An Overview of the UA Maskless Lithography Tool

March 4, 2008

Milster Research Group

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Milster Research Group 2008

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Outline

- Motivation
- Similarities and Differences Compared to a Commercial Laser Printer
- System Characteristics
- System Components
- Dry Pattern Transfer
- Results
- Future Work

Motivation

- Provide computer-generated gray-scale patterning of surfaces for applications including diffractive optical elements (DOEs), computer-generated holograms (CGHs), alignment features, masks, micro-machines, etc.
- Basic Method:
  - Design desired surface profile
  - Print and develop profile in resist
  - Perform other process steps (pattern transfer, Cr etch, alignment and overlay, etc.)

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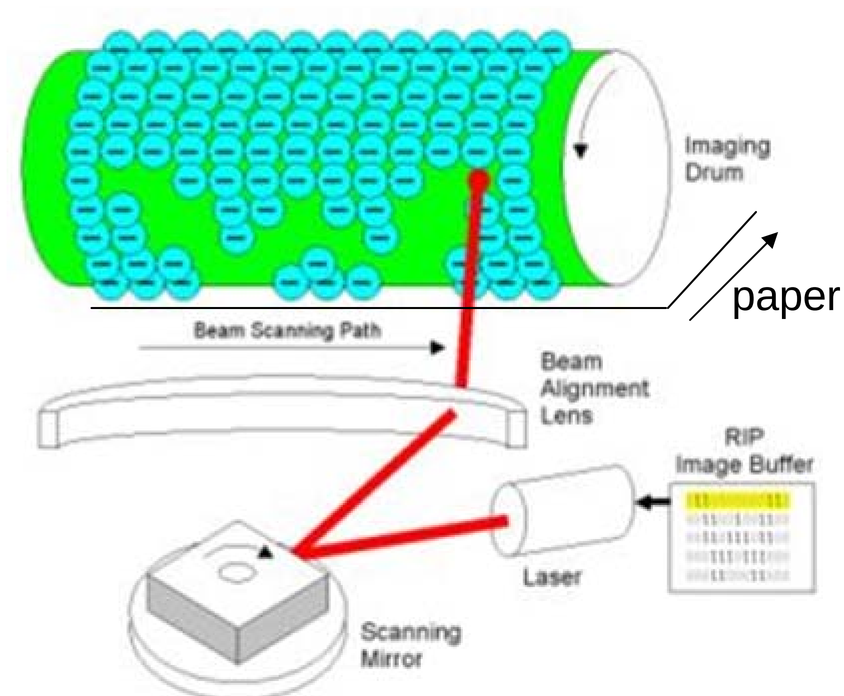
Commercial Laser Printer

- **The laser is aimed at a rotating mirror**
- **The laser beam is directed through a system of lenses and mirrors onto the photoreceptor**
- **The beam sweeps across the photoreceptor in straight line**
- **A stream of rasterized data held in memory turns the laser on and off to form the dots on the cylinder**
- **Cylinder prints on paper**

Commercial Printer



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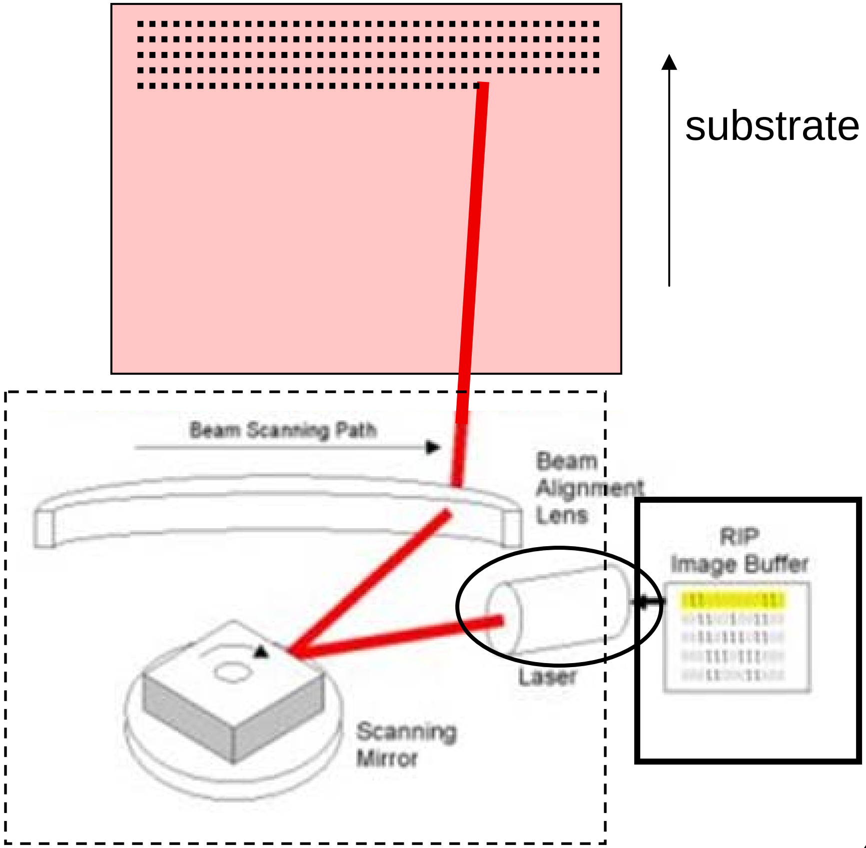
Differences from a Commercial Laser Printer

- **Replace drum and paper with precision stage and substrate with photosensitive material.**
- **Use high-quality optics**
- **Use i-line laser with advanced beam control gray-scale modulation**
- **Use custom, high-performance electronics**

