Focused Ion Beam Technology: Tailoring Matter on the Nanoscale

Specifications I

Source and FIB Column

- Ga^+ Liquid Metal Ion Source (LMIS)
- Acceleration Voltage: 10kV ... 50kV
- Field of View: 1um ... 1000um @ 50kV
- Image Resolution: 5nm in Secondary Electron Mode

SEM

- Acceleration Voltage: 1kV ... 20kV
- Field of View: 1um ... 3500um @ 5kV
- Resolution: < 5nm in Sec. Electron Mode @ 20kV

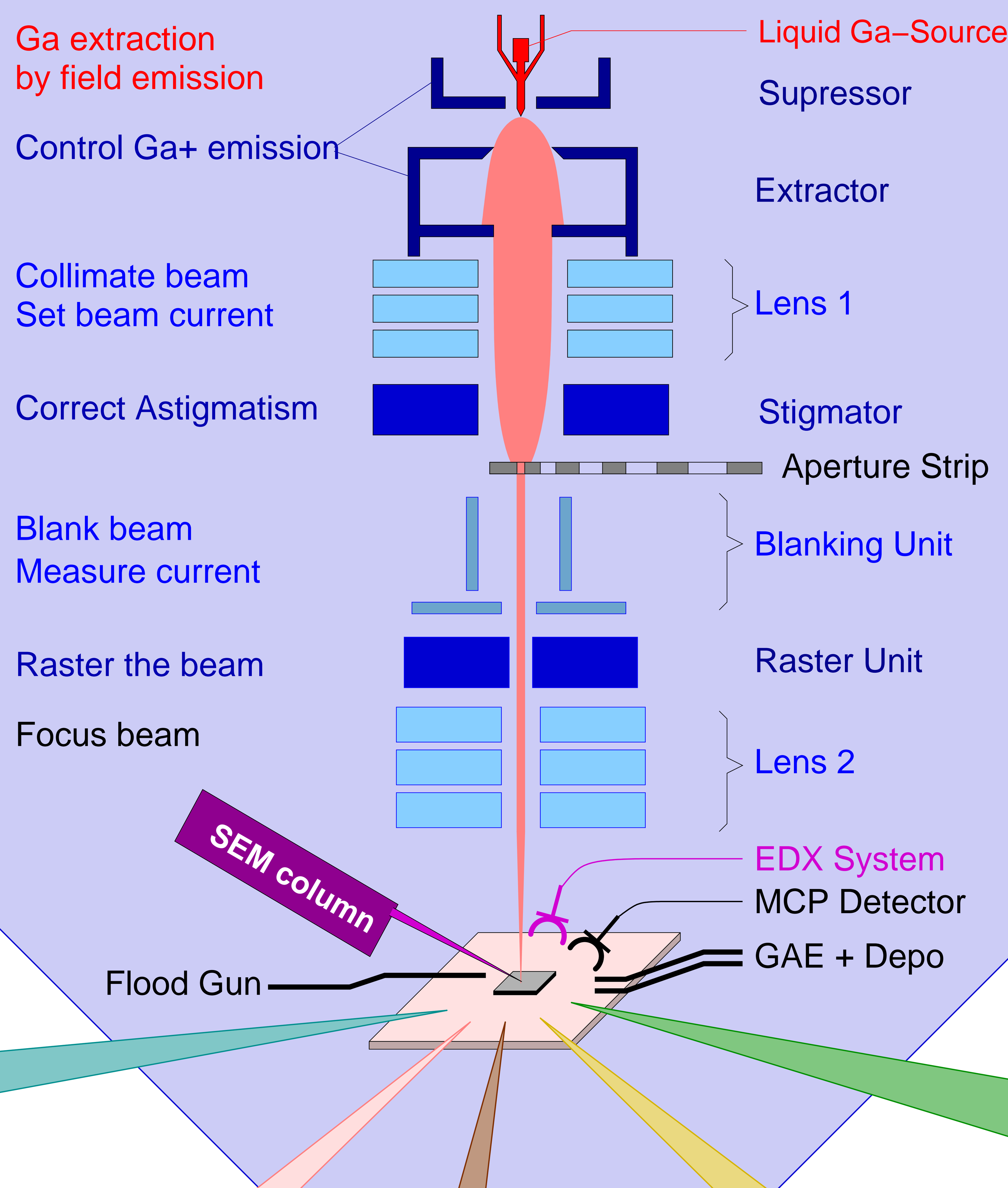
Detectors

- Principle: Multi–Channel–Plate (MCP)
- Image Mode: Sec. Electron / Sec. Ion
- Backscattered Electron (BSE) / X–Ray (EDX)

Flood Gun

- Avoid charging by neutralising ions

Micrion 9500 Dual Beam FIB/SEM



Specifications II

Aperture Strip

Smallest: 15um Diameter
- Beam Size = 5nm; Current = 1pA

Largest: 400um Diameter
- Beam Size = 500nm; Current = 11nA

Stage

- Six Axis Eucentric Stage (x,y,z,z',tilt and rotate)
- Size: 200mm (8–inch)
- Stage Accuracy: +/–1um within a die

