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Wafer based production of Micro Targets

Bob Stevens
Process Development Group Leader

Micro and Nanotechnology Centre
Rutherford Appleton Laboratory

Contents

- The Micro and Nanotechnology Centre
- Examples of mass produced laser targets
- Some Processes for Volume Manufacture

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Micro and Nanotechnology Centre

- Launched in September 2008
- Primary strategic objective:Deliver the Micro and Nanotechnology NEEDS of STFC's Large Scale Facilities and Programmes and their user communities.
  - Central Laser Facility
  - ISIS Spalation Neutron Facility
  - Diamond Light Source
  - ESRF

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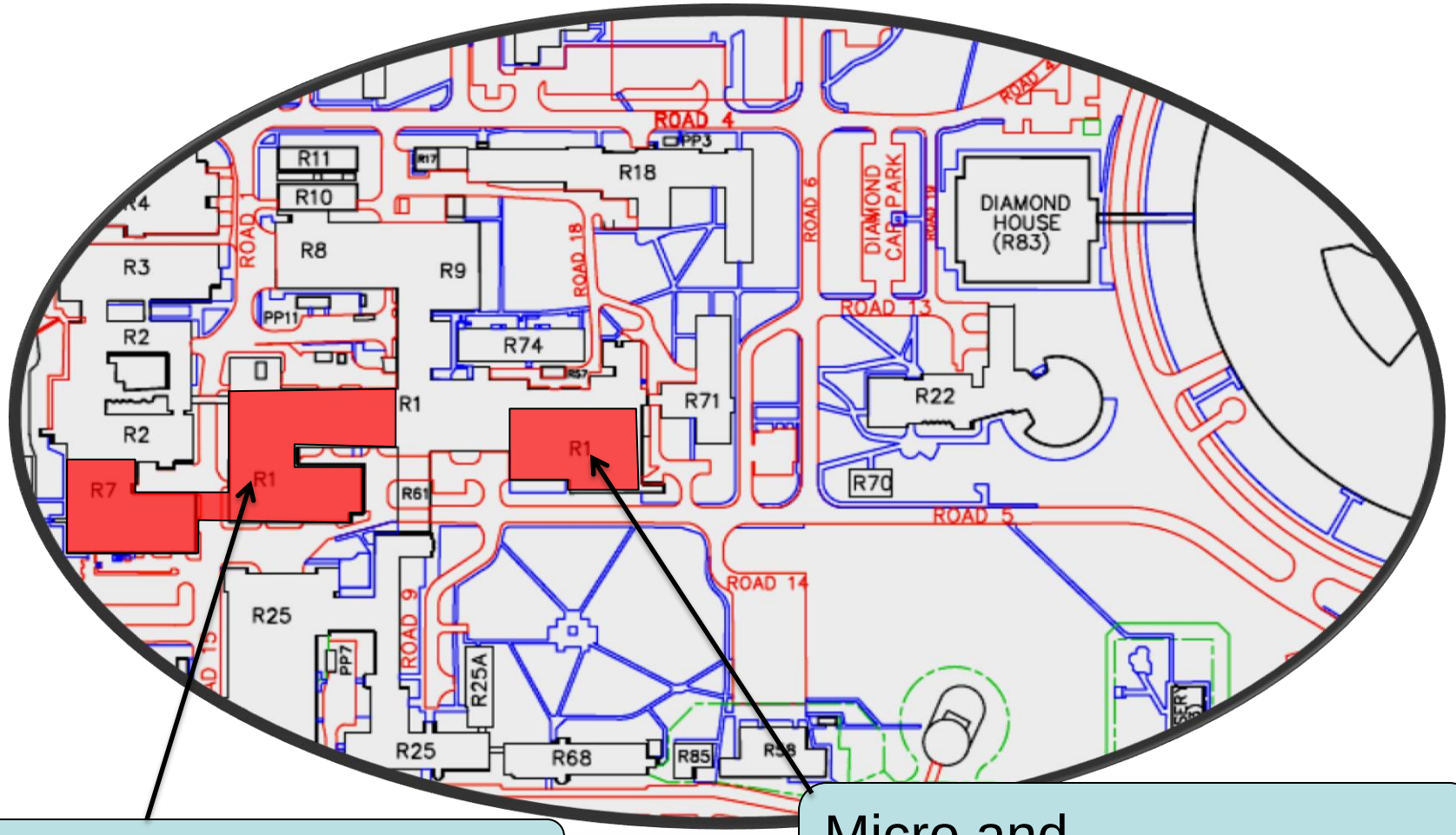
Location

Rutherford Appleton Laboratory



Central Laser Facility

Micro and Nanotechnology Centre

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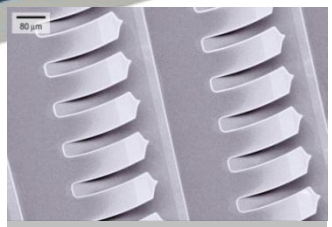
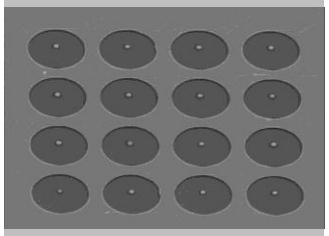
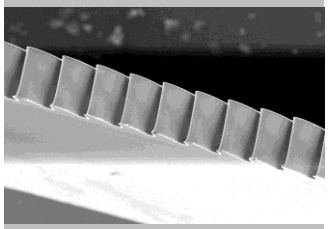
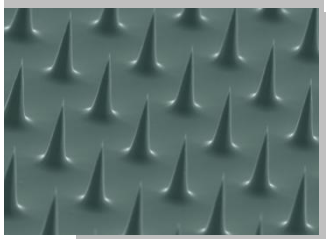
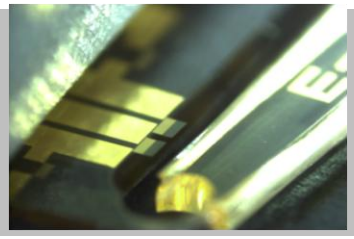
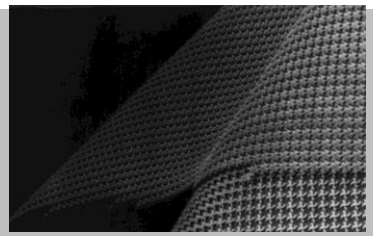
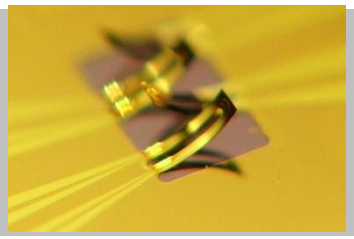
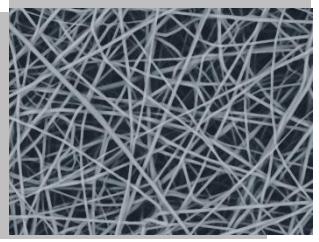
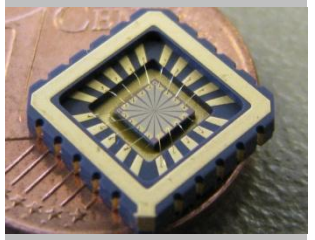
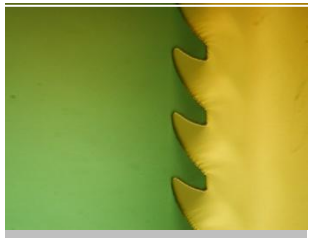
Micro and Nanotechnology Centreo



Healthcare

Defense & Security

Energy

Environment

Microneedles

X-ray optics

Biosensors

Laser targets

Electrodes

Detectors

Cantilevers

Aeroactuators

Nanolithography

Spinouts: Microvisk, Oxsensis, Electrospinning Company

Hosted companies: AML , Qudos, Micronanics

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MNT Centre Facilities

- Lithography
  - Electron Beam
  - Optical (Contact and Stepper)
- Deposition
  - Thermal Oxidation
  - Plasma Enhanced CVD. Silicon, Oxides and Nitrides
  - DC Magnetron Sputtering
  - Four pocket E-Gun Evaporation with variable angle substrates
  - Wet chemical etch. (Spray and Tank processes)
- Etching
  - Reactive Ion Etch,
  - Deep RIE (Silicon, Germanium, Sapphire, Diamond**)
  - Wet Etch
- Wafer Cleaning
- Metrology and Test
- Wafer Bonding*
- Indium evaporation & Bump Bonding
- Nano Materials Development and Handling
- Electrospinning of Micro & Nano Fibres
- Electroplating Centre. (Au, In, Ni, Cu)
- Powder Blasting

Examples of:

