Park Quarterly Newsletter, May 2014 Vol 2.

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MESSAGE FROM PRESIDENT:

Research and engineering at nanoscale is the basis for the next industrial revolution. The vast potential of nanoscale technology to create opportunities with wide-ranging applications for improvements and advances in society is unlimited. *Supported by vast amounts of funding, researchers are investigating many new applications in medicine, manufacturing and industry, environmental regulation and national defense.

Park Systems is an industry partner in this pioneering research, supplying key scanning probe microscopy tools for next generation imaging solutions. Since the inception of Park's first commercial atomic force microscope (AFM) in 1989, Park Systems has been the leader in providing new technologies to enable nanoscale advances.

Technology applied in nanoscale helps us to understand how nanoscale particles interact with humans, animals, plants, and the environment. Through the expansion of continued research, we are able to gain new insights into bio science such as the examination of individual DNA cells and living cells which is available now using Park XE-BIO. These new advances in bio science are expected to lead to significant breakthroughs in effective and personalized healthcare.

Park Systems Automated Defect Review and powerful features like PinPoint Conductance AFM and QuickStep Scanning Capacitance Microscopy (SCM) make it possible for advanced electronics manufacturing with minimum defect in the midst of ever shrinking device geometries.

The field of nanoscale sciend and technology is highly diverseinvolving physics, chemistry, biology, medicine, and materials science. We plan to continue to stay at the forefront of leading edge and emerging advanced microscopy technologies, providing new ideas and innovations which has become our trademark by hiring highly skilled employees.

Park's expansion goals are primarily based on partnerships with our now over 1,000 customers for active joint research and engineering programs designed to bring new ideas from research into affordable commercial manufacturing. We employ scientists and a growing staff of more than 50 dedicated research and development engineers who work in collaboration with our research and industry partners to ensure cohesive products in AFM that align with industry's specifications.

Our future plans include increasing our staff so we can continue to provide the AFM industry with the technology and innovation they have grown to expect.

On behalf of all of Park's employees, we send you a clear message. We are committed to our mutual success in the boundless pursuit of excellence in microscopy. We enable nanoscale advances thru hard work, dedication and these achievements are brought to realization thru collaboration with all of you.

We look forward to exciting times ahead!

*The National Science Foundation projects it to constitute a $1–trillion-a-year megamarket by 2015 growing at an unprecedented rate of 30% annually.

SPOTLIGHT ON EMPLOYEE

Ardavan Zandiatashbar is an applications scientist at Park Systems. Prior to Park he worked as an adjunct faculty at School of Engineering, Rensselaer Polytechnic Institute, Troy, NY. Ardavan received his PhD in Mechanical Engineering for his work on studying multi-scale mechanical properties of graphene-filled epoxy nanocomposites in 2012. During his doctoral studies, he worked with Park Systems and Veeco AFM machines. His main research was performed using a Park XE-100 atomic force microscopy system to study the mechanical properties of defective graphene sheets in a collaborative effort with Columbia University. He has been also active in leadership and service and has been selected as a member of Phalanx Honor Society at Rensselaer.

Question: Dr. Zandiatashbar, you have done a lot of research on identifying defects in graphene, why is this a significant subject to study?

Answer: While in general culture "defect" is usually referred to an undesirable condition, in materials research we learn that defects are present everywhere and in any material, and they can be utilized to our interest. We can engineer the defects and design new materials. Pristine graphene is known to be the strongest material in the world. However, we were interested in learninghow it responds in presence of defects. In significant number of applications, graphene is not used in its pristine form. For example, in DNA-decorated graphene structures the presence of defects is essential for bonding DNA to graphene structure. As another example, graphene fillers that are used in production of lightweight composite materials are containing large number of defects. Although the defects diminish the superior stiffness and strength of pristine graphene, their presence could help to form interfacial bonding with the surrounding matrix. The last but not the least, graphene oxide (GO) has shown promising semiconductor properties. So if a device is made of GO, knowing its mechanical properties becomes essential for the design and fabrication of the device. On the other hand, in order to use graphene in industrial applications, its production needs to be scalable. Graphene in production scale could be different from the graphene produced for research purposes in terms of quality. Therefore, quality control of graphene using non-destructive methods becomes very important. All of the aforementioned reasons gave us enough motivation to study defects in graphene.

