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Micro and Nanotechnology Processes for the High Volume manufacture of laser targets

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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.
  - Photon Science Department
    - Central Laser Facility, Lasers for Science Facility and SRS
  - ISIS
  - Diamond Light Source
  - ESRF

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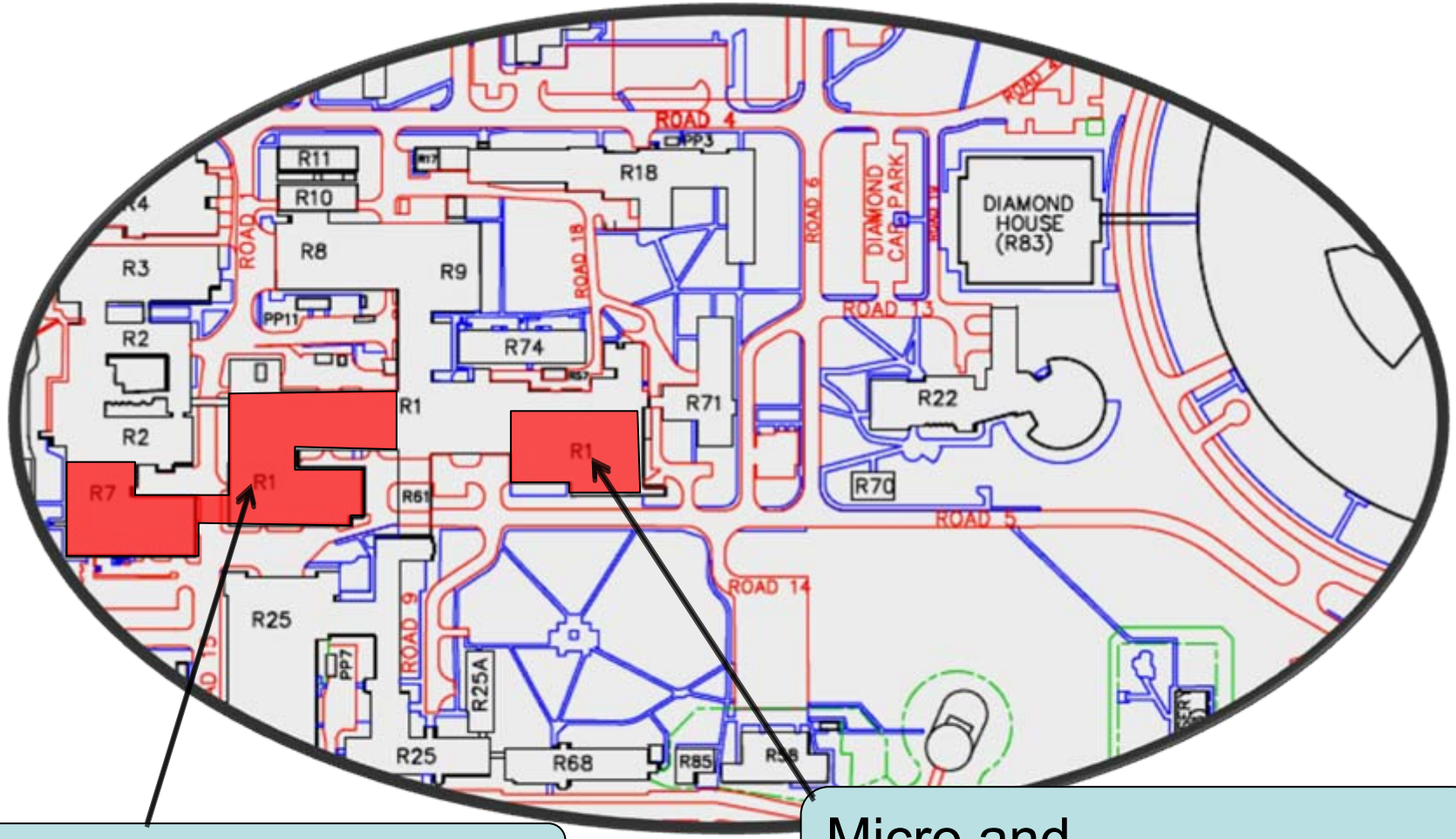
Location

Rutherford Appleton Laboratory



Central Laser Facility

Micro and Nanotechnology Centre

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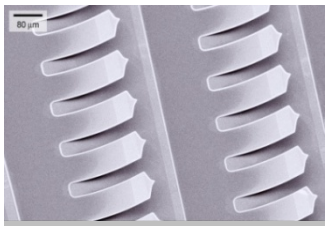
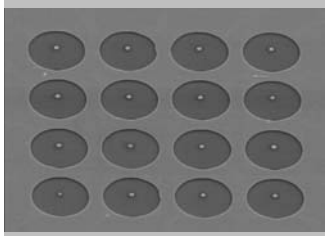
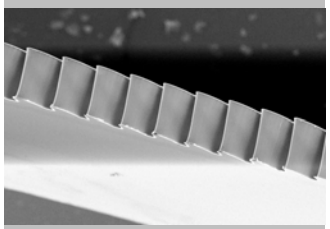
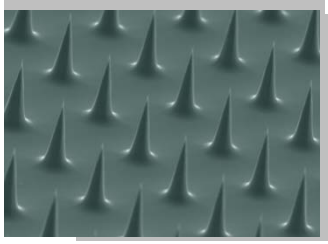
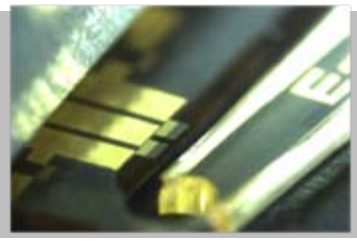
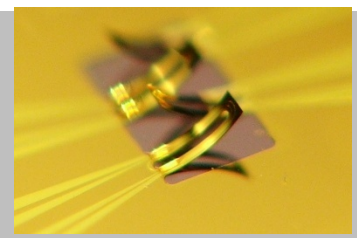
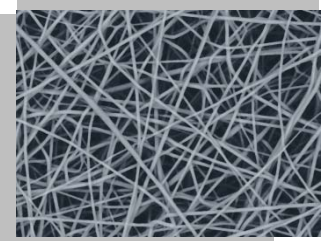
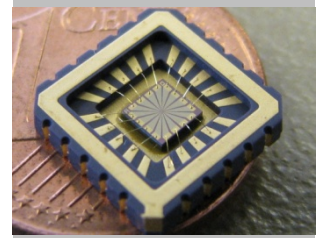
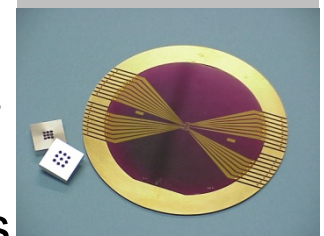
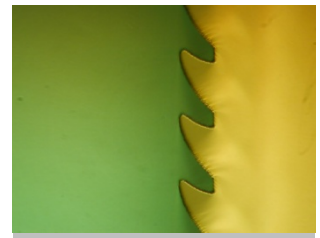
Micro and Nanotechnology Centre Portfolio