Wafer based Laser targets

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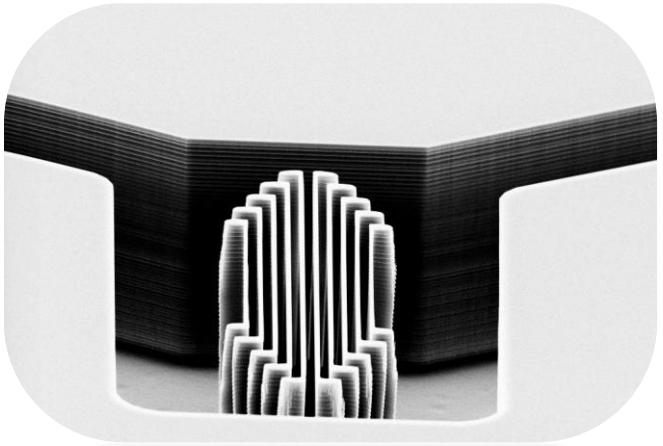
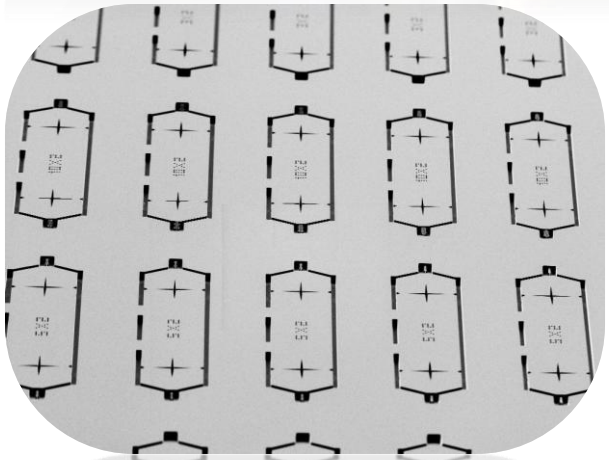
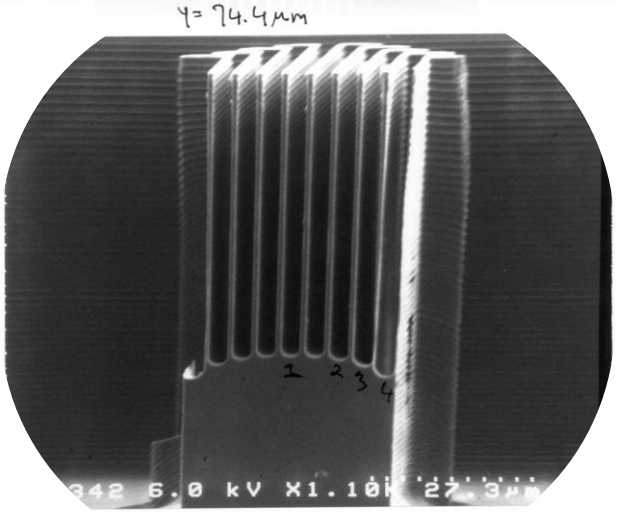
Multi-vane Targets



Key processes.

Double sided optical lithography
PECVD Oxide
RIE Oxide Etch
HF Etch
Deep Silicon Etch





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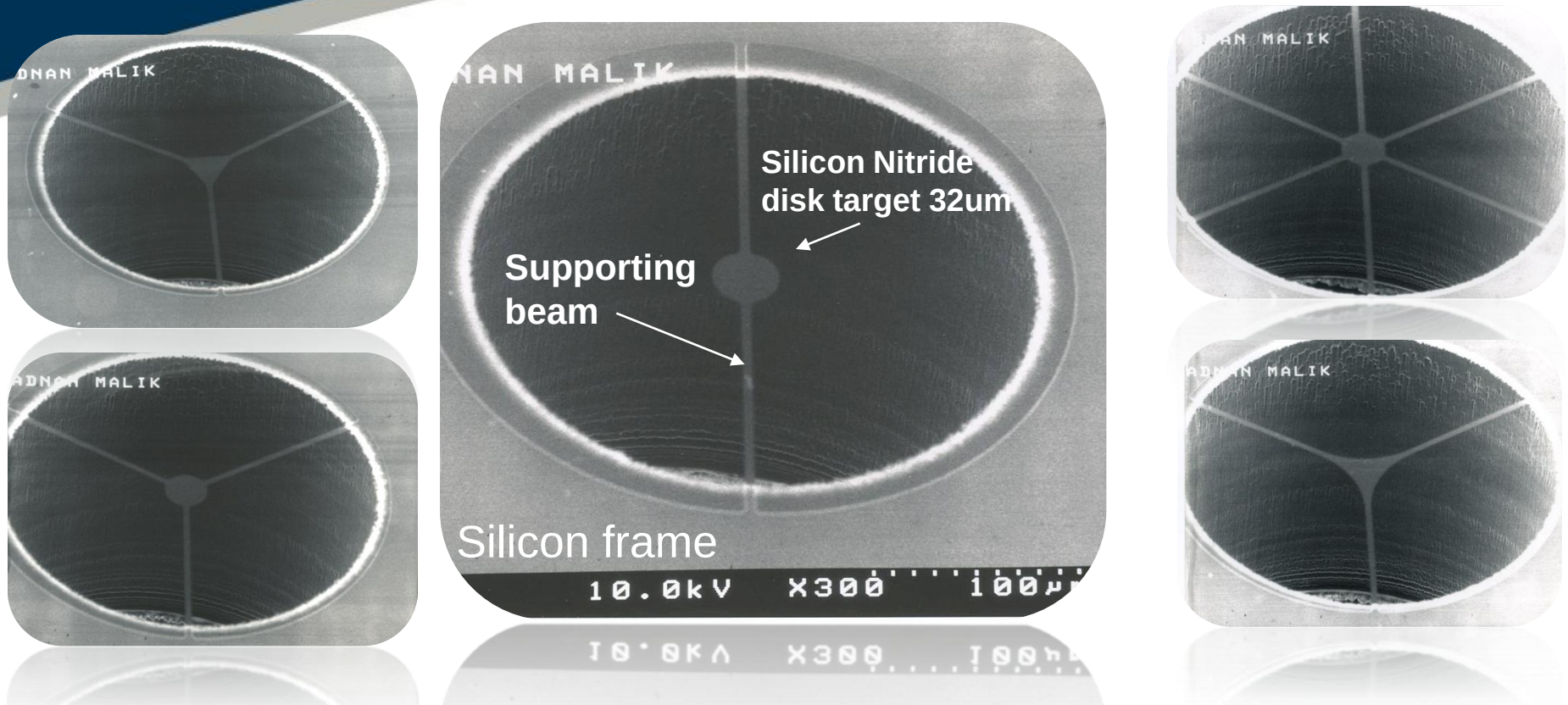
Microspoke Targets



Suspended 100 nm thick Silicon Nitride Laser Targets

Key Processes:

-LPCVD Silicon Nitride and Low Temperature Oxide
-Deep Reactive Ion Etching of Silicon
- Photolithography with backside alignment
- Reactive Ion Etching of Silicon Nitride and Oxide
- Deposition of PECVD Silicon Dioxide
- Hydrofluoric Acid Etching

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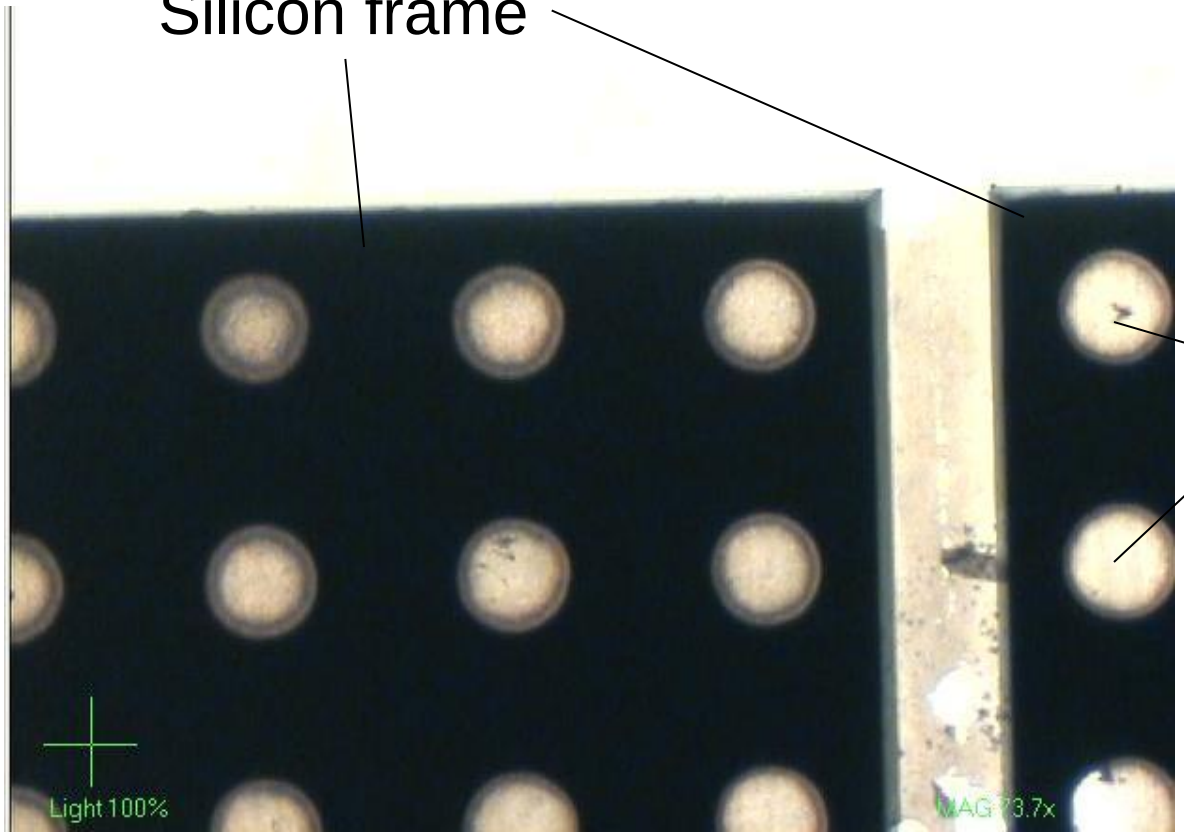
CVD Diamond and DLC membranes



