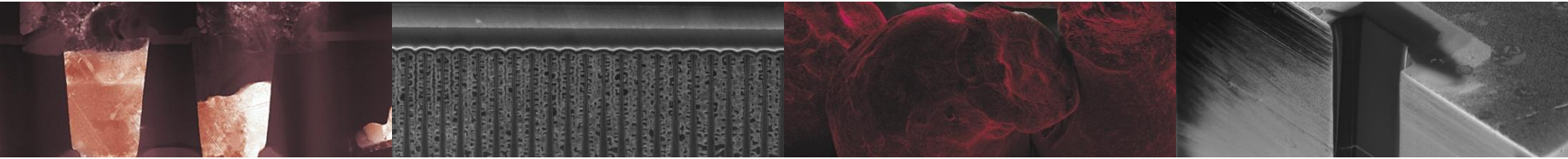
FEI™ Explore. Discover. Resolve.

Package Level Editing with Plasma FIB Technology

David Donnet

EFUG Cagliari, Italy

October 1, 2012



Acknowledgements

Thanks to:

Pete Carleson
Chad Rue
Brianna Carrigan
Surendra Madala
Various Customer Partners

Introducing the Vion™ Plasma FIB from FEI

- Xe^+ Inductively Coupled Plasma Ion Source
- Optimized for large cross-sections; Greater than 100 µm easily achievable without artifacts caused by mechanical methods
- Wide Current Range: 1.5 pA to 1.3 µA
- Flexible Accelerating Voltage Range: 2-30 kV
- Image Resolution <30nm
- Multiple Xe^+ ion induced CVD and enhanced etch gas chemistries available.
- Common hardware and software platform with other FEI products for proven reliability.

SPEED

PRECISION

RELIABILITY

Comparing the Vion™ PFIB system with a Ga-FIB system

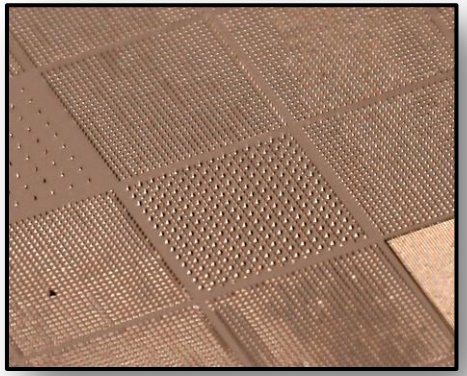
Key Differences:

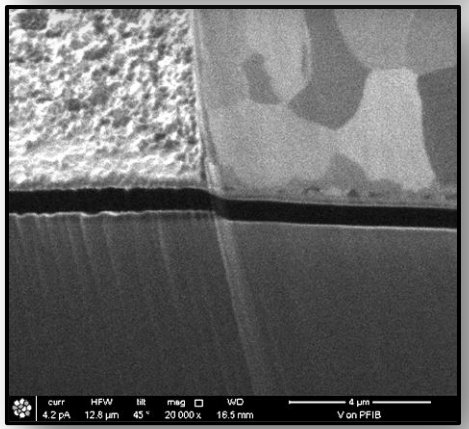
- ICP source
- Three lens FIB column
  - Beam current range 1.5 pA to > 1 µA

Similarities:

- 150 mm piezo-ceramic stage
- SE/SI detector (CDEM)
- GIS for deposition & etching
- Charge Neutraliser
- Optical & IR microscopes
- CAD & Defect navigation
- Common Software Platform to other FEI systems
- Automation software

