High-Throughput Atomic Force Microscopy
for semiconductor metrology applications

Roland van Vliet, Hamed Sadeghian

E-mail: roland.vanvliet@nearfieldinstruments.com
Tel. +31-6-20 36 97 41
Next-generation metrology challenges

- Higher resolution and sensitivity in next-node metrology is required
- New types of metrology questions arise

- Industry ‘workhorses’ run into limits
  - Electron Beam metrology
    - Not suitable for electron sensitive materials (resist, SAM, III-V)
    - Sample damage (carbon growth)
    - Very limited 3D information (optimization of FIN/nanowire/DL process window)

- Optical metrology
  - Limited by the diffraction of light (only returns ‘average’ values at nanometer scale)
  - No 3D or sub-surface information (especially in presence of metal layer)
  - Height sensitivity is process dependent

- Alternative/complementary metrology technology required
Atomic Force Microscopy (AFM)

- AFM could fulfill several of next-node metrology requirements
  - Atomic resolution
  - 3D capability
  - Suitable for fragile/sensitive (soft) materials
  - More than only topography measurements:
    - mechanical, electrical, magnetic, thermal, sub-surface

- However, current AFM systems
  - Are very slow (extremely low wafer throughput)
  - Have no true control of probe-sample interaction

**Nearfield Instruments’ mission:**

to enable the application of disruptive semiconductor scaling technologies by providing atom-scale metrology solutions at industry-level throughput

Introducing **High-Throughput Atomic Force Microscopy**
High-Speed AFM

- Standard AFM systems have a measurement bandwidth limited to less than 2 kHz [1]
- At the same image quality, the NI AFM has a bandwidth up to 50 kHz [2] (patented)
- Standard AFM systems, tip approach time can take 60 seconds, killing effective throughput
- The approach time of the NI AFM is less than 6 seconds (patented)

Multiple, Parallel AFM

- Multiple dies per wafer
- Up to 30 sites in parallel
- Independent operation
- True die-to-die comparison
- Simultaneous multiple parameter measurement

Automatic Tip Exchange and Alignment

- Current automated AFMs take around 60 seconds to exchange and align a single tip
  - require additional interfaces to be attached to the chip or z-stage
- NI AFM can automatically exchange and align a probe in less than 6 seconds
  - reliability tests on demonstrator setup show over 10,000 exchanges without failure
- Flexibility in exchanging single probe or multiple probes at once
  - no time impact, compatible with every available tip/chip, no modification to tip/chip required
Proof-of-Concept realized

Parallel AFM 4-arm demonstrator

- Wafer stage
- Parallel positioning arms

Positioning unit

- Mini AFM
- Positioning arm
- Probe exchange unit
- High-speed mini-AFM
PoC Measurement Examples

nm size contact holes

Position (nm)

Height (nm)

Tip shape

EUV mask, 5x5µm, 20 Hz

EUV mask, 5x5µm, 60 Hz

Alignment marker in

±50 nm thick EUV resist layer

Measured steps, 1.5 nm
Defect metrology for SAM: missing molecules

Defect metrology

Defect density

Number of defects

Size distribution of defects
Sub-surface imaging mode
Nearfield Instruments

• Nearfield Instruments has developed **Multiple Parallel Atomic Force Microscopy**
  • Total AFM throughput increase: up to 1000x compared to standard AFM systems
  • Independent, multiple parallel AFM scan head architecture
    • Compatible with all single AFM measurements done today with in lab or near fab
    • Enables many simultaneous and varied measurements across wafer, e.g. true die-to-die comparison
    • Complement near-fab (R&D) and in-fab metrology toolset
  • Comprehensive patent portfolio

• Nearfield Instruments is currently
  • Working together with potential customers (top-tier IDMs and IMEC) on application development
  • Establishing manufacturing supply chain (outsourced production, calibration/quality check @ NI)
  • Raising EUR 10 million in equity to finance alpha-tool development (launch Q1/2018)
Get closer.

Visit us at booth #S16 (North Hall)
Or contact us at
roland.vanvliet@nearfieldinstruments.com
+31-6-20369741