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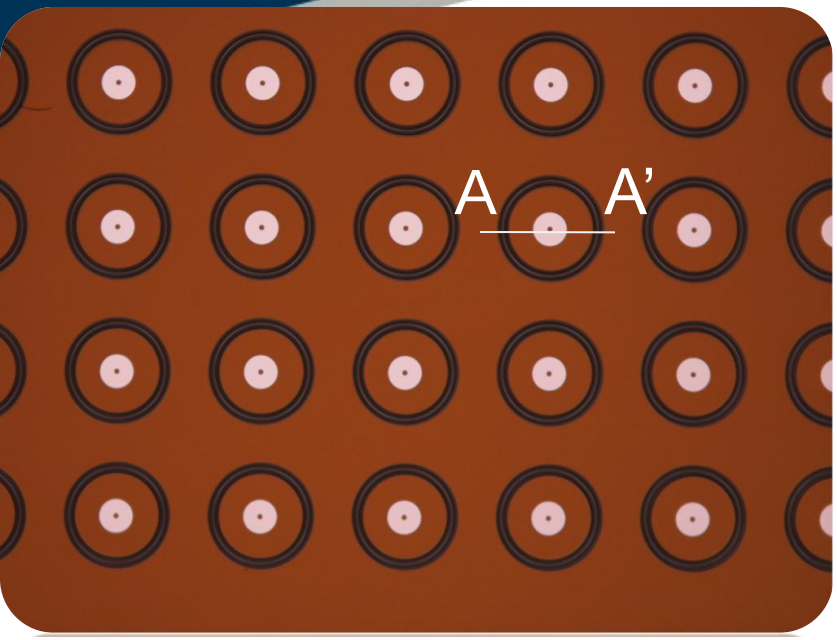
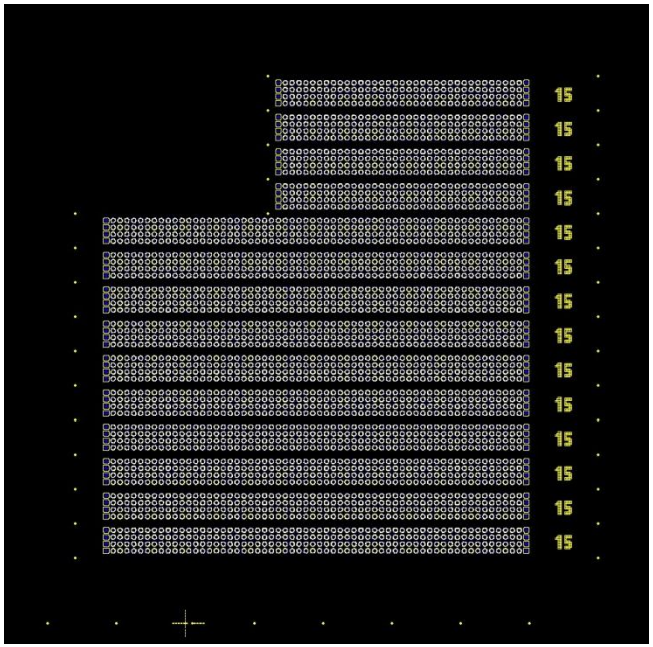
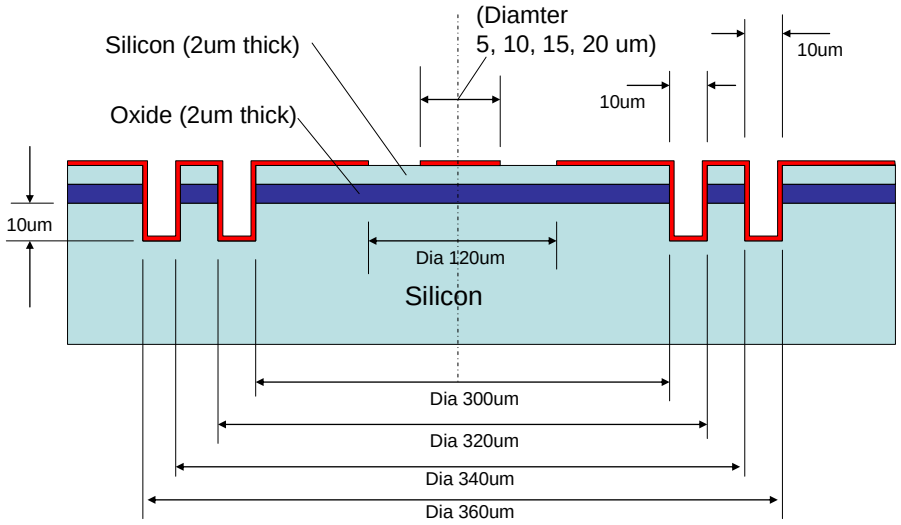
Disc Targets







Cross-section A-A'

Key Processes

- Single sided Photolithography
- Deposition of LPCVD Silicon Nitride
- Deep Silicon Etching
- Reactive Ion Etching of Silicon Nitride and Silicon Dioxide.
- Wafer Dicing

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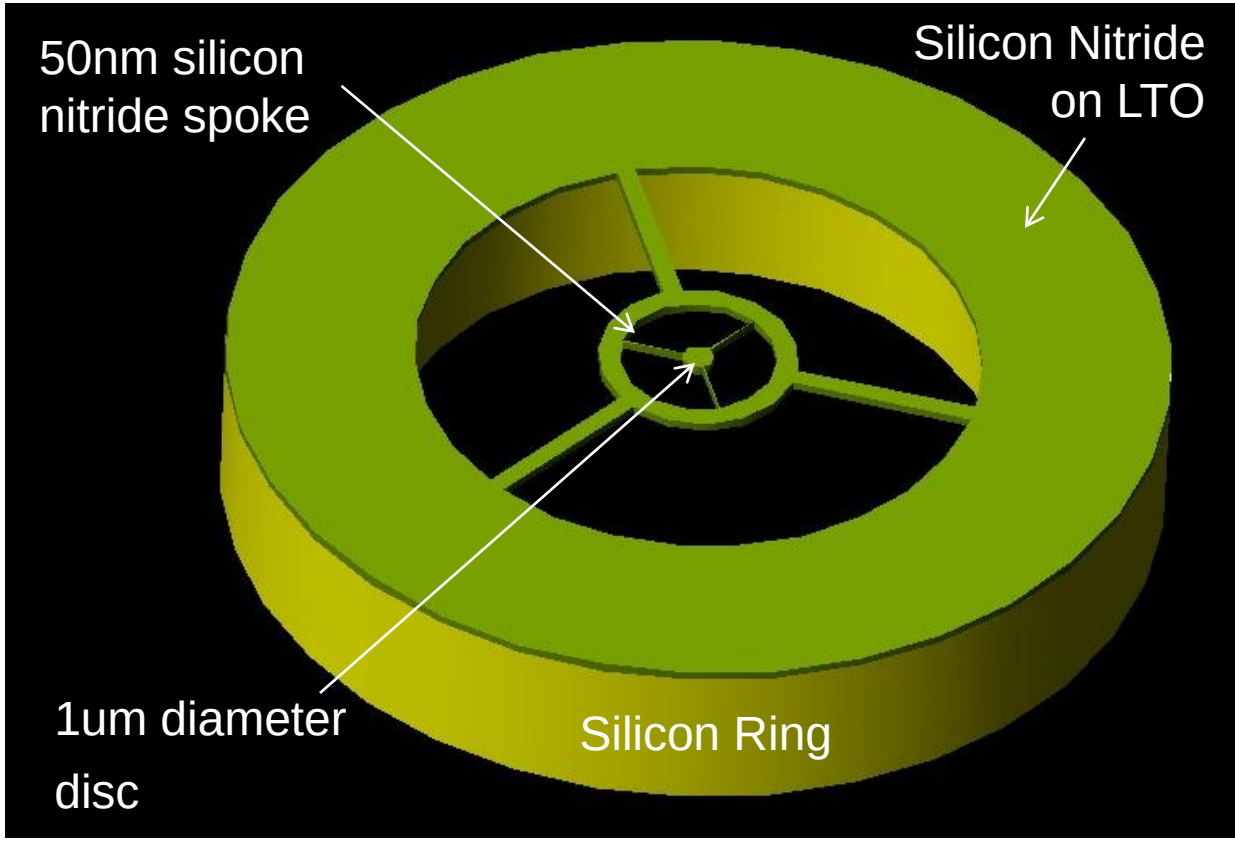
Nanospoke Targets

Key Processes
- Deposition of LPCVD Silicon Nitride
- Deep Silicon Etch
- Photolithography with backside alignment
- Electron Beam Lithography
- Deposition of PECVD Oxide
- Reactive ion etching of Silicon dioxide and nitride
- Hydrofluoric Acid etch of silicon dioxide.