World Class Science & Instrumentation

Healthcare

Security

Energy

Transport

Microneedles

X-ray optics

Biosensors

Laser targets

Electrodes

Detectors

Cantilevers

Aeroactuators

Nanolithography

Spinouts: Microvisk, Oxsensis, Electrospinning

Hosted companies: AML Qudos

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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
- Chemical Mechanical Polishing*
- Wafer Cleaning
- Metrology and Test
- Wafer Bonding*
- Indium evaporation & Bump Bonding
- Nano Materials Development and Handling
- Electrospinning of Nano Fibres
- Electroplating Centre. (Au, In, Ni)
- Powder Blasting
- Screen and Stencil printing

Examples of Laser targets

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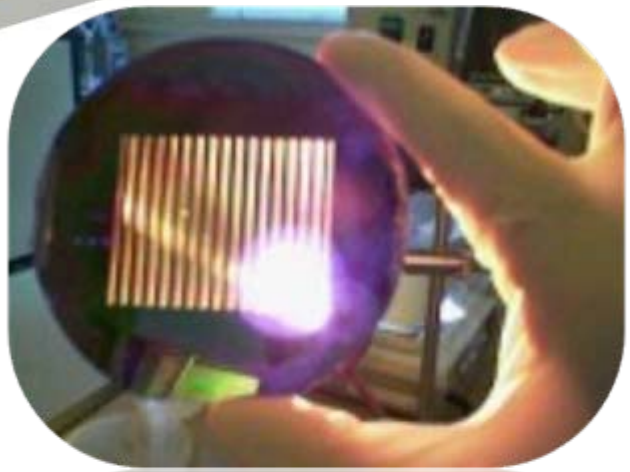
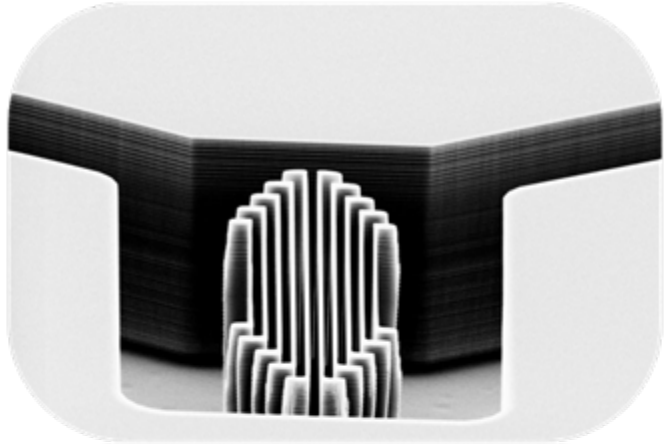
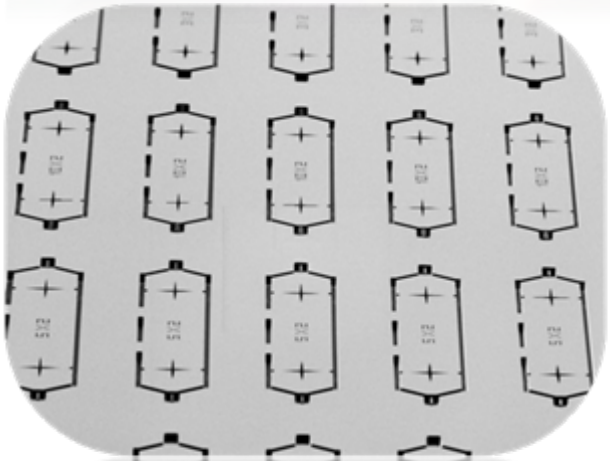
Multi-vane Targets