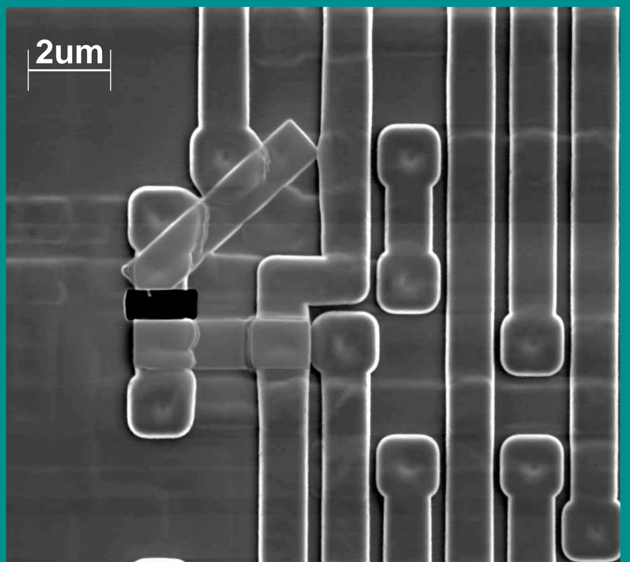
Gas Assisted Etching (GAE)

- Chlorine (for Metal)
- XeF_2 (for Oxide)

Deposition

- TEOS (Insulator Deposition)
- Tungsten (Metal Deposition)

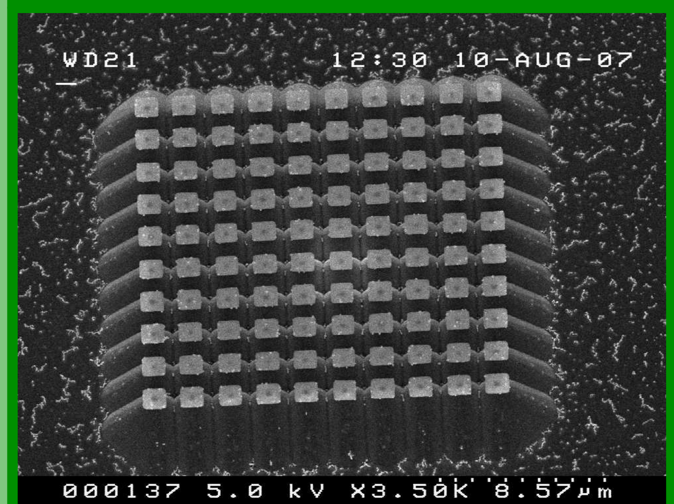
Chip Modification



FIB image of the worksite during chip modification.

- FIB induced Tungsten deposition
- XeF_2 and Cl_2 FIB enhanced etch
- FIB induced TEOS deposition