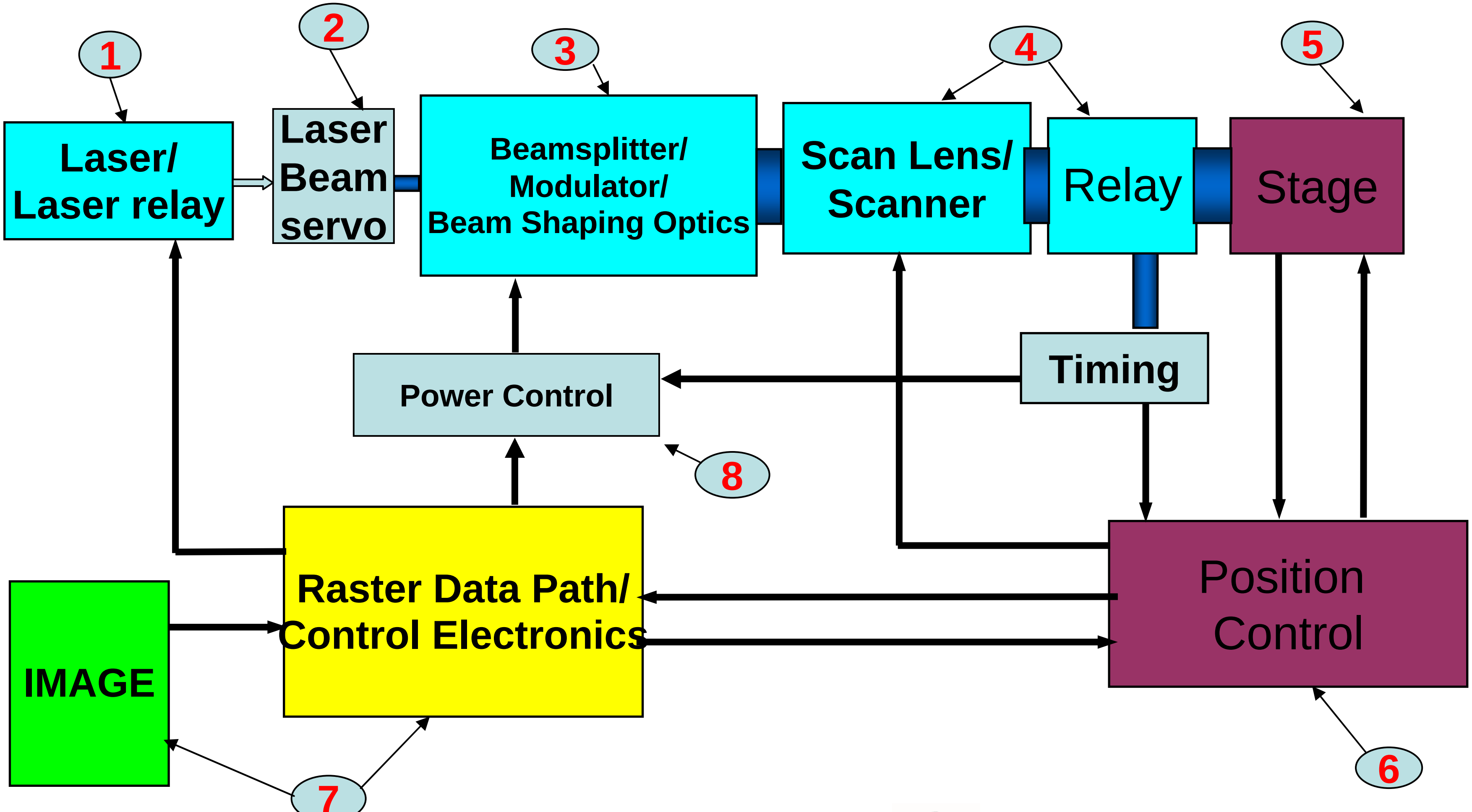


System Characteristics

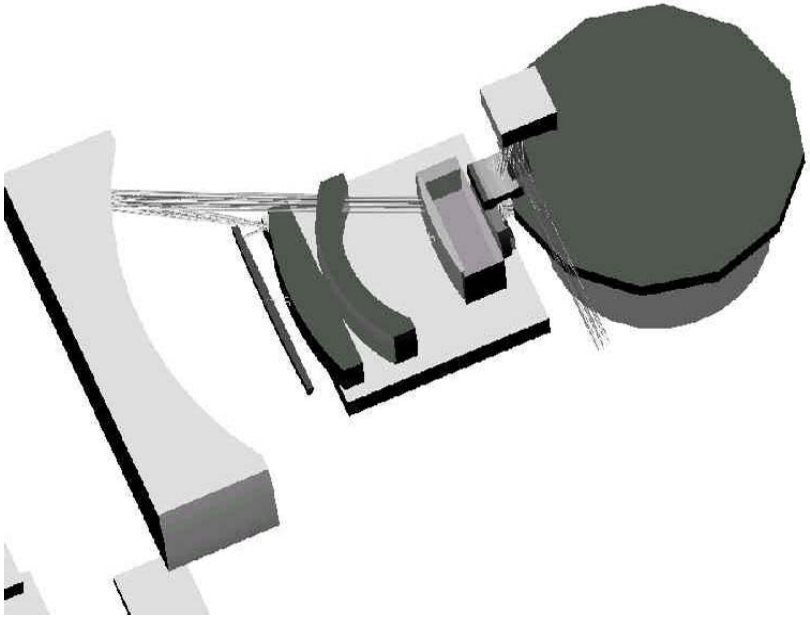
- 20 mm Scan Line Length
- 2.5 micron laser spot size (λ=365nm)
- 2.1 um pixel size
- 2 Watt multi line CW Argon Ion Laser
- 30% transmission efficiency
- A/O modulation
- 24 Mpixel/sec data rate
- 10-bit Grayscale Modulation
- 3000 RPM, 12-facet Polygon Mirror on air bearing spindle
- Achromatic optical system from 350-380 nm
- Telecentric image plane
- 90mm by 140mm stitch area