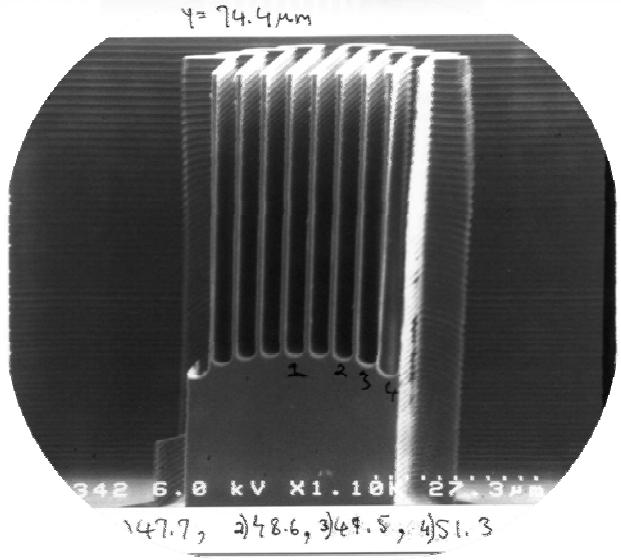




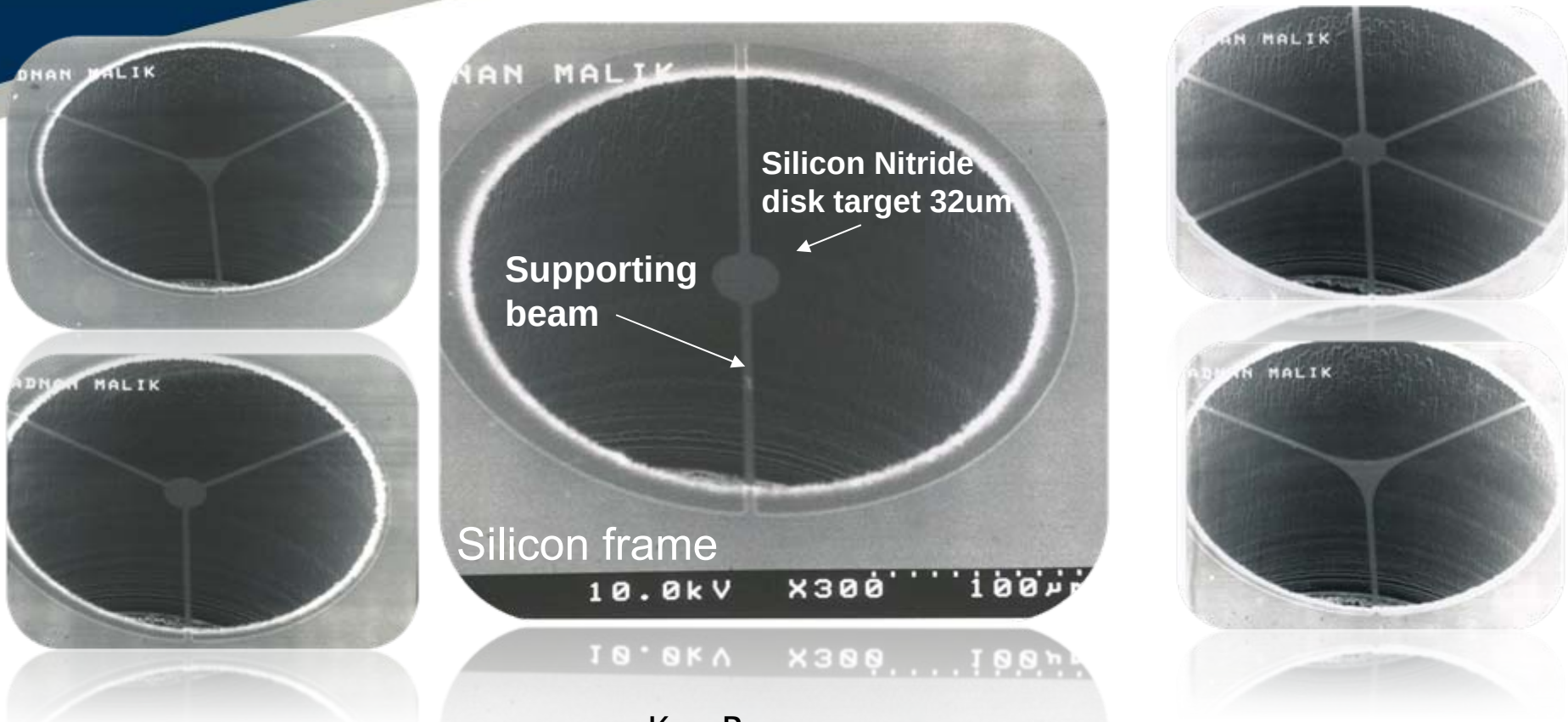
Key processes.

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





Membrane 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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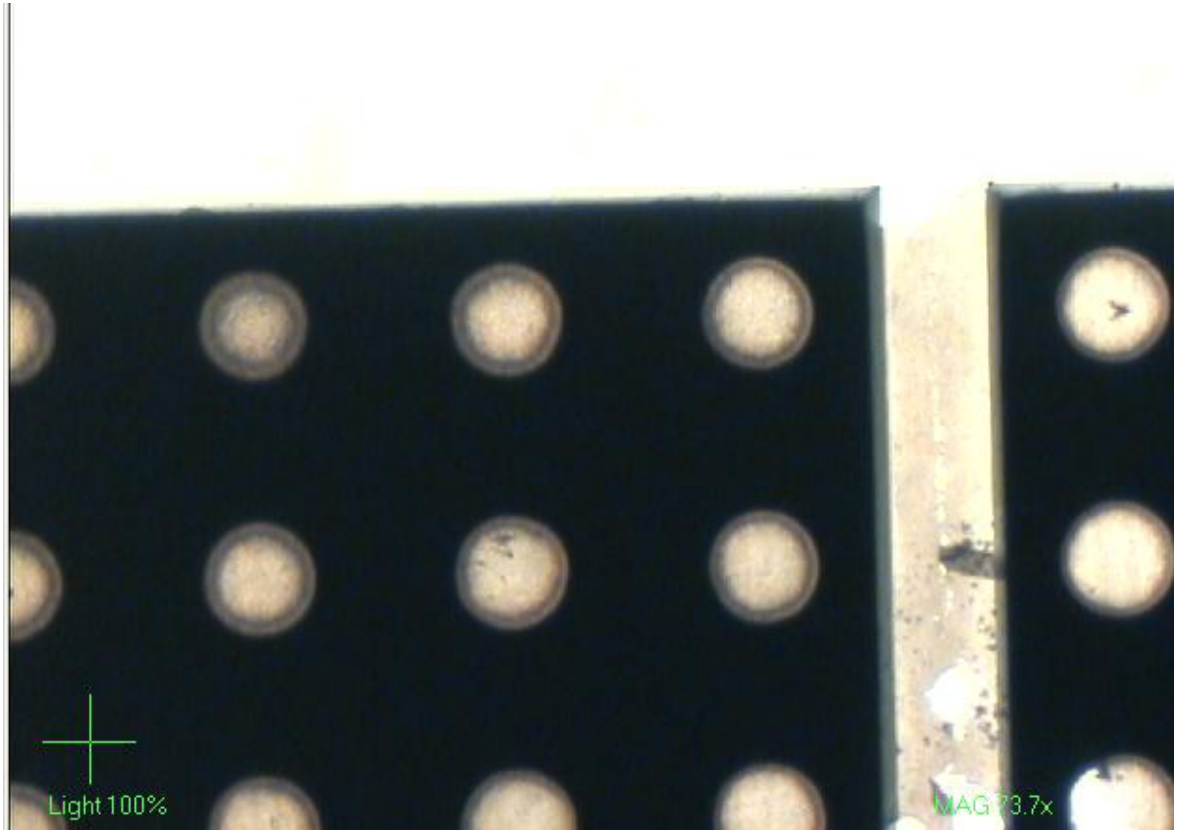
Diamond and DLC membranes



