

# NANOscientific

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The Magazine for Nanotechnology

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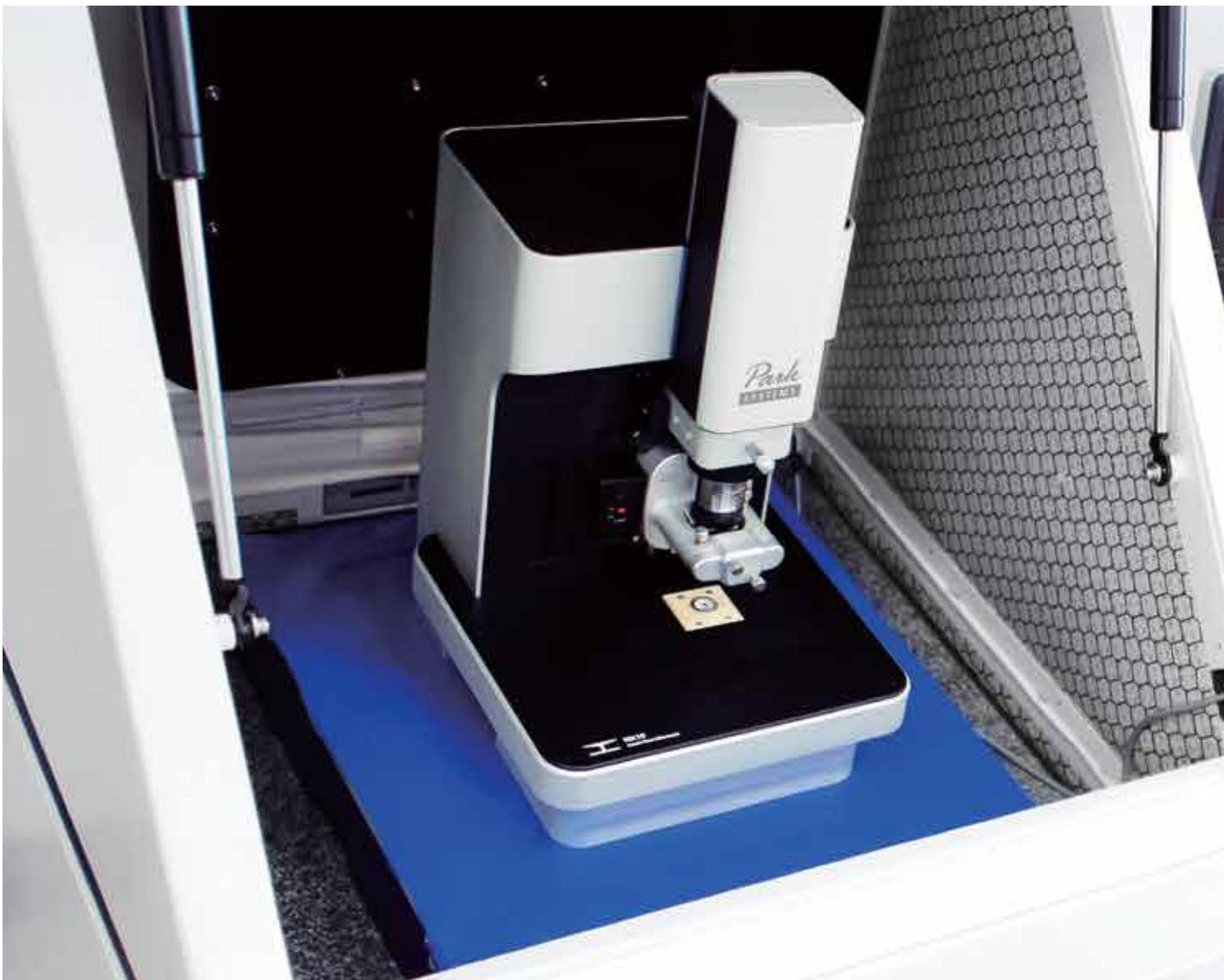
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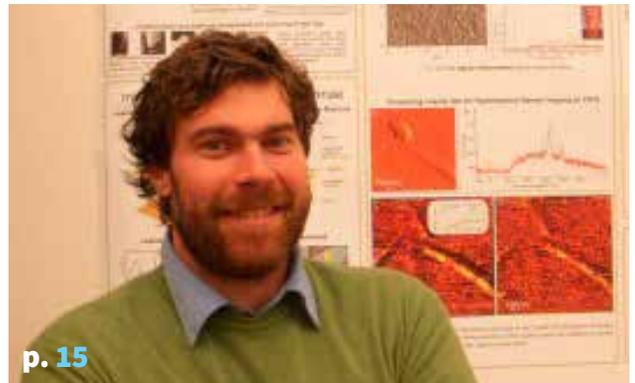
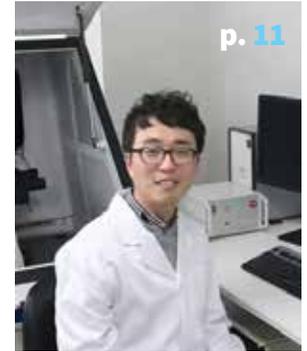
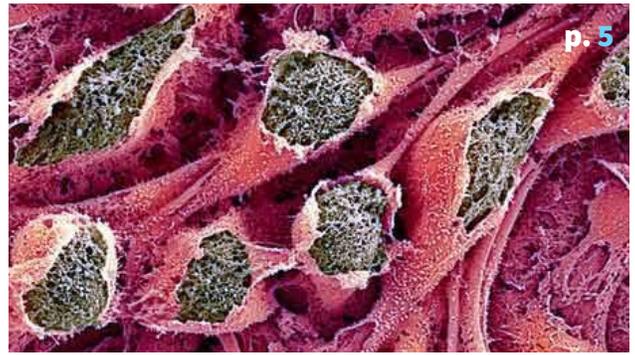
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## NANOscientific

The Magazine for Nanotechnology

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Keibock Lee,  
Editor-in-Chief

# MESSAGE FROM EDITOR

**The pace of nanotechnology related innovation has been accelerating showing no signs of slowing down. A testament to this high growth is the release of this year's US budget that continues to escalate the enormous support of nanoscale science, engineering, and R&D technology across multiple industries in excess of over 21 billion since 2001.**

The future is rapidly approaching where wearables and smart nanoparticles can change our lives. Textiles used in "smart clothes" now being developed can take your vitals, generate power for other devices, and warn of UV rays. Wearable devices now on the market such as the new Microsoft band comes equipped many of those features and a GPS. Apple's new smart watch debuting this month is positioned to make wearables part of the new smart phone culture, where today's youth are incorporating them into their daily lives as soon as they can hold it in their hands.

Up to the present date, the driving factor pushing the envelope of technological advances using nano science has been design engineering, with manufacturing busily trying to keep up with the pace to produce products at an affordable cost. However, as semiconductor devices get ever more miniaturized and the geometries

shrink towards single digit nanometers, newer methods of nanometrology are becoming critically important in the production line to ensure quality in the finished products.

Evidence of the importance of nanometrology is best demonstrated by the recent purchase by imec of the first automated AFM tool (Park NX-3DM) for their production line. This is a significant trend because of imec's leadership role and extensive expertise in semiconductor technology. Imec performs world-leading research in nano-electronics and nano-technology. Its staff of close to 2,000 people includes over 600 industrial residents and guest researchers and the research is applied in better healthcare, smart electronics, sustainable energy, and safer transport. Traditionally, semiconductor production lines employed scanning electron microscopy techniques such as CD-SEM, and scatterometry, a secondary electron emission-based technology

and an optical diffraction based method, respectively. However, with narrower nodes and increasing importance of quality in all three dimensions, a two dimensional data of CD-SEM (and its destructive nature) or model based scatterometry is proving inadequate for full production line quality assurance.

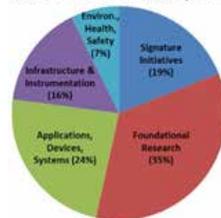
An automated AFM signifies the missing puzzle piece for all new and future generations of nanotechnology devices that are the brains for computers, smart phones, smart cars, textiles, et cetera. The next generation 3D-AFM that Imec and Park Systems have announced their intention to jointly develop is a trend worth watching and we will keep you informed as it moves forward. On the other spectrum of technological trends, investments in life sciences world-wide are exploring ways to find not only cures for diseases like cancer, but to also revolutionize healthcare. Advanced research methodology, now at the molecular level, allows

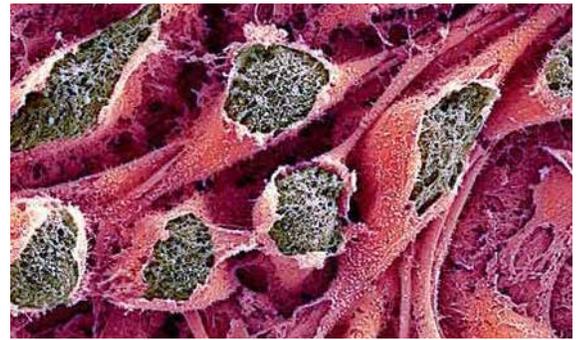
scientists to truly understand what is happening beyond what has been observed using optical microscopes which had been limited to 250 nm resolution at best.

TEMs (transmission electron microscopes) and SEMs (scanning electron microscopes) have been the standards used to study cells at the nanoscale level, but they have many limitations in trying to study living cells because the study method itself actually kills the cells. Now, advancements using Bio AFM are gaining popularity because it allows for imaging of live cells and further, for allowing researchers to study various nanomechanical properties of the live cells and their responses to stimulus under study. This is a huge advancement for research science of living cells and has resulted in the onset of many innovative ideas.

The new emerging truly non-invasive technology is scanning ion conductance

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microscopy (SICM) and it allows imaging cells and structures that are very soft such as neuronal cells, as well as, enabling targeted patch clamping to study the ionic responses from the cell. It's worth watching Park NX-Bio that was introduced this year by Park Systems as an exciting 3-in-1 tool for life science research because it incorporates the newest nanoscale metrology for the most advanced research. We are excited about what developments will follow. With new live cell research methods, revolutionary advances in medicine now being researched include a technique that allows nano scientists to transform stem cells into bone cells on command which could lead to turning stem cells into any type of cell on command, according to the team at Northwestern University who is developing it. And another is using nanotechnology to create globular forms of DNA designed to treat cancer and other disease. Google has been hard at work to develop health care technology that sends tiny magnetic particles to patrol the human body for signs of cancer and other diseases using nanoparticles less than one-thousandth the width of a red blood cell that seek out and attach themselves

to cells, proteins or other molecules inside the body.