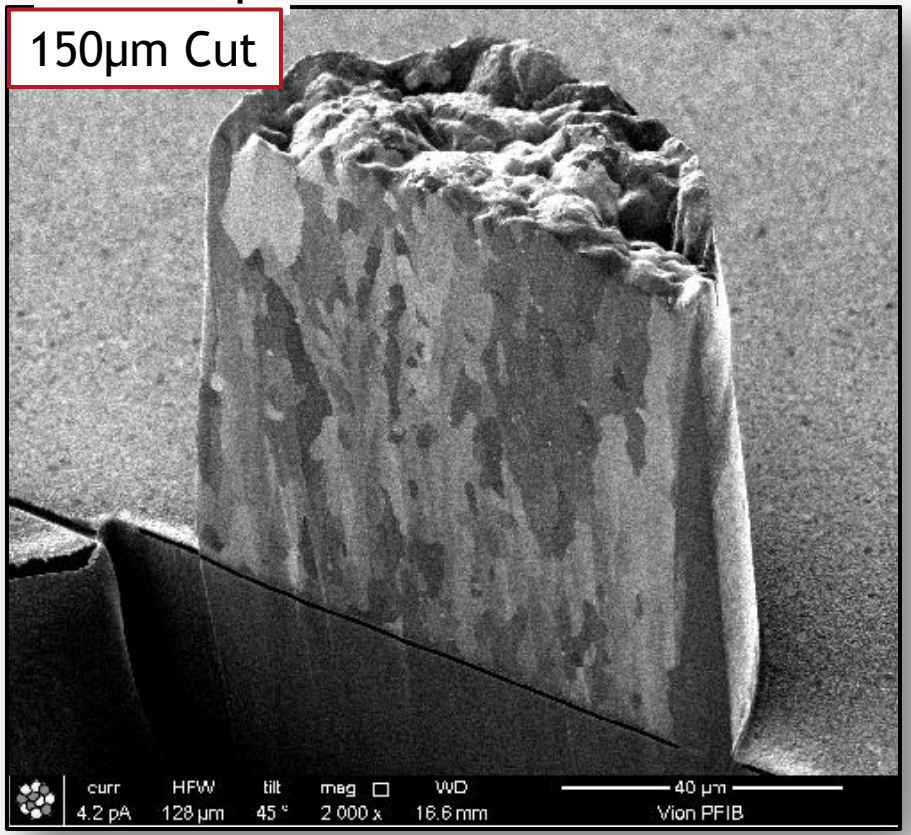
Plasma FIB Applications





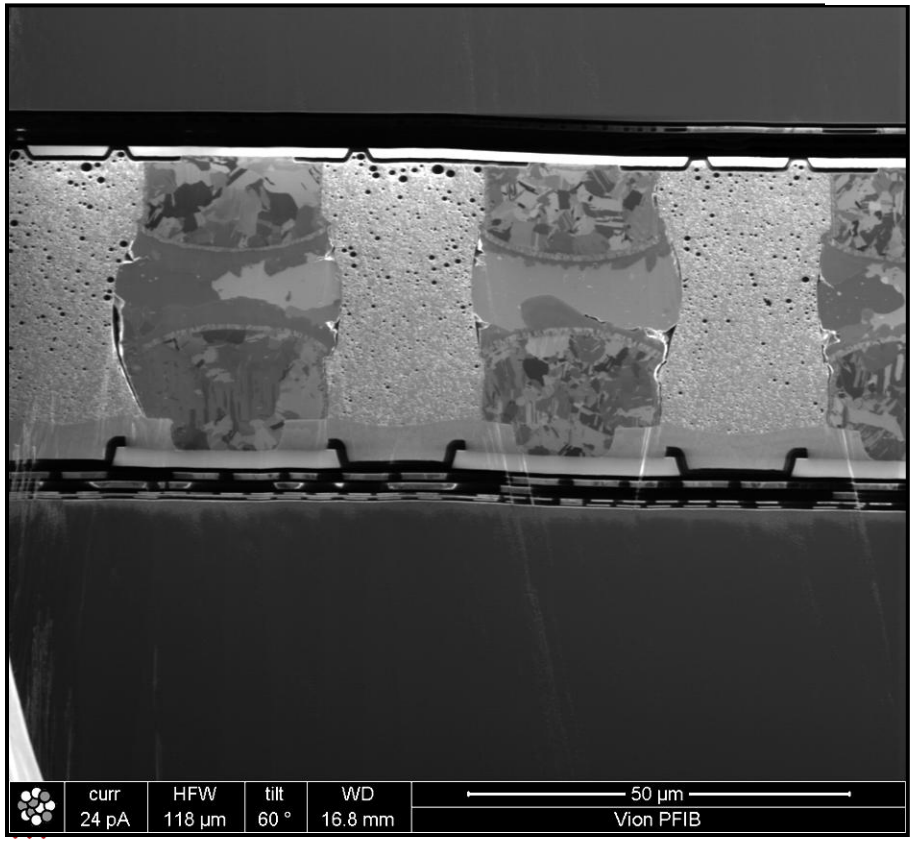
Cu Bump

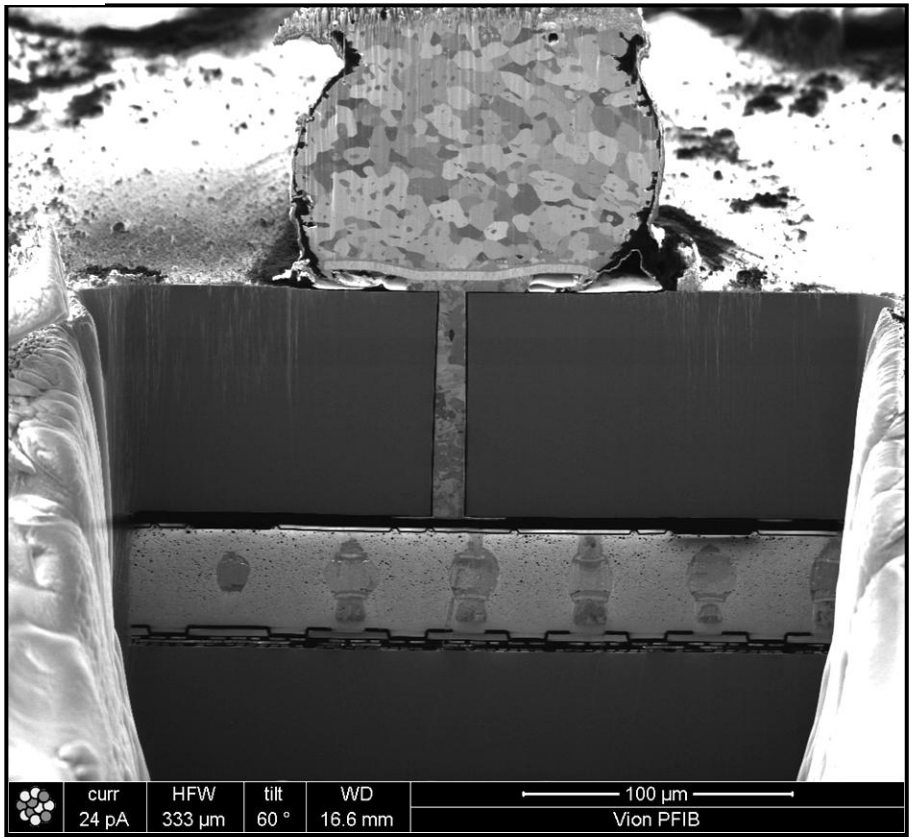
150µm Cut



Plasma FIB Applications

Cu Bump





Investigating PFIB for Package Level Editing

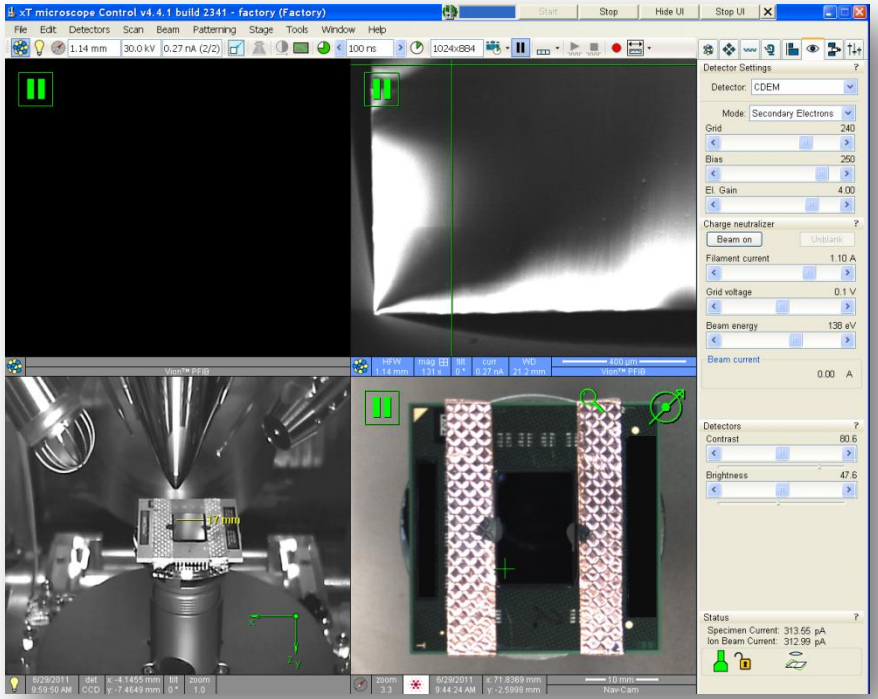
Package Level Editing

Implement change in silicon as mask spin: 6 – 8 weeks
Implement change in package layout: 1-2 weeks
Time savings: 5-6 weeks per edit

