DIGITCONCEPT

Microelectronics & HighTech Equipment

Nanoprobing at the 22nm and 16nm nodes

Success Cultivates Success

For Competitive Semiconductor Companies
and Failure Analysis Engineers

MULTI PROBE

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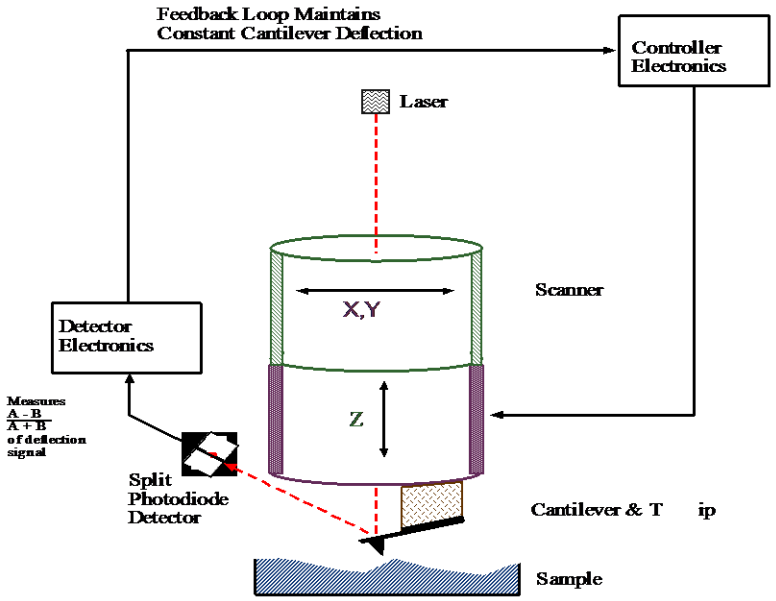
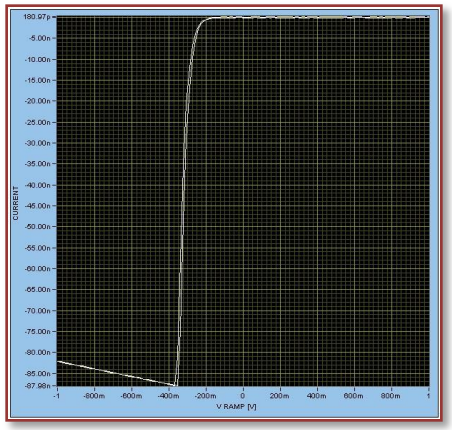
Atomic Force Technology

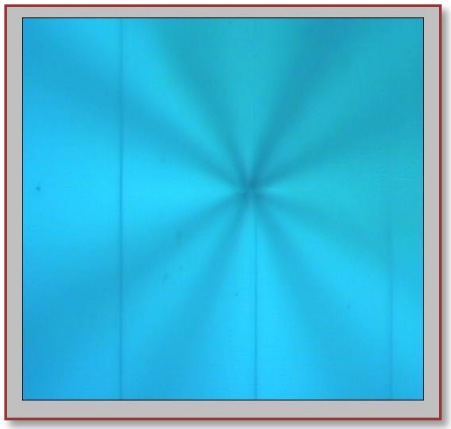
- The AFP characterizes the electrical properties of an individual device using measured topography as an aid to probe placement.
- A constant tip-sample force is maintained throughout the measurement making the AFP non-destructive and easy to use.
- Why an AFM:
  - force feedback
  - non-destructive
  - non-contaminating
  - current imaging (PicoCurrent™)
  - scanning capacitance