It appears right now that the sky is the limit for new ideas of ways that nanotechnology can enrich and improve our lives, and looking towards space is the next frontier. NASA and the European Space Agency have some ambitious plans and if manned missions to Mars, super-thin spacesuits and shoebox-sized shuttles become a reality, then nanotechnology will undoubtedly have played a key role. More to come on that in upcoming issues, I hope you enjoy this third issue of NanoScientific please send us your stories and ideas and share your new innovations with us!

*Keibock Lee,  
Editor-in-Chief*



# THE ROLE OF NANOSCALE TECHNOLOGIES IN SEMICONDUCTOR'S NEXT STAGE IN EVOLUTIONARY BREAKTHROUGHS

FEATURE STORY



Phil Kaszuba is an Advisory Engineer/Scientist for IBM's Systems and Technology Group. He currently directs the Scanning Probe Microscopy Laboratory in the Analytical Services organization at IBM's Essex Junction, Vermont semiconductor fabrication facility. He holds a B.S.E.E. from the University of Vermont with a concentration in semiconductor device physics. His work is centered on applied SPM for nanoscale semiconductor technology analysis and nanoinstrumentation development. Having worked in SPM for 23 years, Phil is a recognized expert in the field and one of the foremost authorities in applied SPM for nanoscale semiconductor technology analysis. Phil was involved with the initial development of many of the SPM based analytical techniques and instruments used in the semiconductor industry today. He is currently developing new SPM based analytical techniques for applications in nanoscale semiconductor technology development, fabrication line monitoring, device characterization, and failure analysis. Phil has authored numerous articles and papers including invited speaking engagements at universities, industry seminars, and classroom instruction. He holds a number of U.S. and international patents in the field of Scanning Probe Microscopy. Included in his portfolio are the patents for the Scanning Surface Photo Voltage Microscope (SSPVM) and Silicided Silicon Conductive Tips. Phil is a member of the Electronic Device Failure Analysis Society. He serves regularly as a review panel member for the National Science Foundation and a technical advisor to the Defense Advanced Research Projects Agency (DARPA). Phil is also a 15 year committee chair veteran and contributing author to the International Symposium for Testing and Failure Analysis.

## AN INTERVIEW WITH PHIL KASZUBA, DIRECTOR, SCANNING PROBE MICROSCOPY LABORATORY AT IBM

**Phil Kaszuba who currently directs the Scanning Probe Microscopy Laboratory at IBM is an active user of Park Systems AFM, the industry's leading atomic force microscope for Semiconductor Defect Review and microscopy analysis.**

With the growing complexity of new processes and introduction of new materials the needs for product yield management and process control are placing unprecedented demands on failure analysis laboratories in the semiconductor industry. These demands are calling for faster and superior analytical capabilities to determine root cause failure

mechanisms in semiconductor devices fabricated using deep sub-micron processes. The Scanning Probe Microscope (SPM) is an analytical instrument used in root cause failure analysis. Scanning Capacitance Microscopy is a SPM technique that maps the dopant profile of a semiconductor device while simultaneously obtaining a topographic image. Using constantly evolving and newly developed techniques a plethora of physical, electrical, and chemical properties of a sample may be routinely analyzed. AFM has become a mainstay technique for metrology applications especially in manufacturing line monitoring for critical dimension analysis and patterned structure sidewall analysis.



**You have been in the field of Scanning Probe Microscopy (SPM) for over 23 years and worked with one of the first AFMs at IBM. What have been the major milestones as the industry advanced into nanoscale microscopy?**

Working with a prototype AFM in the early 90's was dramatically different than the SPMs of today. Virtually all of the system set up was performed manually using racks of discrete electronic equipment and a laser interferometer. Typical set up time was 1-2 hours. Analytical techniques were largely limited to non-contact Atomic Force Microscopy (which sensed the van der Waals attractive force between the tip and sample surface) and Scanning Kelvin Probe Microscopy (SKPM). Resolution was adequate for semiconductor device sizes of the era. With current systems, the discrete electronics (which once took up half of a room) have been consolidated into a unit the size of a desktop computer, the interferometer and optical bench have been replaced by a laser diode/photo detector, and system controls are facilitated with software. Set up time can be as little as 10 minutes. Using constantly evolving and newly developed techniques a plethora of physical, electrical, and chemical properties of a sample may be routinely analyzed. Additionally, advancements in probe technology have enabled nanometer to sub nanometer resolution for various techniques. In this interview, Phil explains how new advances in the evolving Semiconductor

at increasing nanoscale is creating frontier science in medicine, energy and space exploration that greatly impact each of us and our environment.

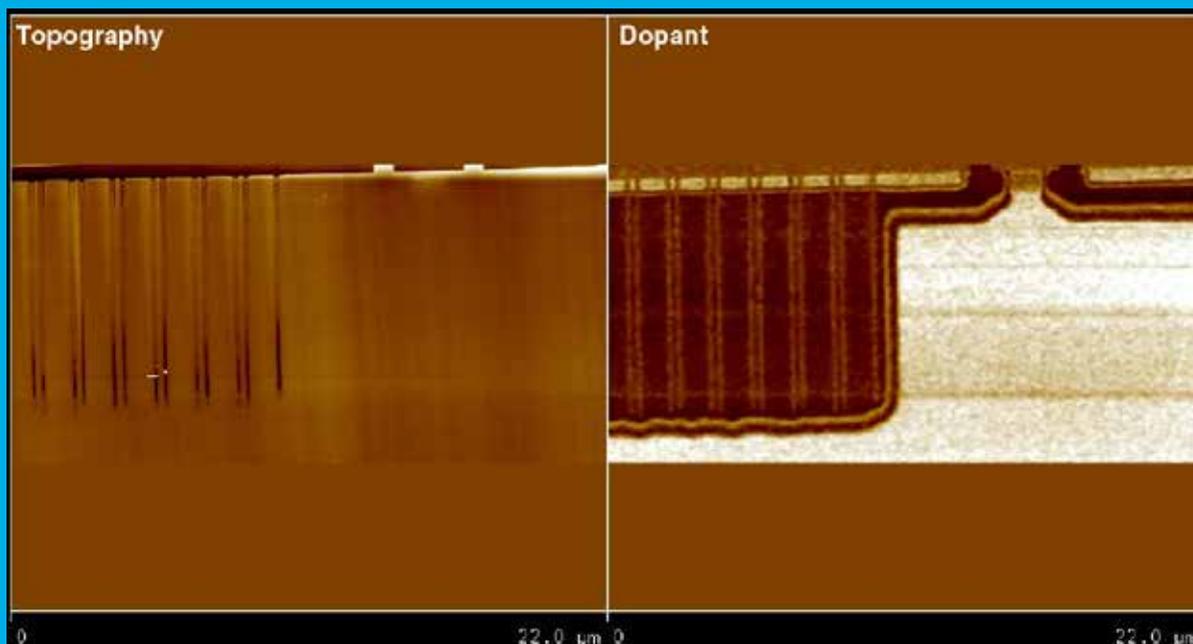
**How does Scanning Probe Microscopy (SPM) help to make semiconductor devices smaller, faster and use less power?**

In the semiconductor industry, the evolution of each new technology node is driven by three primary objectives: devices need to be smaller, faster, and use less power. Consider the amount of data storage, control, or computing power available now in the personal electronic devices that fit in our pocket. The technology to build such devices was enabled by rapid evolutionary advances in the semiconductor industry with SPM providing invaluable data from research to development to production. Critical to the successful development of each new technology is a thorough understanding of the basic circuit elements that are combined to comprise functional electronic devices. Prior to the development of applied SPM techniques, researchers and development engineers relied heavily on technology simulation algorithms to aid them in understanding device performance and fabrication process development. AFM, SKPM and Scanning Capacitance Microscopy (SCM) analyses have provided empirical data that reflects the true outcome of a device design or fabrication process, and how that translates into smaller, faster, and more efficient.

**Why is topographical information so important in semiconductor manufacturing and failure analysis?**

Devices continue to get smaller in all three dimensions with the introduction of each new technology node. Consequentially, it has become increasingly important to fully understand the physical morphology of silicon substrates as well as the numerous films that are grown or deposited and patterned in the fabrication of functional electronic devices. Displacements of atoms from the normal crystal lattice are commonplace and such a displacement in a silicon substrate, as little as a single atomic plane can cause catastrophic failure if it occurs in the wrong place. AFM can routinely reveal such single plane displacements as well as other detrimental features in a non-destructive fashion. Understanding film roughness has become critically important, especially after Chemical-Mechanical Polishing (CMP) and gate dielectric growth steps. Using appropriate post processing algorithms, high resolution AFM topographic data can be used to 'quantify' the physical characteristics of a film or layer after such processing steps using industry standard metrics. Lastly AFM has become a mainstay technique for metrology applications especially in manufacturing line monitoring for critical dimension analysis and patterned structure sidewall analysis.

**What has been the most important contribution of Scanning Probe**



## Microscopes to the semiconductor manufacturers?

To gain a good understanding of SPM's most significant contribution to the semiconductor industry let's first look at some of the fundamental fabrication steps of semiconductor devices. Purified silicon is grown into single crystal silicon, processed into 'wafers' and rendered conductive in very specific areas through the implantation of atomic impurities or 'dopants'. Proper placement of dopant atoms (in all 3 dimensions) in single crystal silicon is the foundation for fabricating semiconductor circuit elements such as transistors, diodes, resistors, and capacitors. Scanning Capacitance Microscopy (SCM) has been the single most important scanning probe analytical technique to the industry because with SCM it becomes possible to accurately detect (with nanometer resolution) the position, distribution, and relative concentration of dopant atoms in silicon. Prior to the availability of SCM there was no practical analytical method that could show dopant distribution across a complete structure.

## Can you explain how you analyze dopant profiles in silicon semiconductor devices?

As mentioned previously, specific dopants are implanted into select areas in the silicon to alter their conductivity. It is important that after implantation, the dopants are rendered

electrically active by annealing the implanted silicon at a high enough temperature for a requisite period of time. Depending on the dopant species there will either be a net excess of electrons (n-type) or shortage of electrons (p-type) in the implanted areas. A charge carrier in n-type silicon is called simply an 'electron' and in p-type type silicon the electron void that moves throughout is called a 'hole'. Dopant concentrations determine the level of electrical conductivity. SCM is a technique that uses an externally applied electrical stimulus to move these carriers. This controlled carrier motion is sensed by the SCM probe which is in contact with the silicon surface which has been lightly oxidized. Knowing the magnitude and polarity of the applied bias along with the carrier response it is straightforward to determine the dopant polarity and relative concentration of the area being analyzed. Raster scanning the probe throughout an area of interest yields a map of the dopant type and relative concentration for a given area.

