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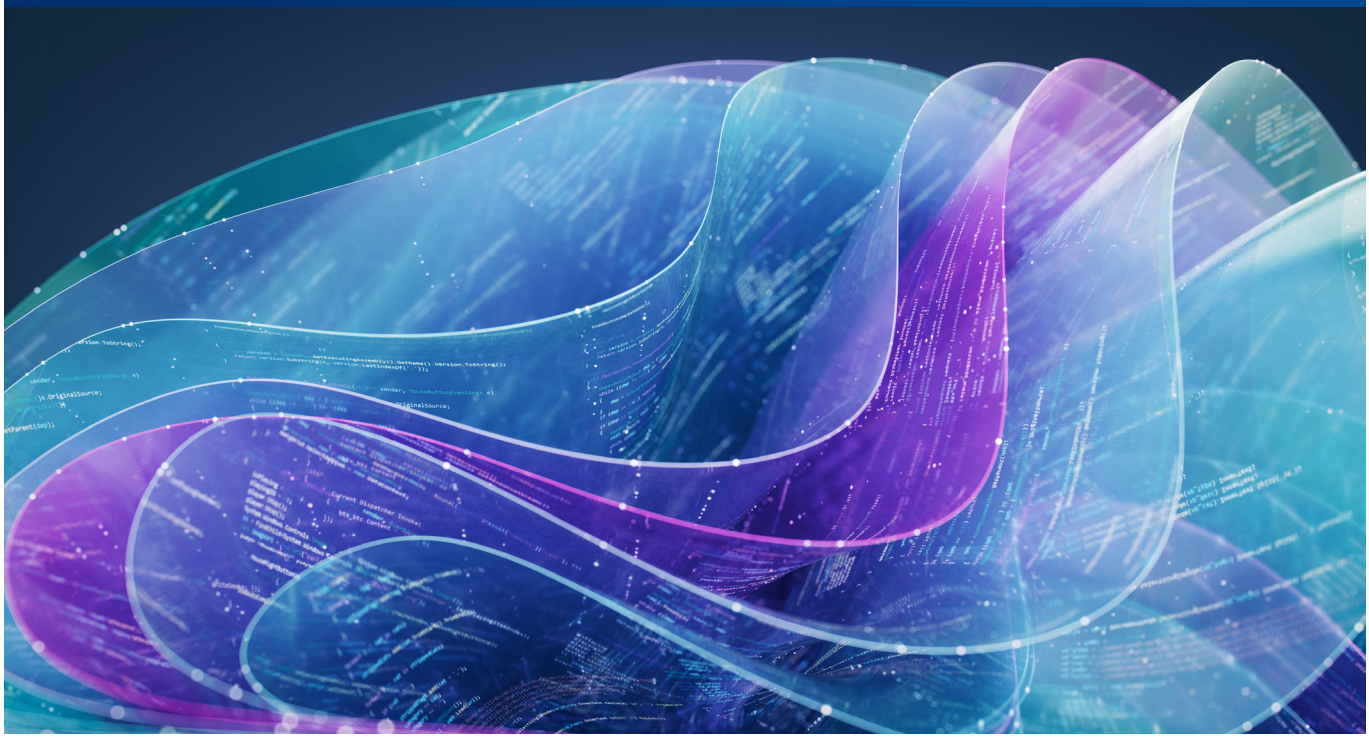
Innovation meets precision: How ConnectomX are redefining life sciences slice by slice

ConnectomX Limited produces the katana microtome™, a literal 'cutting edge' technology, which uses a diamond knife edge to make nanometre-scale cuts through samples such as plants and batteries, allowing researchers to study complex materials at different depths. A smoother cut means more accurate measurement data for each slice, and thinner slices means higher resolution 3D information about the sample. So it is critical that the knife cuts through the material cleanly and precisely.

Once the nanoscale slices are cut, samples can be measured using a scanning electron microscope (SEM) to build a three-dimensional picture of their structure. This approach – known as serial block-face imaging – has been used to study wide-ranging biological processes, the neural pathways of the brain, and how seeds respond to treatments that help them grow. Increasingly, it is used to study materials like batteries with complex layers and chemistries.

A handful of companies make microtomes, but most are bulky instruments designed for specific SEMs. A katana microtome™ is unique in that it is a small, standalone device that can work with nearly any SEM, making laboratory setups simpler and quicker.



Challenge

To slice a sample, a piezoelectric actuator moves the diamond blade in a sawing motion. This can be tuned to different frequencies, which determine the speed of the sawing motion. To ensure their product was the best it could possibly be, ConnectomX wanted to understand the optimal frequencies for creating the smoothest possible cut, but they lacked the tools and knowledge to study this themselves.

Solution

Working with NPL through the A4I programme, ConnectomX was able to access advanced measurement tools, and associated expertise, to answer their questions.

In the first stage, NPL used a Scanning Doppler Vibrometer, which used a laser beam to precisely measure vibrations and oscillations of the microtome's knife.

The data was provided to ConnectomX for processing.

"We were looking for the optimal ratio of the in-plane to out-of-plane vibration," says Joe Durk, Applications and Product Specialist at ConnectomX. "In other words, we wanted sufficiently intense horizontal sawing movements through the sample, with minimal up-and-down vibration of the blade. We believed that was the sweet spot where we'd get the perfect slice".

The data revealed a handful of 'sweet spot' frequencies which optimised that ratio. That pointed the way, but further experimental work was needed to confirm this.

The katana microtome™ was put to work in NPL's state-of-the-art SEM, where it cut multiple slices at a variety of frequencies, both those identified as promising and others to provide control measurements. NPL designed an innovative measurement approach where they cut markers into the sample with a focused ion beam and measured their position during the cutting process. The hypothesised frequencies – good and bad – behaved as expected, with those identified as promising giving the cleanest cut.

Impact

The project led to significant improvement in the katana microtome™, which has been hugely valuable to ConnectomX's customers, who are researchers in areas such as neurology and material sciences, where precision is paramount.

The first step in delivering this benefit was to provide existing customers with optimal frequencies to tune their instruments. The next was to update the default software settings and pushing those software updates to customers' microtomes so that they automatically set the optimal frequency. The next stage will be to utilise an embedded sensor which can detect oscillations and make changes to optimise the cut on the fly.

"The improvements to our katana microtome™ from the A4I project are attracting attention from customers who need to conduct precise studies of biological materials," says Durk. "We recently presented the results at the From 3D Light to 3D Electron Microscopy Conference in Ghent and got a lot of interest. It's too early to put numbers on it, but based on conversations so far, we are confident it will lead to more sales and a higher market share in the coming year and beyond. This is a small and specialist market, so anything that can help us sell just a few more units is a huge deal to our business."

"What's more, the data from the A4I project is allowing us to show not just improved performance of our technology, but also that the ability to tune the cutting frequency – a key selling point of our instrument over our competitors – can make a real difference to the quality of the surface cut," says Durk. "There is not a lot of published work on slice thickness accuracy" he adds, "but it's something customers tell us they want to know more about, so this work will augment the global body of knowledge on an important, but poorly understood process in the study of biological samples."

The improvements to the katana microtome™ enabled by NPL expertise bring benefits to researchers studying important fields, from treating neurological disease to improving battery chemistry, allowing them to obtain higher quality data, at speed, and with confidence.

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