IN-LINE 3D AFM FOR CRITICAL DIMENSION AND SIDEWALL ROUGHNESS OF SI PHOTONIC WAVEGUIDE AND CORRELATION WITH ITS PROPAGATION LOSS

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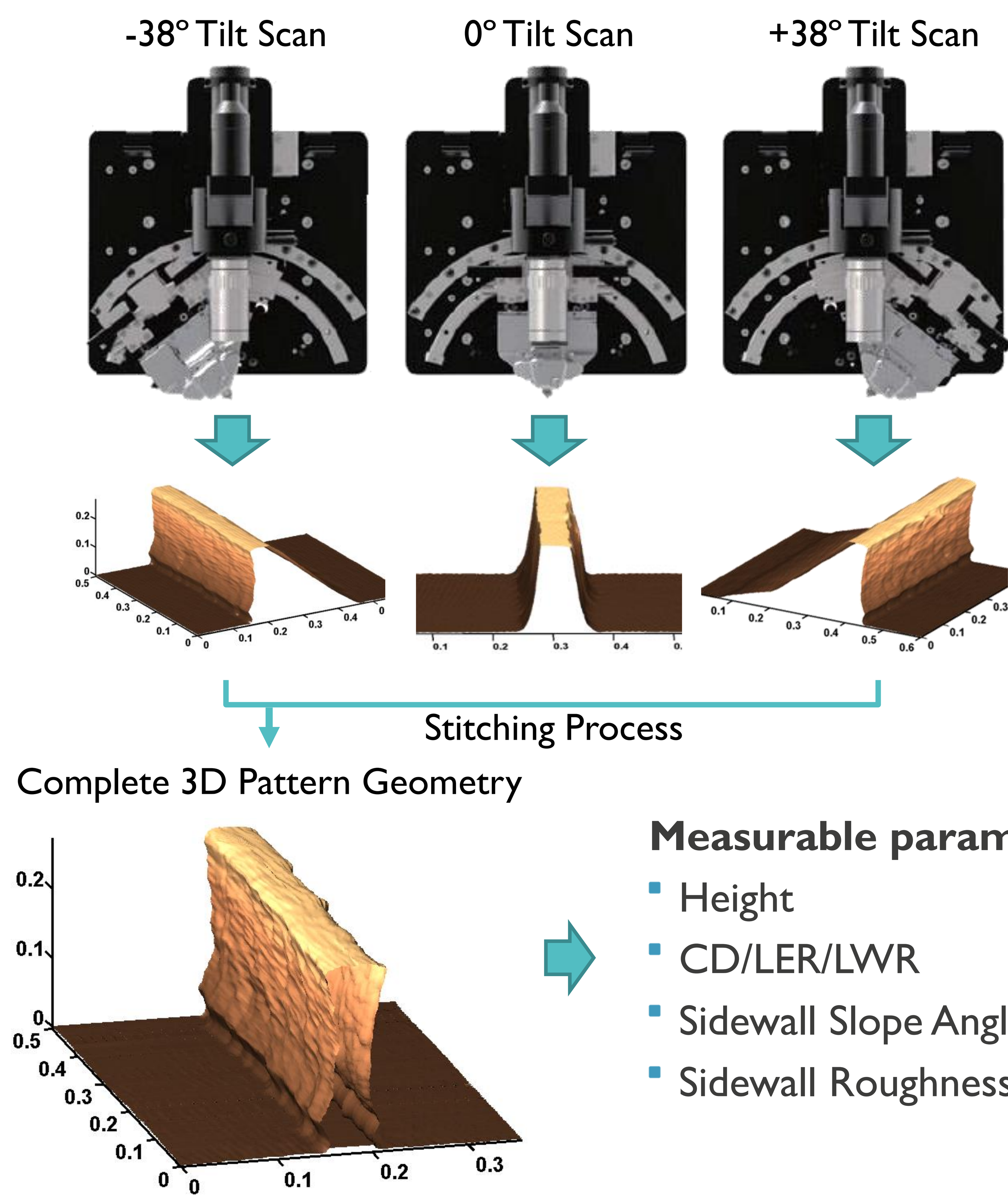
imec

Park SYSTEMS

3D AFM Measurement Methodology

- Decoupled XY and Z scanner allows to tilt Z scanner head by ±19° and ± 38°
- Tilt Z scanner head allows probe to access waveguide sidewall
- Completed 3D geometry could be constructed by measuring 3 sides, top, left and right and stitching them together
  - Single sidewall could be characterized as well by single tilt scan