Nanometer resolution has been achieved using the latest in SCM probe technology. This has been, and continues to be the "workhorse" technique for transistor dopant analysis since refinement of the technique in the early 90's.

## What are the next steps in the evolution of nanoscale technologies as they apply to the Semiconductor industry?

The semiconductor industry has followed a very aggressive roadmap as it transitions to each new technology node. Technologies evolved from 45nm to 32nm to 22nm quite rapidly and this evolution involved not only shrinking device geometries dimensionally, but the introduction of novel materials in order to address issues that arose from building transistors with channel lengths that are a mere 40 atoms long and dielectrics a few molecules in thickness. The next major step for the industry is the transition from 22nm to 14 nm which has seen a major redesign of the basic transistor. After 14nm

we move on to 10nm followed by 7nm! SPM provides critical data in the analysis of devices at each of these technology nodes from basic research to full production.

## What new materials are being researched currently? have been developed recently?

The fundamental circuit element in integrated circuits is the Field Effect Transistor (FET). The basic FET structure is comprised of doped regions of silicon onto which a thin "gate dielectric" is grown. A conductive stripe or "gate" is deposited on the gate dielectric to turn the FET on and off. The most critical film in this 'stack' is the gate dielectric which had traditionally been SiO<sub>2</sub> that was typically tens of angstroms in thickness. As technologies progressed and dimensions shrunk, this film was made thinner and thinner to the point where it was only a few molecular layers in thickness. Quantum tunneling effects between the gate and substrate became a concern so it was therefore

**"THE SCANNING PROBE MICROSCOPE HAS PLAYED A VITAL ROLE THROUGH PROVIDING CRITICAL DATA IN SUPPORT OF THE EVOLUTION OF EACH NEW SEMICONDUCTOR TECHNOLOGY NODE AS DEVICES GEOMETRIES APPROACH A MOLECULAR SCALE. THE SEMICONDUCTOR INDUSTRY HAS TAKEN ON AN AGGRESSIVE PATH IN DEVELOPING EMERGING TECHNOLOGIES AND APPLICATIONS ENABLING CAPABILITIES SUCH AS CONTROLLING EVERY HOME APPLIANCE, FROM ANY LOCATION, WITH A SIMPLE HANDHELD DEVICE, AUTOMOBILES THAT MANEUVER THEMSELVES, AND MACHINES THAT HAVE THAT CAPABILITY TO "THINK" AND EVEN WIN AT "JEOPARDY!". Continued advancements in semiconductors will enable faster medical diagnoses, better understanding of diseases and their cures, rapid development and deployment of pharmaceuticals through simulation of chemical, physical, and biological processes and exploration of our solar system from Mars and beyond, to the far reaches of the universe. Solutions to the planet's insatiable demand for energy could be realized through understanding and learning to safely harvest the immense power available from atomic interactions by running massive computer simulations. Semiconductor industry breakthroughs will aid in the creation of prosthetics that adapt seamlessly and function identically to original human body parts. The list is only limited by the ingenuity and creativity of today's scientists and the Scanning Probe Microscope will have an increasingly more important role as an analytical instrument in the realms of research, development, and manufacturing."**



necessary to modify the dielectric to alleviate this problem. Incorporating Hafnium into the gate dielectric increases the dielectric constant thereby solving this scaling problem. The implementation of HfO<sub>2</sub> was probably the single biggest recent breakthrough in planar FET technology.

### **How is Conductive AFM (C-AFM) used to locate molecular contaminants and why is this important?**

As FET gate dielectric layers continued to thin it became evident that molecular contaminants in this insulating layer between the gate and substrate could readily compromise device functionality. With millions of FETs on a chip it is likely that this will occur sporadically and it is therefore important to have a thorough understanding of gate dielectrics. C-AFM is an electrical method that has the ability to map current flow properties through a sample with nanometer resolution and femto-amp sensitivity. C-AFM has proven to be an invaluable technique in localizing even the most subtle of electrical inhomogeneities in that most critical layer; the gate dielectric. A dielectric film may be analyzed 'as grown' or on a fully constructed FET. In the case of a fully constructed FET, the device must be de-constructed using a combination of mechanical and chemical steps to essentially reverse the fabrication process until the layer of

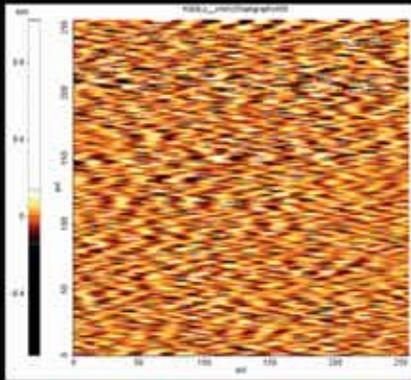
interest, i.e., the gate dielectric, is exposed. It is first inspected using AFM at high resolution using a standard silicon probe to determine whether there are any obvious topographic anomalies. Then C-AFM is used, starting at a low level of applied DC bias. An image is captured and then the process is repeated, increasing the bias with each image in the sequence until either of the following occurs: A localized 'spot' of current flow appears indicating a local variation in dielectric strength...or...low level tunneling current begins to appear in multiple locations across the dielectric surface; this is normal for a good, uniform dielectric. When a small discrete spot is found, other techniques (SKPM, TEM, AFM) may then be used to understand the cause for the local variation in dielectric strength.

### **What are the future technological advances that you think might come from semiconductor SPM research?**

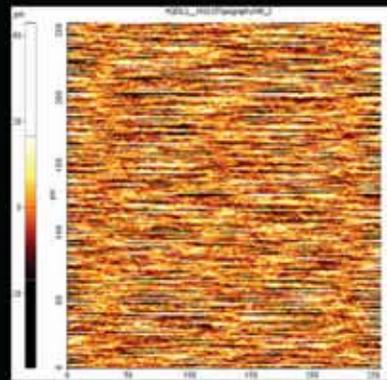
The Scanning Probe Microscope has played a vital role in support of the evolution of each new semiconductor technology node through providing critical and in some cases previously unavailable data as device geometries approach a molecular scale. The semiconductor industry has taken on an aggressive path in developing emerging technologies and applications enabling end user capabilities such as controlling every

home appliance, from any location with a simple handheld personal electronic device, automobiles that maneuver themselves, and massively complex machines that have that capability to "think" and even win at "Jeopardy!". Continued advancements in semiconductors will enable faster medical research, rapid, accurate diagnoses, better understanding of diseases, their causes, and their cures, and rapid development and deployment of pharmaceuticals through simulation of chemical, physical, and biological processes. Forthcoming is even more detailed exploration and understanding of our solar system starting with a manned expedition to Mars and someday beyond; ultimately to the distant reaches of the universe. Solutions to the planet's insatiable demand for energy could be realized through understanding and learning to safely harvest the immense power available from atomic interactions by running massive computer simulations. Semiconductor industry breakthroughs will aid in the creation of prosthetics that adapt seamlessly and function identically to original human body parts. The list is only limited by the ingenuity and creativity of today's scientists and the Scanning Probe Microscope will continue to have an increasingly more important role as an analytical instrument in the realms of research, development, and manufacturing.

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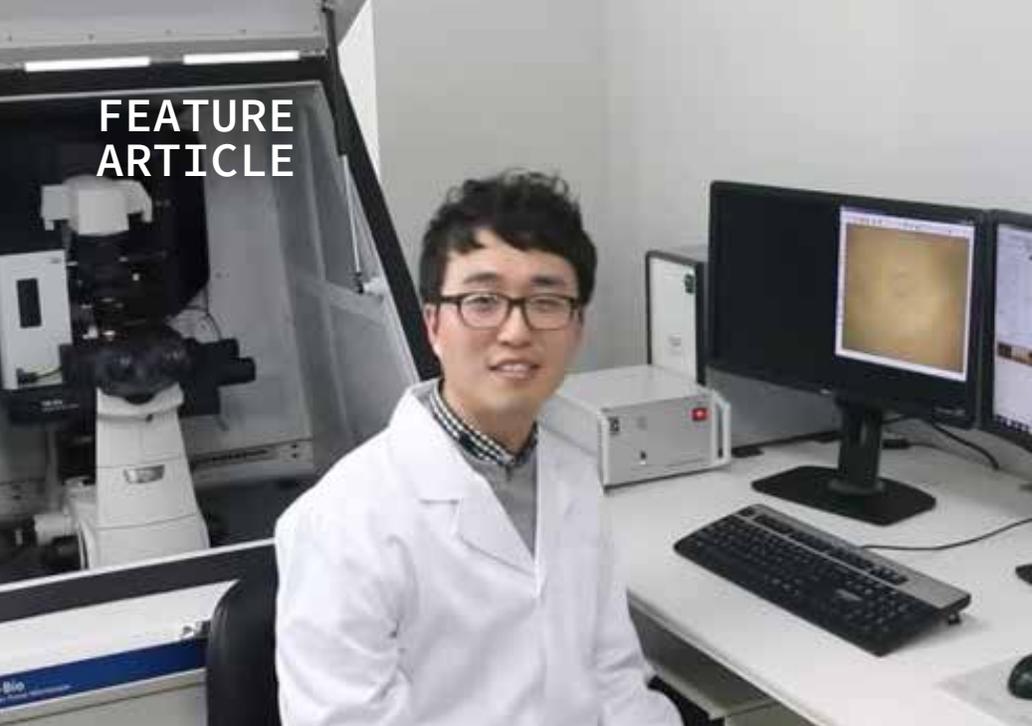
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# PARK PINPOINT™ MODE FOR CELL BIOLOGY

## PinPoint Mode Enables Surface Nano-mechanical Property Imaging

In addition to nano-scale three dimensional imaging, nano-mechanical property measurement is one of the most popular functions of atomic force microscopy (AFM). The basic AFM mode for nano-mechanical property measurement is force-distance (FD) spectroscopy.

FD spectroscopy measures the physical properties of the sample surface, such as its hardness, adhesion, etc. by using nano-size cantilever tip to push the sample in the range of nN-scale.