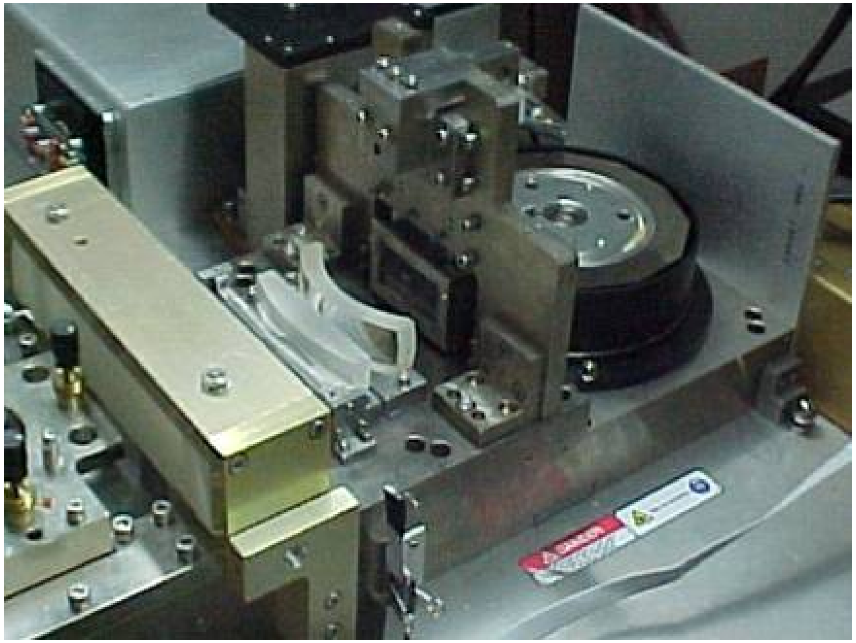
System Components

8 basic building blocks



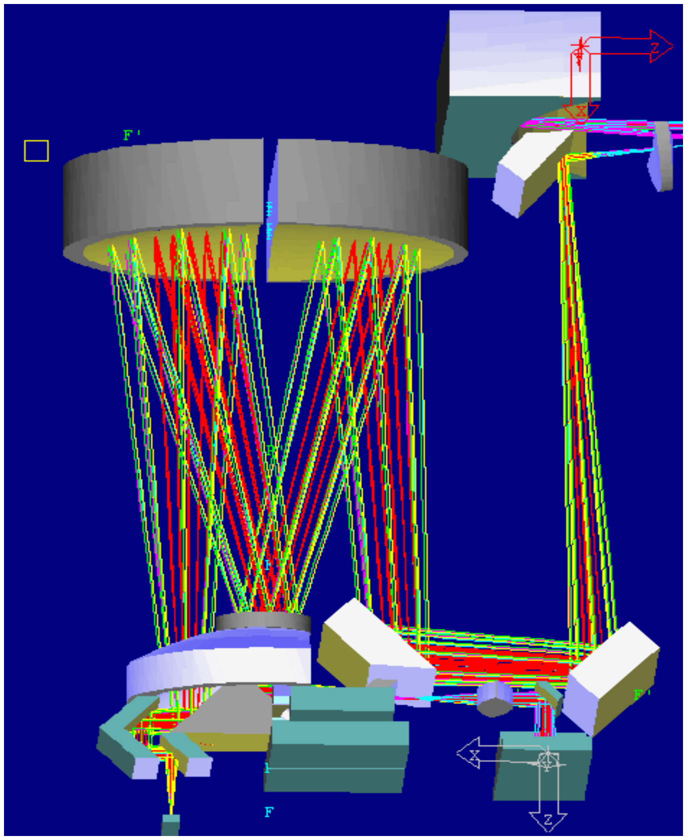
Scanning System

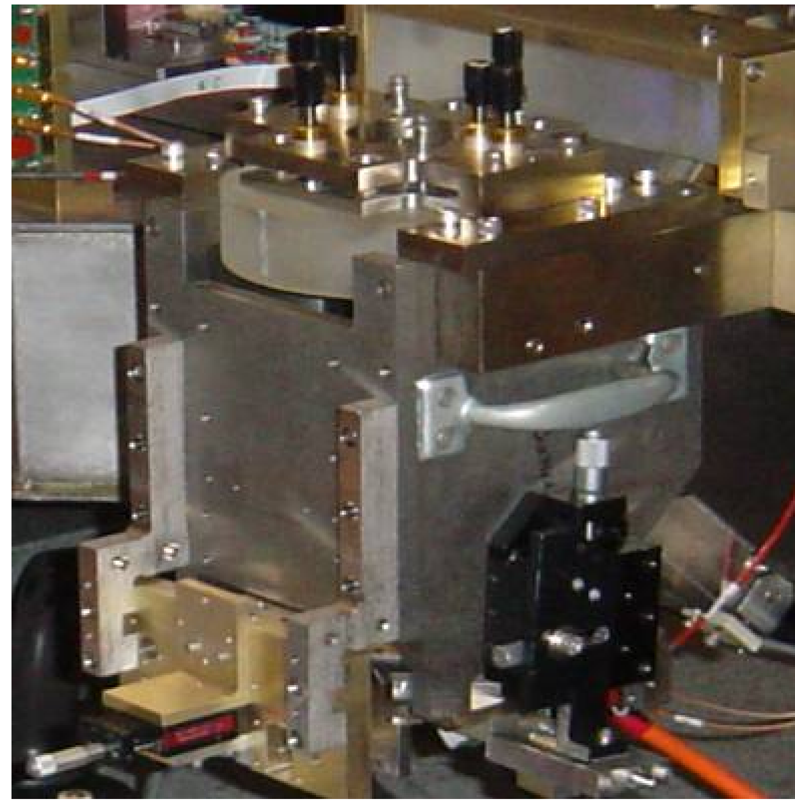




John Tamkin, UA CGH workshop, March 2007

Afocal 2.5x Relay

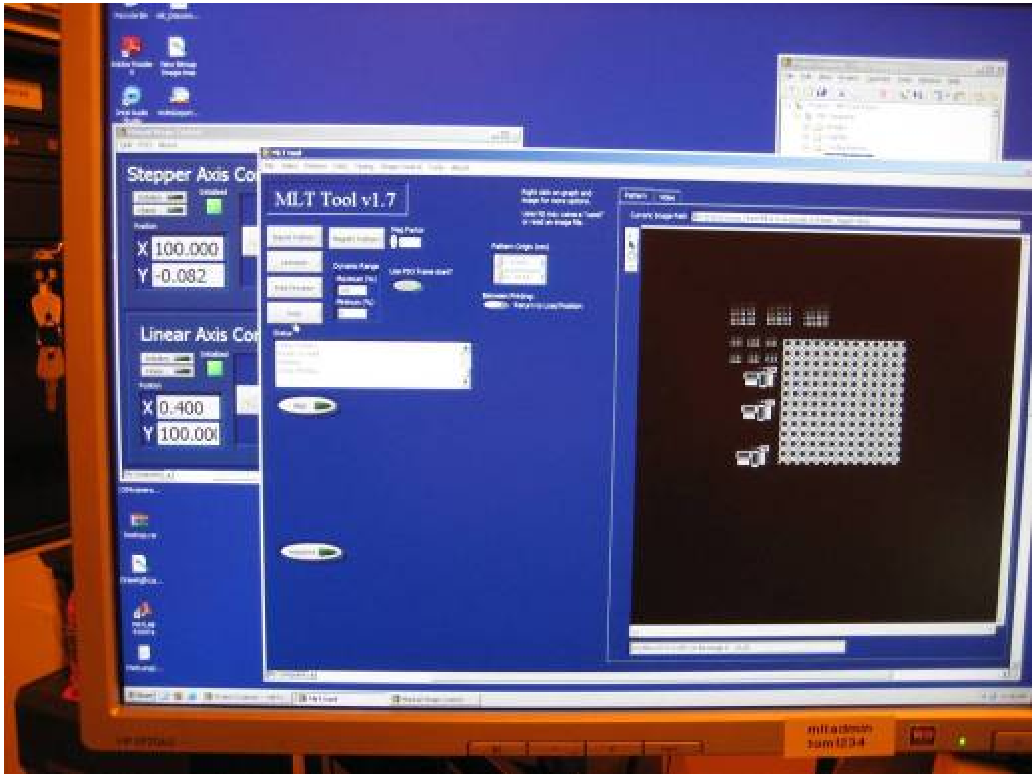




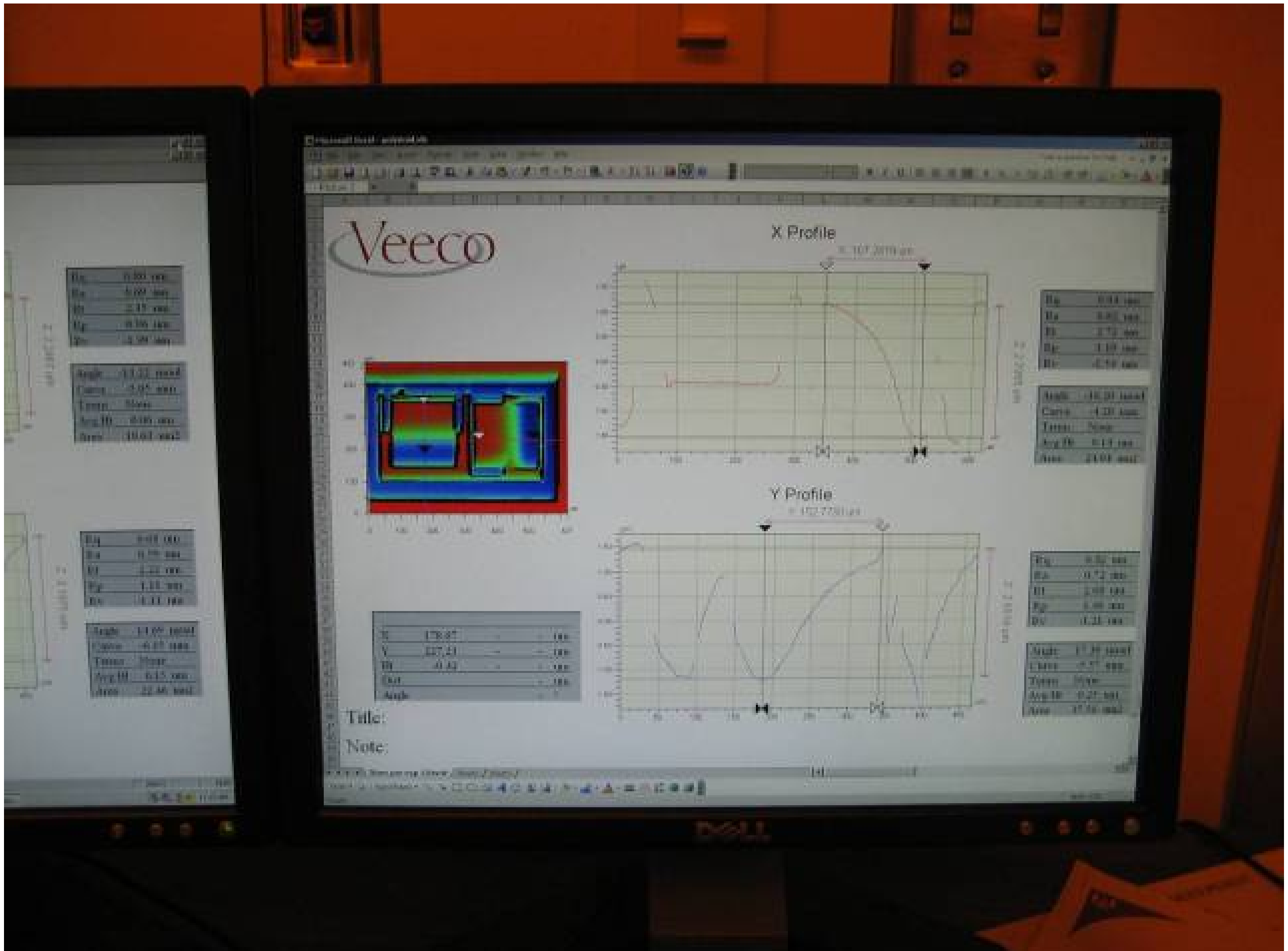
John Tamkin, UA CGH workshop, March 2007

Control Software

- LabView GUI software
- Accepts bit-map bmp file format (One bmp gray-scale pixel => one address unit on substrate.)



