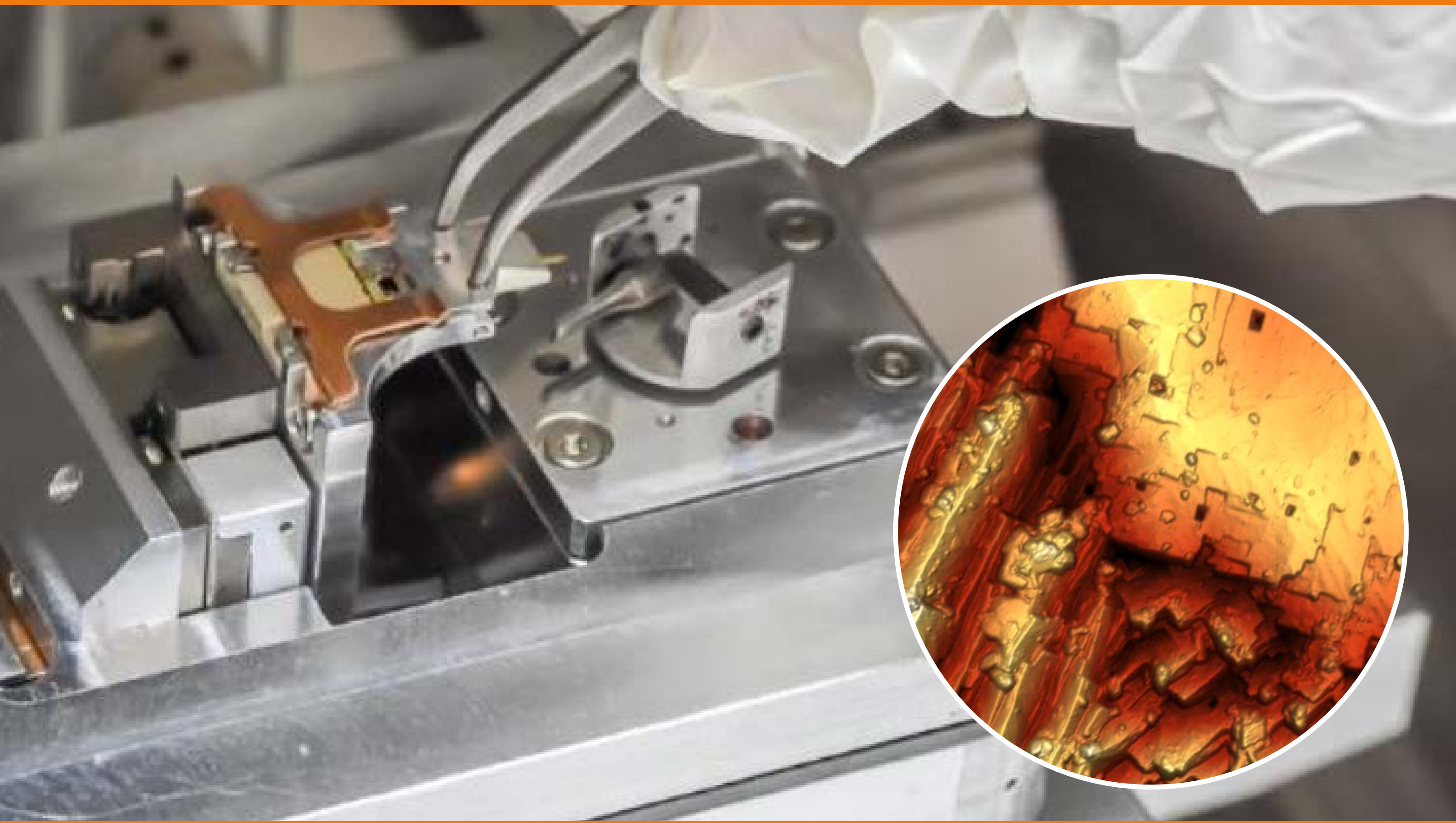
European Metrology Research Programme
Delivering Impact

EURAMET



Nanoscale surface mapping

Manufacturers of nano-materials, such as those used in semiconductors and solar cells, need accurate tools for quality control. Knowing precisely where on a sample's surface measurements are being made and having confidence in the results achieved are key to reliably characterising material properties. Atomic force microscopy has great potential for use in material science, but problems associated with extended measurement run times and instrument drift need to be overcome.

Europe's National Measurement Institutes working together

The European Metrology Research Programme (EMRP) brings together National Measurement Institutes in 23 countries to address key measurement challenges at a European level. It supports collaborative research to ensure that measurement science meets the future needs of industry and wider society.