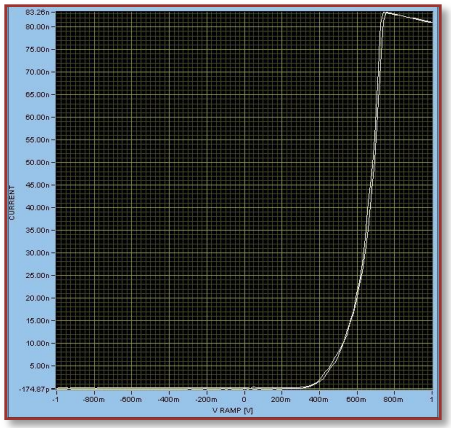


DC Probing

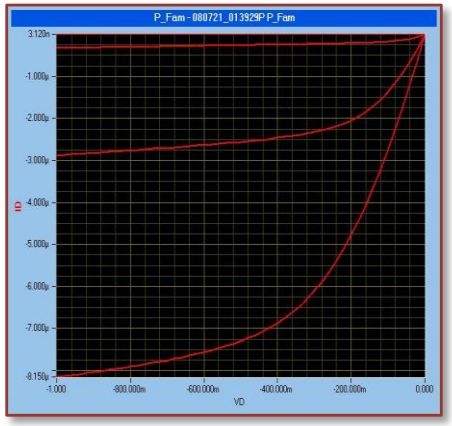


n-contact diode ramp

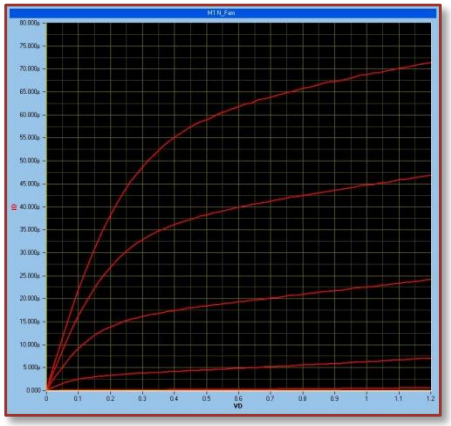




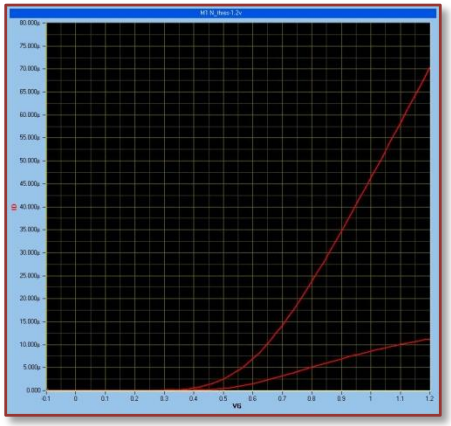
p-contact diode ramp



pull-up transistor



pull-down transistor



threshold voltage characteristics

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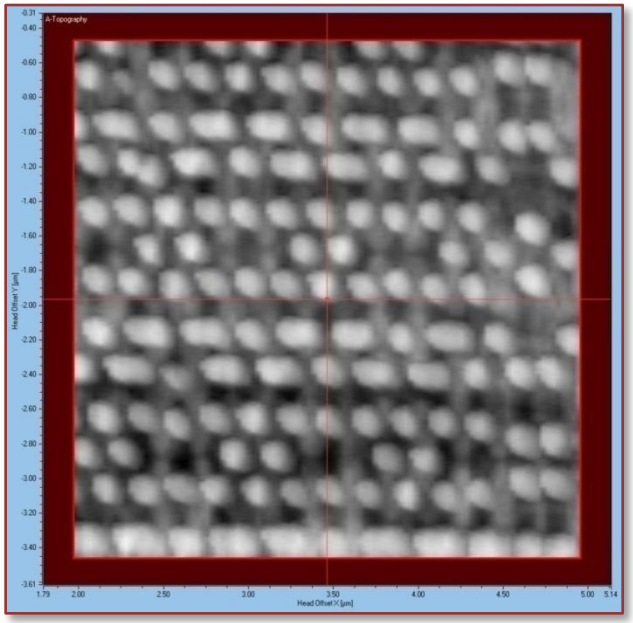
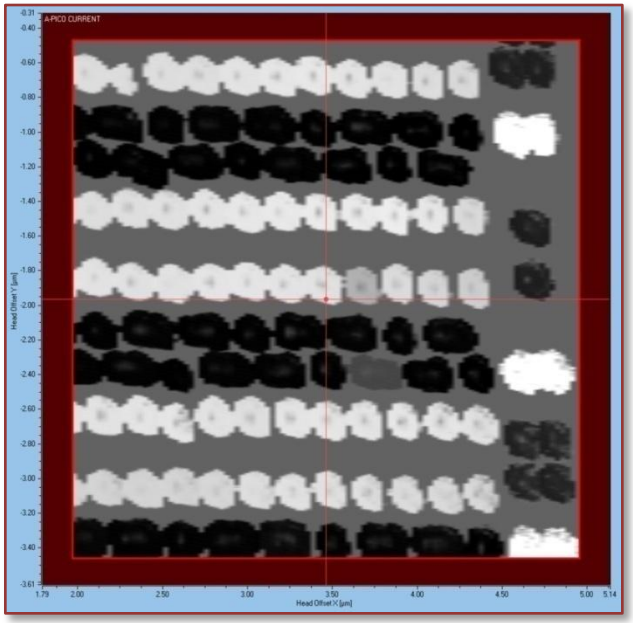
PicoCurrent (Fault localization)