Some Processes for Volume Manufacture

- Deep Silicon Etch
- Electrospinning of Nanofibres
- Greyscale Lithography
- Electroforming
- Atomic Layer Deposition
- Massively Parallel Assembly (Flip Chip)

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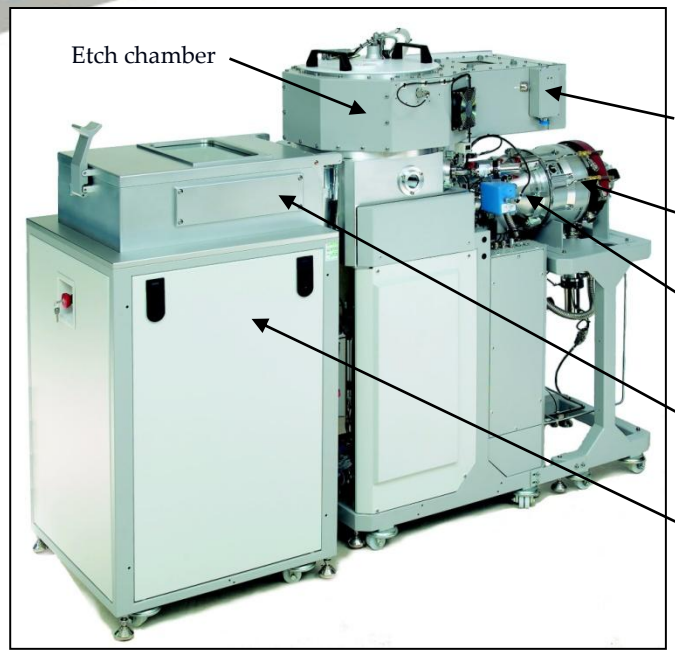
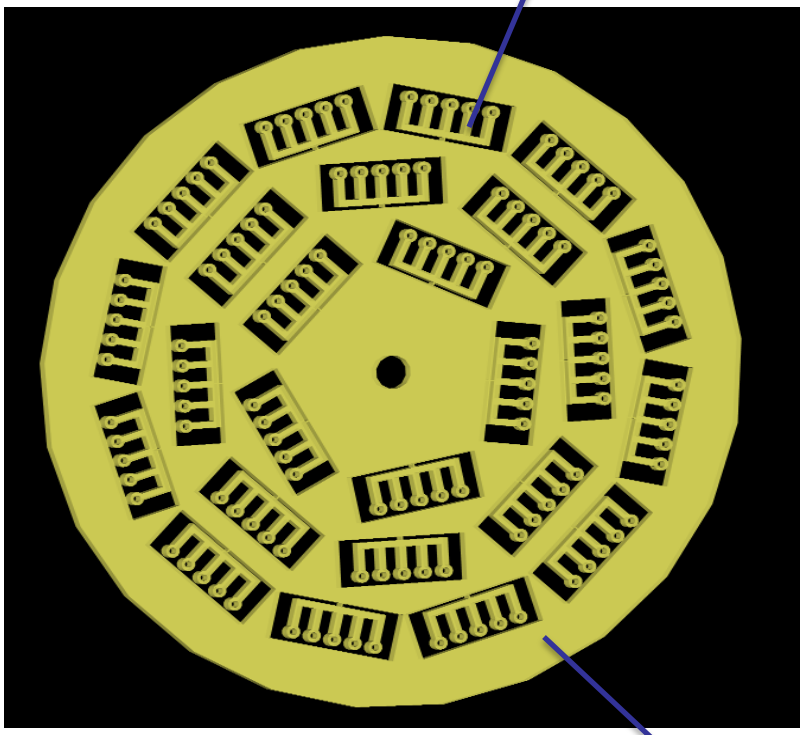
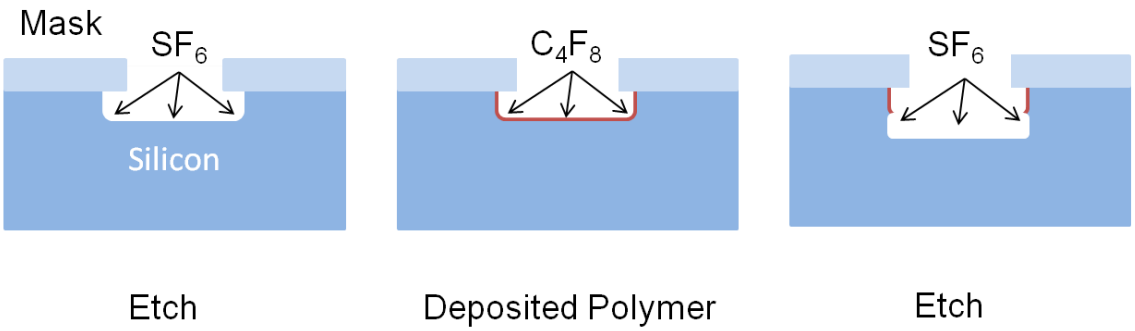
Deep Silicon Etching



STS Deep Silicon Etch Tool

Target wheel





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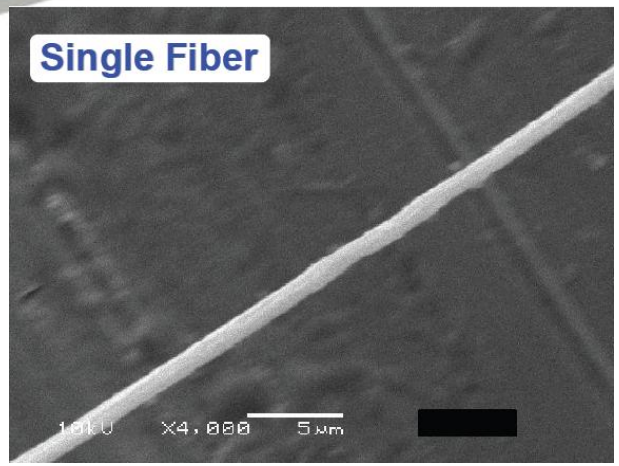
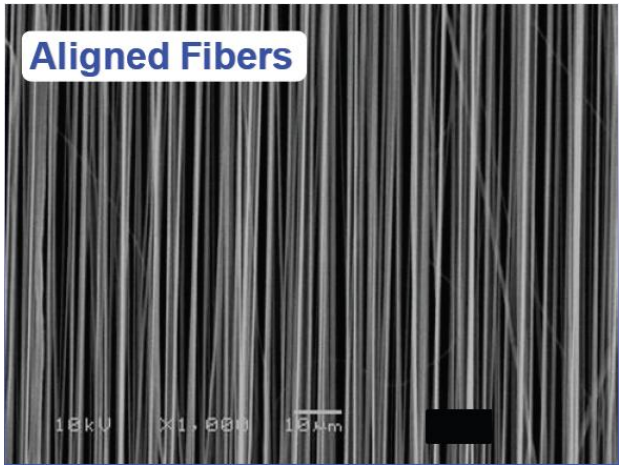
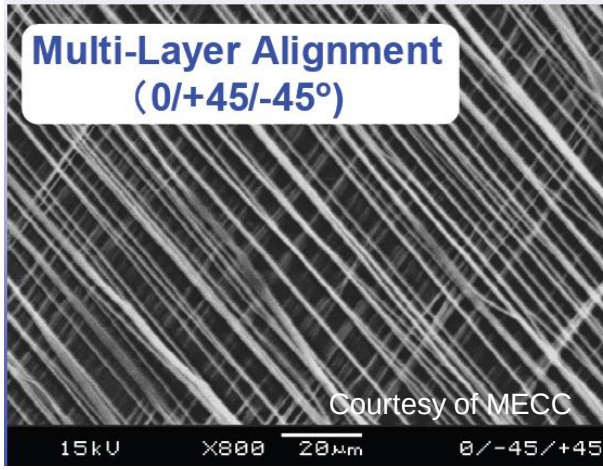
Nanofibres for Fibre Targets







Types of Nanofibre

- Homogenious Fibres
- Core-Shell
- Core-Multishell
- Hollow
- Porous

Nanofibre materials

- Gelatin & Collagen
- PVA, PAN, PEG, PEO, PVDF
- Polysulfone, Polyamides, etc
- PLA, PLGA, PGA, PCL
- Carbon and Graphitised Fibre
- Nanoparticle &CNT composite

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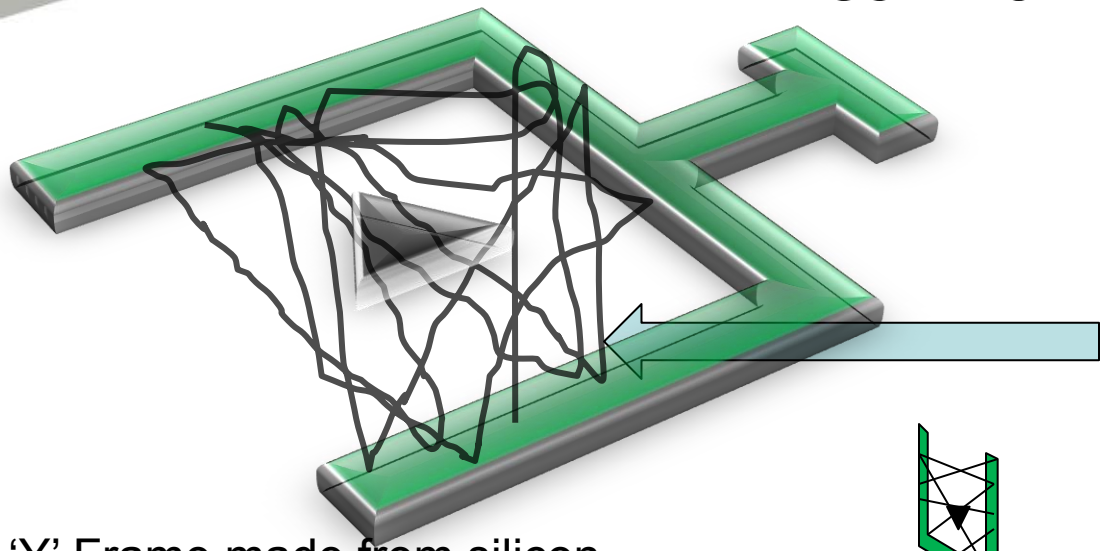
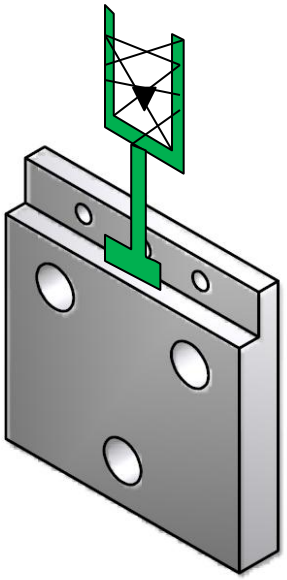
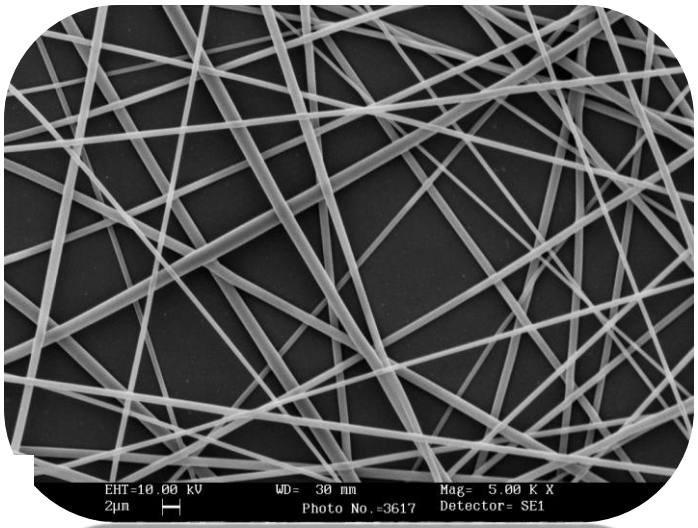
Low density, low mass nanofibre mesh for target supports