Challenge

Advanced manufacturers of nanotechnologies, semiconductors and solar cells are increasingly innovating with multifunctional materials and this requires the accurate characterisation of very small features. Atomic Force Microscopy (AFM) allows very precise sub-nanometre measurements of surface features and could in the future provide manufacturers with the highest accuracy levels for production process quality assurance (QA).

AFM probe tips scan the surface of materials measuring atomic scale interactions and this information can be used to construct 3D images of surface features, as well as for characterising the materials electrical properties. Current AFM topography scans creating maps of surface features are time consuming. Taking large numbers of measurements at regular intervals across a material's surface generates huge amounts of data for processing and the length of time needed creates problems. AFM tips experience wear and slight operating temperature changes can lead to minor drifts over time, both of which compromise measurement accuracy. Overcoming these accuracy limitations is essential to enable greater uptake of AFM as a quality assessment tool.

Solution

The EMRP project, *Metrology for movement and positioning in six degrees of freedom*, developed a new adaptive scanning approach for AFM measurements, allowing users to concentrate measurements on areas of interest, and reducing the number of data points accumulated over a measurement scan. This helps minimise tip wear and speeds scans so reducing the likelihood of temperature drift. The project also investigated factors affecting AFM performance and developed an improved statistical model for determining measurement uncertainties and minimising measurement errors. This knowledge has been incorporated into freely available software (Gwyddion), which enables AFM users to preselect the instrument's measurement pattern removing reliance on conventional equi-spaced data points. The new software, backed by an open data library of test parameters provides optimised AFM scanning, reducing tip wear and measurement time.

Impact

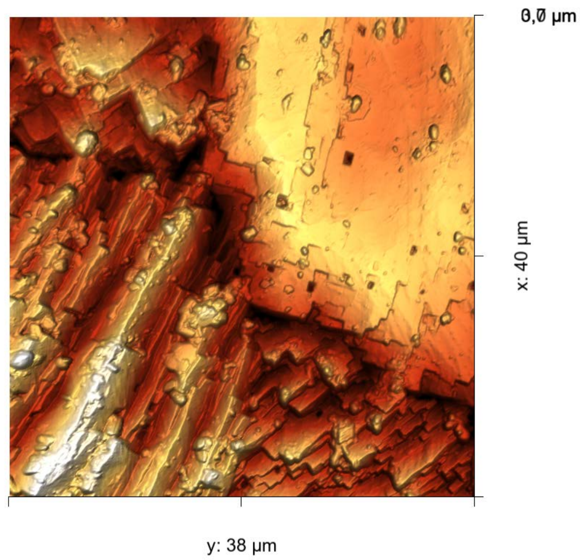
NenoVision s.r.o, a Brno University of Technology spinout, markets the Litescope, an AFM accessory for scanning electron microscopes aimed at researchers in the materials science, nanotechnology, semiconductor and solar cell markets worldwide. The Litescope extends the capabilities of electron microscopy machines used for surface imaging to the analysis of a material's mechanical, electrical and magnetic properties. NenoVision were one of the first to incorporate the project's AFM software into its product. Using the free release software saved them the time, money and risk of developing a similar software themselves.

For routine industrial measurements, such as in quality assurance, it is not necessary to measure entire surfaces, just specific features. The Litescope, with project software, now brings adaptive AFM scanning to the market, reducing the number of measurements and time needed to analyse samples. This speeds processing time whilst mitigating the problems of AFM tip wear and drift.

More flexibility and faster scans allow AFM measurements to be applied to a wider range of nanoscale research applications, and opens its use for more routine manufacturing measurements such as QA. This could save time and money in R&D and create a highly accurate measurement tool for innovative nanoscale technologies, improving product quality and reducing waste.

Accurate positioning in three dimensions

The EMRP project *Metrology for movement and positioning in six degrees of freedom*, has increased the accuracy for determining machine tool and positioning stage micro-movements and developed ways to increase the usability of rapid and extensive scanning probe microscopy measurements. The project developed a mobile, easy to use measurement system for characterising the motion of precision machine tools, and strategies to decrease the effects of tip wear and instrument drift during extended or rapid scanning of surface features using atomic force microscopy. Traceable nanometre measurements of position, angle and straightness, are essential in many industries and research fields, for example the precise positioning stages used in semiconductor manufacture or for manipulating samples during analysis using electron microscopy.



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Jens Flügge

PTB, Germany
+49 531 592 5200 | jens.fluegge@ptb.de

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