- Find failures without the need to probe



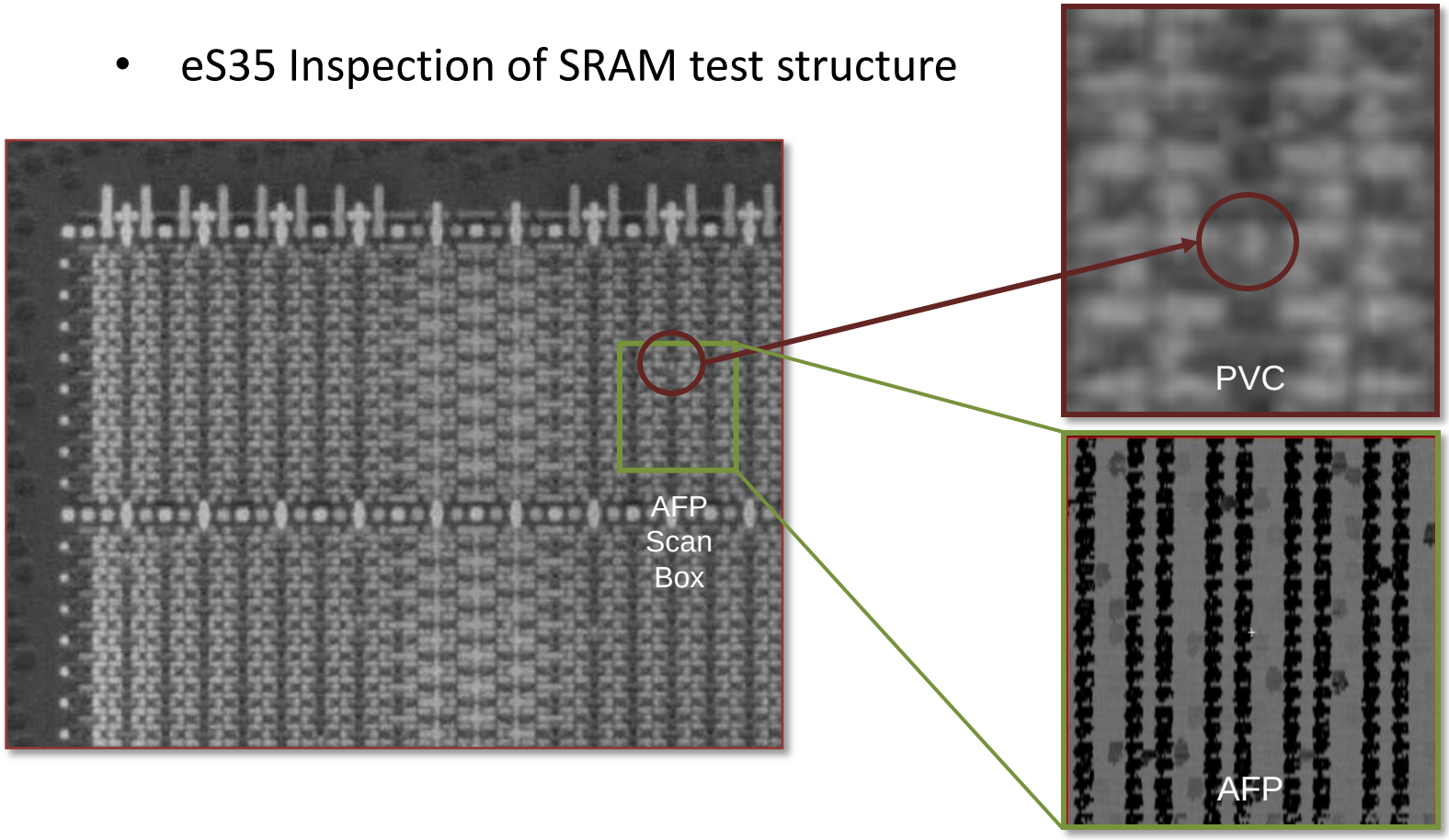
- Topography



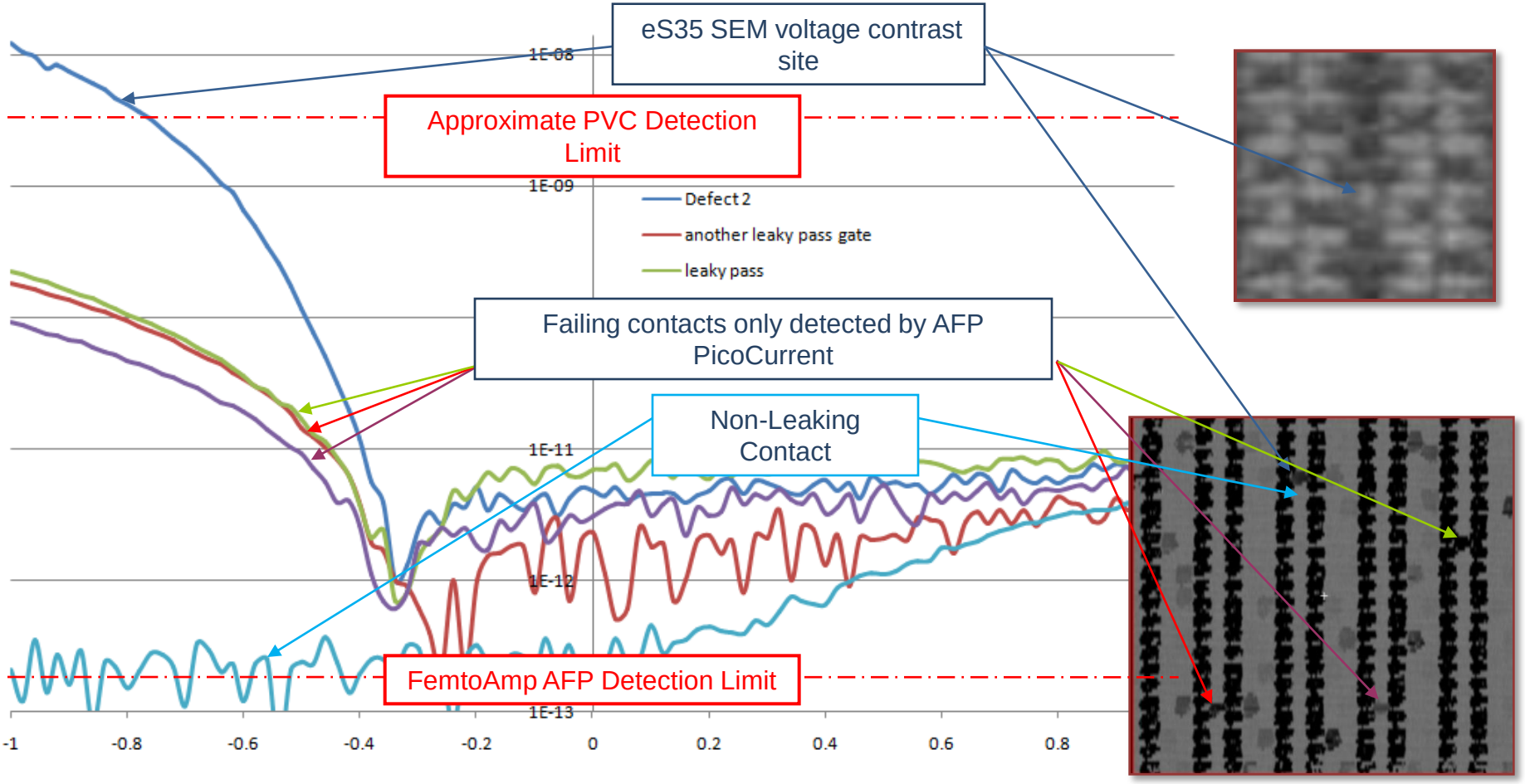
- PicoCurrent

PicoCurrent More Sensitive c.f. PVC

- eS35 Inspection of SRAM test structure