Die Level Editing

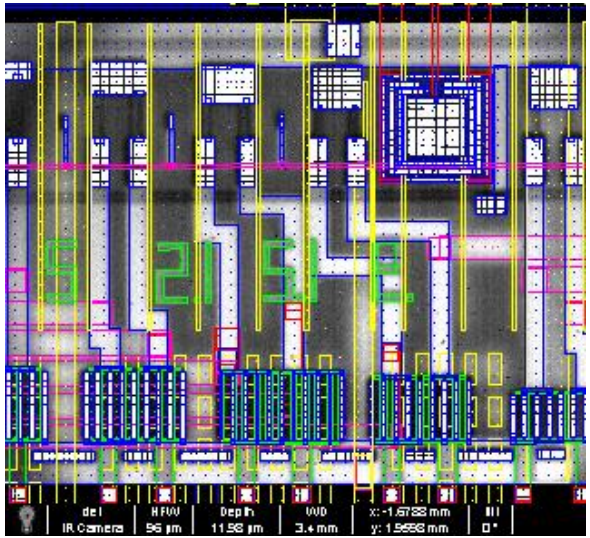
Trenching step
Long straps
Exposing features
Time savings: varies

Course Navigation Assisted by NavCam

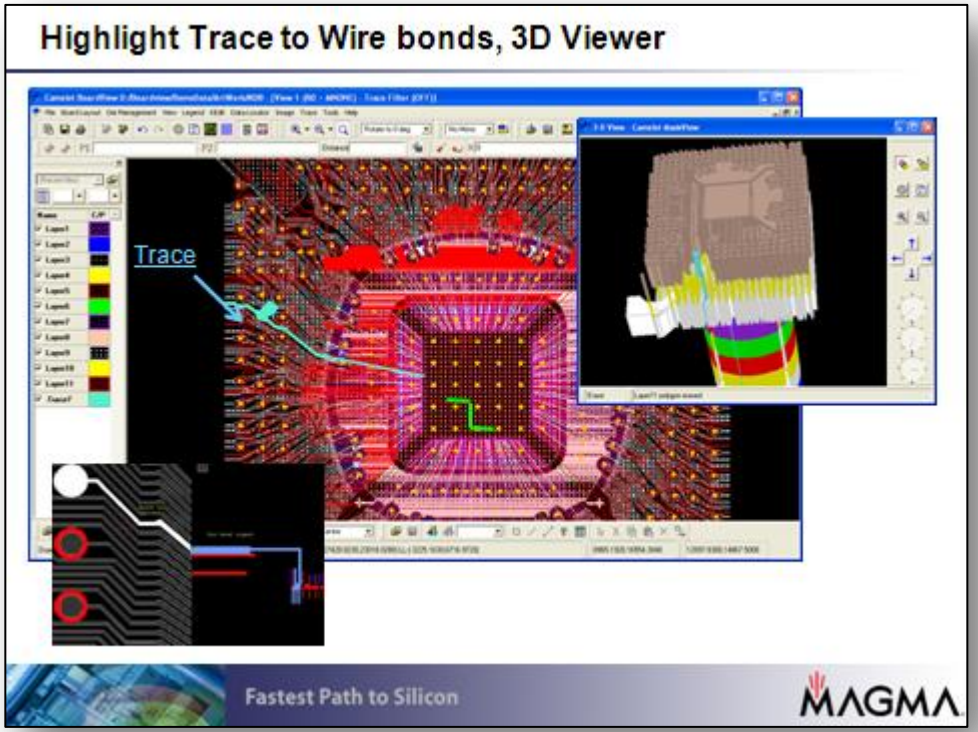


Local Navigation

Navigation at both die and package level

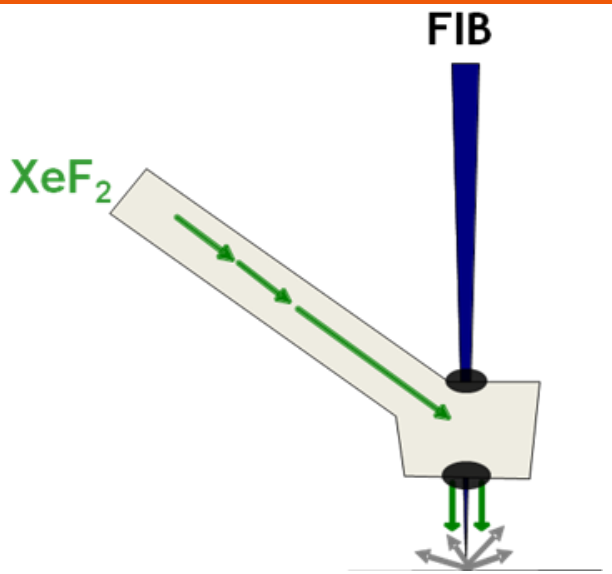


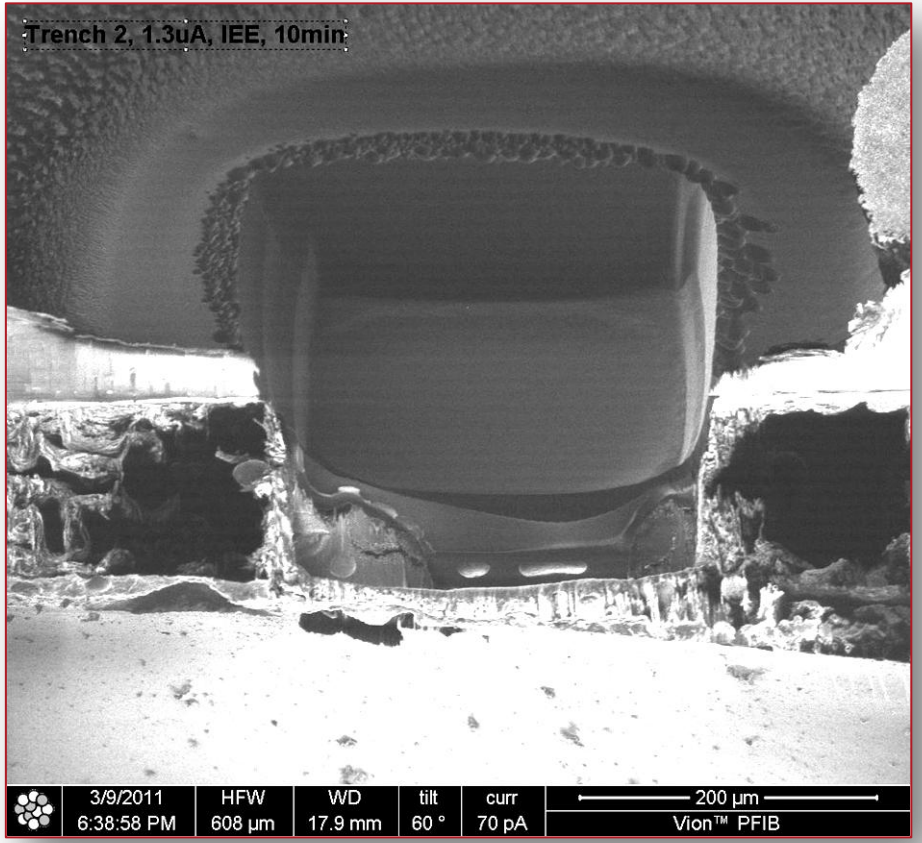
Die level CAD overlay with IR image



SystemNav displays board level layout data

Elements of Editing: Si Trenching



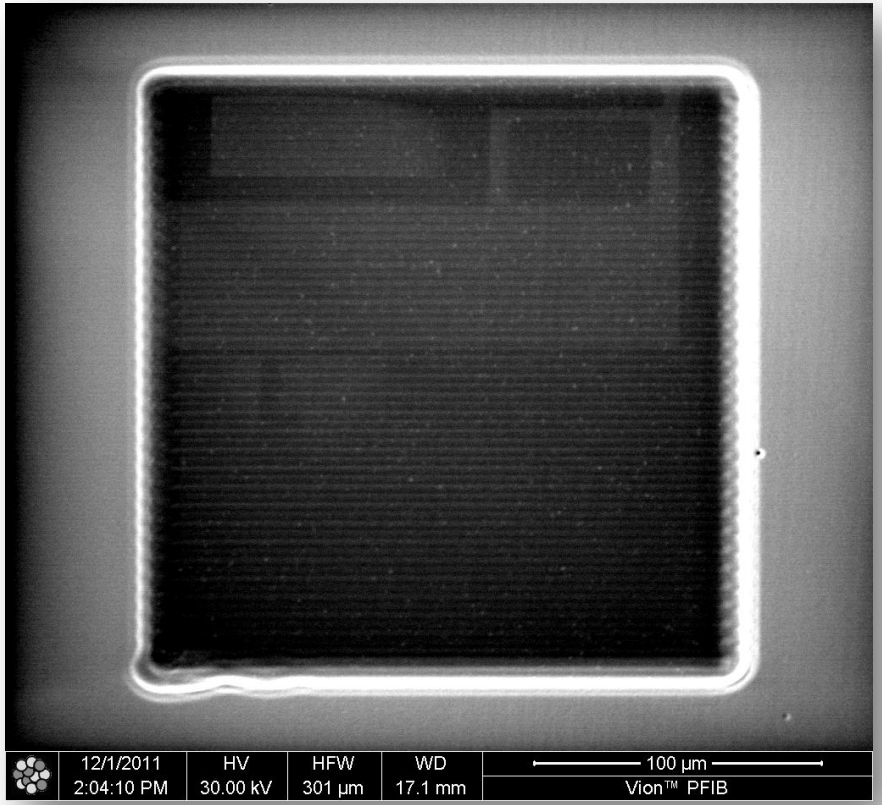


- Smooth trench floors are obtained even with 1.3 µA
- Best removal rate so far ~700k μm^3/min (Ga^+ is typically 100k – 200k)

Elements of Editing: Si Trenching Nwell Contrast