Veeco NT9800 Measurement



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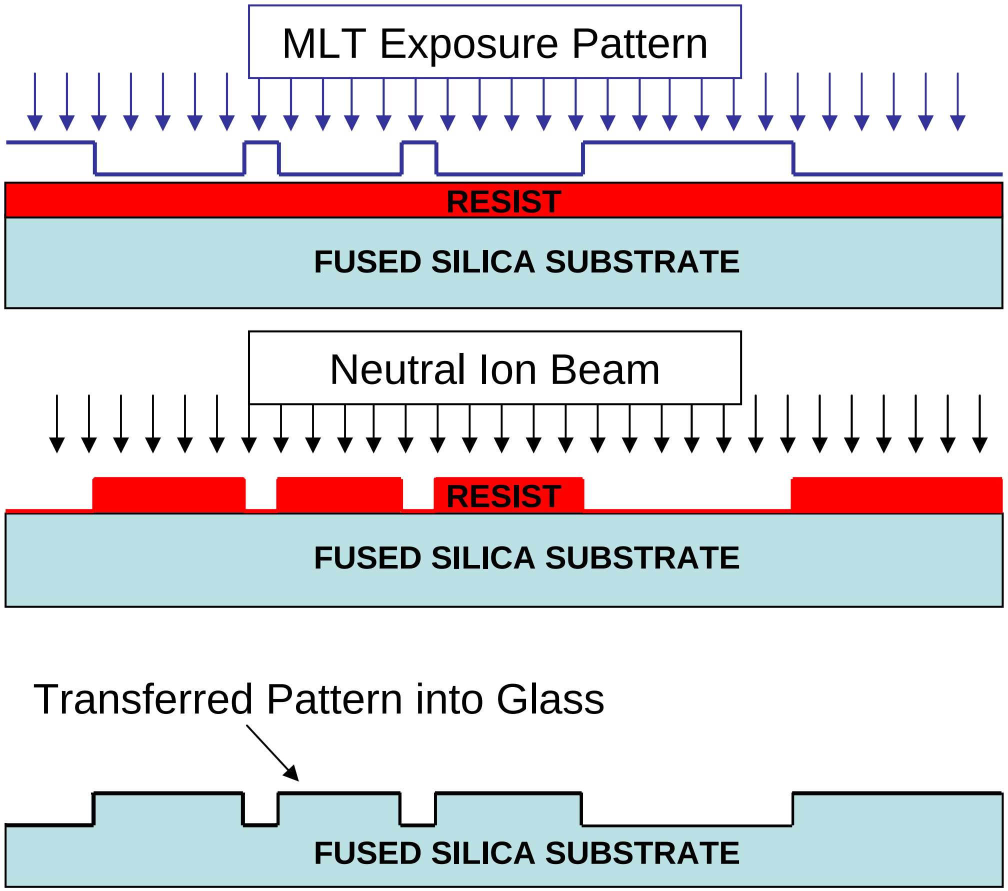
Dry Pattern Transfer Using an Ion Mill

Step 1: Pattern Photoresist with MLT

Step 2: Ion Mill

Result: Pattern in Glass



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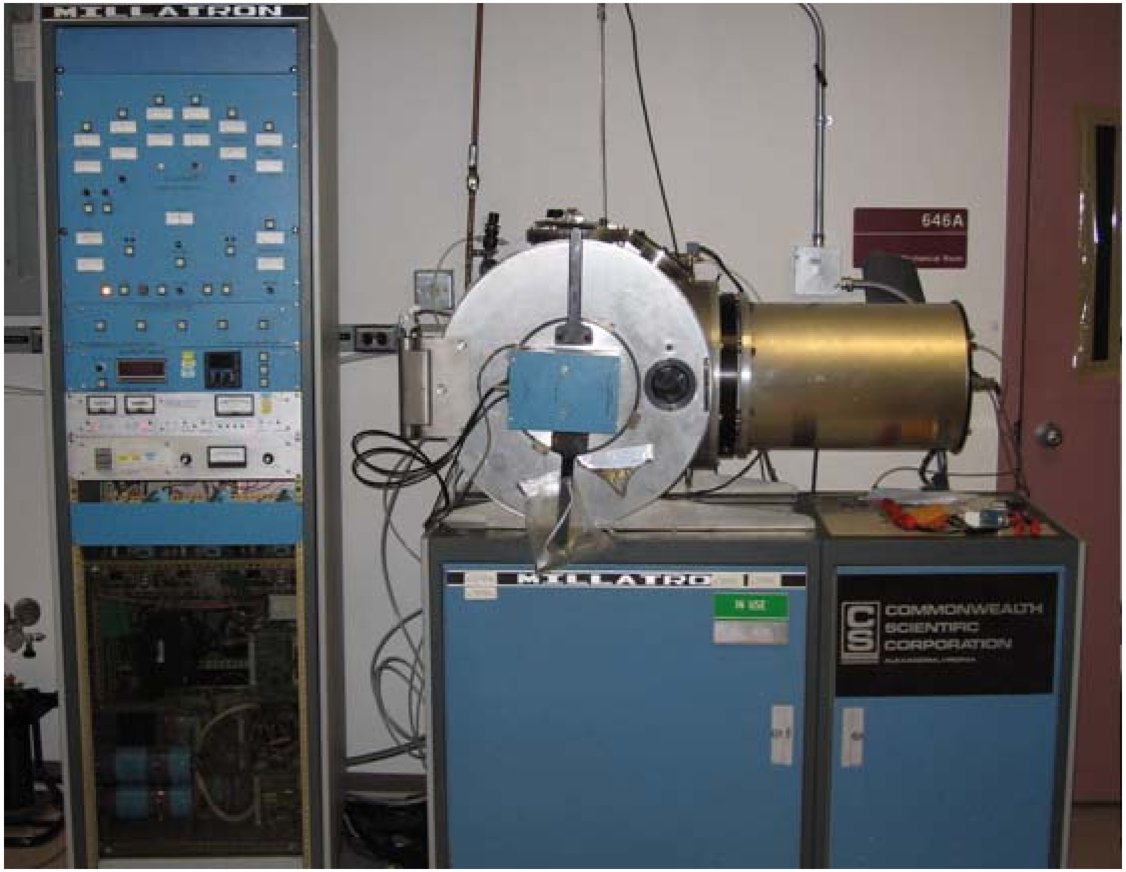
Dry Pattern Transfer Using an Ion Mill

- Model: Commonwealth Scientific Corporation’s Millatron VIII
- Uses a Kaufman (gridded) Design
- Electro-magnet type anode