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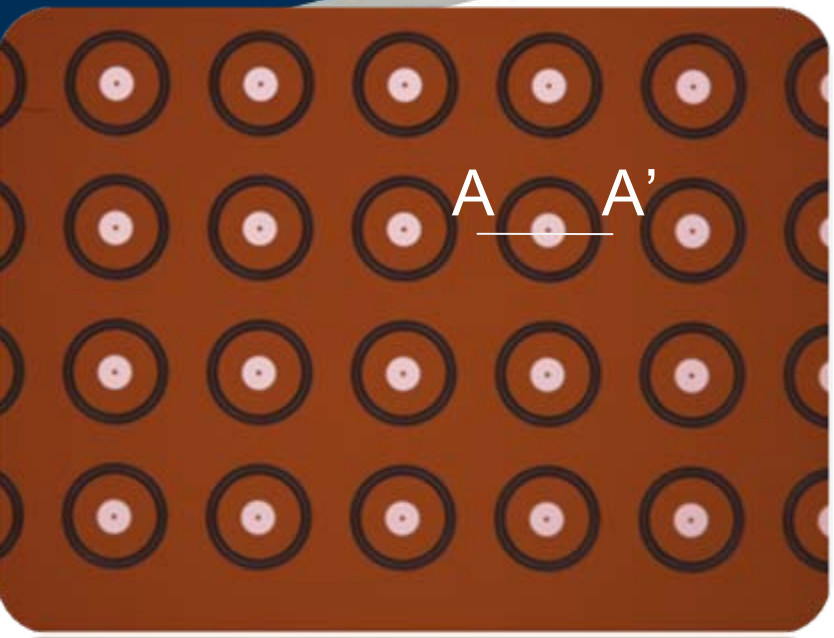
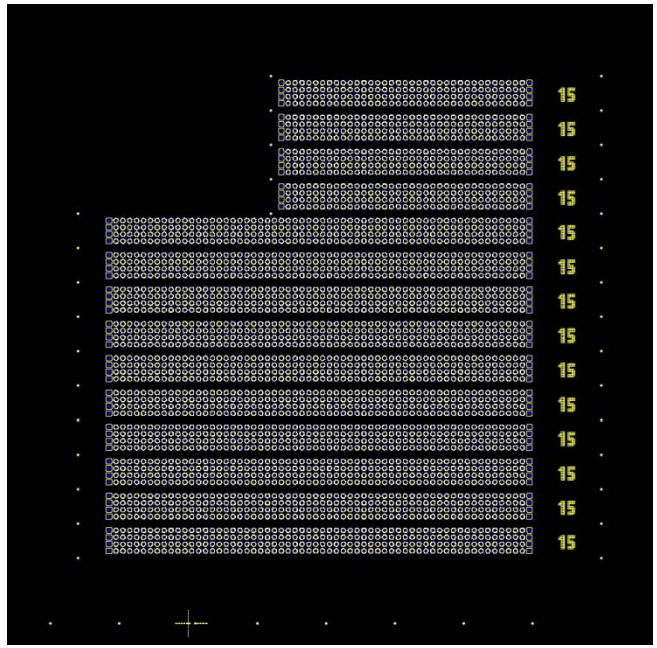
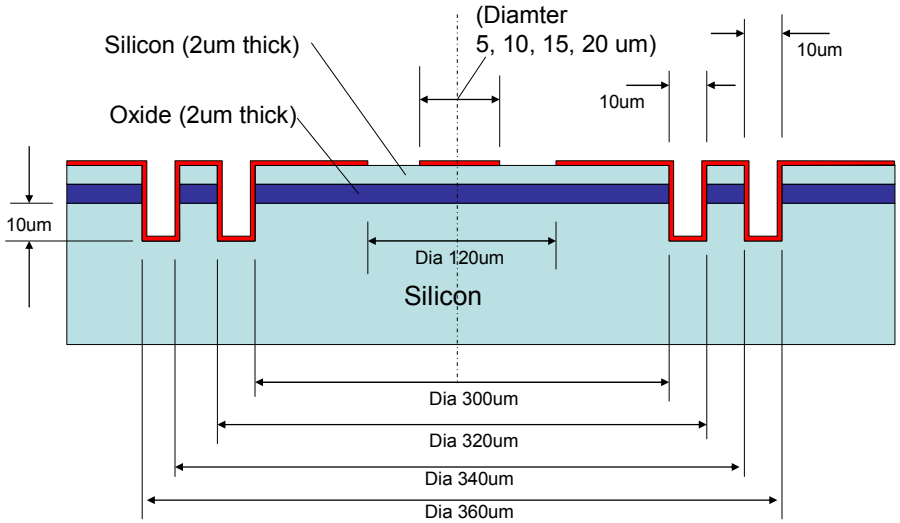
Disc Targets







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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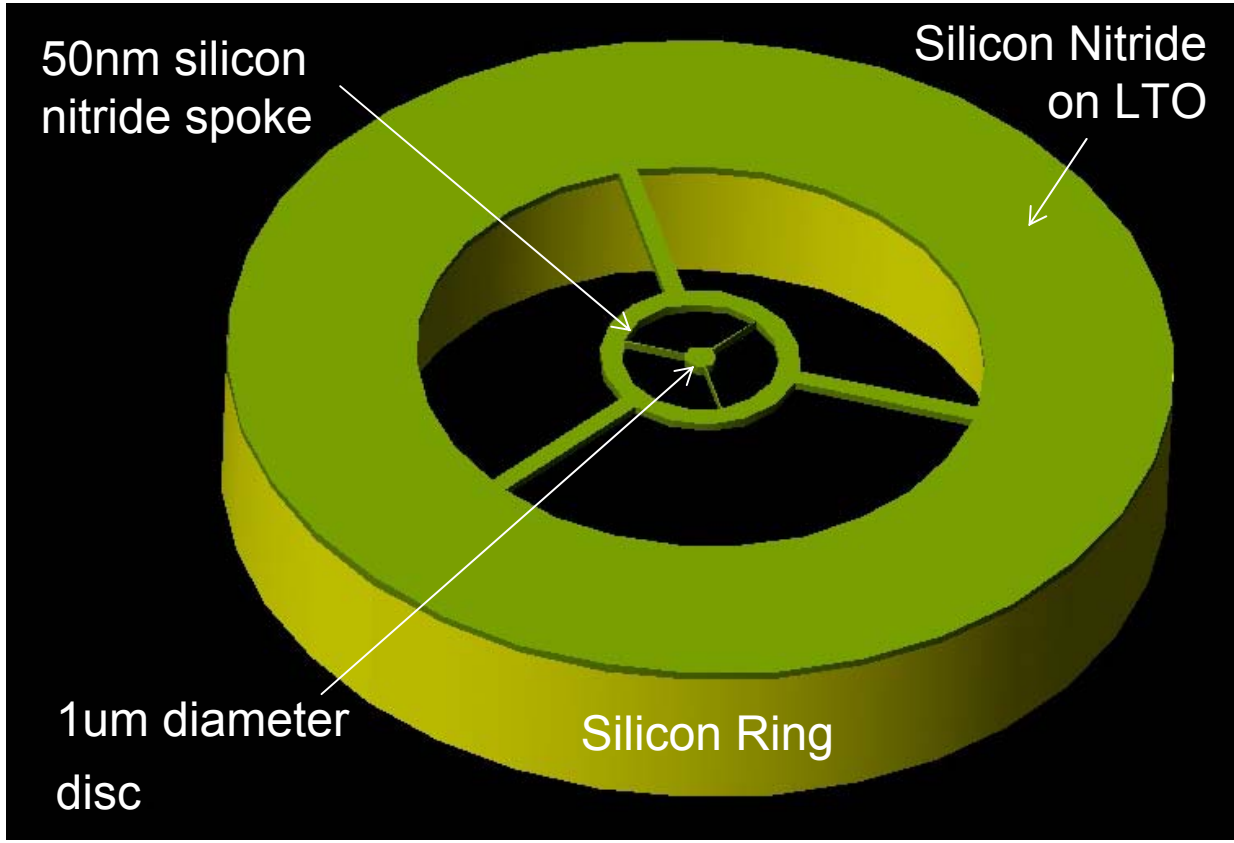
Nanospoke Targets