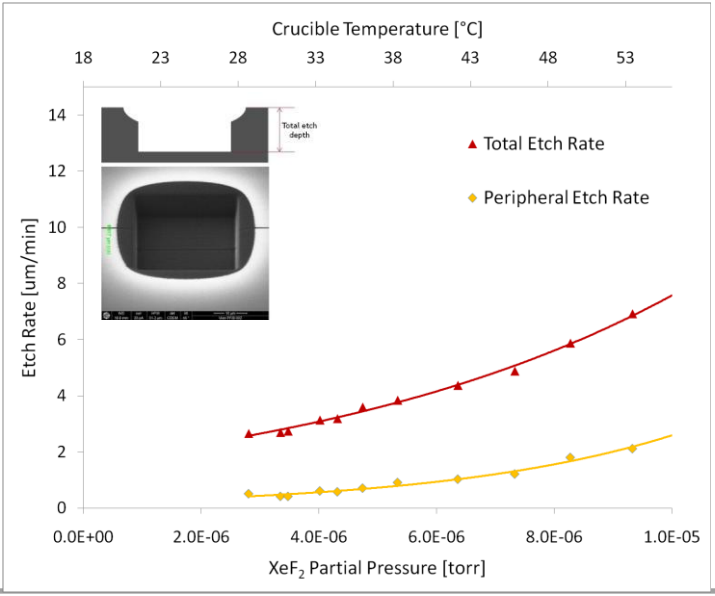
- Nwell contrast visible 2-4 um before circuitry

- 200 x 200 x 50 um
- 12 minutes so ~4 um per minute



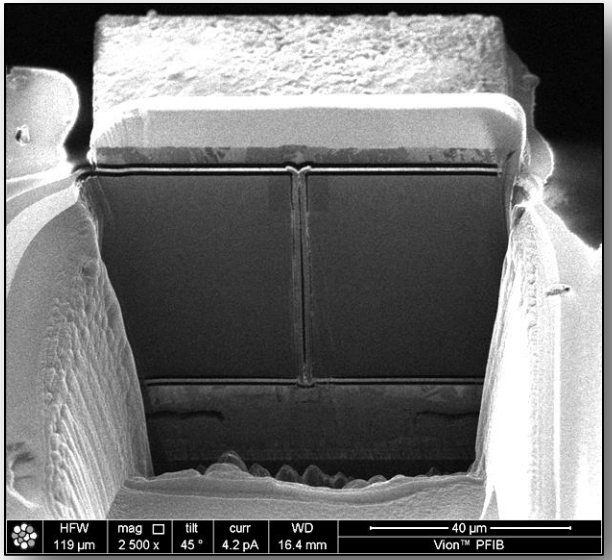
Elements of Editing: Si Trenching

	Ga	Xe-PFIB
Typical volume rate (μm^3/min)	100-200k	400-600k
Typical depth rate (µm/min)	5-10	3-8
Highest volume rate (μm^3/min)	400k	>1M



Gas limited process (for both Ga and Xe FIBs):
→ Cannot make full use of the extra Xe-PFIB beam current
Gas scattering seems more pronounced with Xe than with Ga – limits max gas flux for PFIB:
→Ga-FIB currently higher max linear rate (µm/min)
Larger needle bore allows larger area to be scanned:
→Further increases PFIB volumetric rate (μm^3/min)