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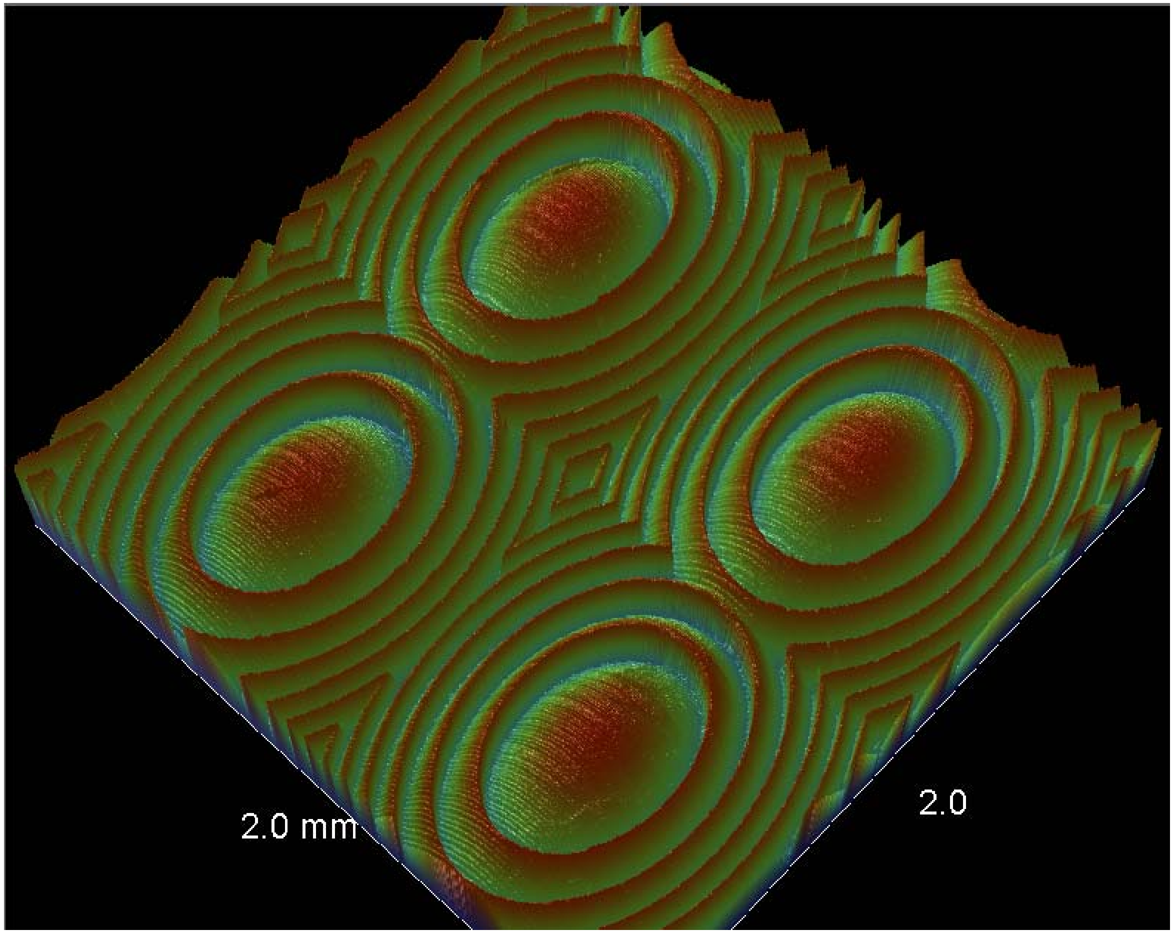
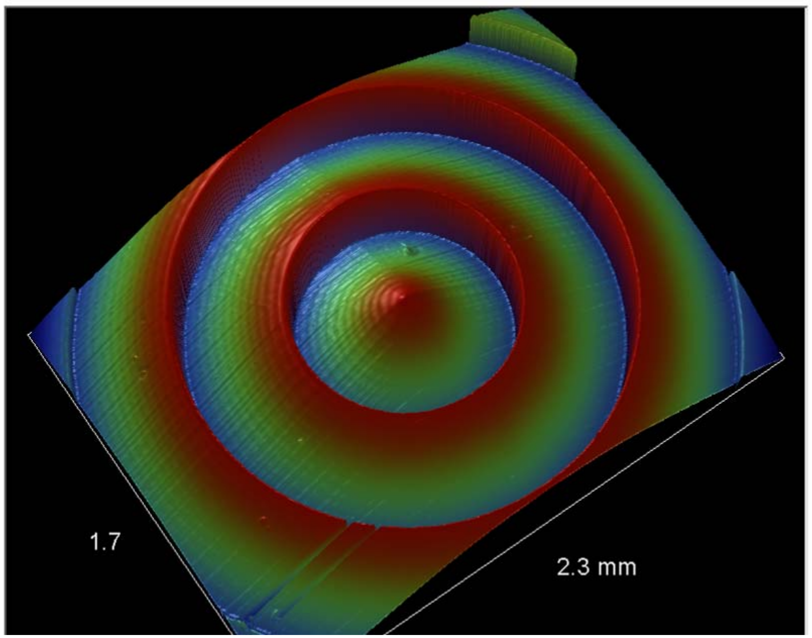
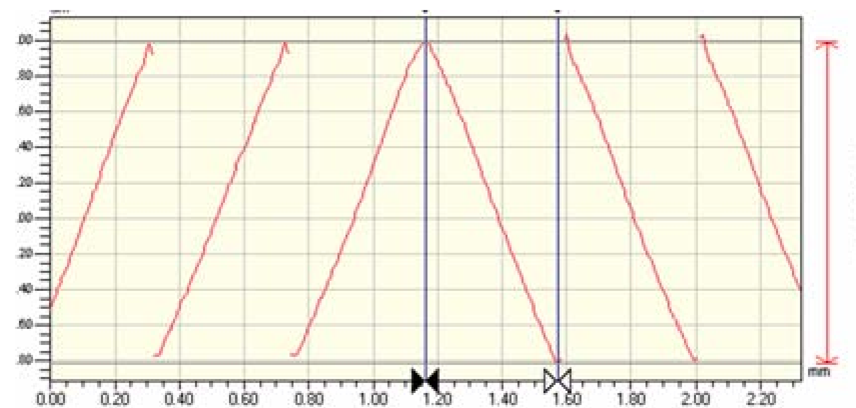
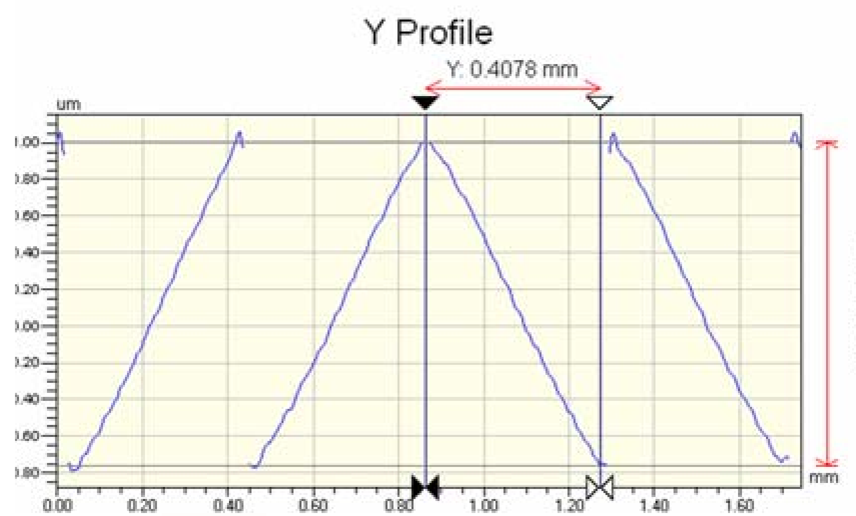
Results – Astigmatic Fresnel Lens Array