Nano-mechanical property characterization at the nN-scale is possible only with the AFM therefore it is widely used in material science, physics, chemistry, etc. for various nano level research. FD spectroscopy is also popular in biological research because it is the only technique available which can physically measure the single molecular binding force. Recently, new application of FD spectroscopy is being developed which is the study of comparing physical properties of a single cell or a tissue with various functions or diseases to make a diagnosis.

In order to analyze the physical properties of a single cell in accordance with the biological functions, FD spectroscopy should be aligned exactly with the topographical data. In general, the topography of a sample is acquired first and FD spectroscopy is performed on the specific position using topographical data as a

reference map.

AC AFM mode (dynamic or tapping mode) is generally used to minimize the AFM artifact from sample-tip interaction in biological sample imaging. However, it is very difficult to avoid the positional errors correlating topographical data and FD spectroscopy data because the soft and sticky nature of the biological samples introduce unavoidable various AFM artifacts even during AC mode. The PinPoint mode was newly developed to compensate the positional errors between topographical and FD data. The PinPoint mode does this by its capability to simultaneously acquire topographical data and the FD data at each pixel, as shown in Fig 1. There is a significant difference from the conventional AFM imaging of the raster scan with Z scanner feedback. In the PinPoint mode operation, the cantilever approaches at each pixel in the entire scan area (for example 256x256 pixel = 65536 points) to acquire the height of the sample surface to generate 3D topographical image of the sample and FD spectroscopy information at the same time.

By lifting the cantilever tip perpendicularly from the sample surface at every pixel, it provides extra clearance space when the cantilever tip moves to the next pixel position during the PinPoint mode as shown in Fig. 2. Even if there is an adhesive interaction between the sample surface and the cantilever tip at the previous point (Pixel a) that connection is completely removed before arrival at the next pixel point

## PinPoint™ mode: How to Operate

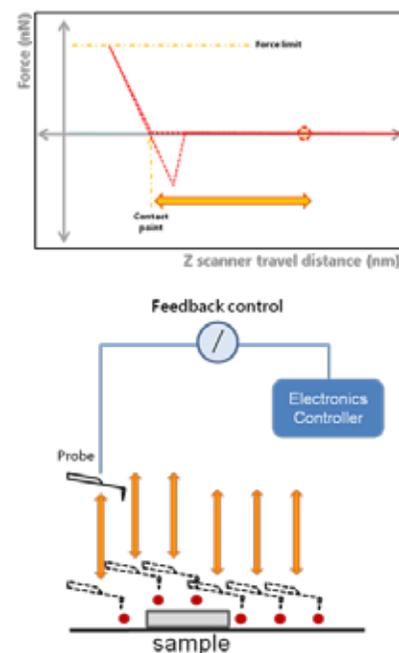


Figure 1. The PinPoint mode operation principle and the scheme.

(Pixel a+1), hence an accurate topographical information is obtained and the tip-sample interaction information at each pixel can be saved.

This is the biggest advantage of the PinPoint mode, in that simultaneous acquisition of height and FD data guarantees the accuracy of correlating between two types of information. PinPoint mode operation can be controlled by users using preset parameters shown on the left column of Fig. 3.

The preset parameters include such as the control height, the stiffness threshold for topographical and FD data, the approach and retract time, the lift height, the XY pixel to pixel move time, and the pre-approach delay for determining a scanning speed, etc. The important preset parameters to be determined carefully are the stiffness threshold and the control height.

The AFM cantilever presses on the sample surface repeatedly with certain amount of force determined by the stiffness threshold. In order to obtain accurate FD spectroscopy data, the stiffness threshold should be determined carefully.

The control height determines the retraction height during movement between pixels after cantilever pushes away from the sample surface. The control height is the most delicate parameter to control because it greatly depends on the type of sample surface characteristic. Generally speaking, smaller number can be used for smaller step height

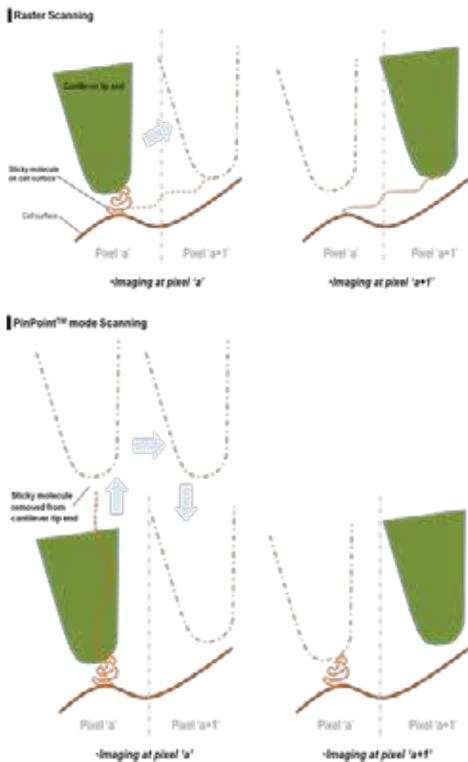


Figure 2. Raster vs. PinPoint Mode Scanning

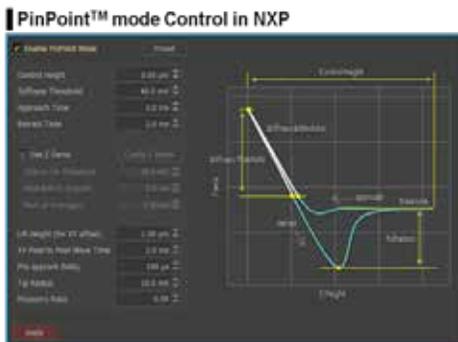


Figure 3. The user interface for the PinPoint mode operation in the NXP software and its control parameters.

and bigger number for bigger step height. However, in the case of a sample with sticky surface the control height should be appropriately increased in order to clearly disconnect the tip-sample interaction before moving to the next pixel, even if the step height is small.

The three physical properties which can be obtained simultaneously through PinPoint mode are the surface morphology, elasticity map, and adhesion force map.

### a. Surface Morphology (Height)

The height information constituting the morphology of the sample surface is

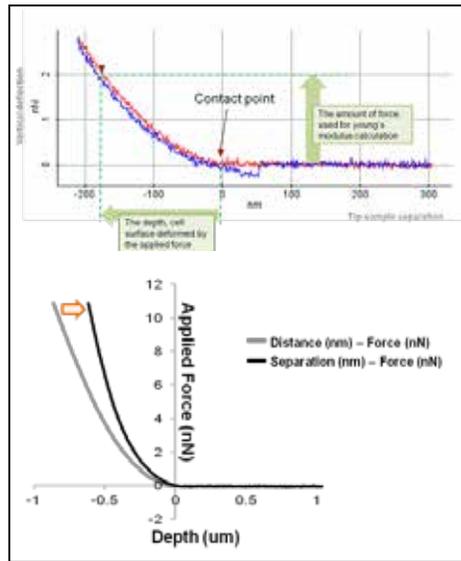


Figure 4. Force-Distance curve generated by the PinPoint mode

determined when the designated stiffness threshold is reached. In other words, the Z detector records how much Z scanner is extended when the certain cantilever deflection, determined by preset stiffness threshold, is reached. The level of cantilever deflection can be accurately designated in the NXP software from Park Systems for optimized surface morphology.

### b. Elasticity (Stiffness)

The elasticity (stiffness) at the certain position of sample surface can be obtained by the same way in the FD spectroscopy. The stiffness can be obtained from the slope of FD curve from contact point to deflection threshold generated during the PinPoint mode operation. Applying Hertz model, designed for soft and elastic samples, user can calculate elasticity (Young's modulus) from the slope, too.

In order to calculate Young's modulus using Hertz model equation, FD curve should be converted to tip-sample separation curve to determine the deformation depth from the sample surface. (Fig. 4) For the accurate measurement of the Young's modulus, the accurate positioning to determine the contact point with cantilever tip is very important. The data processing algorithm of NXP automatically generate a Young's modulus image map from the PinPoint mode operation.

### c. Adhesion

In addition to the elasticity map, the adhesion map also can be generated by using PinPoint mode imaging. The adhesion image is generated based on the maximum adhesion

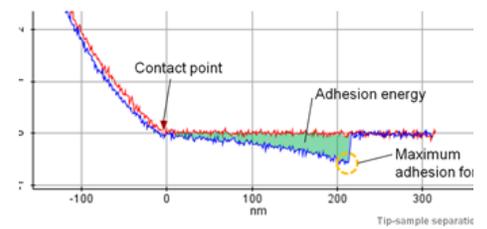


Figure 5. The calculation of the adhesion energy

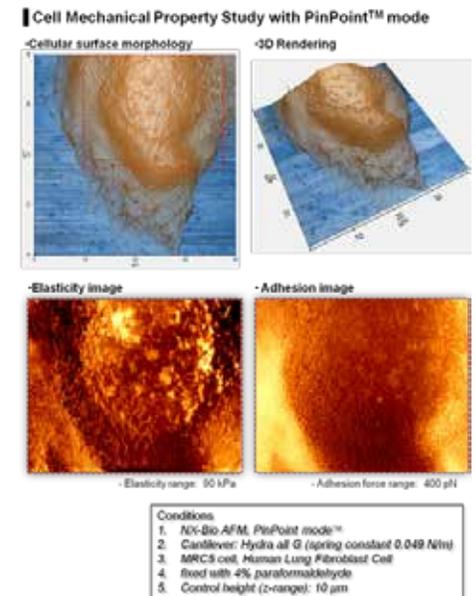


Figure 6. The elasticity and the adhesion map of a MRC5 cell generated by PinPoint mode

force value. The total adhesion energy at each pixel also can be obtained by measuring green area in Fig. 5.

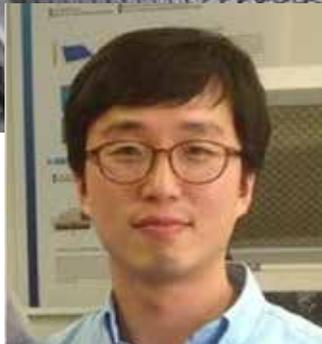
### Application

As shown in Fig. 6, the elasticity and the adhesion map of a single MRC5 cell was obtained one 3D topographical image at the same time on the NX-Bio using PinPoint mode. The coloring of each pixel representing the elasticity and the adhesion map was determined from the calculation generated by PinPoint FD curve at each pixel. 3D topography shows exact positional match with the FD spectroscopy maps. The higher elastic property can be noted on the nucleus compared to its surrounding areas. The absence of AFM artifacts, such as scratch or streak marks which can be seen frequently in imaging a cell or biological samples in liquid, is an additional benefit of PinPoint mode.