Elements of Editing: Pt Deposition



Full parameter space for characterizing deposition is very large (current, dwell, overlap, area, gas flux, refresh time, …)

Comparing typical Ga section:
300 pA, 15 by 2 µm, 3 mins → ~1 µm thick

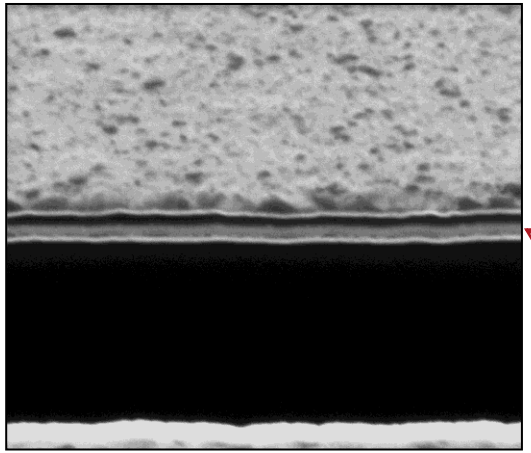
PFIB Example:
74 nA, 80 by 15 µm, 6 mins → ~10 µm thick

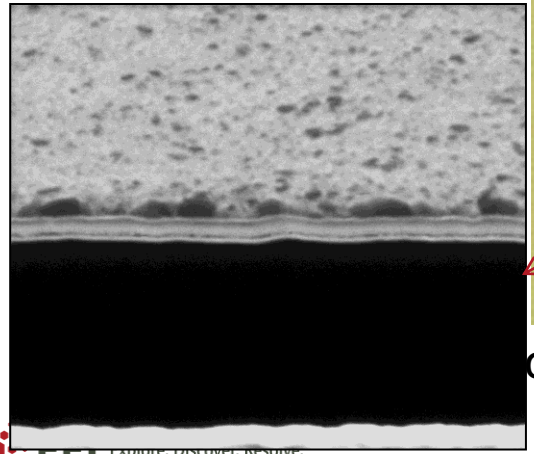
Deposition trends seen with Xe-PFIB:

More tolerant of higher current density (also seen with higher current Ga too?)

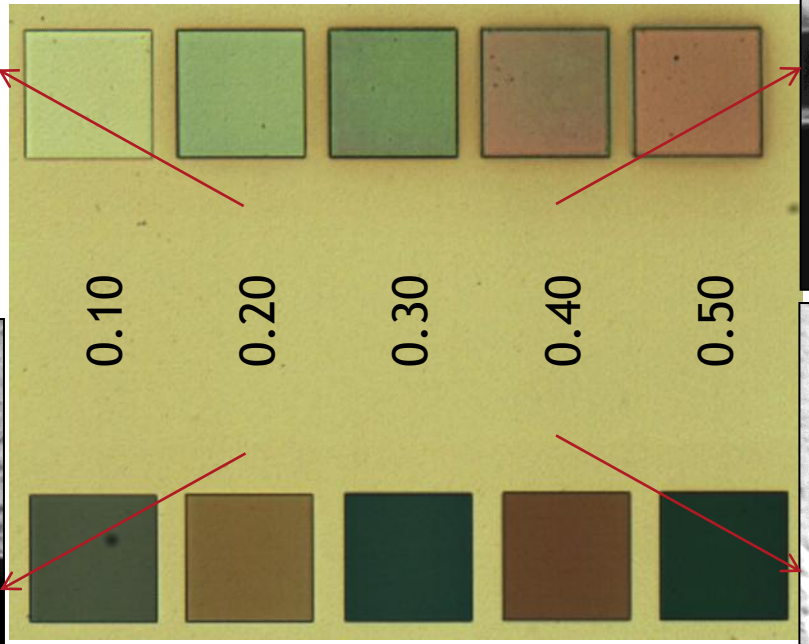
- Similar-to-higher volume rates, similar resistivity
- Faster thickness rates → Thicker, large area straps/connections in reasonable time