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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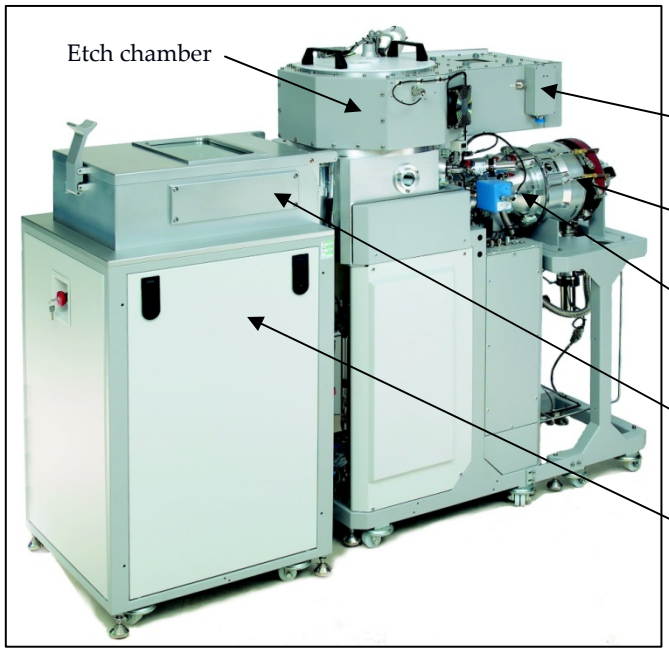
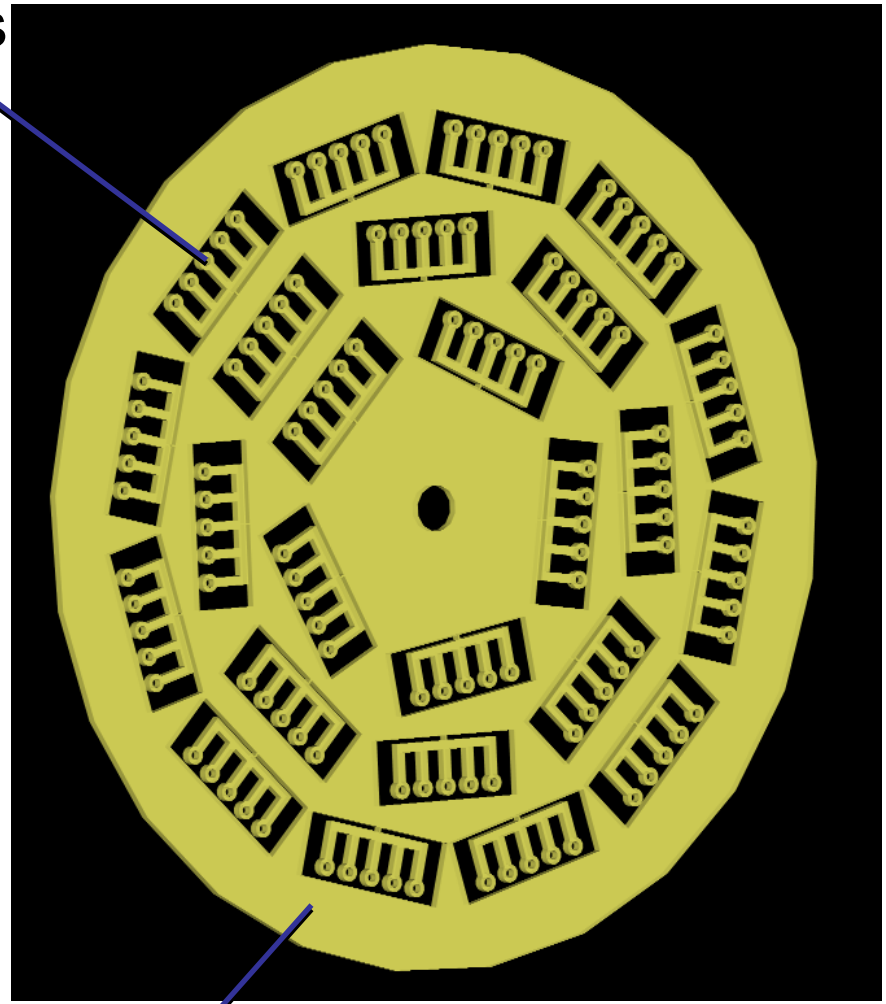
Target wheel