Measurable parameters

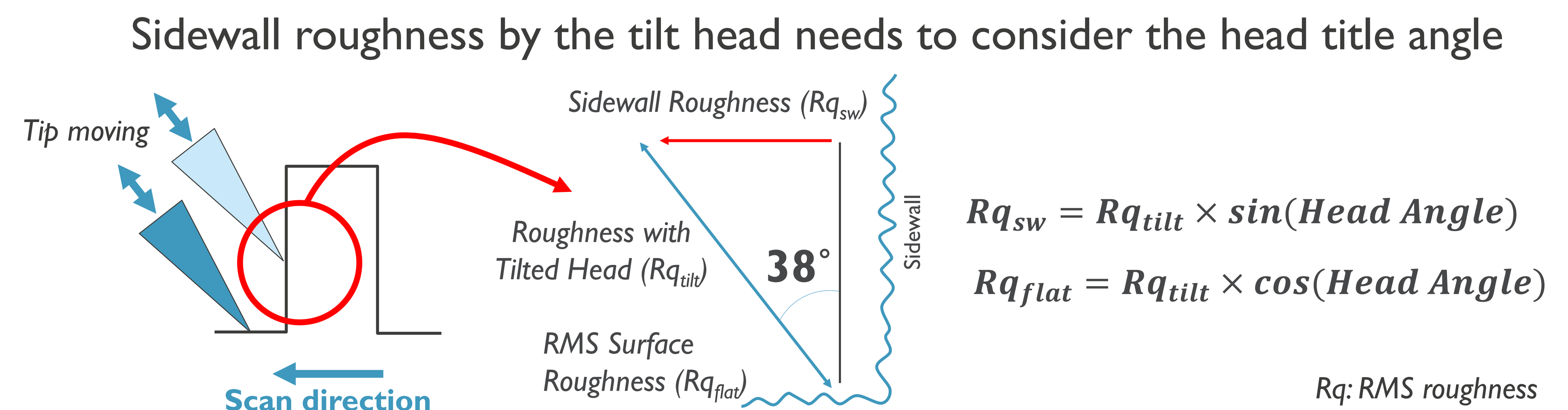
- Height
- CD/LER/LWR
- Sidewall Slope Angle
- Sidewall Roughness

In-line 3D AFM at imec

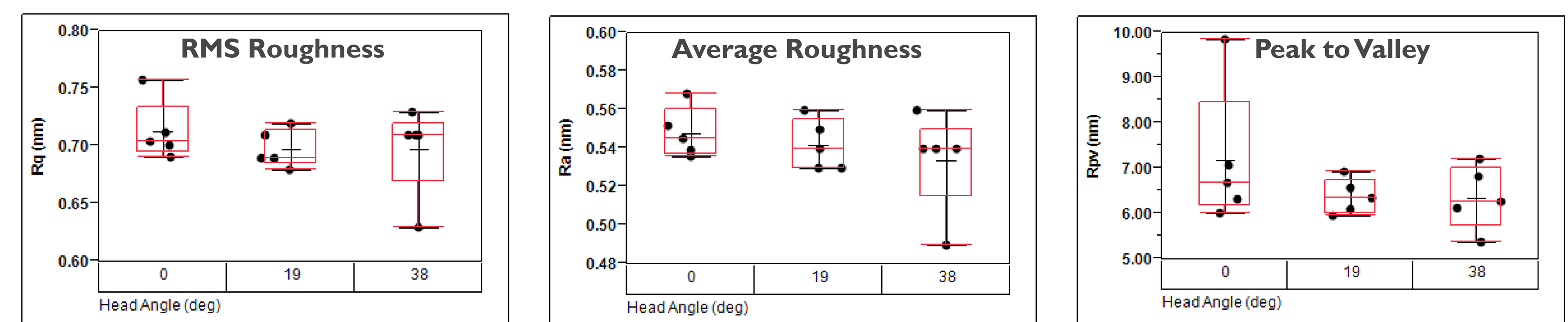
- Tool: NX3DM, Park Systems
- 24/7 operational at 300 mm P-line
- Fully automated for 300 mm wafer
- Scanning System
  - True non-contact measurement
    - Minimum probe-sample damage
    - Long tip lifetime and good reliability
- Scanner Specification
  - XY scan area: 100 x 100 μm²
- Fully automated tool
  - Automatic Tip Exchanger
  - Fab Automation (SECS/GEM)