Results – Diffractive Axicon







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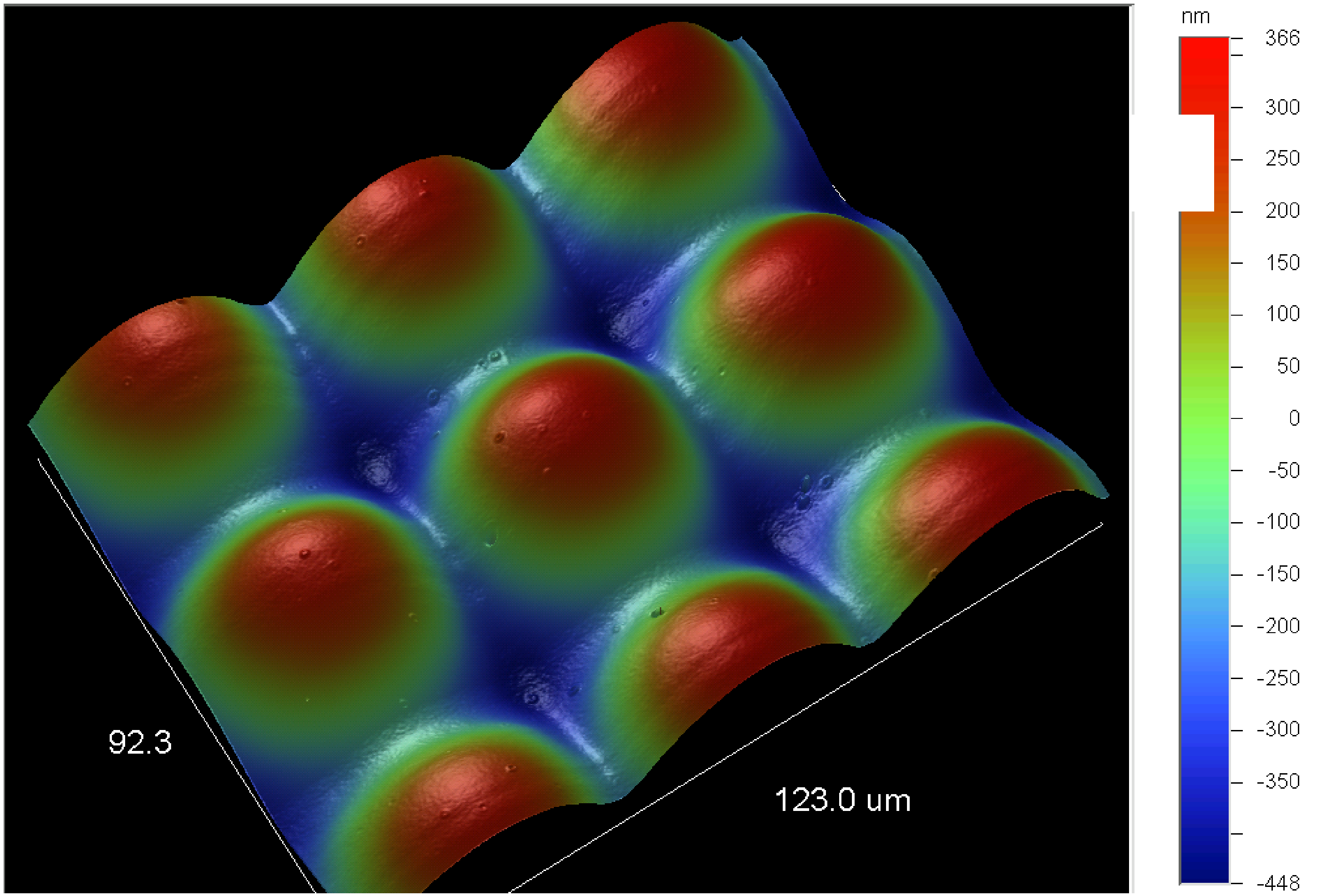
Results – MicroLens Array (Direct Print)



Lens Pattern in Photo-Resist (Crossed Lenses)

Veeco **3-Dimensional Interactive Display**

Date: 12/05/2007
Time: 13:50:16

Surface Stats:

Ra: 911.16 nm

Rq: 978.85 nm

Rt: 3.16 um

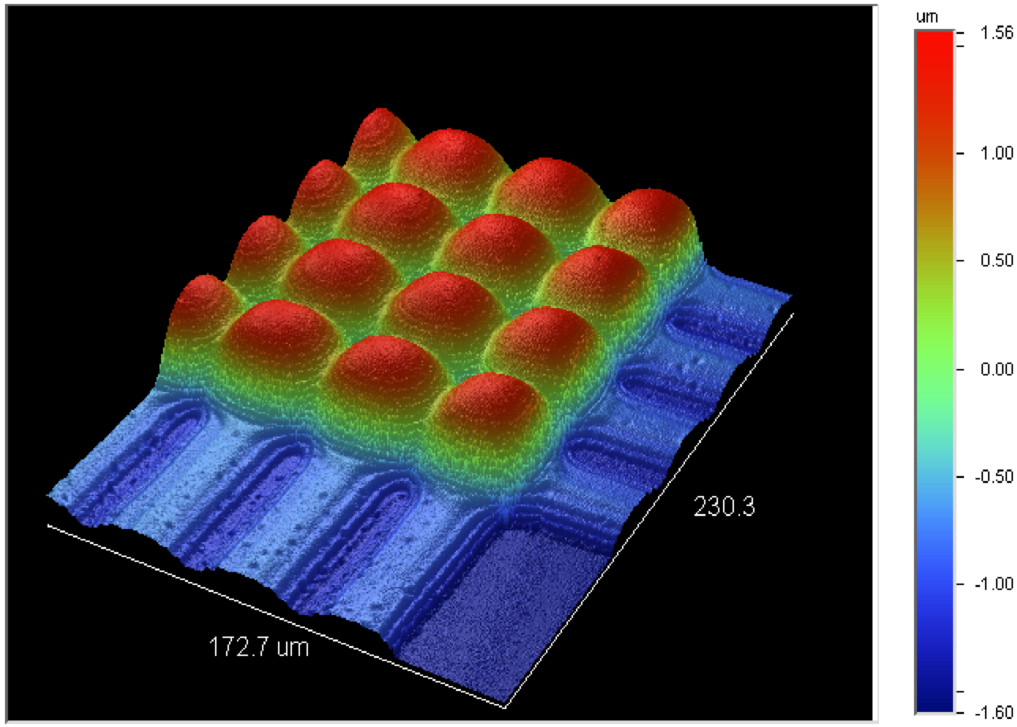
Measurement Info:

Magnification: 27.52

Measurement Mode: VSI

Sampling: 359.78 nm

Array Size: 640 X 480



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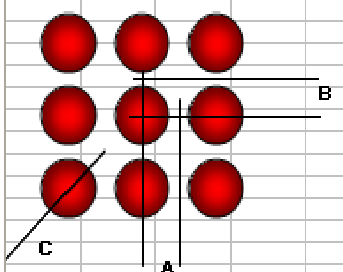
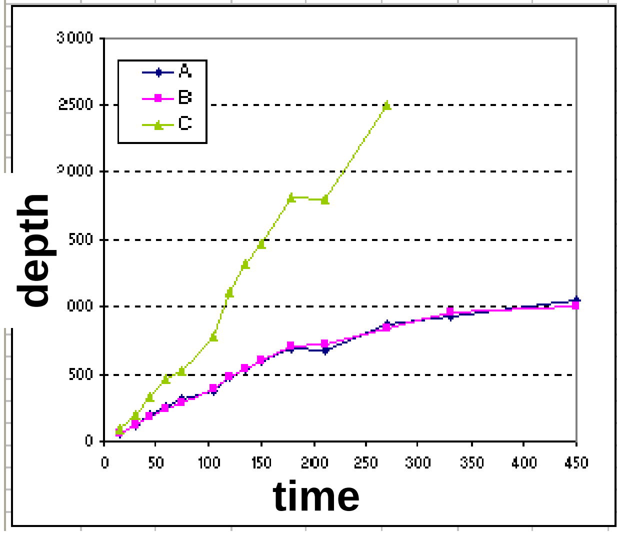
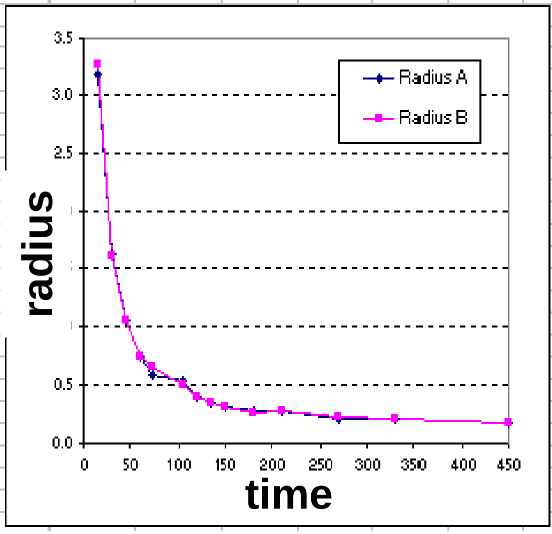
Optimization of Lens Shape in Photo-Resist