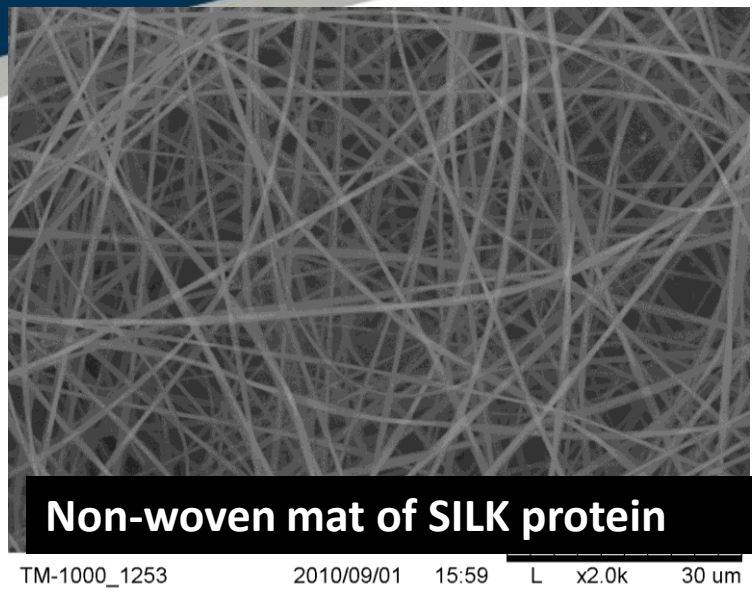


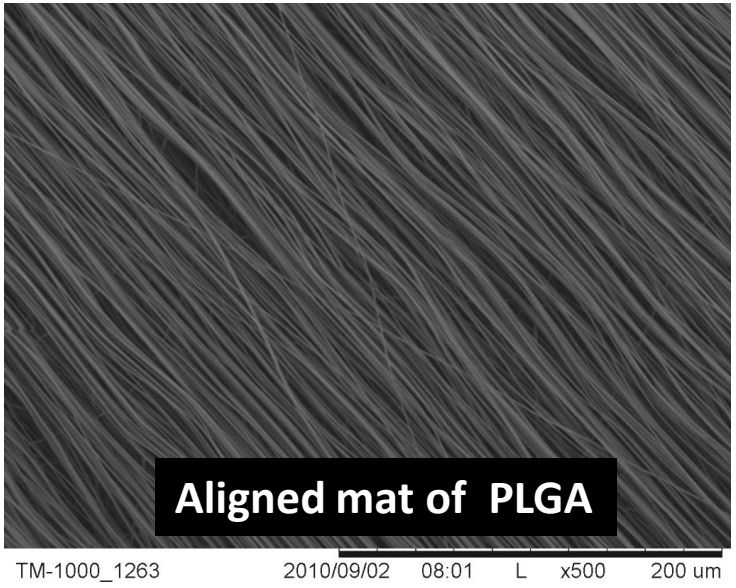
'Y' Frame made from silicon, ceramic or polymer. It would have location tag for low attachment to transfer puck & alignment fiducials for placement measurements.

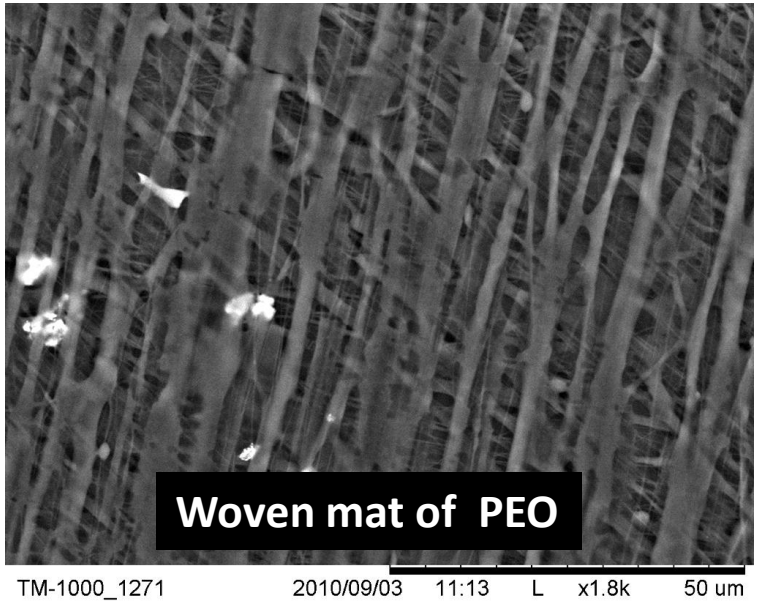
Web of fibres is electrospun over the frame to form a support for the target.

Electrospun Nanocomposite Nanofibres.

Diameters 10nm to 10um


Non-woven mat of SILK protein
TM-1000_1253 2010/09/01 15:59 L x2.0k 30 um


Aligned mat of PLGA
TM-1000_1263 2010/09/02 08:01 L x500 200 um


Woven mat of PEO
TM-1000_1271 2010/09/03 11:13 L x1.8k 50 um

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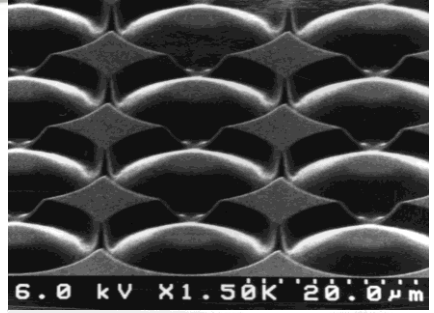
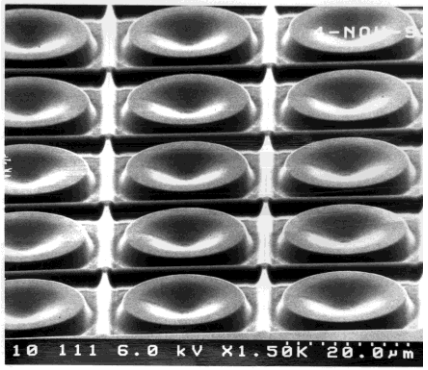
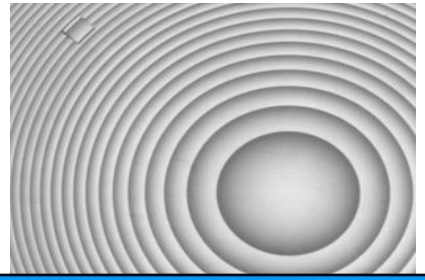
Greyscale Lithography





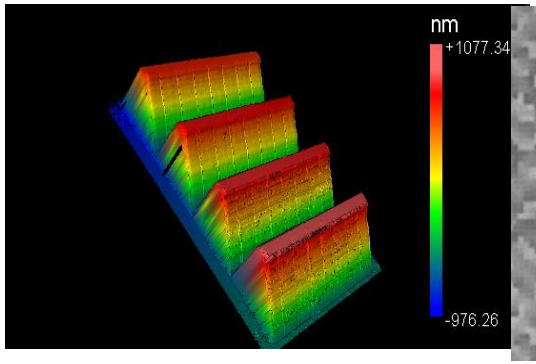


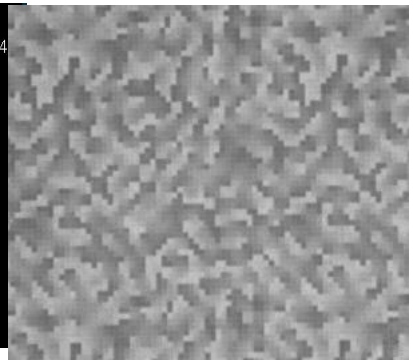
Photomasks with 1250 grey levels, 0.05 um resolution.

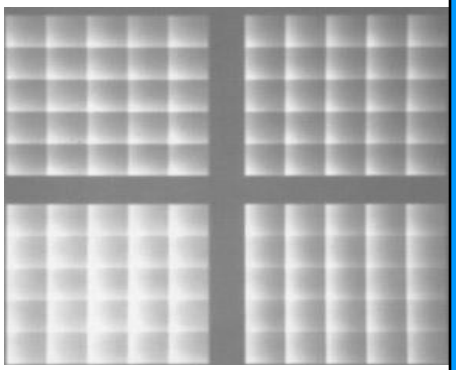
Production of spherical and aspheric microlenses, micro prisms, (domes, wedges, steps, etc).