Elements of Editing: Insulator Deposition

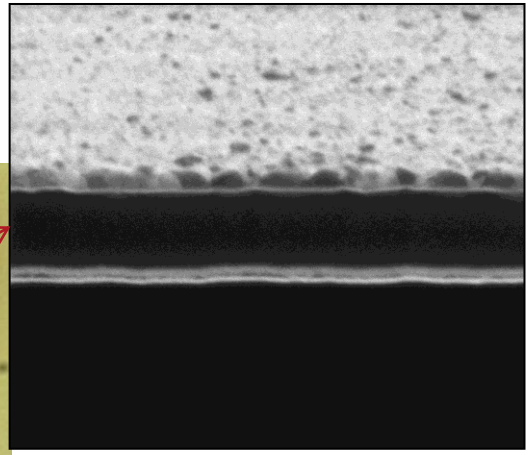


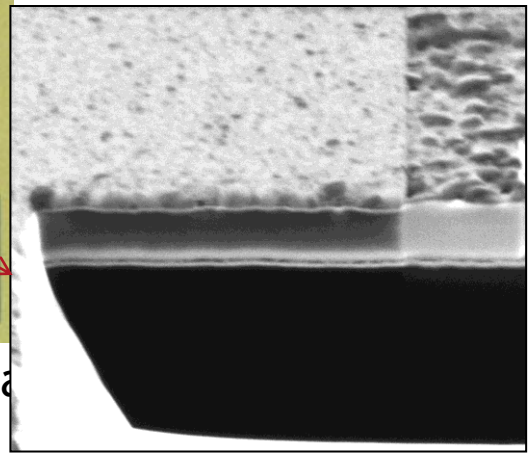


Top Row: HMCHS/O_2 depos with Xe^+



ottom Row: TMCTS/O_2 depos with Ga





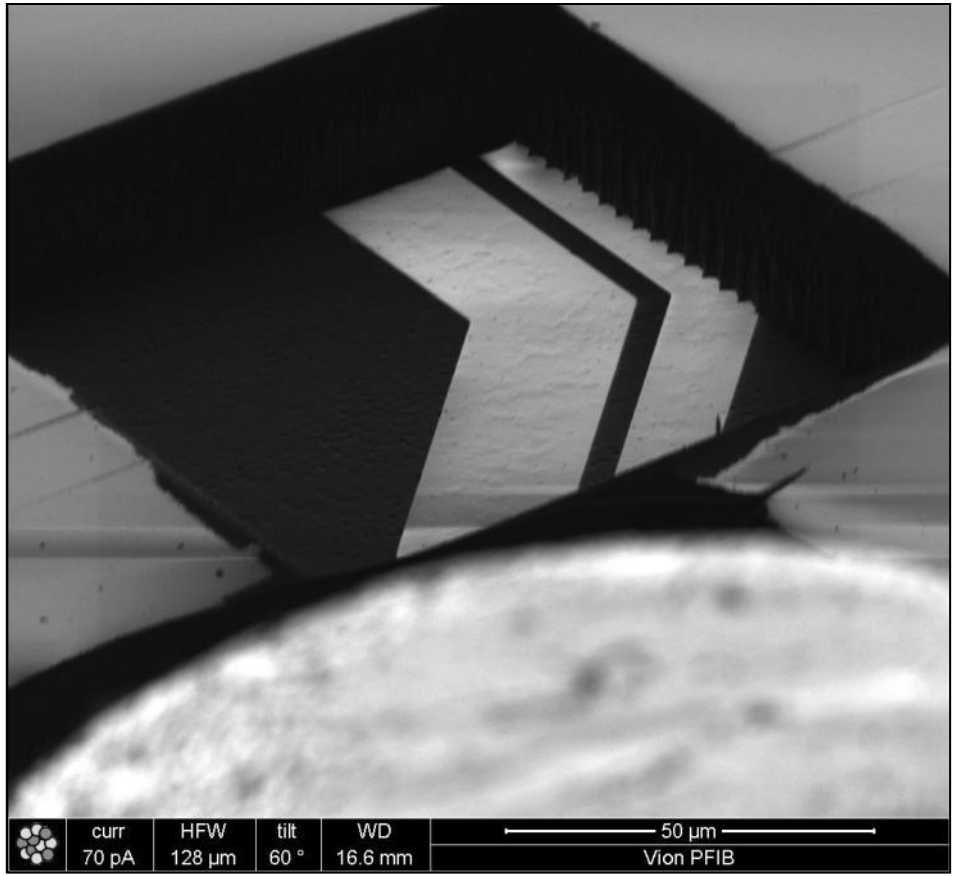
Elements of Editing: Insulator Deposition

- Preliminary results indicate HMCHS/O_2 depositions performed with Xe^+ are significantly more resistive than TMCTS/O_2 depositions performed with Ga^+.

- Resistivities appear to be $>>10^{16}$ μΩ·cm. An oxide deposition of 0.3 nC/μm^2 over an area of 100 μm^2 results in > 1 TΩ of resistance.

- Besides resistivity data, we will also be measuring breakdown voltage.

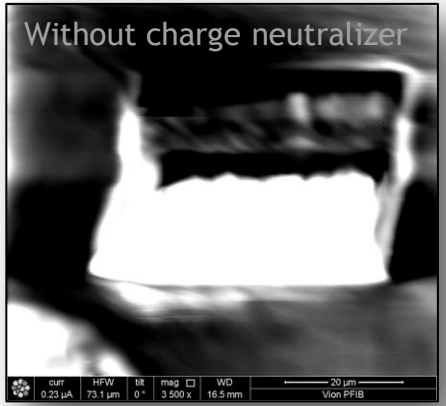
Elements of Editing: PI Removal

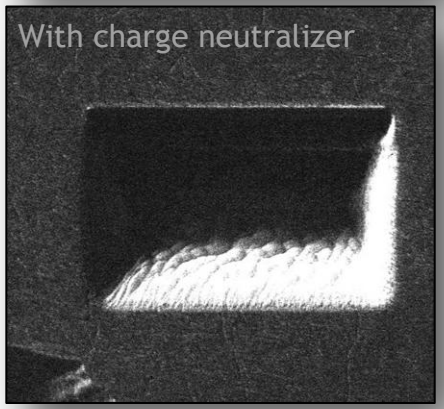


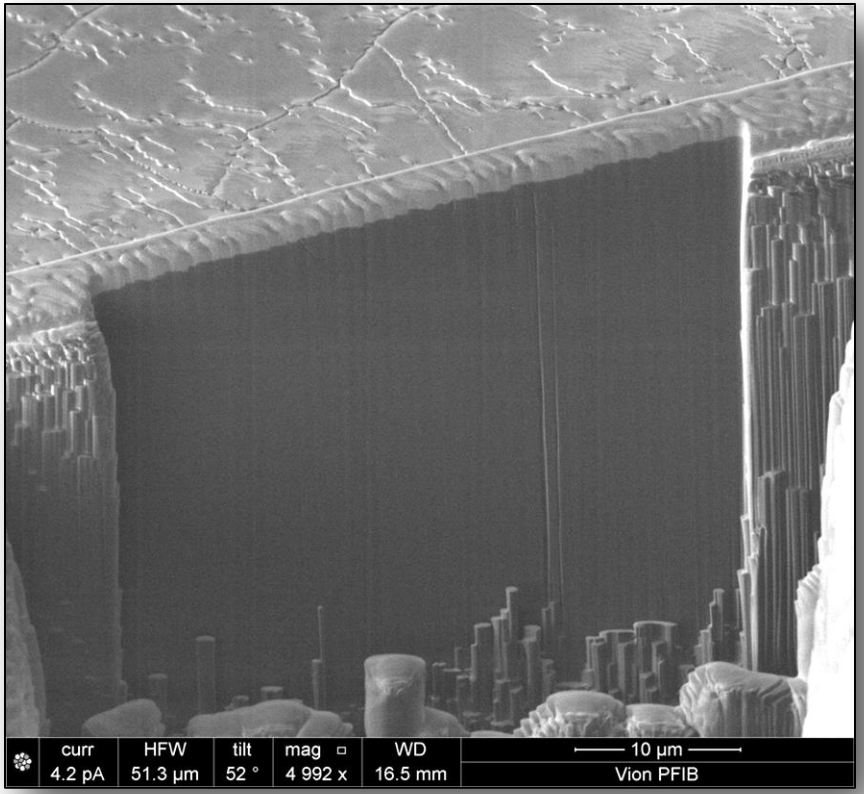
Low kV O_2 assisted recipe developed to cleanly remove polyimide

Clear endpointing to stop on oxide which is then removed with XeF_2 assisted etching to expose metal

