Where we are
Automatic and manual tools
Agenda

- Micro 4 Point Probe
- CIPTech-Probe
- Fin-FET Resistance Measurement
Background

**Engineering Challenges**
- Eliminate cantilever position errors
- Production of micro probe
- High accuracy surface detection
- Reduction of vibrational noise

**Advantages**
- Measures near-surface properties
- Measures accurate $R_s$ with µm resolution
- Measurements on small structures

50x50µm pads in the dicing streets
Micro 4 Point Probe

- Optimized cantilever shape
- Measurements on USJ and Hall Mobility

- Micro 4 Point Probe
The micro 4 Point Probe

8µm spacing
L-shaped cantilevers

- L shape cantilever ensures steady contact point through 3-way flexible cantilevers.
- Relatively large vibrations (~50nm and above) can be absorbed without losing contact or sliding.
Sheet Resistance mapping of a 300mm blanket wafer

Blanket wafer
USJ, doped and annealed
Probes for characterization of MTJ films

Min Pitch 0.5µm
Electrical surface detection
Excellent vibration absorption

Min Pitch 1.5µm
Mechanical surface detection
Excellent Vibration absorption

Min Pitch 0.75 µm
Electrical surface detection
Poor vibration absorption
Magnetic Tunnel Junction

Free Layer

Bottom Layer
Pinned

Barrier

Parallel Spin $\rightarrow$ Low resistance
Anti-Parallel Spin $\rightarrow$ High Resistance
Probes for characterization of MTJ films

MTJ parameters:

- Top layer sheet resistance- Rt
- Bottom layer sheet resistance – Rb
- Barrier resistance area product – Ra
- Magnetoresistance – MR

\[
MR = \frac{Ra_{high} - Ra_{low}}{Ra_{low}}
\]
Multiple pitches on a single probe

TOP LAYER [FREE]

BARRIER

BOTTOM LAYER [PINNED]
Multiple pitches on a single probe

- TOP LAYER [FREE]
- BARRIER
- BOTTOM LAYER [PINNED]
Multiple pitches on a single probe

\[ \begin{align*}
I_+ & \quad V_+ \\
V_+ & \quad V_- \\
I_- & \quad V_-
\end{align*} \]

- **TOP LAYER [FREE]**
  - \( R_t \cdot x \)

- **BARRIER**
  - \( \frac{R_A}{x} \)

- **BOTTOM LAYER [PINNED]**
  - \( R_b \cdot x \)
Small probe pitch measures $R_t$
Intermediate probe pitch measures $R_A$ and $M_R$
Large probe pitch measures $R_T \parallel R_B$
Measurements on MTJs
Resistance Measurements of fins and nanowires

Fin-FET Resistance Measurement

**Metrology goals:**

1. Non-destructive
2. High measurement yield
3. High accuracy (1% σ)
Direct 4pp measurements on fins

Non-destructive

High measurement yield

High accuracy (~1% $\sigma$)

Destructive

Medium-low measurement yield

Lower accuracy (>1% $\sigma$)
Design concept, the LOOP probe
Zero lateral forces:

- Symmetry of the cantilevers in the Y direction → no damage to the fins.
- Cantilevers designed for zero forces in the X direction → no sliding.
Electrical interface and measurement quality

- Mechanical contact to large number of fins
  
  But… no electrical contact without punch through!

- A single fin is "selected" by the punch through process.

$\sim 6 \text{ µm}$

3.5 µm pitch
Measurement validation

Based on a sequence of different configurations

- **Equal**
  - Ra
    - $I^+$  $V^+$  $V^-$  $I^-$

- **Zero**
  - Ra'
    - $V^+$  $I^+$  $I^-$  $V^-$

  - Rb
    - $I^+$  $V^+$  $I^-$  $V^-$

  - Rb'
    - $V^+$  $I^+$  $V^-$  $I^-$

  - Rc
    - $I^+$  $I^-$  $V^+$  $V^-$

  - Rc'
    - $I^+$  $I^-$  $V^+$  $V^-$
Test run 2

59 out of 149 data points are validated
Standard deviations are in a range of 1-3%

Outliers!

Average fin resistance vs. width

$y = 115.72x^{-1.026}$
Summary

Automatic Tool

- Micro 4 Point Probe
- CIPTech-Probe
- Fin-FET Resistance Measurement
Thank You!