Deep Silicon Etching



STS Deep Silicon Etch Tool



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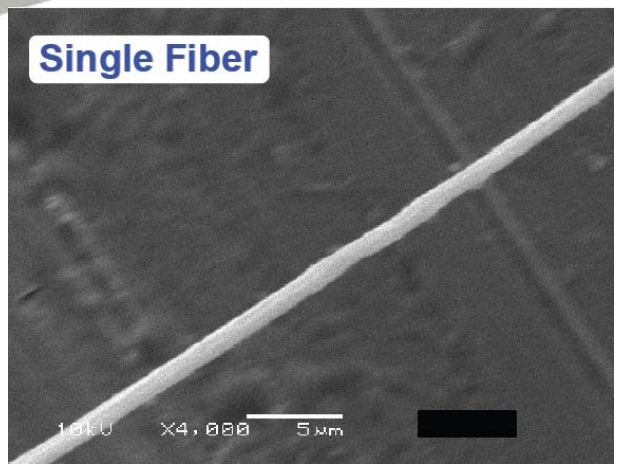
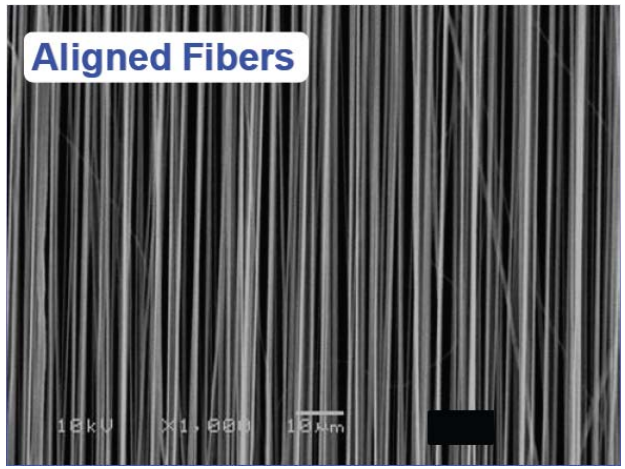
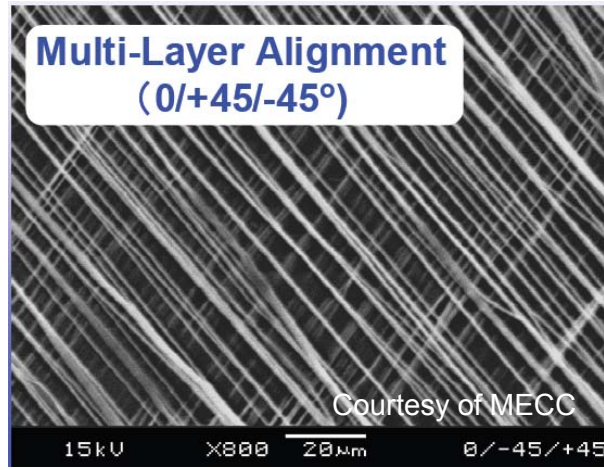
Nanofibres for Fibre Targets







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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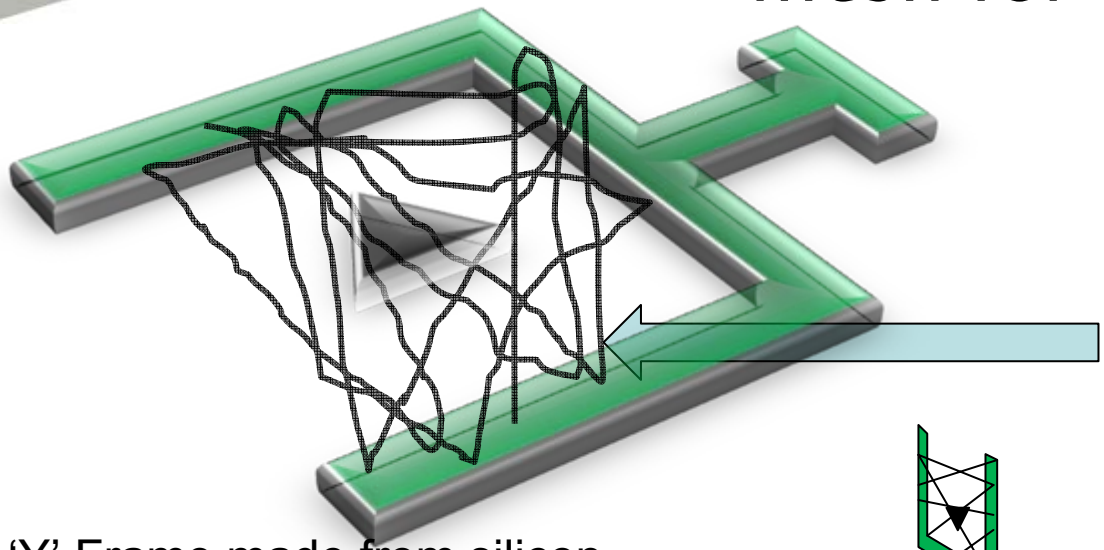
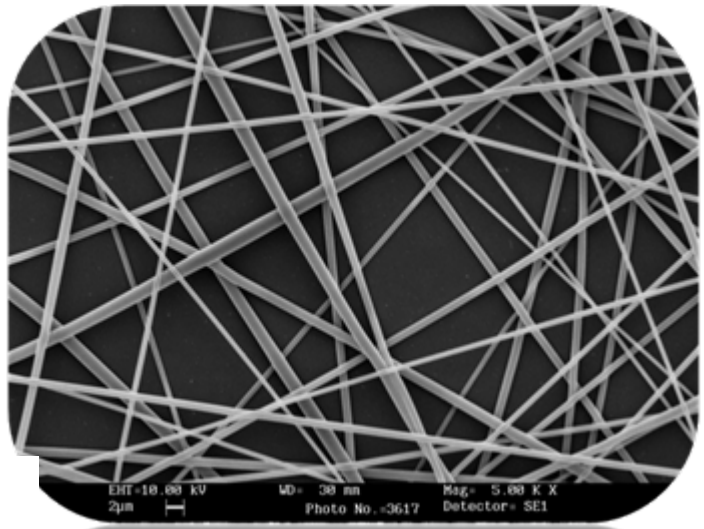
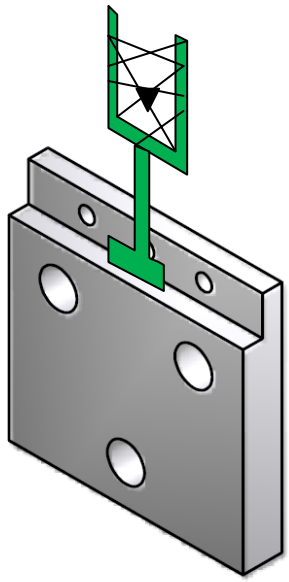
Low density, low mass nanofibre mesh for target supports







'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

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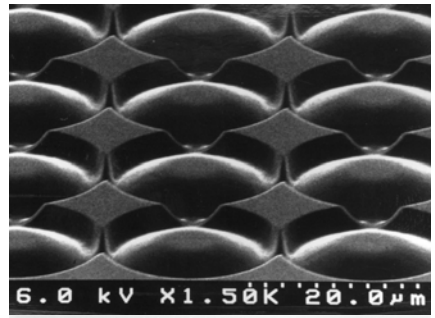
Greyscale Lithography

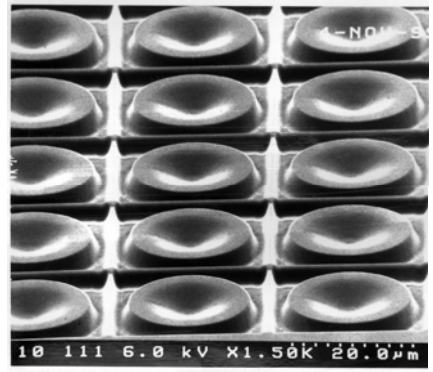
Photomasks with 512 grey levels, 0.1um resolution. OD 0.1 to 4

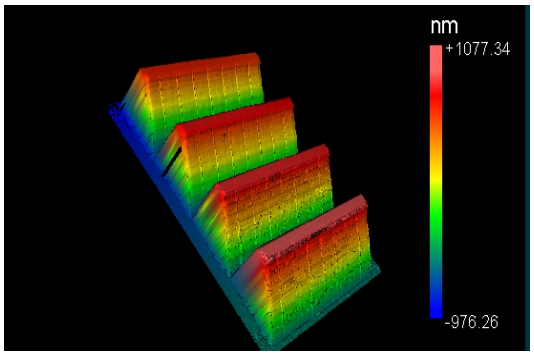
Production of microlenses, micro prisms.