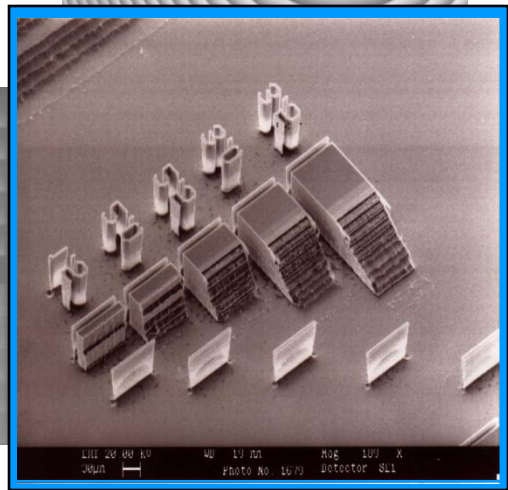
Pattern transfer using Plasmas and Ion Milling

Production of moulds to form greyscale components









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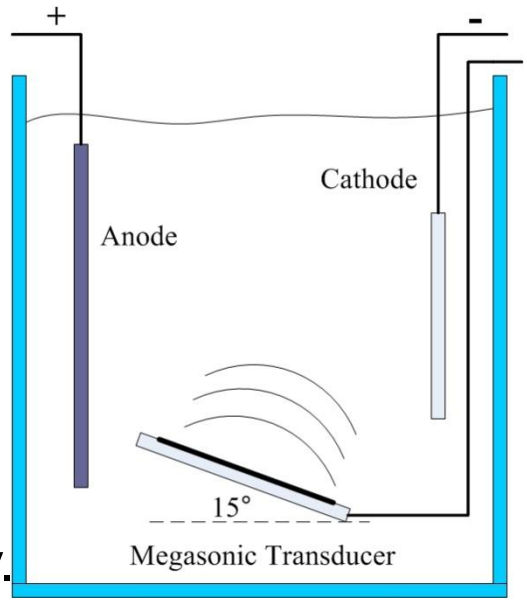
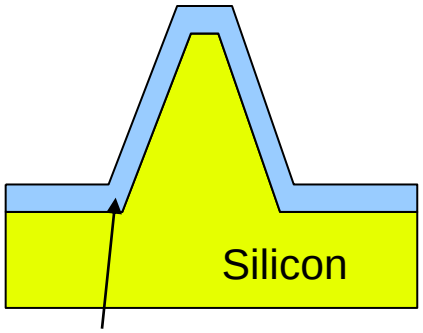
Electroforming

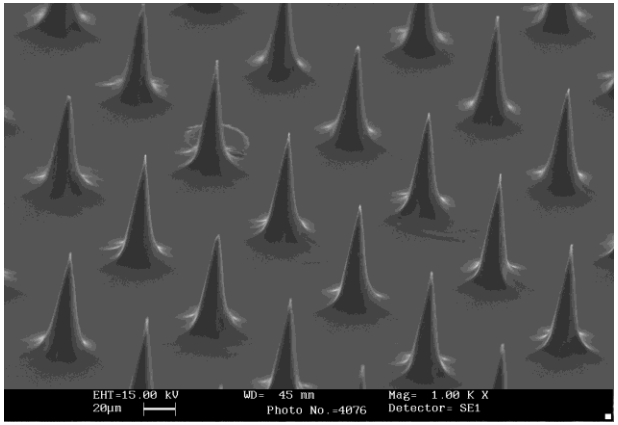
Processes

- Au, In, Ni, Cu up to 200mm diameter wafers
- Plating Moulds (SU8, AZ9260, DRIE Silicon, etc)
- Arbitary waveform Plating supply for DC, Unipolar, Bipolar for plating of surfaces with high aspect ratio structures
- Megasonic agitation for improved process yield for fine structures, improved plating rate and uniformity.

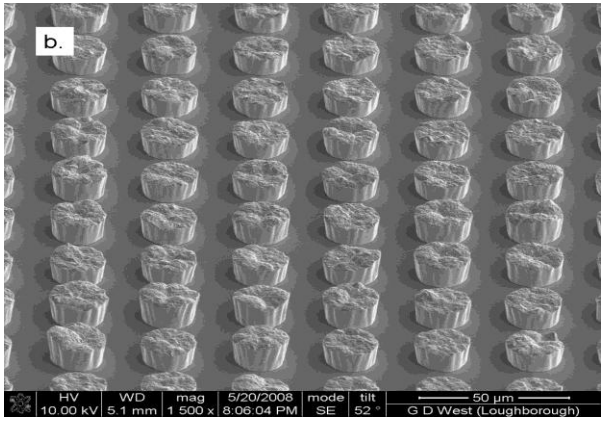




Coating defined by pulse-reverse plating



Silicon Microneedles



18um Indium Bumps

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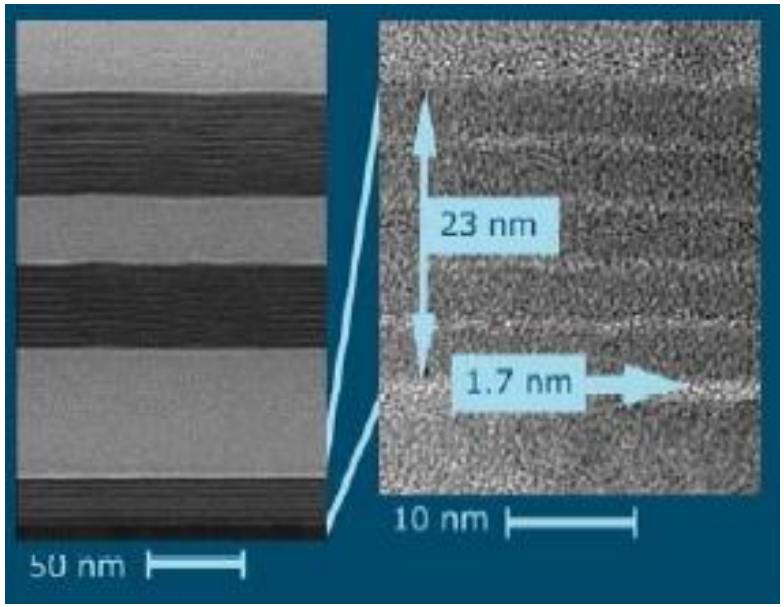
Atomic Layer Deposition

Nanolaminates, Nanocomposites and Ultra Thin structures

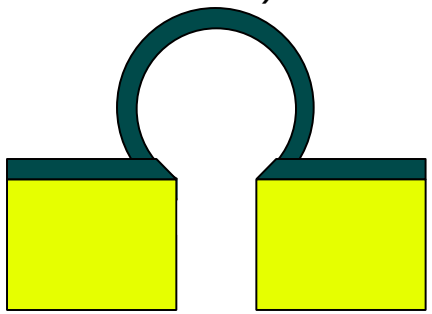
Low temperature (able to coat plastics)
Pin hole free coatings.
Highly Conformal (Able to coat aspect ratio of 1000:1)
Film thicknesses (2nm to 10um)
Single substrate, batch processing, continuous mode and reel to reel



Materials
- Metals
- Dielectrics
- Rare Earth doped Oxides (Phosphors),
- Nitrides, Carbides

.....

Applications in Laser Targets.
- Engineering of Nanocomposite/Nanolaminate Target Materials (Elemental control)
- Coating of moulds to form thin wall vessels
- (e.g. thin walled shells, multi-layers (ARC, filters, reflectors...)



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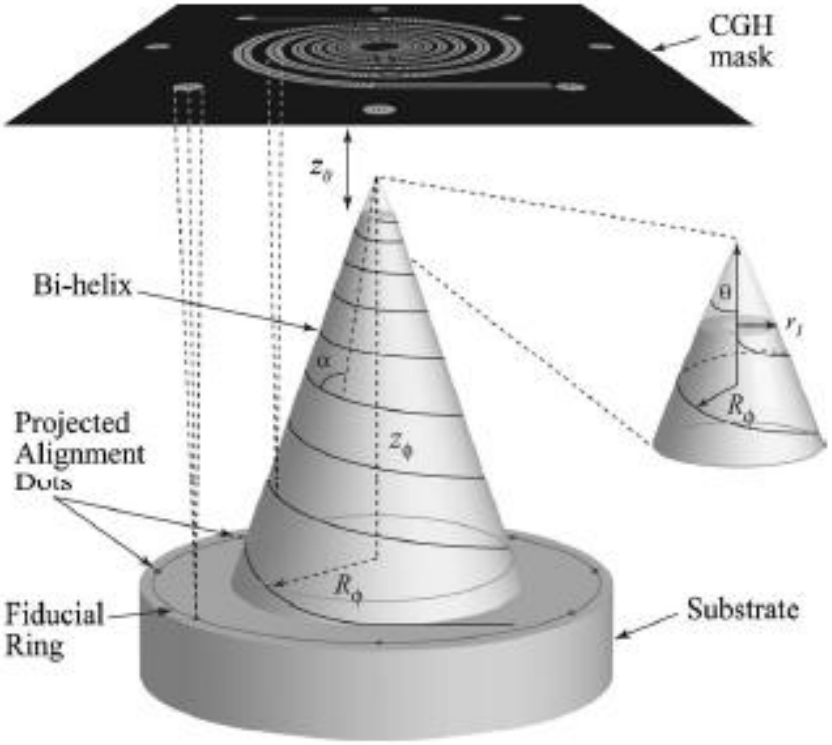
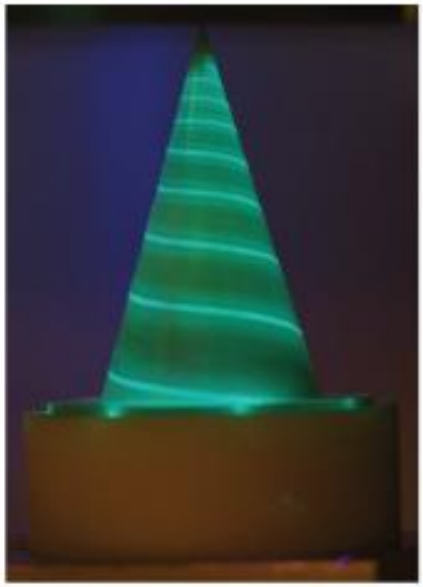
Holographic Lithography





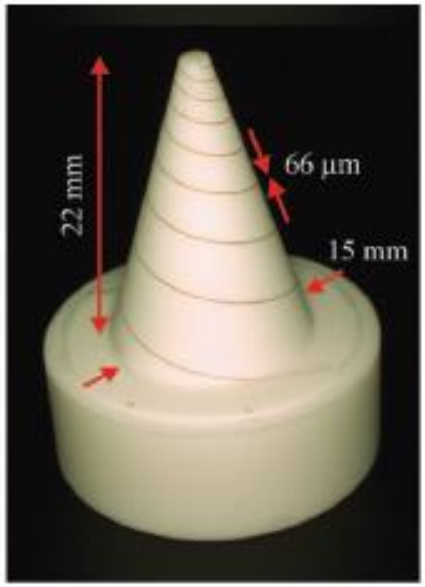


Fig. 1 Nonplanar photolithography system: θ=16.5 deg is the cone half-angle, z_0=8.4 mm is the exposure offset, r_1=1 mm is the initial helix radius, and α=74.2 deg is the wrap angle of the helix.