AFP DC Measurements at Contact Post CMP



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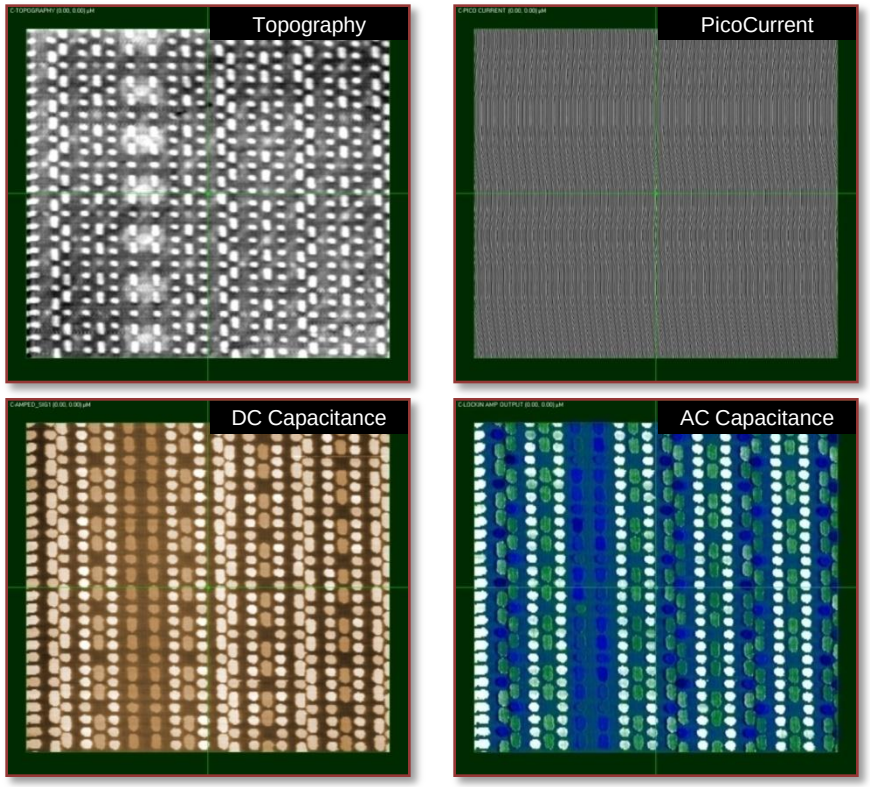
Current Imaging Is Not Applicable To SOI

- The presence of a buried dielectric layer inhibits current flow



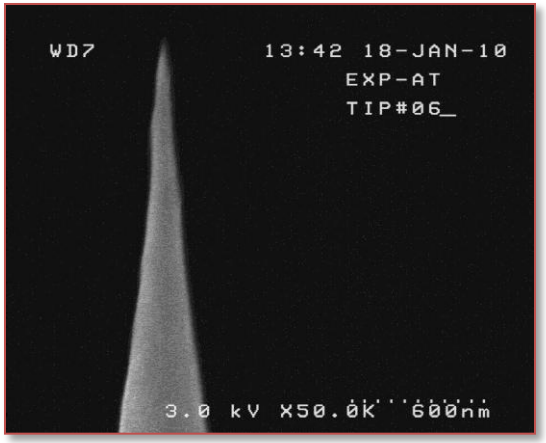
- The lack of PicoCurrent™ data with SOI devices makes localization of soft fails more difficult.
- When used as a contrast mechanism, capacitance data brings back the ability to identify contacts.