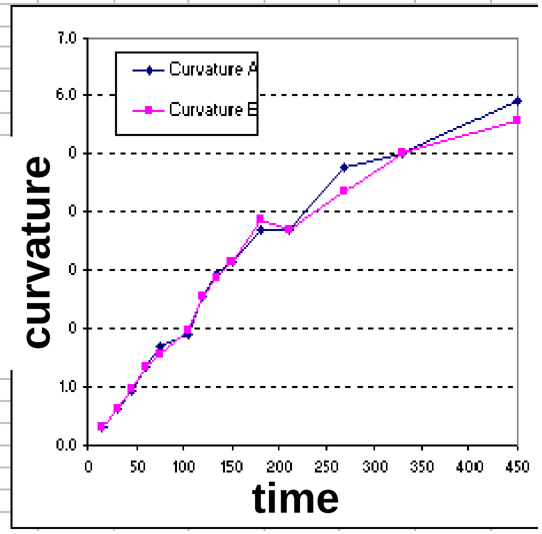


dev time	A	B	C	Radius A	Radius B	Curvature	Curvature B
15	64	59	93	3.17	3.25	0.31546	0.30769
30	122	118	200	1.63	1.61	0.6135	0.62112
45	188	181	326	1.06	1.05	0.9434	0.95238
60	249.9	243.75	466	0.74	0.74	1.35135	1.35135
75	310.4	288.7	517.3	0.59	0.65	1.69492	1.53846
105	370.4	381.25	775.1	0.53	0.51	1.88679	1.96078
120	483.95	482.1	1109.9	0.39	0.39	2.5641	2.5641
135	543.2	539.95	1307.7	0.34	0.35	2.94118	2.85714
150	591.8	594.8	1469.6	0.32	0.32	3.125	3.125
180	688.9	701.1	1804.4	0.27	0.26	3.7037	3.84615
210	675.05	713.15	1784.5	0.27	0.27	3.7037	3.7037
270	864.05	830.95	2499.1	0.21	0.23	4.7619	4.34783
330	929.25	949.7		0.2	0.2	5	5
450	1047.85	995.65		0.17	0.18	5.88235	5.55556

By modifying the development time, lens curvature can be adjusted.







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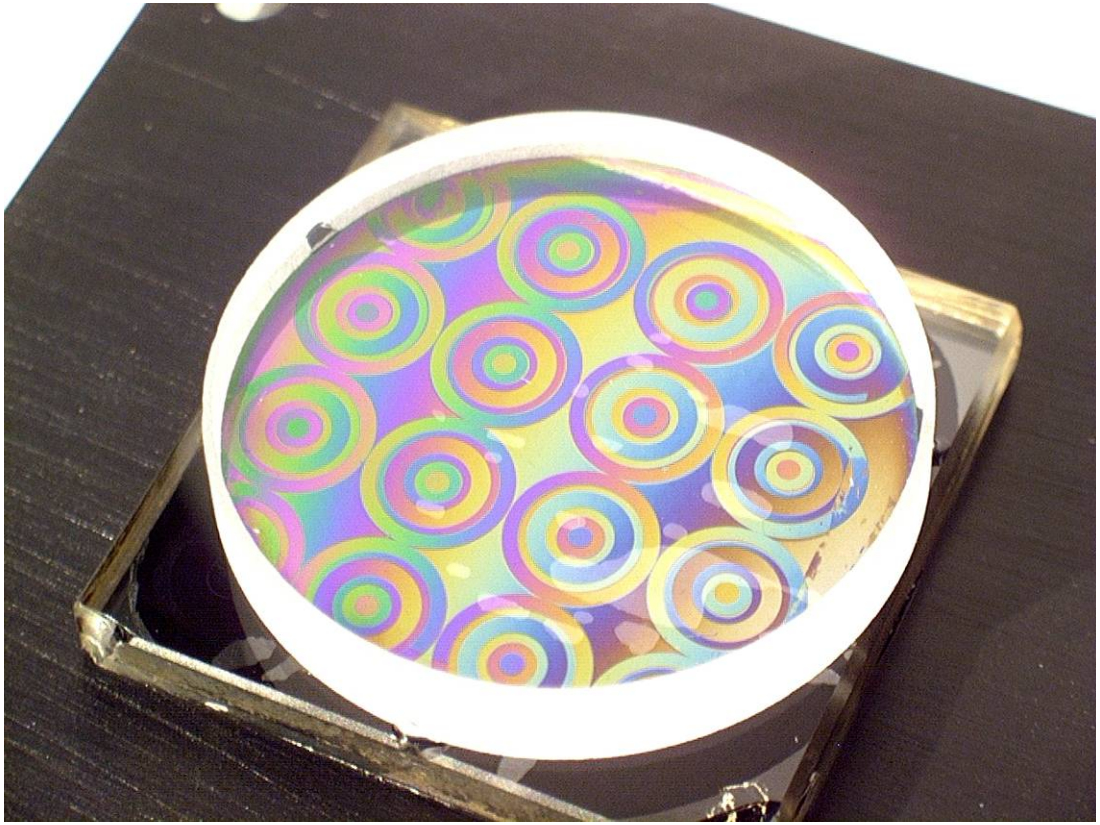
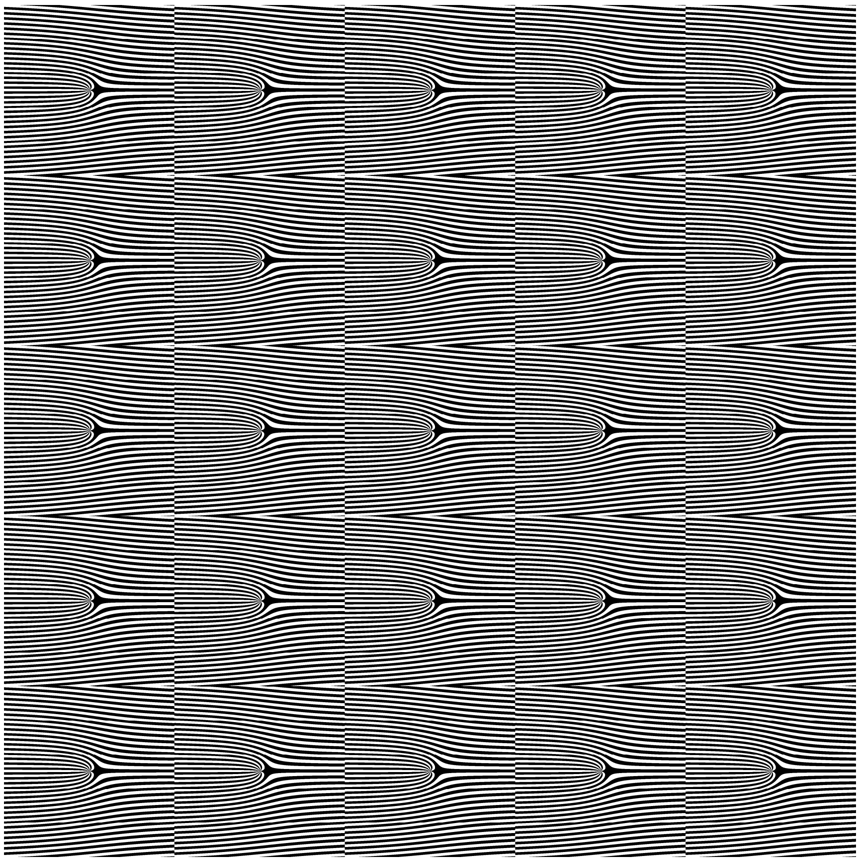
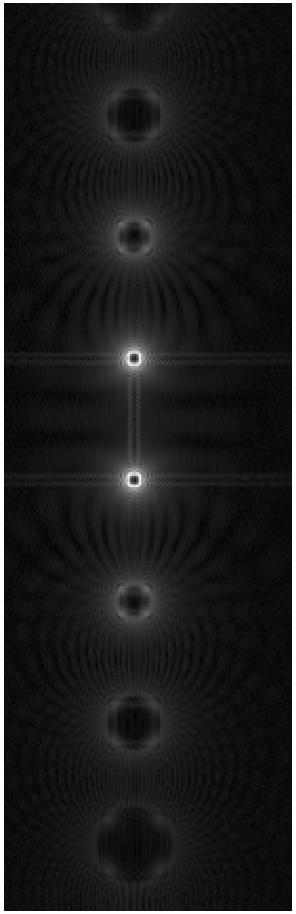
Results – Spherical Aberration Compensator Array