## AN INTERVIEW WITH BRIAN CHOI, BIO-APPLICATION SCIENTIST AND BIO- PRODUCT MANAGER AT PARK SYSTEMS ABOUT USING PINPOINT MODE FOR ADVANCED CANCER CELL RESEARCH APPLICATIONS

**BRIAN CHOI IS BIO-APPLICATION SCIENTIST AND BIO-PRODUCT MANAGER AT PARK SYSTEMS. AFTER MAJORING IN BIOLOGY/BIOTECHNOLOGY, HE HAS WORKED AT PARK SYSTEMS FOR 6 YEARS. HE HAS VARIOUS EXPERIENCES ABOUT BIO-AFM MEASUREMENT SUCH AS CELL, SINGLE MOLECULE, TISSUE. HE IS FOCUSING ON DEVELOPING AND INTRODUCING PRACTICAL APPLICATIONS OF NANO-MICROSCOPIES (AFM AND SICM) FOR BIOLOGY RESEARCH.**



Brian Choi,  
Bio-application Scientist

### Can cell analysis be done using PinPoint that will help with research on cancer cells?

Researchers have been trying to study cancer by using Atomic Force Microscope (AFM) since its introduction. In order to study cancer at the fundamental level, cancer cell's physical properties (morphology and stiffness/elasticity/adhesion force) must be able to measured accurately. For instance, many previous studies about cancer cell diagnosis with AFM have shown that cancer cells are less stiff than normal cells. More importantly, the measured data (cell morphology and stiffness/elasticity/adhesion force) should be distinguishable between cancer cell and normal cell.

Conventional AFM imaging method (AC mode, contact mode) for cell (normal or cancer) could not fulfill such technical requirements due to the lack of accurate feedback control in liquid conditions. Even for cancer cells, it is more difficult because of the higher liquidity than normal cells. After obtaining cell morphology, nanomechanical properties

(stiffness/elasticity/adhesion force) were acquired by force-distance spectroscopy on the specific position of cells using the inaccurate morphology data as a reference map. In this process, it is difficult to avoid the positional errors correlating morphological data and nanomechanical data.

PinPoint mode solves these problematic issues by:

- acquiring cell morphology more accurately than before with reliable and repeatable quality.
- obtaining nanomechanical properties (stiffness/elasticity/adhesion force as an image) simultaneously.

### Can PinPoint be used in any type of medical

### applications that are new ways to examine cells and give us more information about them?

Adhesion force imaging of PinPoint mode will allow us to detect the real existence of specific protein, being expressed on the membrane of cancer cell. For example, using functionalized AFM tip, the real time monitoring of ligand-receptor chemical interaction on cancer cell would be a good medical application with PinPoint mode AFM. This application will help to elucidate immunohistochemical analysis for cancer research by identifying various cancer specific protein expression directly on cell membrane and cancer tissue sections.

### What types of new advancements like PinPoint can we expect to see to help with Cell Analysis at the nanoscale level in the future?

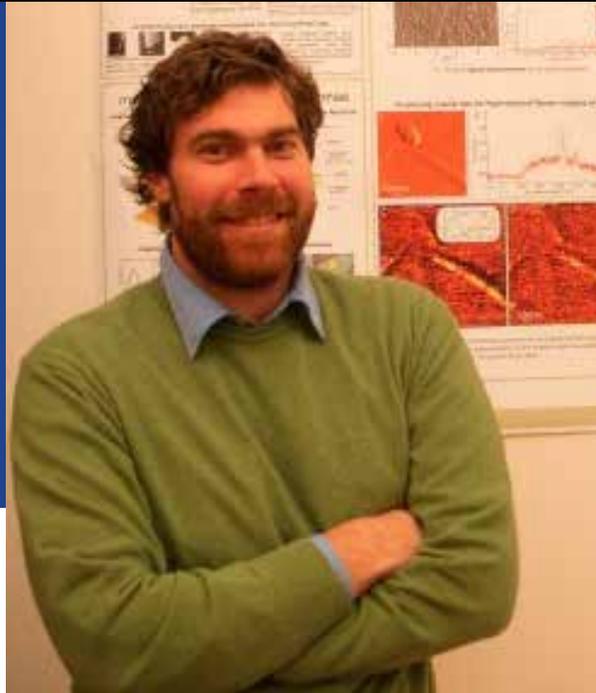
For cell analysis and study, knowing and observing what's happening in cell at nanoscale is important. Yet, most researchers use AFM for this purpose. However, AFM is a contact-based imaging

microscopy. Thus, it gives external physical stimulus to cell which is the main reason, live cell study is not possible to be a routine study for AFM. Even PinPoint mode allows us to accurately control the applying force on cell and minimize it during imaging, the feedback signal comes from AFM tip-contact even against cell surface.

In the near future, such all cell studies should be done in non-contact status, from which live cell is not influenced by any external physical stimulus thus the live cell keep expressing its nature during imaging by microscope. To fulfill this requirement, Park SICM (Scanning Ion Conductance Microscopy) has developed and equipped in NX-Bio system. SICM provides the non-contact based cell imaging in liquid conditions, resulting in discovering more detail cell surface features for all cell types, even for tissue.

We expect that Park SICM would have various applications such as nanomechanical property and electrochemical property in the future.

# CRITICAL EMERGING SCIENCE OF OPTO ELECTRONICS USES NANO-LIGHT PROBES TO HARVEST LIGHT



**An Interview with Dr. Alexander Weber-Bargioni, Lead Scientist - Opto electronics research group at the Molecular Foundry of the Lawrence Berkeley National Laboratory**

The Weber-Bargioni group is a highly interdisciplinary and collaborative team at the Molecular Foundry, focused on exploring fundamental optoelectronic nano material properties to ultimately provide a set of rules that enable the systematic development of next generation light harvesting materials.

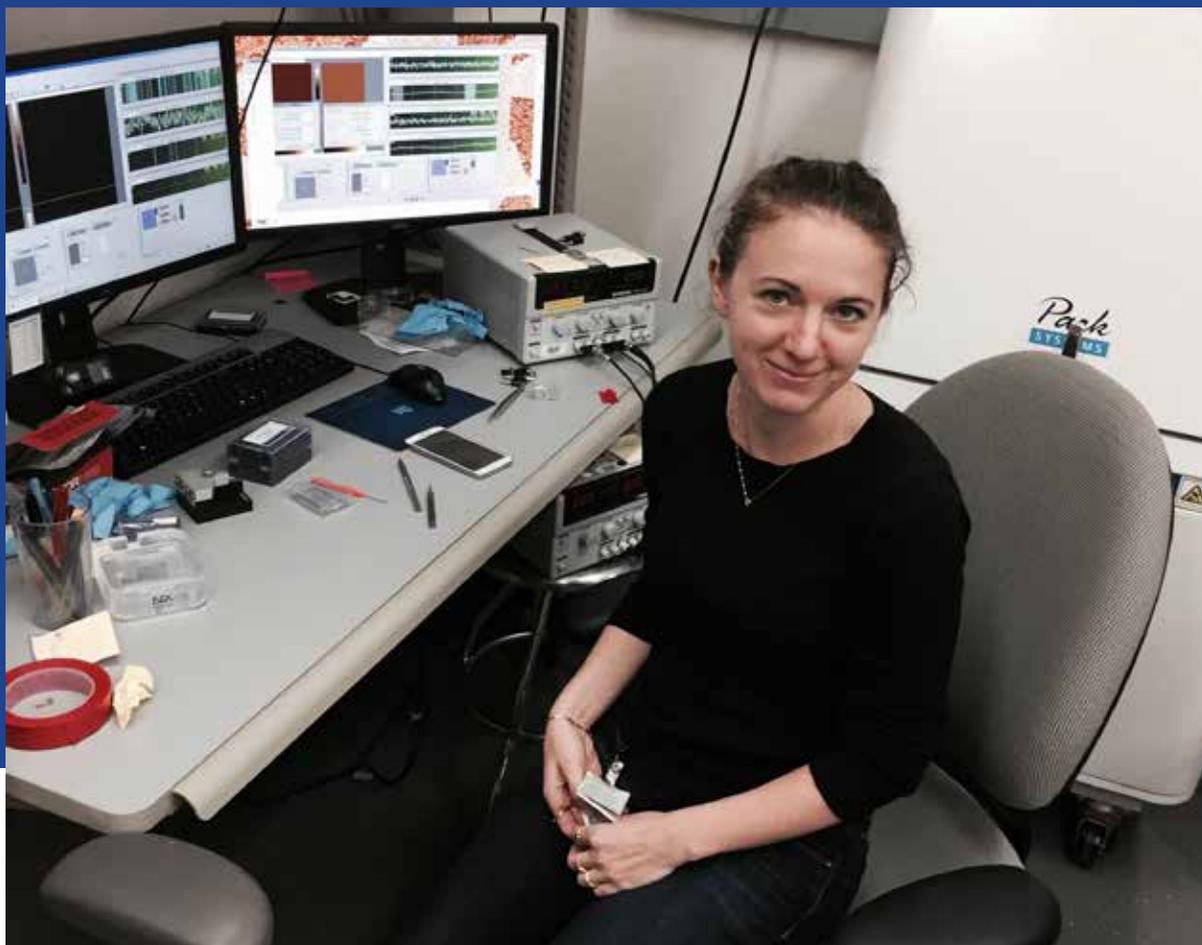
Dr. Weber-Bargioni's group is focused on imaging and correlating local optical properties and the local electronic structure to provide an insight into optoelectronic processes at the native length scale via state of the art nano optics, Kelvin Probe Microscopy and Scanning Tunneling Microscopy Spectroscopy.

## **How has nanoscale imaging such as AFM helped you to analyze changes in the electronic structure of light harvesting devices?**

AFM is not only good to image the local topography. By functionalizing the tip, e.g. making the tip conductive with a metal layer, we can measure electrostatic forces between sample and tip with high sensitivity or applying bias between sample and tip and measure the local resistivity. Local resistivity, Local Photo Current generation or local Electric Field distributions provide us with insights on the opto electronic processes in light harvesting materials at the length scale these processes happen.