- Note the green contact in a sea of blue; a sure indication of a soft fail

Roadmap to 16nm:
High Sensitivity Levers, sharper tips

Mirrored levers have higher sensitivity

- 6mV/nm c.f. 1mV/nm with standard levers
- Better force control
  - Smaller reflected laser spot
    - 3x higher sensitivity
  - Shorter lever
    - 2x higher sensitivity

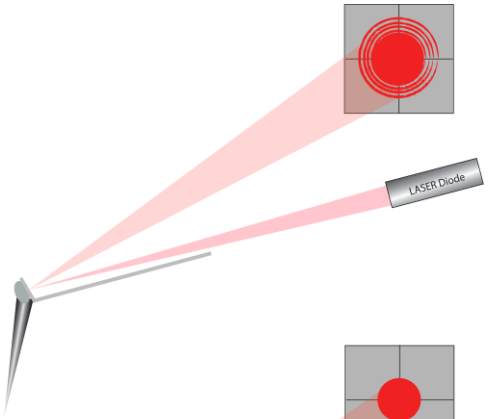


- Sharper than 45nm
- Conductive
- Contamination free

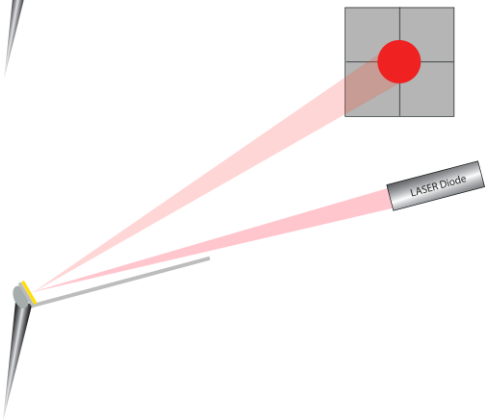
High Sensitivity Levers

Smaller reflected LASER spot at the photo-detector

Standard levers



Mirrored levers



Mirrored levers have:

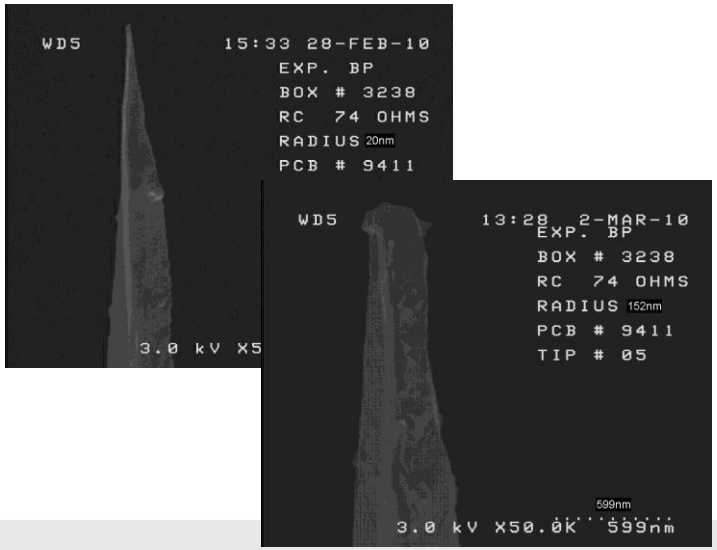
- Lower non-specula reflections
- Lower optical interference
- Higher lever sensitivity