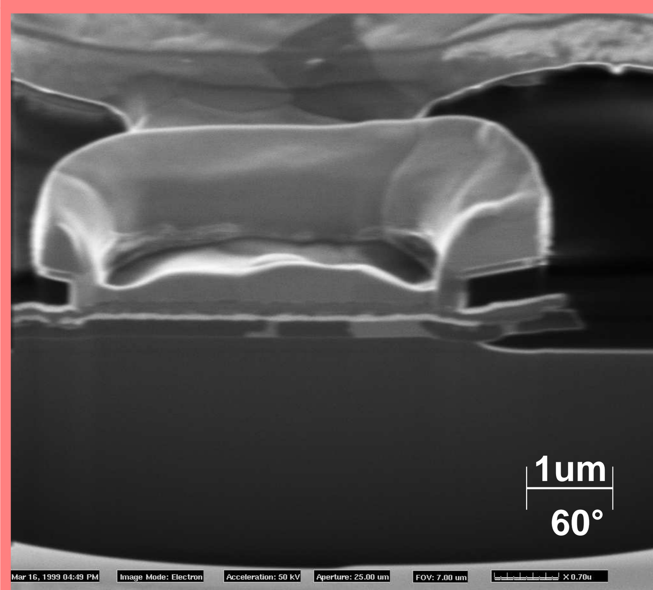
Ga Etch Stop in KOH



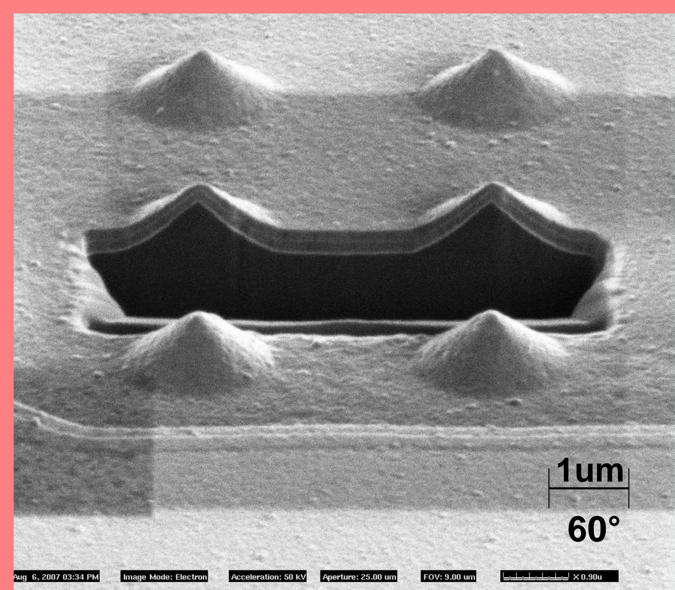
SEM image of KOH etched Si tip arrays by locally implanted Ga.

- Ga etch stop at moderate dose
- Direct lithography in Si possible

Failure Analysis and Film Characterisation



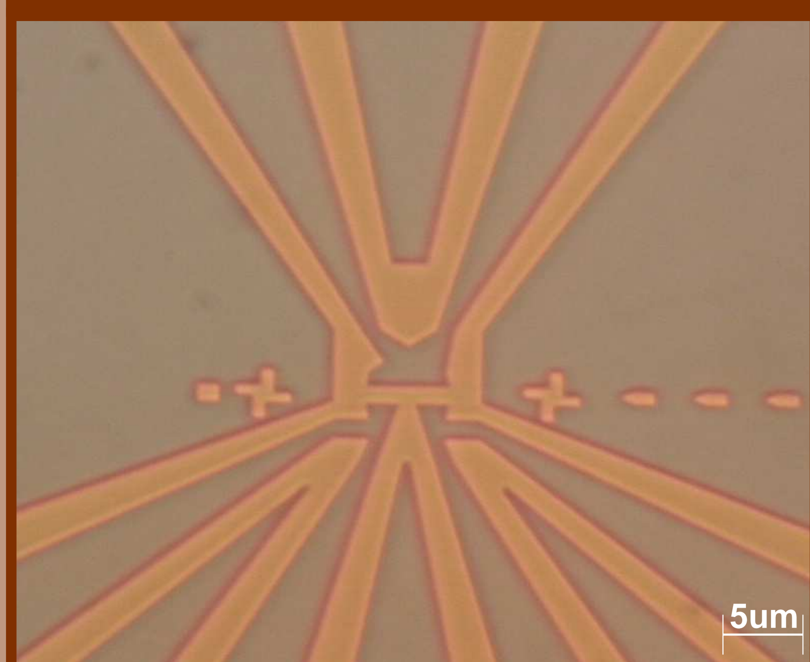
Cross–section of a chip via, imaged at 60° tilt with the built–in SEM.



Cross–section of two Si field–emitter tips fabricated by anisotropic TMAH etching.

- Failure analysis by cross–sectioning through DUT
- Built–in SEM for low–impact and high–resolution imaging

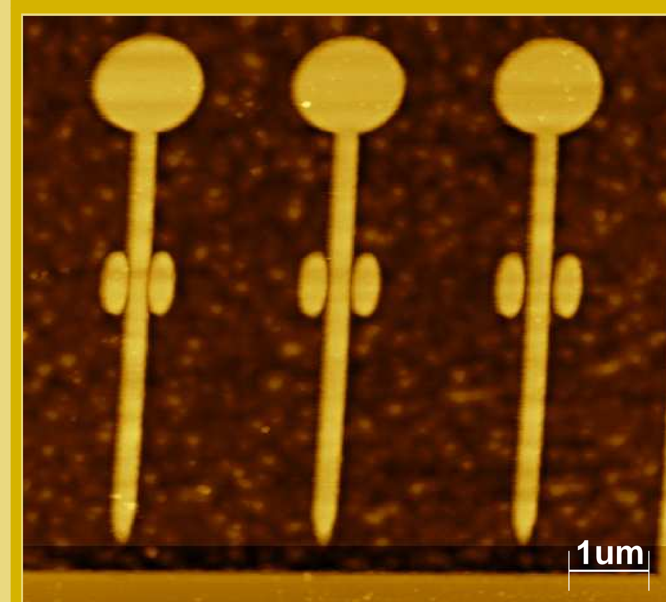
Lithography



Optical microscopy image of FIB irradiated photoresist for high–resolution LITHO.

- Moderate FIB dose sufficient
- No ion impact in substrate
- Dry development in RIE

Fabrication of Nanomagnets by Direct Writing



Topography AFM image (left) of a domain wall conductor fabricated by direct FIB milling. MFM image (right) with magnetic dipoles (+ pole: dark, – pole: bright).

- Magnetic thin films are very sensitive to ion irradiation
- Set the magnetic properties by either FIB dose or energy impact

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