COVALENT ACADEMY Q&A

Episode 20: Energizing Research in Battery Performance with Advanced AFM

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Q: How fast a state-of-the-art AFM can go for in situ imaging?

A: The answer to this question has a little bit of nuance that I think is interesting to share. The short answer is that we can scan up to 10+ images per second (aka 10+ frames/s) with our Cypher VRS. The nuance comes from the fact that the real speed limit is in the number of data points (pixels) per second that can be acquired, so you can scan slower or faster depending on the pixel resolution of the image you're acquiring. What this ultimately means is that you can observe phenomena (e.g. DNA cleavage, collagen self assembly, etc) that transpire on the <1 second time scale! Of course, not everything needs to be imaged at maximum speed, so I typically go a little slower for some electrochemical phenomena, more like 0.3 frames/s. Still blazing fast!

02 Q: Are there specific sample and probe tip requirements that must be met in order to achieve sub-nm resolution?

A: Most commercial probes can achieve sub-nm resolution, as long as the tip is sharp. One key experimental parameter for ensuring sub-nm resolution is to use small drive amplitudes (meaning < 2 nm of actual motion in space) because this minimizes the amount of force that the tip can experience, and that serves to protect the sharpness of the tip. For sub-nm resolution, I like to use probes that have a high bandwidth, such as the FS-1500 from Asylum, because these can image really fast and are compatible with blueDrive, which makes stable atomic resolution imaging possible. Beyond that, sample preparation is always critical: you want the sample to be as freshly prepared as possible and free of grit and contaminants (and even particles and aromatic compounds in the air can contribute to that contamination over time!)

03 Q: Can sub-nm resolution be achieved on any sample?

A: Typically very rough samples make it hard to achieve sub-nm resolution because the tip will experience a lot of dramatic forces and become dull, so the flatter or more-polished you can get a sample before measuring, the better. Additionally, if it is possible to solvent clean, UV clean or plasma clean your sample to remove grit and contaminants, this will help with achieving high resolution as well. One strategy for high resolution is to start scanning at really small scan sizes first (rather than doing a large survey scan first) because this will minimize intense tip-sample interactions.

04 Q: How do you compensate the drift in the sample scanner?

A: We have built in drift compensation that will calculate a frame-to-frame offest to correct for drift (it's a checkbox in the parms tab of the Master Panel), but I very rarely use drift compensation while scanning for a couple of reasons. First, the stability from the small mechanicla loop in our Cypher and Jupiter scanners is very high, so it is rarely needed in my experience because thermal equilibration occurs quickly. Second, at these very small scan sizes, we can scan at very fast line rates, which allows you to overcome any drift by simply beating the speed of the drift with the speed of the scan.

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Q: Do these experiments require running the scanner for a couple of hours before the actual data collection? In particular, I'm concerned that drift can be more significant for small area scans.

A: Not at all! I'm usually able to see atoms on the first scan of, say, gypsum or calcite. If you really need to compensate for thermal fluctuations (which is usually the mechanism causing drift), using something like an automatic temperature controller (ATC) can help control the temperature to a set value and mitigate drift.

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