Issues When Using High-Sensitivity Levers

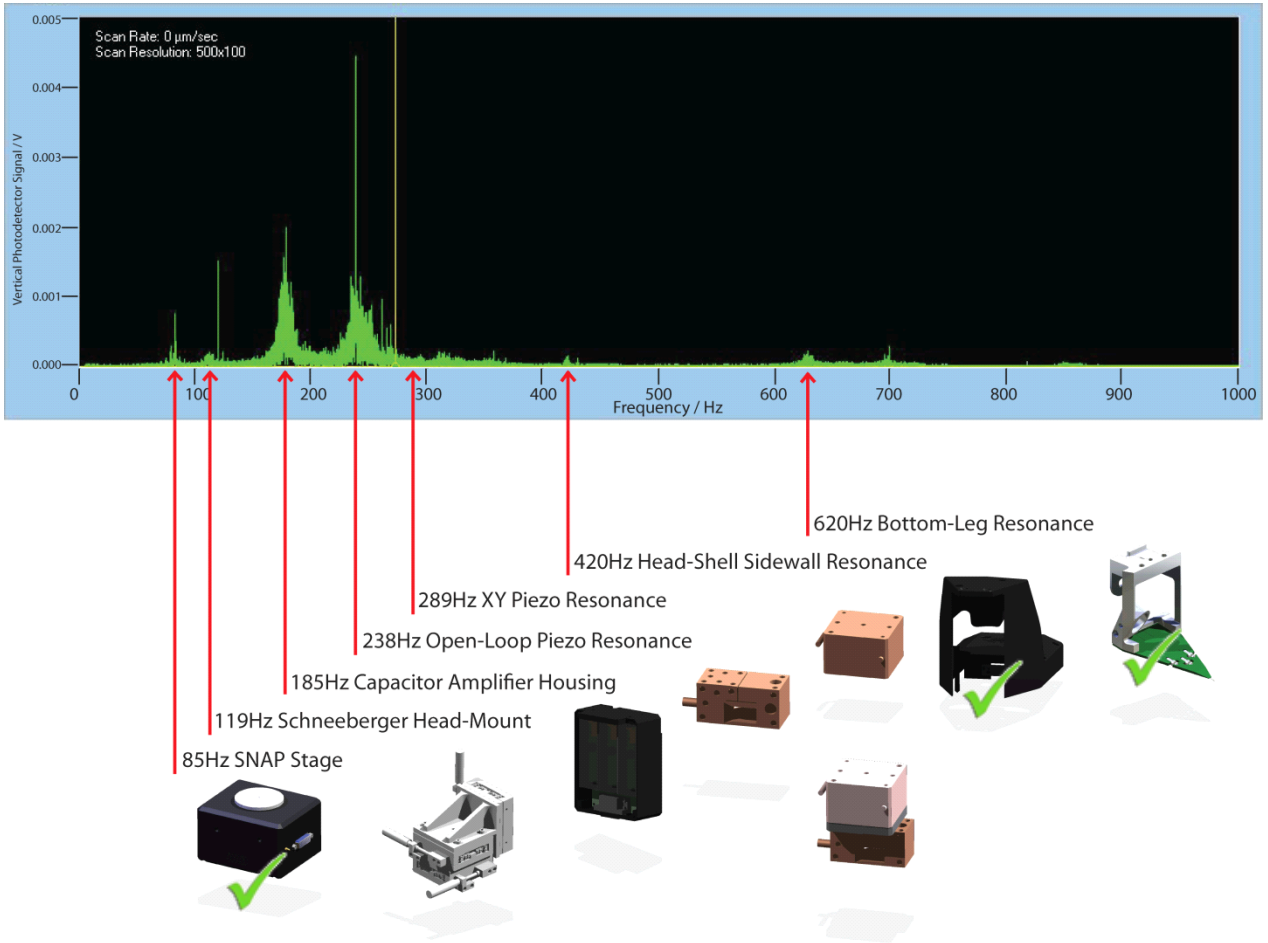
The high-sensitivity levers reveal the limits of the current MPII design

- Observations
  - Cantilever goes into resonance
  - No stable imaging
    - excessive force
    - tip/sample damage
- System Noise Too High

- MPII does not support the feedback bandwidth required for the preservation of “Ultra-Sharp” probes