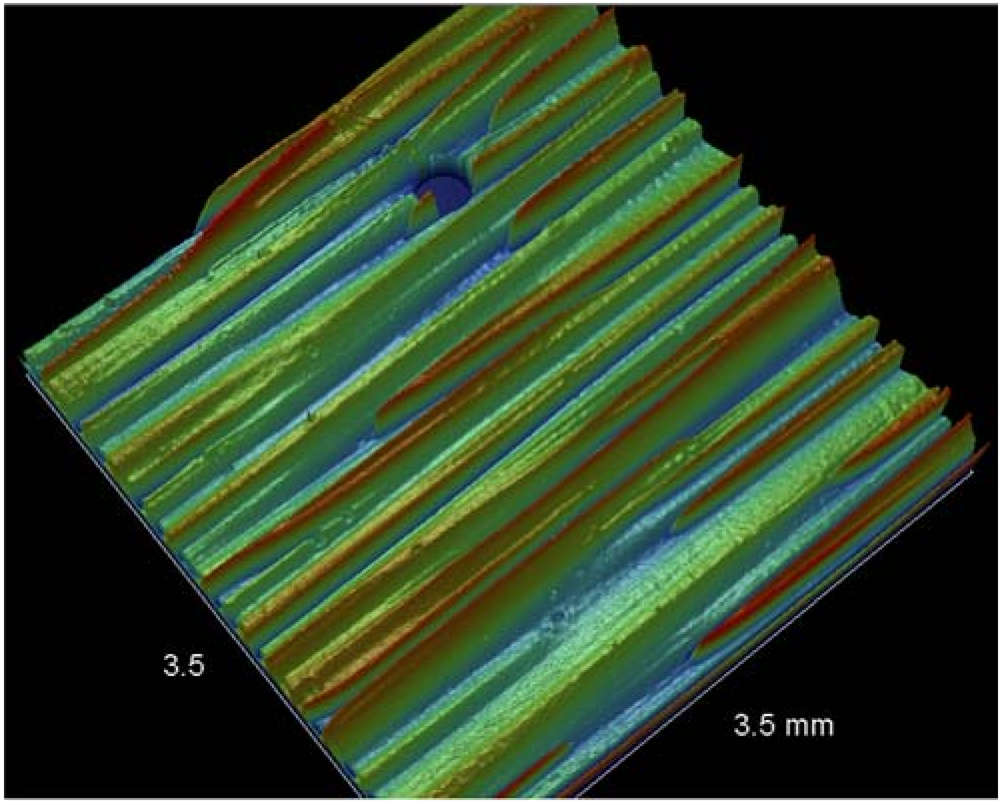


Results – Diffractive Vortex Array





Results – CGH Beam Diffuser



Gray-Scale Diffuser for Peyghambarian Group Holographic Display Device. Large format (5”x 3”) tiled array.

Future Work

- We are looking forward to working with industry and academia on research and prototype projects.
- Desired Tool Improvements:
  - Optimization of beam stability servo
  - Focus calibration
  - Stage reconfiguration
  - Extended scan stages
  - Software improvements
  - Spot drift/quality control

CGH/DOE Workshop

- 3-Day Workshop covers concepts and working knowledge of diffractive optical elements (DOEs) and computer generated holograms (CGHs).
- Extensive instruction on optical testing with CGHs.
- “Hands on” laboratories complement classroom instruction.
- Workshop Schedule:
    - March 17-21, 2008
    - March 16-20, 2009

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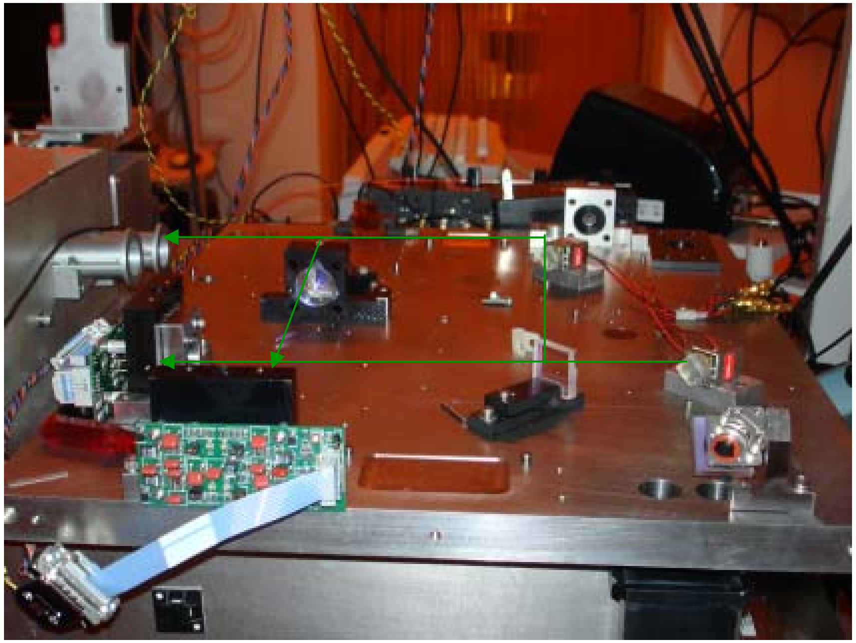
Thank You!

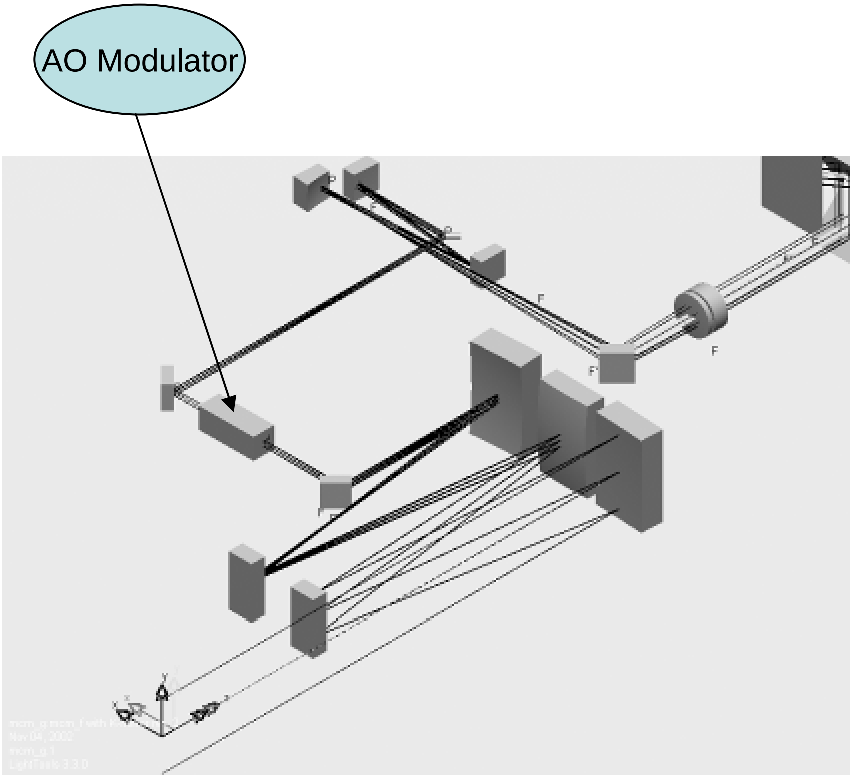
Laser Beam Stabilization System

- **Pointing stability of laser systems is a question of major concern, since fluctuations of the lateral or angular beam position can cause pattern errors.**
- **A Servo Laser Beam Stabilization System was developed for beam drift compensation.**



Modulation Subsystem

- The laser beam is compressed via a 3 mirror afocal telescope to get the right size before entering the acousto-optic modulator
- 8 channel acousto-optic modulator controls up to 8 beams of light (Only one is in use at this time)
- Each channel reaches 24 MHZ of modulation frequency
- The beam is re-expanded via another 3 mirror afocal system to gain smaller focused spot size



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Working Stage

- **Aerotech ALS 130 series**
- **Bi-directional repeatability to 0.1 µm**
- **Direct-drive linear motor for ultra-precise motion**
- **High-accuracy non-contact linear encoder**
- **Cross-roller bearings for smooth motion**
- **90mm by 140mm stitch area**