J. Micro/Nanolith. MEMS MOEMS 64, 043015 Oct–Dec 2007

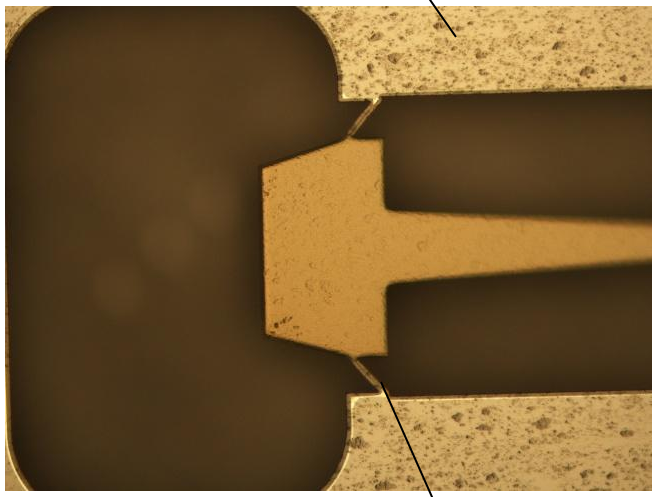
Possible future targets

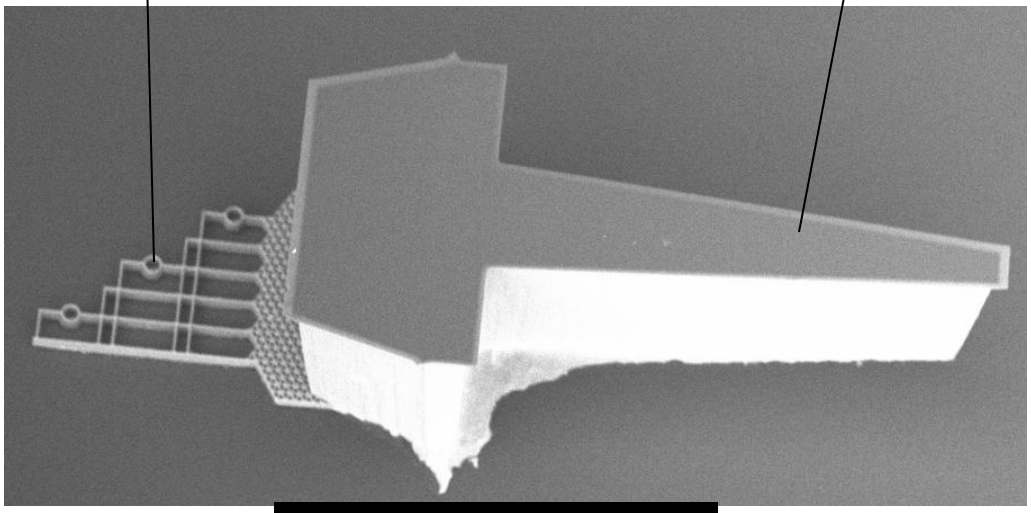
Silicon ‘Airfix’ target kits

Silicon frame

Micro target/target holder

Silicon Post





Target and post

20 um wide ‘Snap Out’ silicon bridge

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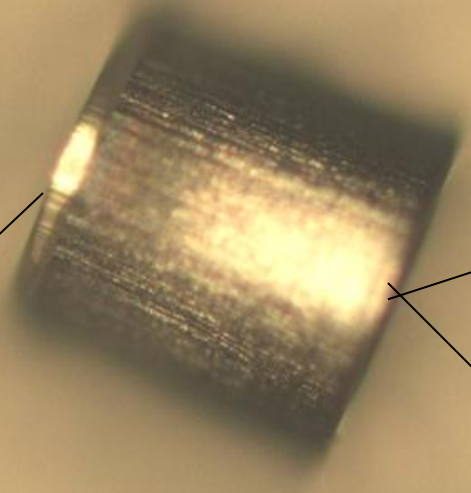
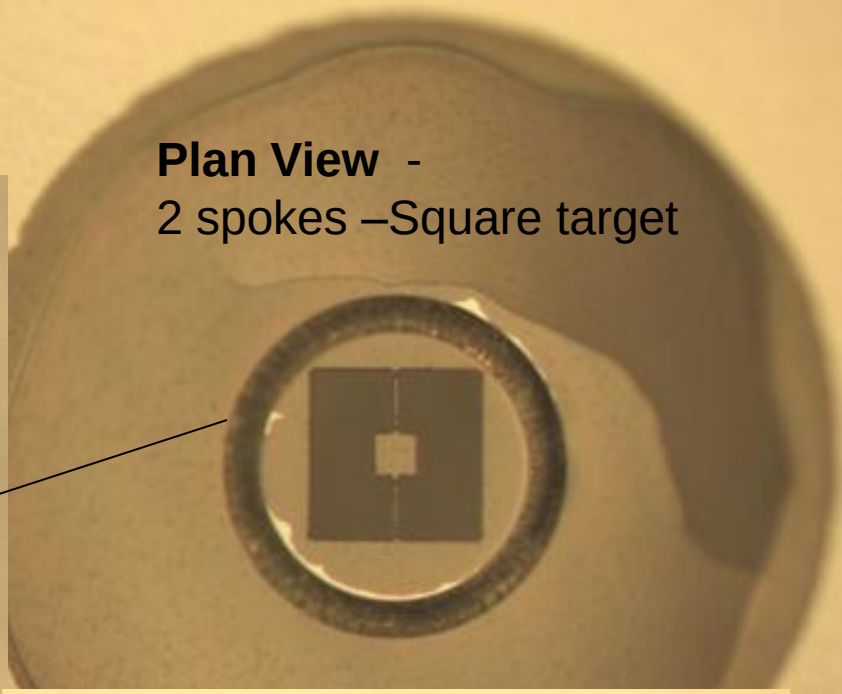
Side View