Sidewall Roughness Characterization

Sidewall roughness by the tilt head needs to consider the head title angle

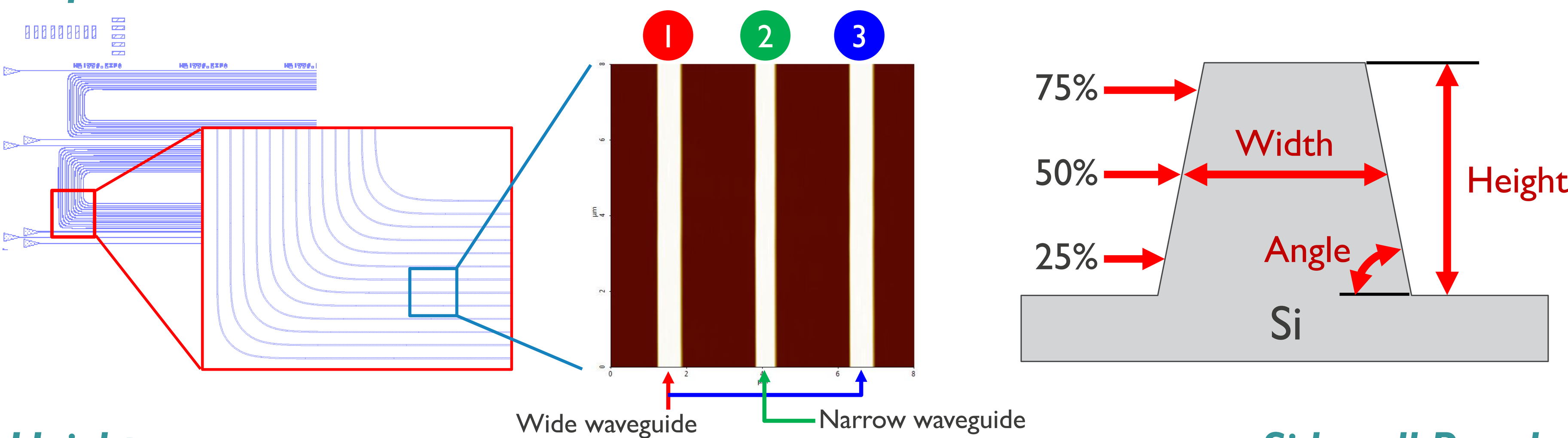


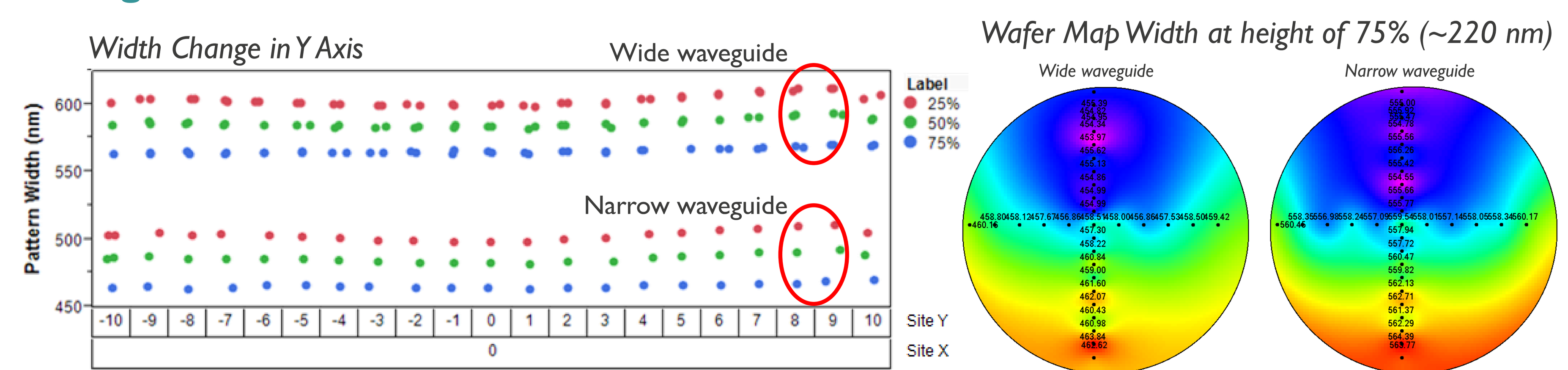
Evaluation of roughness, measured at the head angle of 0, 19 and 38° on *Flat Surface*