MPII Noise Spectrum

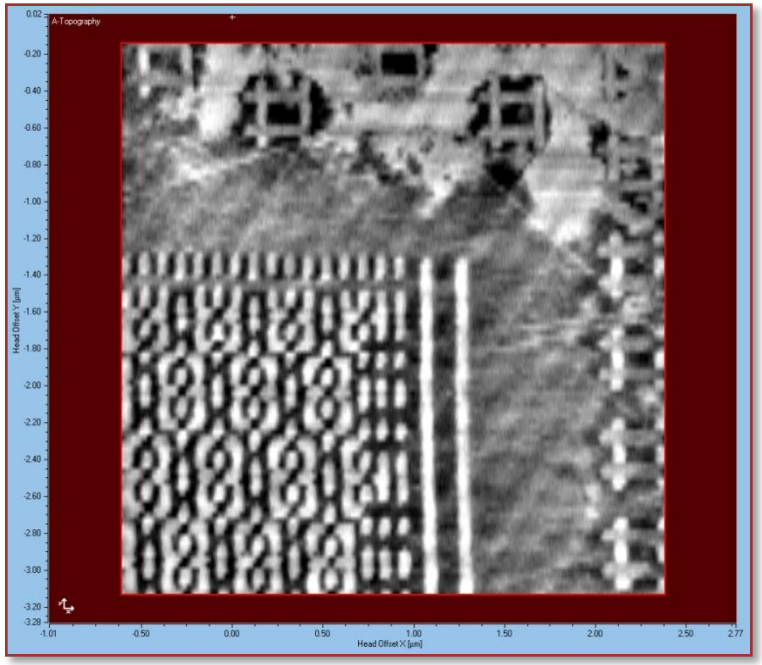


MPII vs. MPIIb

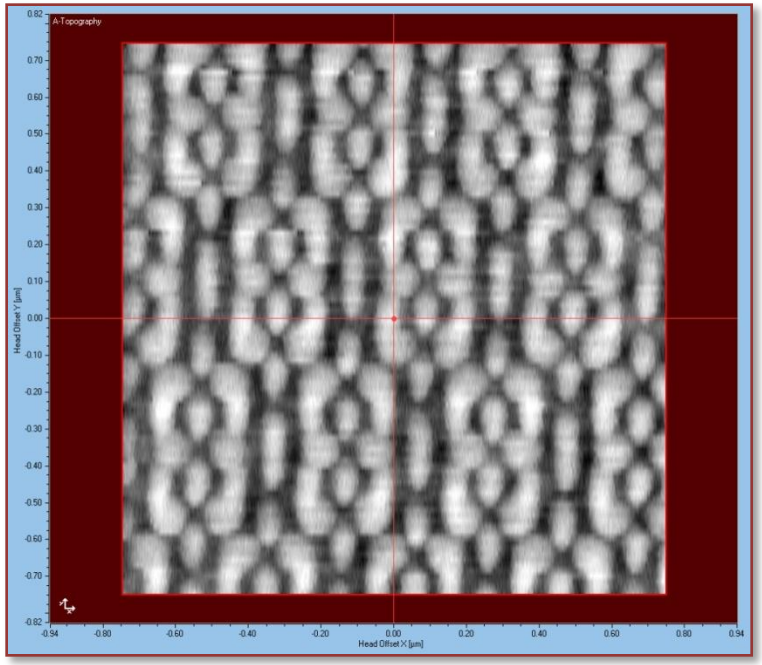
	MPII	MPIIb
Maximum number of heads	6	
XY scan range	24um	
XY positional accuracy	5nm	
Electrical resolution	<1p A	
Imaging modes	Topography, Pico Current, Scanning Capacitance	
Smallest accessible technology node	<32nm	**16nm (22nm demonstrated)**
Topographical resolution (Z)	5nm	**2nm**
Lever Sensitivity (typical)	1mV/nm	**6mV/nm**
Settling time after installing probes (typical)	2hrs	**15min**
Imaging force (typical)	0.24uN	**0.025uN**
Probe life (typical at 32nm node)	25 images + probing	**150 images + probing**
Stability	> 10min IV curve on 32nm	**>10min IV curve on 22nm**
Compatible probe types	AFP-065, AFP-045	**AFP-065, AFP-045, AFP-035M**

22nm Topography

MPII vs. MPIIb



MPII



MPIIb