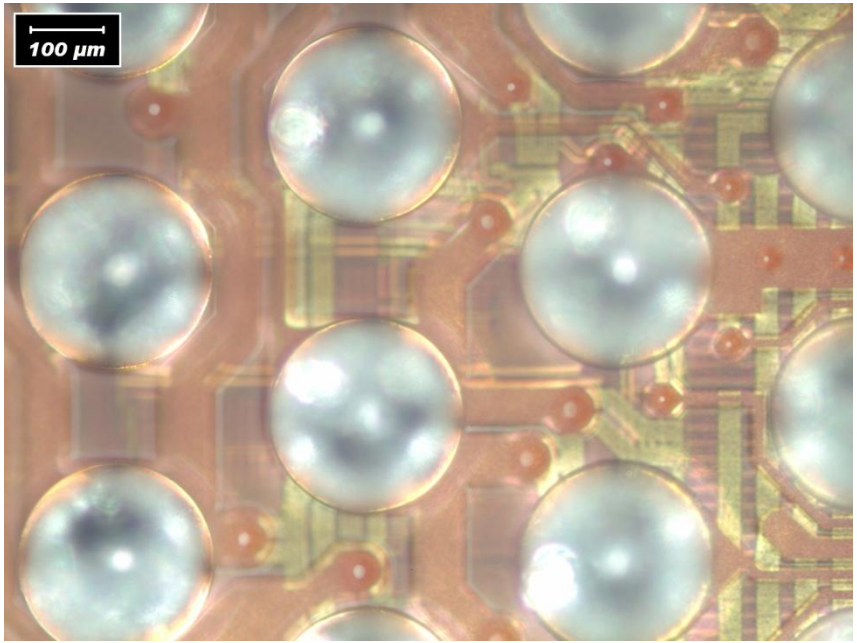
Elements of Editing: Charge Neutralisation



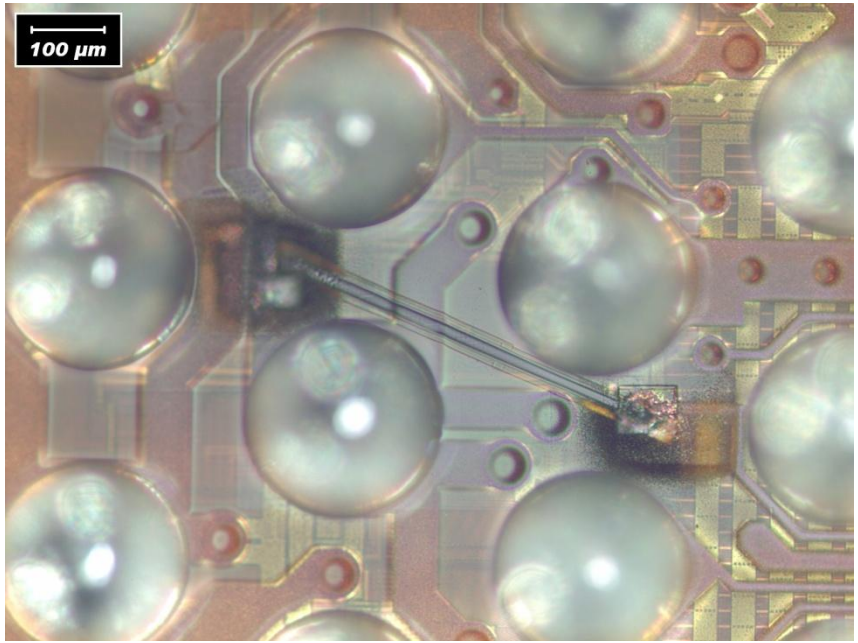




Package Edit Example I

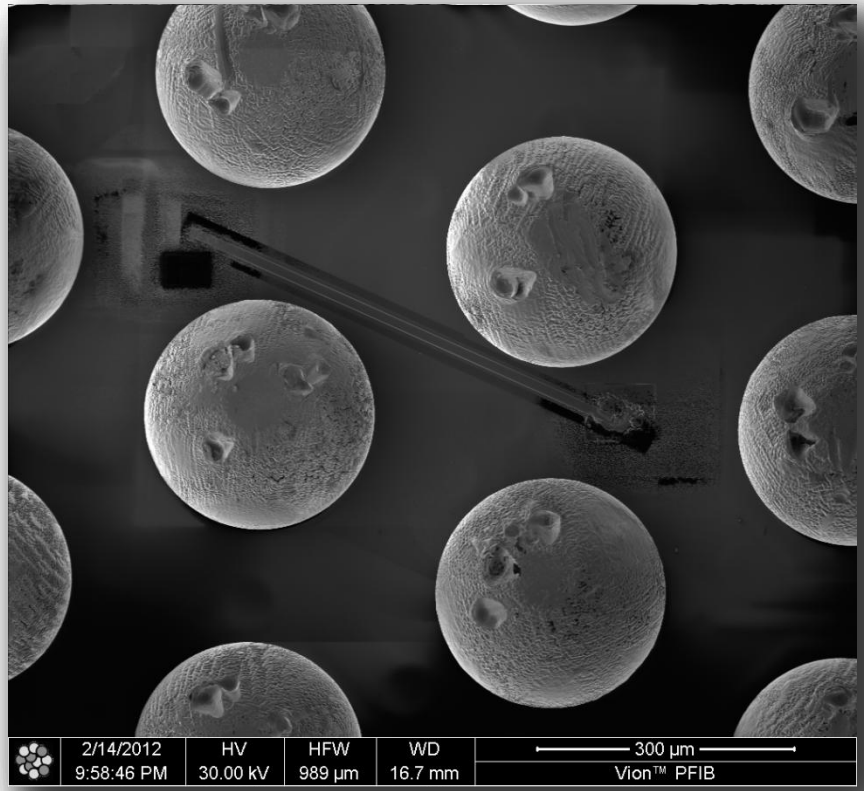


Before FIB



After FIB

Package Edit Example I (a closer look)