## **How do nanoscale materials have the potential to create transformative technology?**

The fascination of nanoscale materials arises from the fact that material properties (e.g. the color, their conductivity, etc) change when we make them smaller than typically 10 nm. Unlike macroscopic building blocks, nanoscale building blocks change their properties also depending on their environment. For example two stones put together to build a house have still the same properties when we put them together. Two nanoparticles attached to each other may change their individual properties substantially. While this is fascinating and provides an enormous amount of possibilities it is also the challenge to understand how do



properties change and where can we use it to deliberately design new material properties.

### **Why is the study of opto electric properties important?**

Opto Electronic properties and processes govern an enormous range of applications: Lasers, Solar cells Light Emitting Diodes, Telecommunication, etc... IF we want to either miniaturize devices, or optimize solar cells taking advantage in both cases of the tenability of properties of nano scale materials we need to understand how do these properties change at the nm scale, how are they modified in different configurations and can we use that to make e.g. a solar cell that works at the theoretical limit. TO do so we cannot integrate over many processes of many different nano building blocks, but we need to be able to visualize individual processes in individual nano building blocks to know how to engineer novel materials.

### **What is a nano light probe and how is it used is optoelectronics?**

Nano Light probes are nanofabricated optical antennae. The concept of optical Antennae

has been discovered only a few years ago, whereby we use nanofabricated optical antennae to squeeze light well below the previously thought smallest light spot possible, also called the diffraction limit. With that we can optically excite a material with just a 10nm spot and study using optical spectroscopy with a spatial resolution of 10nm the opto electronic properties of a material.

### **What kind of research have you been doing on new nano materials? Can you explain what perovskites is and why it is an important discovery?**

We study opto electronic processes in perovskite materials because they are a new class of thin film PV materials which have a power

conversion efficiency of 20% and this was achieved by only a few research groups in barely 5 years - because of the success there are now of course many research groups jumping on this materials such as my group. We hope to map and understand the local process of light to electric energy process conversion and where the bottlenecks are to provide a systematic pathway of optimization of these materials towards the theoretical limit.

### **What types of advanced imaging techniques do you commonly depend upon for your research to ensure accuracy?**

My laboratory is heavily focused on Scanning Probe Microscopy and light. We have a Scanning Tunneling Microscope that works in Ultra

High Vacuum with a base pressure lower than what you have in outer space – at least in our solar system It also works at 4 Kelving – so just 4 degrees Celsius above the absolute lowest temperature – and therefore we have the stability to see individual atoms, push them around, and very important for us – we can image the spatial extend of the molecular orbitals of individual molecules. We have a Near Field optical Microscope where we combine Nano Optical Antennae at the end of a scanning probe microscope tip to scan it over the sample and study optically the properties of materials, e.g. how efficient can we excite a material in one position versus another position. Last but not least we use a Park AFM in a controlled environment (glove box) where we can couple light in which mimics



**“THE MOTIVATION IS SIMPLE: HUMANITY MAKES IPHONES THAT FIT IN OUR BACK POCKET WHILE CONTAINING MORE COMPUTING POWER THEN THE GUIDANCE COMPUTERS FOR THE APOLLO 11 MISSION. WE REALLY SHOULD BE ABLE TO DEVELOP MATERIALS THAT COST EFFECTIVELY CONVERTS THE FREE SUN ENERGY INTO ELECTRICAL AND CHEMICAL ENERGY.”**

**DR. ALEXANDER WEBER-BARGIONI, LEAD SCIENTIST OPTO ELECTRONICS RESEARCH, MOLECULAR FOUNDRY, LAWRENCE BERKELEY NATIONAL LABORATORY**



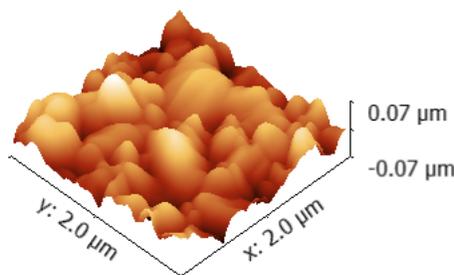
the solar spectrum to study how new solar cell materials operate at the lengthscale where optoelectronic processes happen

### **What can we learn about harvesting light to improve conditions on the Earth that might revolutionize the future of society?**

The question is not what we can learn about harvesting, the question needs to be for our society how can we optimize light harvesting and use it as our main energy source! I and many other scientists believe that the most pressing challenge of our time is to come up with sustainable energy sources that guarantee our kids and generations to come to still be able to live on this planet. I am unfortunately already doubtful if future generations will have the quality of life that we in the western society were allowed to enjoy.

Unfortunately Humans think short term and hence the only argument that seems to fly is if solar becomes cheaper then other energy sources – regardless of the implication of tomorrow. To do so there is only one way: Enhance the efficiency of solar cell devices. Cheap materials don't have as much of an

impact as on the prize (because installation and overhead cost considerably more than typical cell manufacturing) as enhancing the efficiency. To enhance the efficiency we need to operate as close as possible to the theoretical limit which is 28% for a single junction cell, 47% for a tandem solar cell. To reach these high efficiencies we have to make sure that the solar cell absorbs all light impinging on the cell and especially that every photo charge that is created finds its way to the electrode and can be used. To make sure that all photo charges are used, we need to image the processes at the lengthscale of where these opto electronic processes happen.



**Alexander Weber-Bargioni, lead Scientist, opto electronics research group at the Molecular Foundry of the Lawrence Berkeley National Laboratory.**

Dr. Weber-Bargioni's research goal is to understand fundamental processes of light-matter interaction at the nano meter scale with the goal to develop transformative light harvesting and emitting materials. He is leading the opto electronics research group at the Molecular Foundry of the Lawrence Berkeley National Laboratory. He graduated from the University of Konstanz, received his PhD in physics from the University of British Columbia (2007), and did his postdoc at the Lawrence Berkeley National Laboratory. His research group focuses on understanding and controlling fundamental optoelectronic processes at their respective length and time scale, utilizing advancements in plasmonics, near field imaging, and electronic structure and transport studies with molecular scale resolution. For his work he received several awards, such as the DOE Early Career award and the R&D100 award, and teaches at the Technical University Munich.



Dr. Luc Van den hove (President & CEO, Imec) and Dr. Sang-il Park (Chairman & CEO, Park Systems)

# PARK SYSTEMS JOINS FORCES WITH IMEC TO DEVELOP ADVANCEMENTS IN NANOSCALE AFM METROLOGY SOLUTIONS FOR SEMICONDUCTOR MANUFACTURING



Park Systems has officially joined imec's Industrial Affiliation Program (IIAP) and become a new member of IIAP at a signing ceremony in Seoul Korea on Feb 3, 2015. Park Systems is a world-leader in Atomic Force Microscopes (AFM) and signed a Joint Development Project (JDP) with nanoelectronics research center imec, to develop in-line AFM metrology solutions of future technology nodes including but not limited to surface roughness, thickness, critical dimension (CD), and sidewall roughness. The JDP will develop new protocol designed to increase production yield and

device performance for the semiconductor industry. The partnership will develop a broad range of AFM metrology solutions for process development, production, and failure analysis. For surface roughness, the most accurate surface roughness measurement with wafer mapping and incoming material monitoring could be delivered. For thickness, accurate thickness value in pre- and post-processing will be delivered in order to complement the existing ellipsometry solution. More importantly, the partnership will explore a new frontier of high resolution 3D AFM

metrology to address accurate CD, line width roughness (LWR), line edge roughness (LER) measurements, and sidewall roughness during etch, EPI, film deposition, and lithography processes.

The JDP between Park Systems and imec will develop new in-line monitoring and analysis methods for semiconductor manufacturers as well as new production protocol for better process development and control, which will result in improved device performance and production yield. For example, the high



**“WE ARE GRATEFUL FOR THE OPPORTUNITY TO PARTNER WITH IMEC IN A JOINT DEVELOPMENT PROJECT,” COMMENTS DR. SANG-IL PARK, CEO OF PARK SYSTEMS. “THIS PARTNERSHIP BETWEEN PARK SYSTEMS AND IMEC PROVIDES A CRUCIAL LINK OF SCIENTIFIC COLLABORATION THROUGHOUT THE CHAIN OF SUPPLIERS AND VENDORS IN SEMICONDUCTOR WAFER PRODUCTION. SIGNIFICANT FUTURE TECHNOLOGICAL ADVANCES WILL BE MADE FROM THIS JDP FOR AFM-BASED INLINE NANOSCALE METROLOGY.”**

## **IMEC’S PRIMARY FOCUS IS ON RESEARCH PROGRAMS THAT IMPROVE SUSTAINABILITY FOR OUR PLANET**



Imec reported revenue (P&L) totaled 363 million euro in 2014 and their huge investment in nanoelectronics research is geared towards providing products and services for several industries. Their business model focuses on advanced scientific knowledge and an extensive base of global partnerships spanning a world-wide network of key contributors in top industries including ICT, healthcare and energy. Headquartered in Leuven, Belgium, with offices in Belgium, the Netherlands, Taiwan, USA, China, India and Japan, imec has a staff of about 2,200 people including almost 700 industrial residents and guest researchers.

The new technologies under development is developing will be the backbone of a number of

solutions that will make the world a better, more sustainable place.

In life sciences, they will allow for a sustainable healthcare for more people. In communication, they will allow us to cope with the exponential growth in data and required computation. Energy solutions will mitigate our dependence on fossil fuels. Mobility solutions will make cities safer and more comfortable to live in.

But at the same time, the era of easy technology scaling is now far behind us. Every new technology node is becoming more complex and costly to develop. As a result, the R&D challenges and the required R&D budgets for the semiconductor industry keep growing year over year.



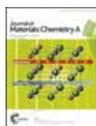
resolution sidewall information on vertical planar and cylindrical structure by Park’s new 3D AFM will bring huge impact on the performance of vertical devices such as FinFET, TFET, STT-MRAM and others.

As the design rule of semiconductor device shrinks, the CD measurement and sidewall variation in LER/LWR measurements became important and directly correlated with the leakage, hence device performance. CD-SEM, TEM, and OCD have been used for the CD metrology, but each

technique has its shortcomings such as resolution and e-beam damage for CD-SEM, sample preparation and sample damage for TEM, and time-consuming process development for OCD. Now, the AFM enabled hybrid metrology is on the rise as the next generation in-line monitoring and analysis method of non-destructive CD control.

