Package Level Editing with Plasma FIB Technology

David Donnet
EFUG Cagliari, Italy
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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
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
• Smooth trench floors are obtained even with 1.3 µA
• Best removal rate so far ~700k µm³/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
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 (µm³/min)
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

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
Elements of Editing: Insulator Deposition

Top Row: HMCHS/O$_2$ depos with Xe$^+$

Bottom Row: TMCTS/O$_2$ depos with Ga$^+$
• 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.
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

Without charge neutralizer

With charge neutralizer
Package Edit Example I

Before FIB

After FIB
Pad after PI removal with 10 kV O₂ etch

Jumper connection with Pt deposition

Metal cut with beam

Overview with insulator covering cut

**Job Successful!**
PFIB image with SystemNav overlay showing location for cut

30 minutes - pumpdown, align, and cut with Xe beam.
3 minutes of XeF2 cleanup
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.
Plasma FIB system introduced for package scale work. Features investigated for “package edit” functions

**Navigation**

Navcam+ → IR Microscope → SystemNav → Camelot

**XeF₂ 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 $>>10^{16} \, \mu\Omega\cdot\text{cm}$

**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
Thank You

Learn More at fei.com/Vion