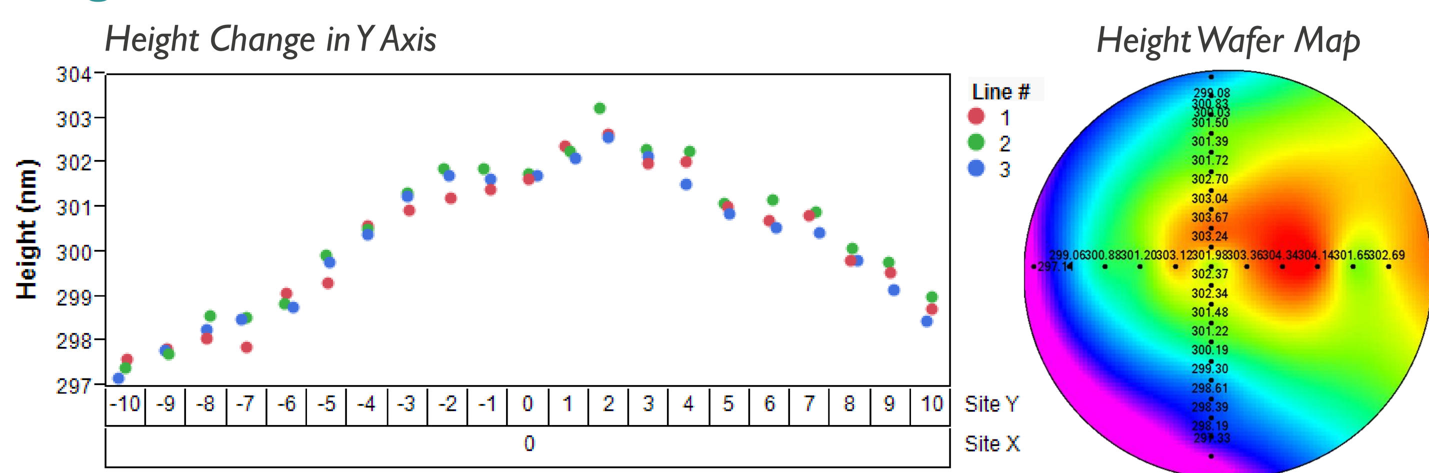


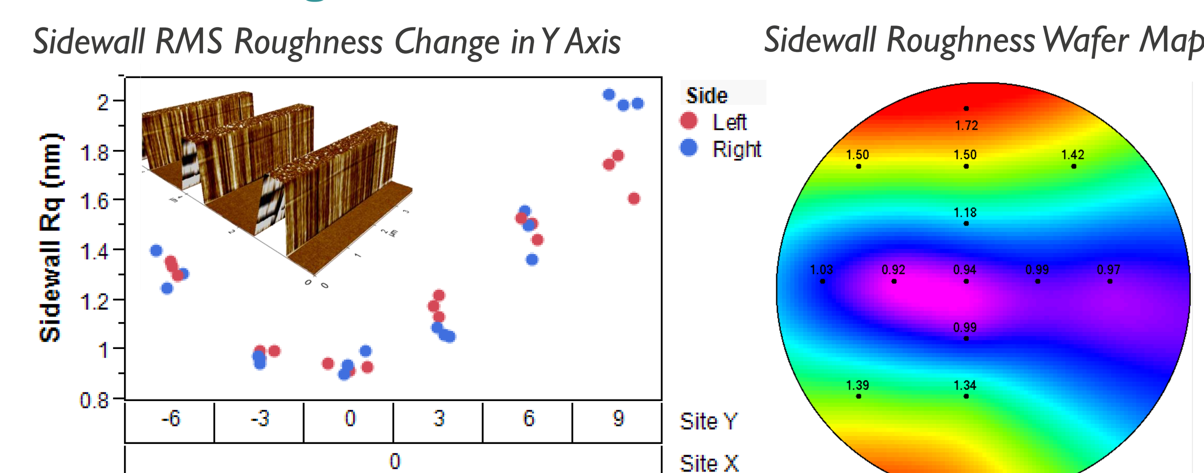
Tilted measurements show a good agreement with roughness value at 0°.