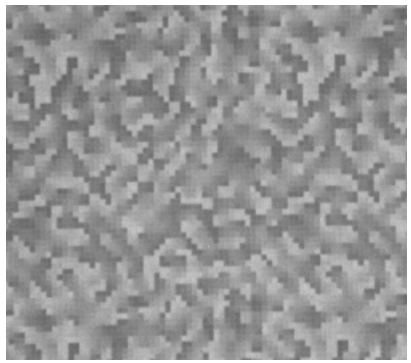
Pattern transfer using Plasma etch and Ion Milling

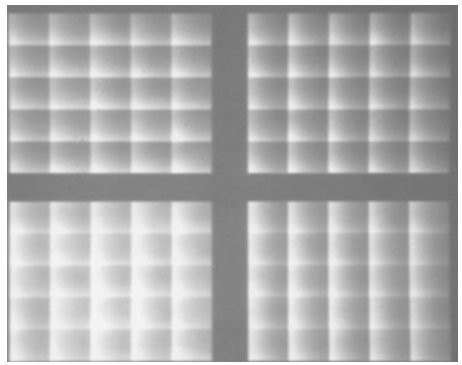
Production of moulds to form greyscale components

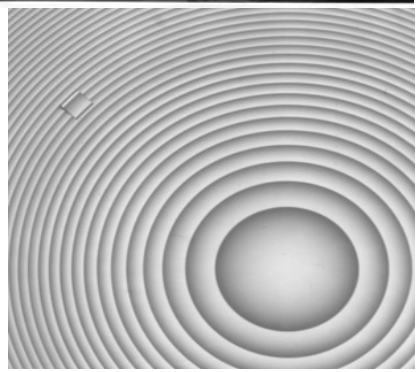












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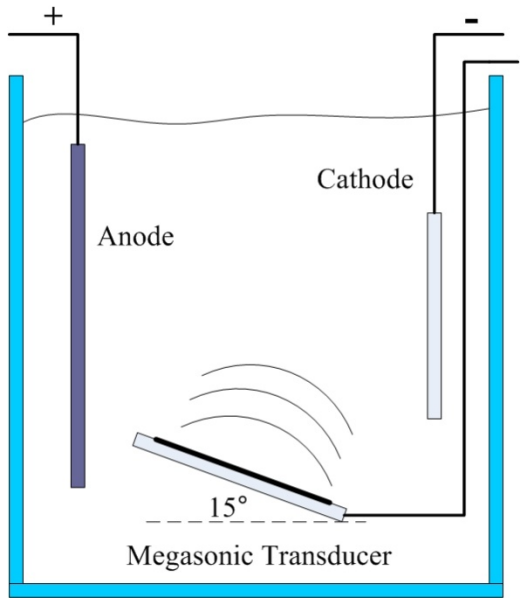
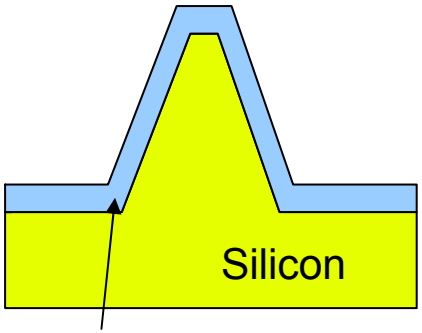
Electroforming

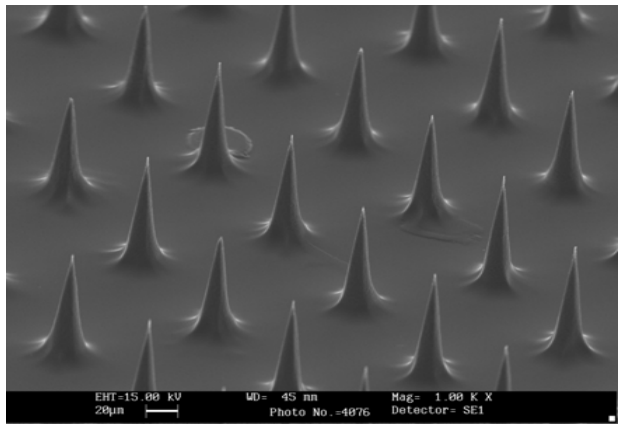
Processes

- Au, In, Ni up to 200mm 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.