Pad after PI removal with 10 kV O_2 etch

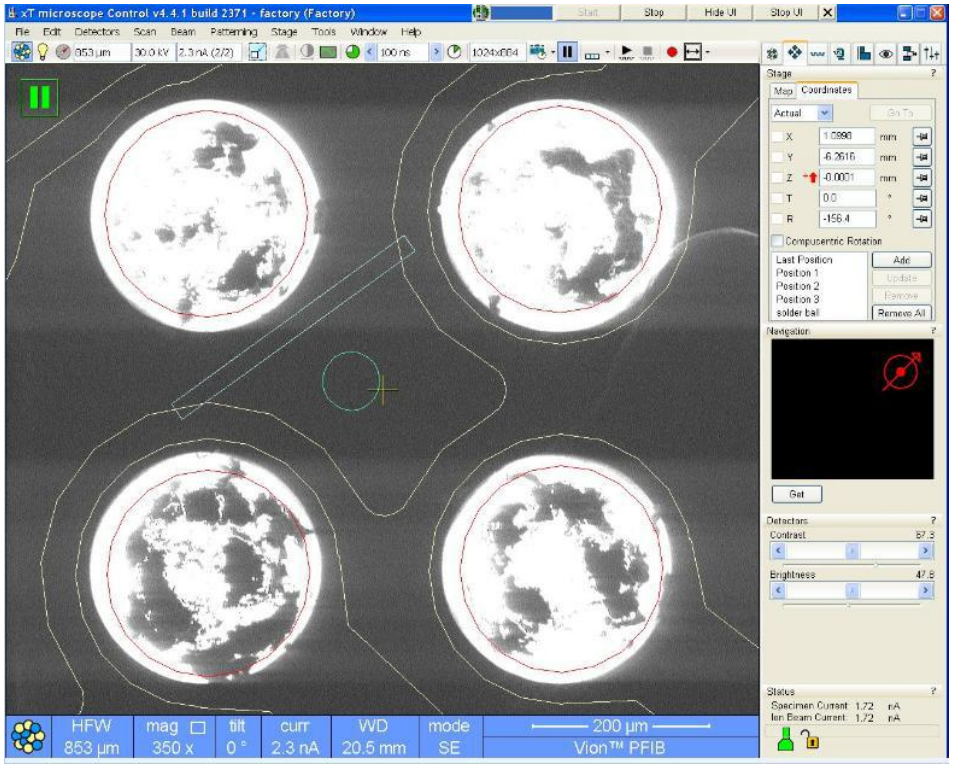
Jumper connection with Pt deposition

Metal cut with beam

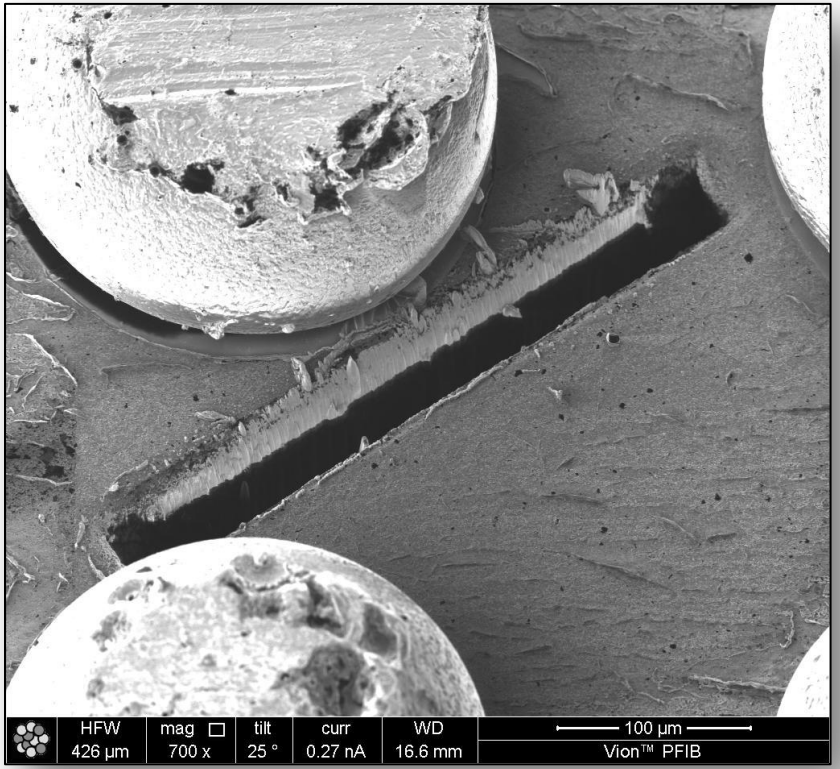
Overview with insulator covering cut

Job Successful!

Package Edit Example II

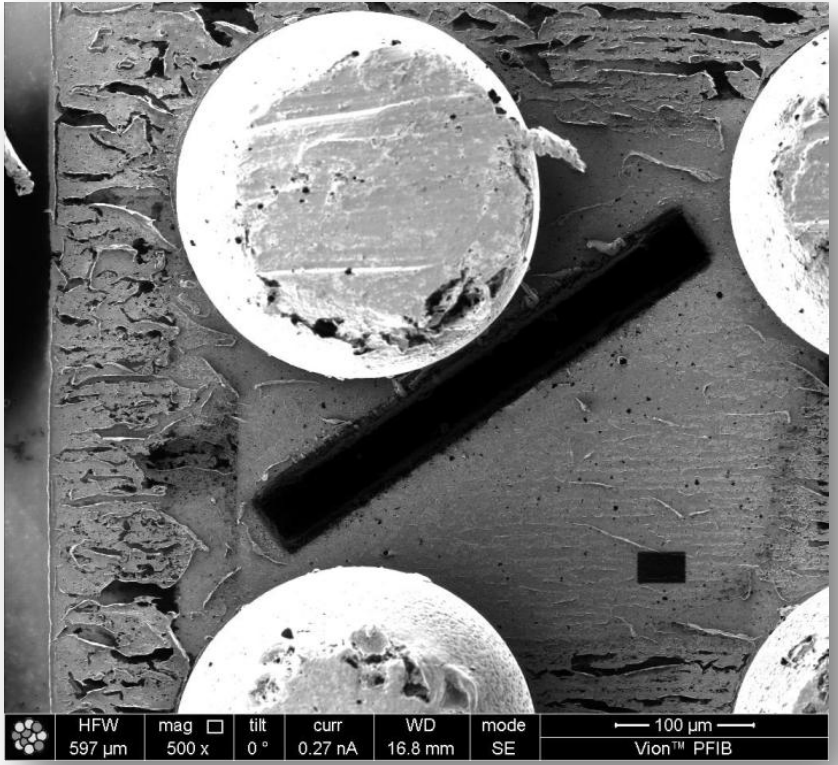


PFIB image with SystemNav overlay showing location for cut



30 minutes - pumpdown, align, and cut with Xe beam.
3 minutes of XeF2 cleanup

Package Edit Example II



5 minutes depo of IDEP3 to fill the cut so that when the solder is re-flowed it does not flow into the cut box.

Job was successful

Summary

Plasma FIB system introduced for package scale work. Features investigated for "package edit" functions

Navigation

Navcam+ → IR Microscope → SystemNav → Camelot

XeF_2 Trenching

Smooth trench floors achieved at ~4x rate of Ga

Platinum Deposition

Successfully deposited for surface protection

Resistivity nominally the same as Ga based depositions at higher yield

Insulator Deposition III

Resistivities appear to be >>10^16 μΩ·cm

Polyimide Etch

A low kv process developed to highly selectively etch polyimide

Charge neutralizer

Proven to work on a highly insulating dental sample

Try them all out together

Case studies demonstrated successful edits connecting the various steps

FEI™ Explore. Discover. Resolve.

Thank You

Learn More at fei.com/Vion