In the most recent decade, the predictive power and correlation of the new hybrid metrology saw a vast improvement, and Park’s new 3D AFM metrology will contribute the detailed sidewall and nanoscale surface information for the critical components in the yield

control matrix. The collaboration between Park Systems and imec will create an information gathering platform from a multi disciplinary team of leading experts of scientists, engineers, and researchers to work together to create the next generation solutions in semiconductor metrology.



Journal of Materials Chemistry A

## ENHANCED THERMOELECTRIC PROPERTIES OF PEDOT: PSS NANOFILMS BY A CHEMICAL DEDOPING PROCESS

Hongkwan Park, Seung Hwan Lee, Felix Sunjoo Kim, Hyang Hee Choi, In Woo Cheong, Jung Hyun Kim Department of Chemical and Biomolecular Engineering, Yonsei University, 50 Yonsei-ro, Seodaemun-gu, Seoul 120-749, Republic of Korea. Department of Chemical Engineering and Materials Science, Chung-Ang University, 84 Heukseok-ro, Dongjak-gu, Seoul 156-756, Republic of Korea. Department of Applied Chemistry, Kyungpook National University, 80 Daehak-ro, Buk-gu, Daegu 702-701, Republic of Korea. Publication Date: Feb. 12, 2014

### ABSTRACT

We report that a simple chemical dedoping treatment of poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) nanofilms enhances the thermoelectric properties of the polymer nanofilms. The dedoping process was done by over-coating a mixture of dimethyl sulfoxide (DMSO) and hydrazine (HZ), a strong chemical reducing agent, onto the PEDOT:PSS nanofilms. This

additional step led to the removal of excess PSS chains and the formation of neutral states of PEDOT chains, resulting in an improvement in the Seebeck coefficient, from 30  $\mu\text{V K}^{-1}$  to 142  $\mu\text{V K}^{-1}$ , and a decrease in the electrical conductivity from 726  $\text{S cm}^{-1}$  to 2  $\text{S cm}^{-1}$ . By controlling the concentration of HZ, we obtained an optimized power factor of 112  $\mu\text{W m}^{-1} \text{K}^{-2}$  at 0.0175 wt% of HZ in DMSO at room temperature. The corresponding electrical

conductivity and Seebeck coefficient under optimized conditions were 578  $\text{S cm}^{-1}$  and 67  $\mu\text{V K}^{-1}$ , respectively. We expect that this simple dedoping process can be applied to general thermoelectric nanofilms based on chemically doped polymers in order to enhance the power factor.

For Full Article go to: <http://pubs.rsc.org/en/content/articlelanding/2014/ta/c3ta14960a#divCitation>



RSC ADVANCES, Issue 39, 2015

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## REDUCED GRAPHENE OXIDE-POLYANILINE COMPOSITES-SYNTHESIS, CHARACTERIZATION AND OPTIMIZATION FOR THERMOELECTRIC APPLICATIONS

Mousumi Mitra, Chiranjit Kulsi, Krishanu Chatterjee, Kajari Kargupta, Saibal Ganguly, Dipali Banerjee, Shyamaprosad Goswami Department of Physics, Indian Institute of Engineering Science and Technology (IIST), Shibpur, Howrah 711103, India. Department of Chemical Engineering, Jadavpur University, Kolkata-700032, India. Chemical Engineering Department, Universiti Teknologi Petronas, Bandar Seri Iskandar, 31750 Tronoh, Perak, Malaysia Department of Chemistry, Indian Institute of Engineering Science and Technology (IIST), Shibpur, Howrah 711103, India. Publication Date: April 7, 2015

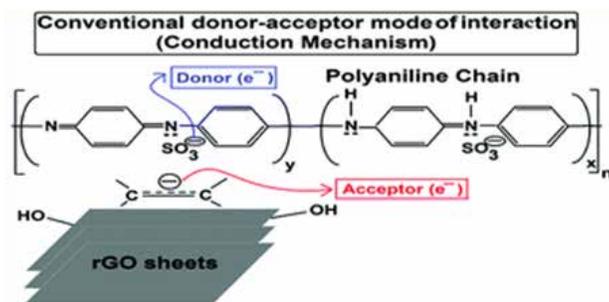
### ABSTRACT

Reduced graphene oxide (rGO) can improve the thermoelectric properties of polyaniline (PANI) by varying its concentration in composites of rGO nanosheets and PANI. The figure of merit (ZT) of rGO-PANI composites is increased with an increasing percentage of rGO (up to 50%), which is 7.5 times higher as compared to pure PANI. High resolution transmission electron microscopy (HRTEM), field emission scanning electron microscopy (FESEM) and X-ray diffraction (XRD) analyses show a uniform growth of PANI over the surface of rGO as a

template, leading to a more ordered structure with high crystallinity during polymerization. Compared to pure PANI, both the electrical conductivity and thermoelectric power of the rGO-PANI composite is higher due to the increased carrier mobility as confirmed by a Hall effect measurement. Fourier transform infrared spectroscopy (FTIR), ultra-violet visible range spectroscopy (UV-Vis) and Raman spectroscopy analyses reveal that strong  $\pi$ - $\pi$  interactions assisted the uniform distribution of PANI on the rGO nanosheets. Other strong interactions include electrostatic forces and

hydrogen bonding between rGO and PANI, which provide a route for constructing highly ordered chain structures with improved thermoelectric performance of PANI. There is no significant change in the thermal conductivity of the rGO-PANI composite as compared to pure PANI, which improves the thermoelectric performance of composite.

For Full Article go to: <http://pubs.rsc.org/en/Content/ArticleLanding/2015/RA/C5RA01794G#divAbstract>





JOURNAL OF EXPERIMENTAL NANOSCIENCE  
Volume 9, Issue 9, 2014

## METAL NANOLAYER FORMED BY TUNNELLING CURRENT THROUGH THIN OXIDE IN THE ELECTROLYTE–OXIDE–SILICON SYSTEM

Seok-Ha Lee<sup>a</sup>, Jun Ho Cheon<sup>b</sup>, Yeonkyu Choi<sup>c</sup>, Seongwook Choi<sup>a</sup> & Young June Park<sup>ab\*</sup>

### ABSTRACT

We propose a method of forming metal nanoparticles or layers on the oxide by tunnelling current of the EOS (electrolyte–oxide–silicon) system. Electrical characteristics of the metal layer and particles obtained

experimentally by the proposed method are compared with the electrolyte–metal–oxide–silicon and the metal–oxide–silicon systems. Also, it is shown that the instability of the EOS system is caused by the H<sup>+</sup> penetration into the oxide and is largely cured by applying

alternative voltage to extract the H<sup>+</sup> ions from the oxide. We show that the proposed technique can selectively deposit extremely thin metal layers on the active sites of the silicon surface in a self-alignment manner.



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## ELECTRICAL CONTROL OF NANOSCALE FUNCTIONALIZATION IN GRAPHENE BY THE SCANNING PROBE TECHNIQUE

Ik-Su Byun<sup>1,10</sup>, Wondong Kim<sup>2,10</sup>, Danil W Boukhvalov<sup>3,10</sup>, Inrok Hwang<sup>1,4</sup>, Jong Wan Son<sup>1</sup>, Gwangtaek Oh<sup>1</sup>, Jin Sik Choi<sup>1,5</sup>, Duhee Yoon<sup>6,7</sup>, Hyeonsik Cheong<sup>7</sup>, Jaeyoon Baik<sup>8</sup>, Hyun-Joon Shin<sup>8</sup>, Hung Wei Shiu<sup>9</sup>, Chia-Hao Chen<sup>9</sup>, Young-Woo Son<sup>3</sup> and Bae Ho Park<sup>1</sup>

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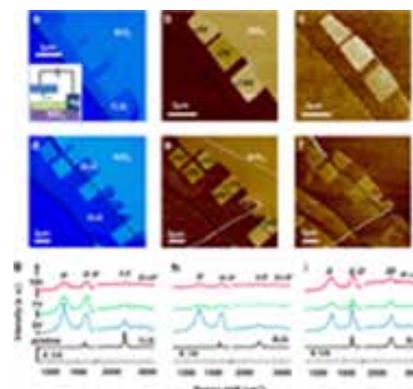
### ABSTRACT

Functionalized graphene is a versatile material that has well-known physical and chemical properties depending on functional groups and their coverage. However, selective control of functional groups on the nanoscale is hardly achievable by conventional methods utilizing chemical modifications. We demonstrate electrical control of nanoscale functionalization of graphene with the desired chemical

coverage of a selective functional group by atomic force microscopy (AFM) lithography and their full recovery through moderate thermal treatments. Surprisingly, our controlled coverage of functional groups can reach 94.9% for oxygen and 49.0% for hydrogen, respectively, well beyond those achieved by conventional methods. This coverage is almost at the theoretical maximum, which is verified through scanning photoelectron microscope

measurements as well as first-principles calculations. We believe that the present method is now ready to realize ‘chemical pencil drawing’ of atomically defined circuit devices on top of a monolayer of graphene.

For Full Article go to:  
<http://www.nature.com/am/journal/v6/n5/full/am201424a.html>



Fabrication and characterization of the three oxidized areas on 1–3LG. (a–f) Optical microscope (a, d), friction force microscopy (FFM) (b, e) and topographic atomic force microscopy (AFM) (c, f) images of pristine and oxidized (using applied voltages of +5, +7 and +10V) 1–3LG. The inset in (a) shows the schematic setup of oxidation lithography using AFM. (g–i) Raman spectra of these pristine and oxidized 1LG (g), 2LG (h) and 3LG (i), respectively.

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### Clean room-compatible

- An aluminum surface plate and body eliminate the possibility of air contamination, and also it requires no air supply.