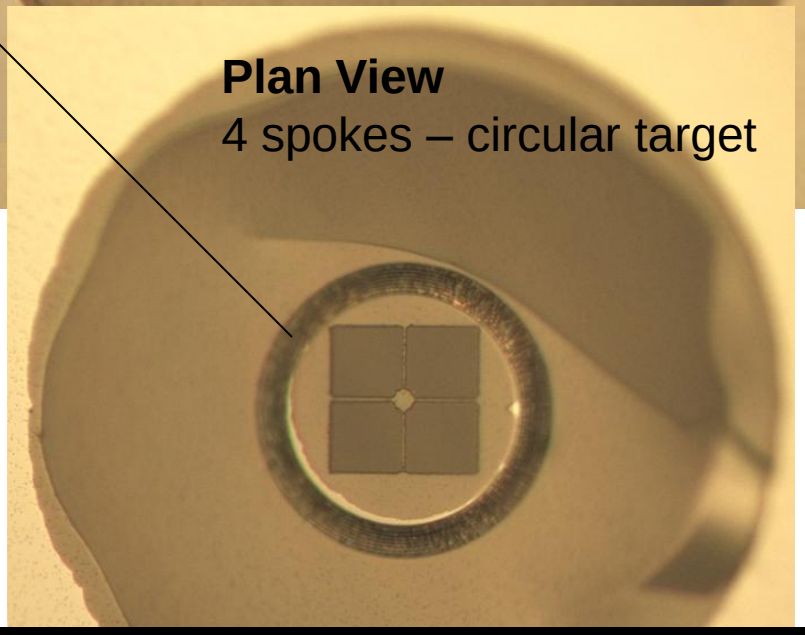


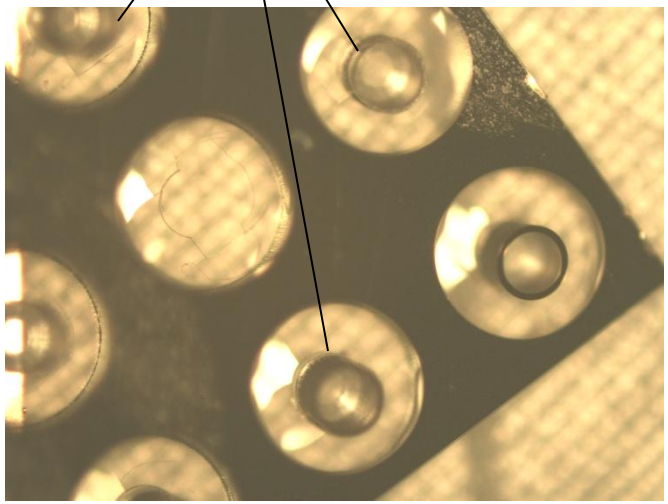
300µm diameter Silicon ring

Plan View -
2 spokes –Square target



Plan View
4 spokes – circular target





3 x 3 Target chip

Injectable membrane targets

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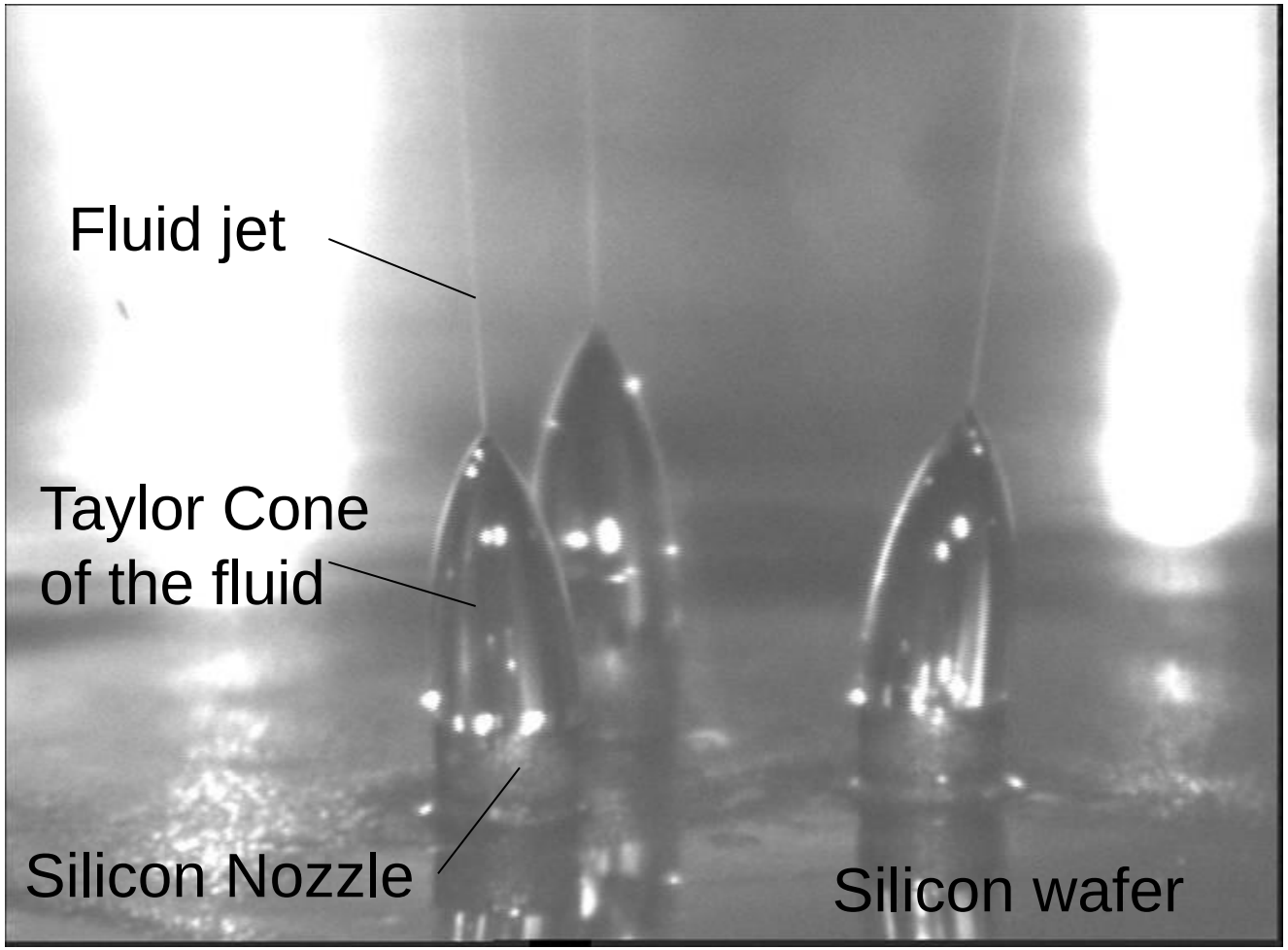
Multiple fluid jet targets



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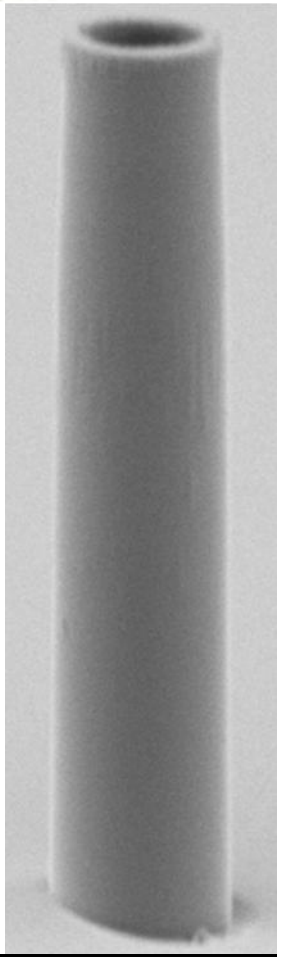
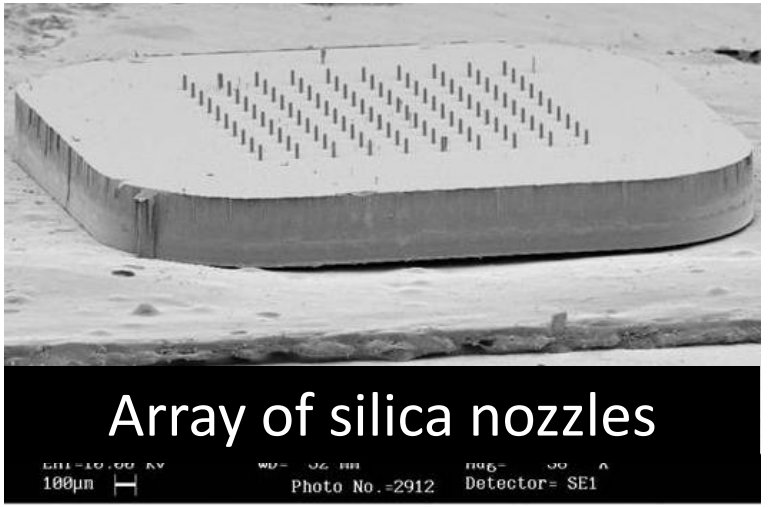
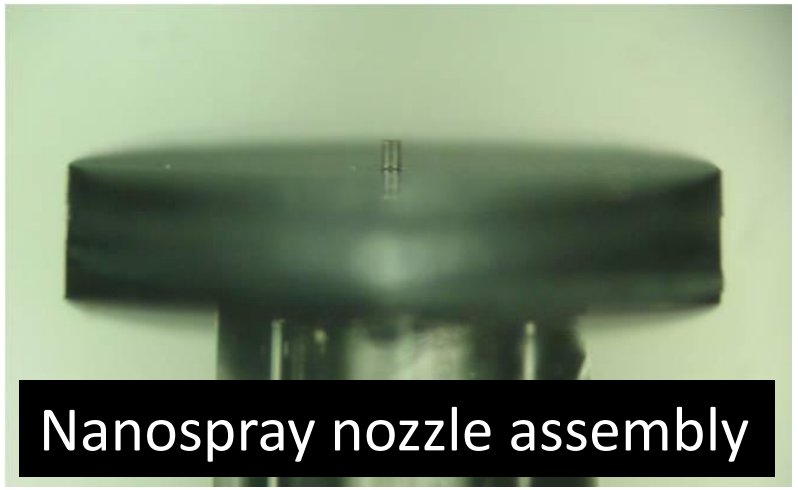
Components for liquid jet targets



10um Silica nozzle



Array of silica nozzles



Nanospray nozzle assembly

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Components for liquid jet targets

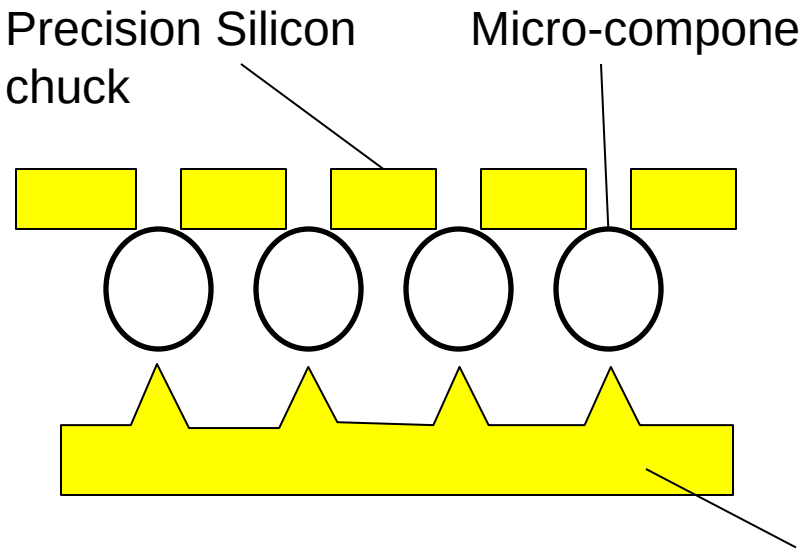
Glass – Silicon Microfluidics

Complex nozzle fluidics
Core + 3 shells

Massively Parallel Assembly

Placement accuracy +/- 1 micron
Heated chucks
Vacuum Pick Up/ Electrostatics

FC250 Flip Chip Die Bonder



Thank you

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