COVALENT METROLOGY

COVALENT ACADEMY Q&A

Episode 4: Stylus Profilometry / Atomic Force Microscopy (AFM) Techniques for High Resolution Surface Metrology and Imaging

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01

Q: In the data set for the attractive and repulsive measurements of the soft layer on Si do the other normal roughness parameters change as well and can briefly explain the changes

A: Yes. For instance, the peak-to-valley roughness (Sz) in attractive mode is almost twice the Sz in repulsive mode. In the case of repulsive mode, it is likely the tip is not tracking the true topography of the surface, but rather is poking through. Depending on the layer thickness, it could also be sensing the silicon substrate underneath.

02

Q: If lateral resolution is important why would I not always choose a sharp tip. What is the disadvantages of using a sharp tip.

A: The disadvantage of using a sharp tip is that they are more fragile. The tip easily can break or wear, even after one scan. This is not ideal if you need to scan for long periods of time.

03

Q: If I measured a hard material with tips with different k values but the same tip size would I see the same number and if not why not.

A: When you are imaging a hard surface with cantilevers of different spring constants (k) if not careful you may apply more force with the higher k cantilever. Too much tip-sample force can lead to tip wear, which could affect the surface roughness parameters. Although cantilevers have a nominal spring constant reported on the box, it is important to calibrate the spring constant so you know how much force you

COVALENT METROLOGY

are applying. This can be done by monitoring the deflection as a function of z piezo position. On a hard surface (diamond or sapphire), both will show a linear slope that allows you to calculate the true spring constant. Once the spring constant is known, you can determine the tip-sample force. A thermal tune can also be used to calculate the spring constant. This assume the tip is a simple harmonic oscillator. The spring constant is derived from equipartition theorem: 1/2 K b T = 1/2 kz 2 where z is the deflection, k is the spring constant, K b is Boltzmann's constant, and T is temperature.

04

Q: How often are R values used in AFM roughness as opposed to S values and what is recommended.

A: R values (line roughness) is not often used as opposed to S values (surface roughness). However, artifacts such as intermittent surface tracking from line to line can lead to differences between R values along the fast scan direction (x) and the slow scan direction (y). Therefore, we typically report Rq long the x and y in addition to the S values. Often, they show agreement.

05

Q: May systems that line scan show different artifacts line to line as opposed to along a line. Does AFM have problems like this and can it cause different R value roughness in the vertical and horizontal.

A: This is similar to question 4. Yes, poor tracking, or mismatch from line to line can lead to different roughness along the slow scan direction than the fast scan direction.

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