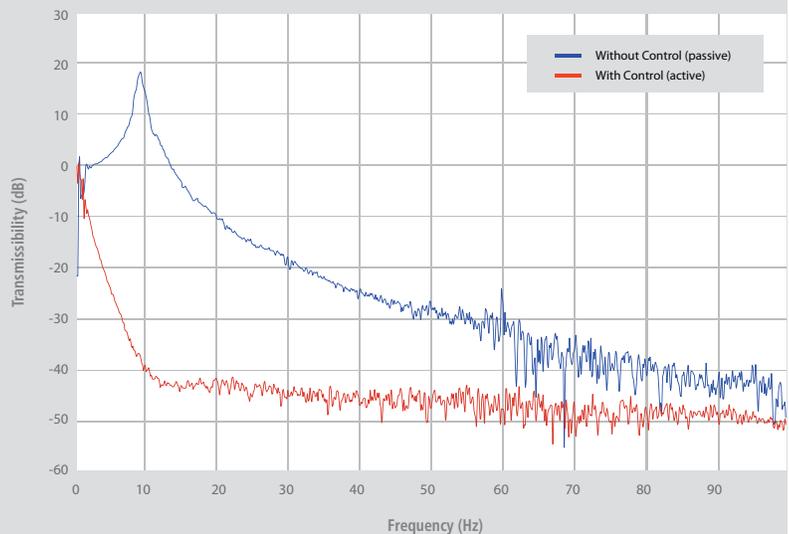
### LCD monitor (standard equipment)

- Accelerogram
- Acceleration response spectrum

### Automatic leveling & Clamping

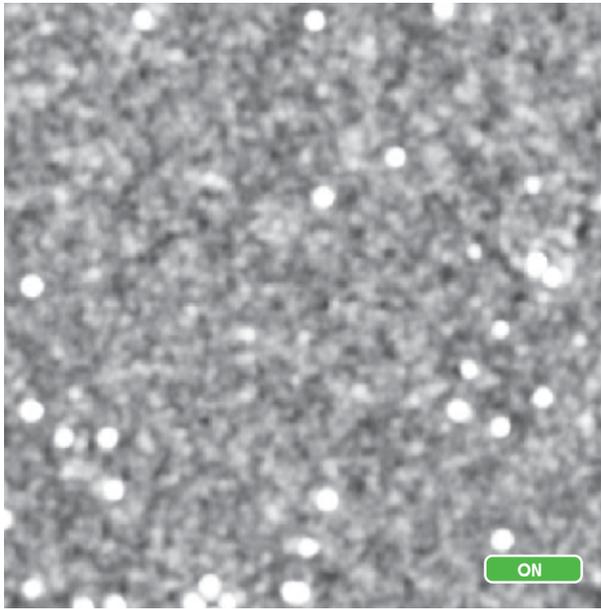
- You can activate automatic leveling and automatic clamping for transport with the push of a button.

6DOF active vibration control produces outstanding vibration isolation performance.

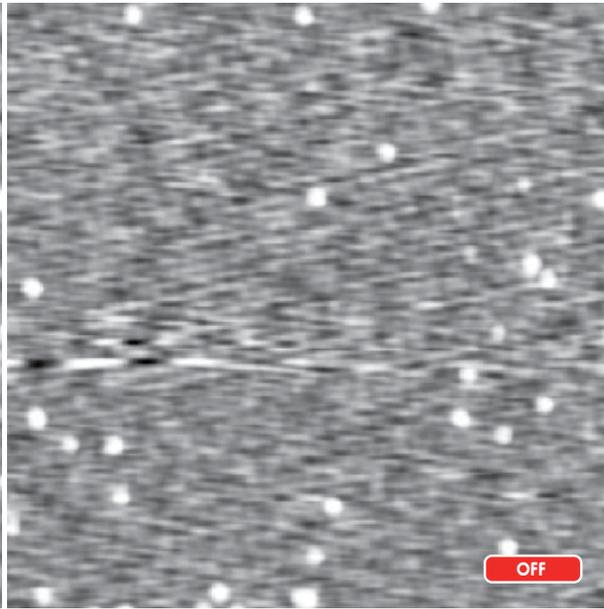


**WITH AVIT (Active Vibration Isolation Table)**

Gold nanoparticles supported on SiO<sub>2</sub> / Si (111)  
Scan size: 500 nm x 500 nm

**WITHOUT AVIT (Active Vibration Isolation Table)**

Gold nanoparticles supported on SiO<sub>2</sub> / Si (111)  
Scan size: 500 nm x 500 nm

**SPECIFICATION**

Dimension (W × D × H)	400 mm × 500 mm × 80 mm
Maximum load capacity (loading impartially)	120 kg
Product mass	19 kg
Power supply	AC 85 - 264 V single-phase 50/60 Hz
Isolation Technology	Across all frequencies, translation, and rotational directions (six freedoms).
Force Directions	Active compensation in all six degrees of freedom
Isolation Performance	5 Hz = 25dB, 10Hz = 40dB
Active Bandwidth	0.8 or less ~ 100 or more Hz
Max Compensation Level	0.35gal(rms) at 5Hz with a load of 60 kg
Stroke of the Actuator	2mm
Max Correction Forces V = Vertical	16N
Max Correction Forces H = Horizontal	8N
Repeatability of Load Adjustment	0.1mm

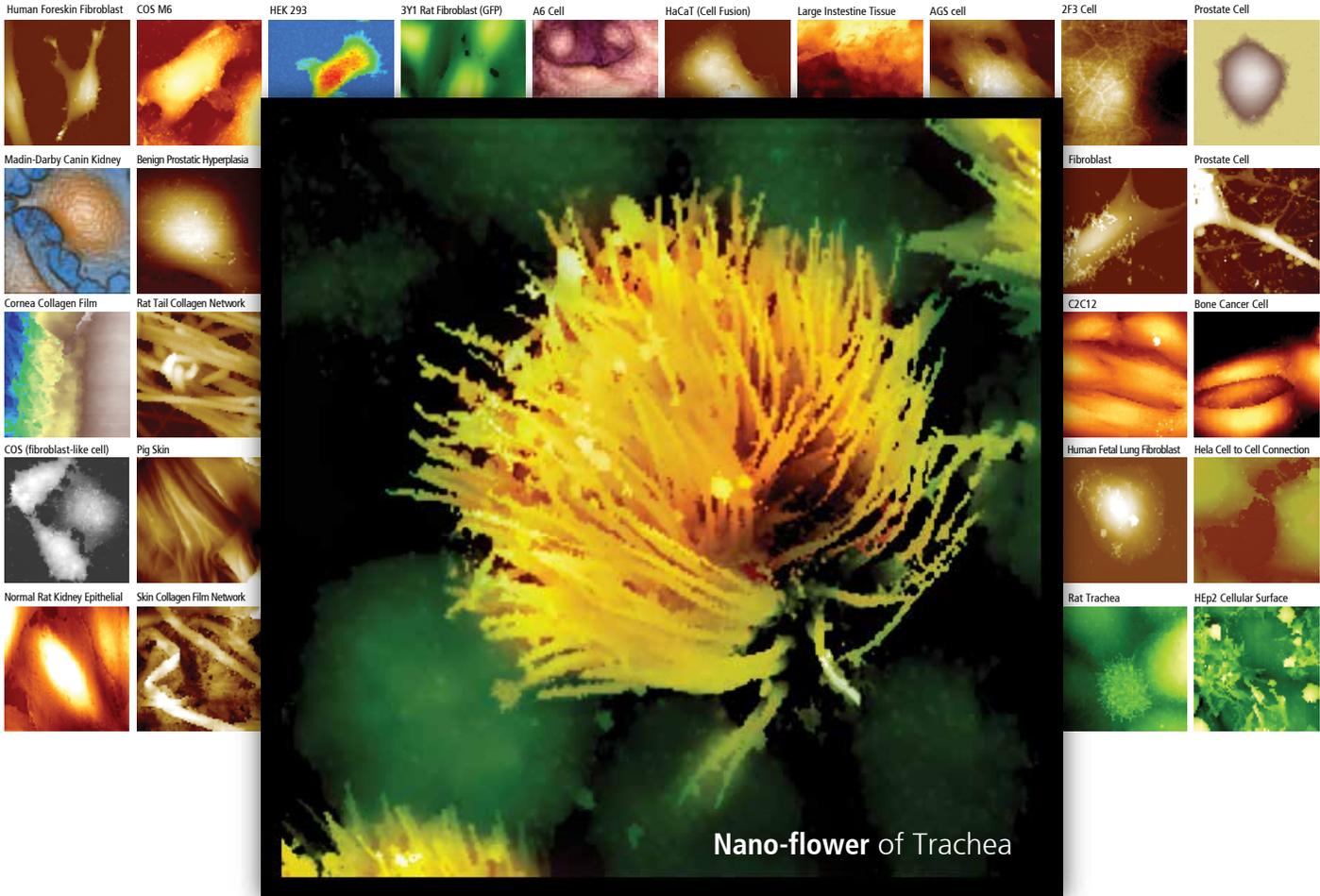


To learn more about Park special sales promotion,  
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# Cell Discovery like Never Before

## In-Liquid Biological Imaging with Park SICM



The main image above shows the world's first observation of tracheal tissue in aqueous condition. Scanning ion conductance microscopy (SICM) by Park Systems successfully imaged the tracheal tissue's luminal surface. Both the ciliated and non-ciliated cells of tracheal tissue are pictured with a particular focus on the hair-like appearance of ciliated cells. A small piece of the tissue was obtained from Wistar rats, then mounted on a glass slide and imaged using Park NX-Bio, a three-in-one microscopy system that combines SICM, an AFM (atomic force microscope) and an inverted optical microscope.

By using the SICM of Park NX-Bio, Professor Ushiki and his team from the Microscopic Anatomy division of Niigata University Medical School captured the ciliated cells of rat trachea in liquid. "We can directly acquire cell and tissue images in liquid condition and the resolution is comparable with SEM," said Prof. Ushiki. "With SICM imaging technique, we don't need to take [the] risk of sample damage that is often caused during SEM sample preparation, causing image artifacts."

Prof. Ushiki has been active in histology and anatomy research using SEM and SICM. Park's SICM has made live cell imaging in liquid not only possible but also practical for his research and routine imaging needs.

The SICM works like this: A glass nanopipette filled with an electrolyte acts as an ion sensor. It provides feedback on its location relative to a sample completely immersed in liquid. The nanopipette tip maintains its distance from the sample by keeping the ionic current constant, applying no force on the sample surface. This way, unlike SEM or AFM, samples are not damaged at all or even disturbed by the nanopipette tip, and physiological morphology can be measured in liquid condition.

Park NX-Bio by Park Systems is a powerful 3-in-1 scientific research tool at nanoscale that uniquely combines the industry's only True Non-Contact AFM with SICM and an inverted optical microscope on the same platform. Park Systems provides its customers with a complete range of SICM solutions including the system, options and software, along with global service and support.



To learn more about Park NX-Bio or to schedule a demo, please call: +1 (408) 986-1110 or email [inquiry@parkafm.com](mailto:inquiry@parkafm.com)

[www.parkAFM.com](http://www.parkAFM.com)

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