Waveguide 3D Geometry and its Sidewall Roughness

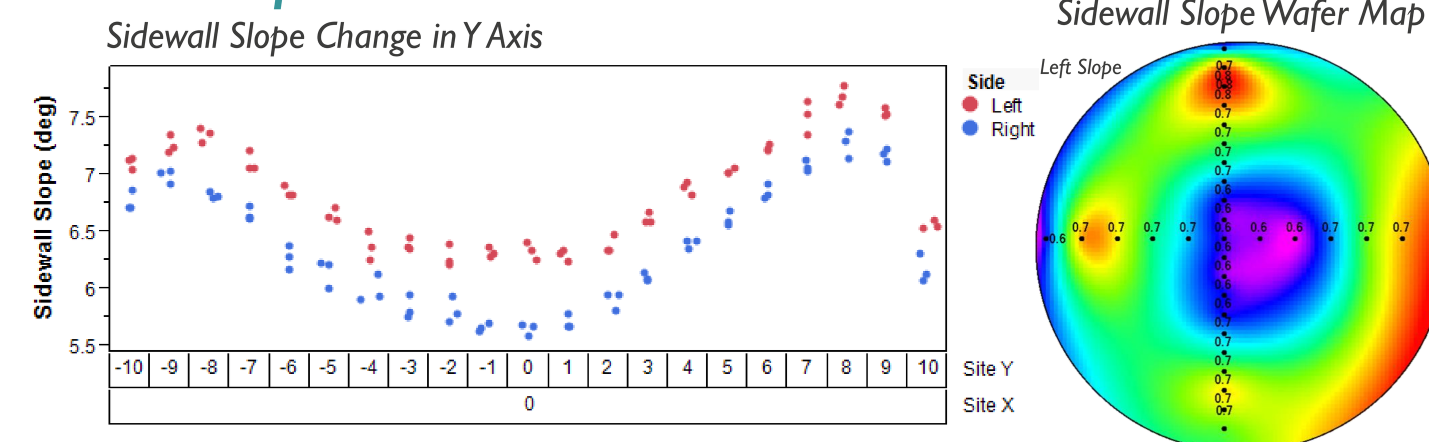


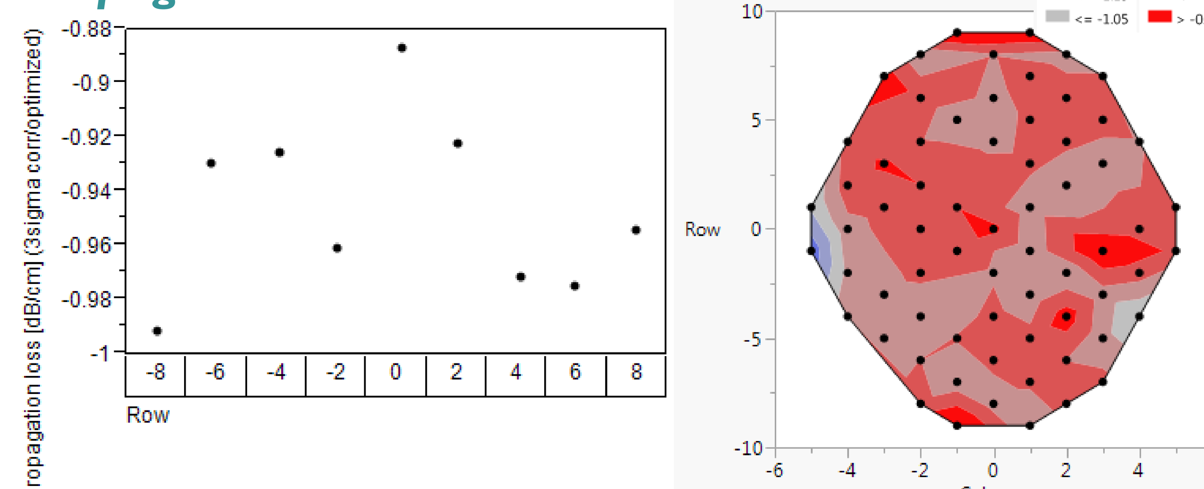






- Width of narrow and wide Si waveguide were captured accurately
- No significant change of waveguide width in Y axis was observed
- The height of Si waveguide at the center is higher than at the edge
- Clear sidewall slope change at different location was observed
- The sidewall slop offset between left and right sides might be caused the offset of tilt angle of head, which could be minimized by calibration of tilt head angle
- Similar sidewall RMS roughnesses were measured on both left and right
- The sidewall slop offset does not impact on sidewall roughness value and the offset can be neglected
- Waveguide with rough sidewall shows propagation loss increase
- Larger waveguide shows lower impact on roughness and lower propagation loss characteristics





In-line 3D AFM** could accurately measure 3D geometry of Si waveguide as well as its **sidewall roughness.

Not only sidewall roughness characteristic but also its dimension could correlate with propagation loss of their waveguide