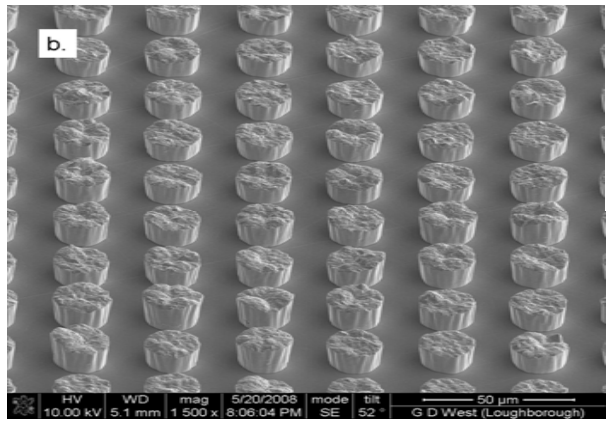




Coating defined by pulse-reverse plating



Silicon Microneedles



18um Indium Bumps

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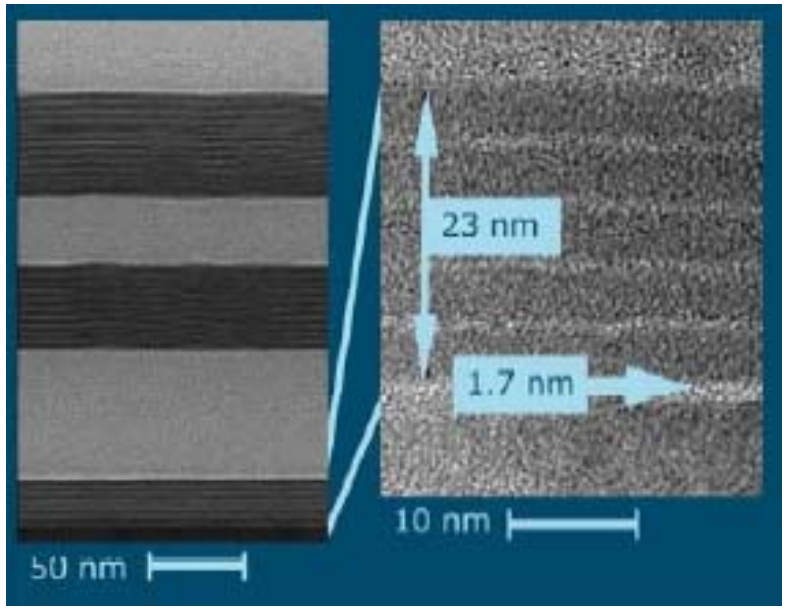
Atomic Layer Deposition

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)
Extremely thin films (5nm)
Single substrate or batch processing

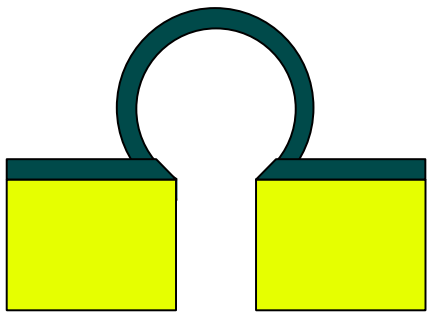


Materials

- Metals
- Dielectrics
- Rare Earth doped Oxides (Phosphors)
- .....

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...



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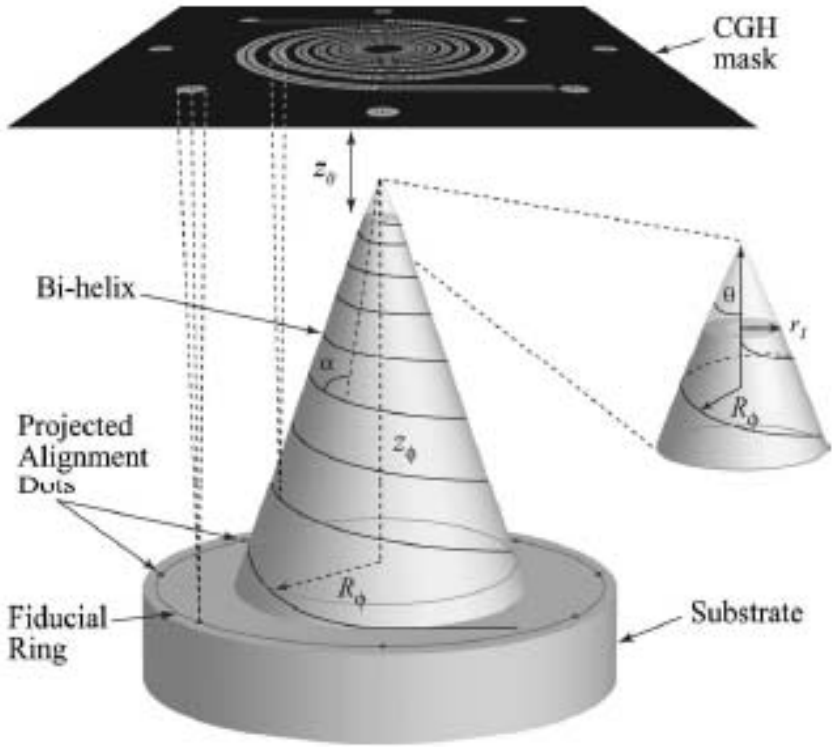
Holographic Lithography



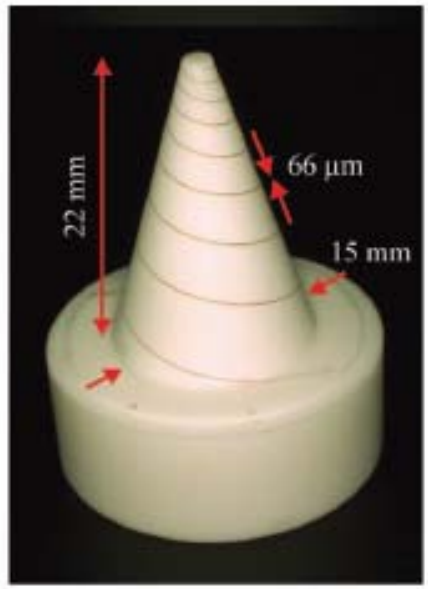


Fig. 1 Nonplanar photolithography system: θ=16.5 deg is the cone half-angle, z_0=8.4 mm is the exposure offset, r_1=1 mm is the initial helix radius, and α=74.2 deg is the wrap angle of the helix.

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

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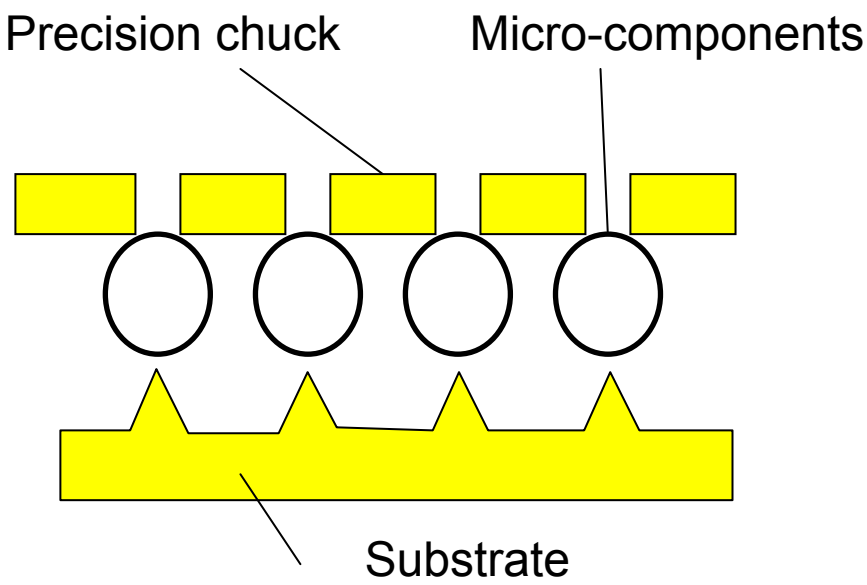
Massively Parallel Assembly

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



FC250 Flip Chip Die Bonder

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