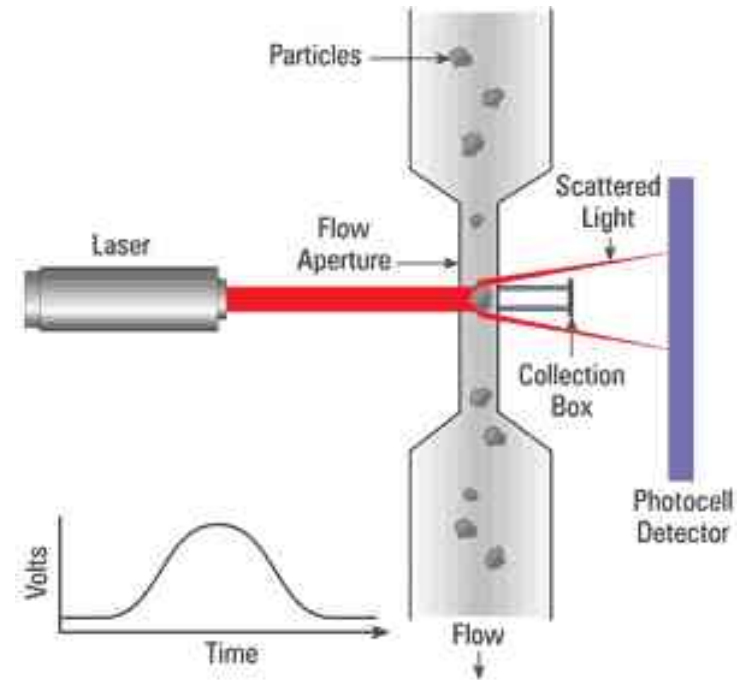


Prism can be used to move laser.

Medical Analysis



flow cytometry



particle analyzer

Prisms can be used in flow cytometry and particle analyzers