Question: What are other areas of industry that might use graphene?

Answer: Currently graphene is extensively studied by many researchers and scholars in both academia and industry. Thanks to its unique properties like transparency, electrical and thermal conductivity, and mechanical properties, it is expected to be utilized in a variety of applications. Lightweight composite materials made by using graphene fillers have been already commercialized. Prototypes of flexible touchscreens using graphene have been already fabricated. Besides researchers has made interesting devices using graphene for energy storage and high performance batteries. It has many more applications in electronics, data storage, sensors, water purification, and conductive inks.

Question: How is Atomic Force Microscopy used to help understand how the mechanical properties of graphene and other substrates are influenced by defects?

Answer: AFM is a unique technique that provides many ways of observation and manipulation of materials and their different properties at very small scales. One helpful feature in AFM is force-displacement spectroscopy, which is widely used. Since a graphene sheet is only one-atom thick, performing mechanical testing on it is very delicate, and requires high levels of accuracy, care, and precision. First you need to image in non-contact mode to avoid damaging the defective graphene samples by a sharp tip, and then you need to select the exact probing spot which won't be possible without AFM closed loop XY scanners. After going to the right position, force-displacement spectroscopy is utilized to test the material.The separated Z and XY scanners, made this experiment very robust and straight-forward.

Question: What advances in 3D Atomic Force Microscopes can help in the analysis of materials such as graphene?

Answer: Currently the semiconductor industry is moving towards smaller nodes, and critical dimensions become more and more important and difficult for measurement with conventional 2D AFM. While AFM scanners are still able to provide the required resolution, there are limitations due to the tip shape and its angle with respect to the sample during the scan. The 3D AFM technique provided by Park Systems, a.k.a. 3DM, has provided a unique way of utilizing AFM forthese applications. Not only limited to critical dimension, 3DM is able to investigate the sidewall roughness and reach the spots on the sample that conventional 2D AFM cannot do. On the other hand, in 2013 researchers introduced 3D graphene materials. Now different 3D structures are being produced using graphene. Overall, I can think about various ways of utilizing 3DM to study graphene like 3D graphene structures, graphene deposited on 3D substrates, manipulating and lithography of graphene devices, and so forth. Note that 3DM can be used not only for topography imaging of the sample, but also for measurements of different properties.

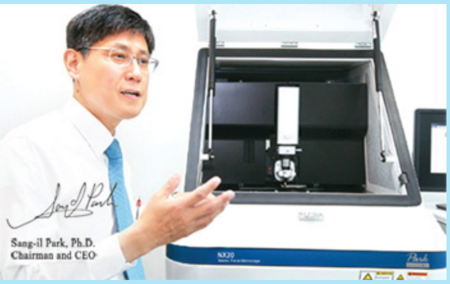
Question: What do you feel are the best features of the Park Systems AFM products?

Answer: When I started using AFM for my research, I had the chance to work with different AFM systems. At that time, I favored Park XE-100 more than the others especially due to its ease of use. Comparing to other AFM systems I had used, the data acquisition and image analysis software packages of Park XE-100 were not only very user-friendly, but also providedthe essential features that I needed for performing my research studies consistently and in a timely manner. In addition, the non-contact mode and closed loop XY scanner, made us able to find the unique spots on the substrate without damaging the samples during the scans, perform our experiments, and verify our results. And to my opinion, putting on the tips was one of the coolest aspects of working with Park XE-100 comparing to other AFM systems!

Question: What are the latest and most relevant innovations in nanoscale material research?

Answer: The nanoscale material research is developing rapidly and present new discoveries almost on a day-to-day basis. There are many interesting news of innovations being published recently. While graphene researchers developed their techniques significantly and was able to learn more on how to work with graphene as a 2D material, now their techniques and know-hows are utilized to study other 2D materials like nitrides, dichalcogenides, and oxides. With so many 2D materials possessing a variety of properties, I am looking forward to seeing new devices and technologies coming to existence and eventually to the market.

PARK SYSTEMS CEO DR. SANG-IL PARK PRESENTER AT MRS SPRING

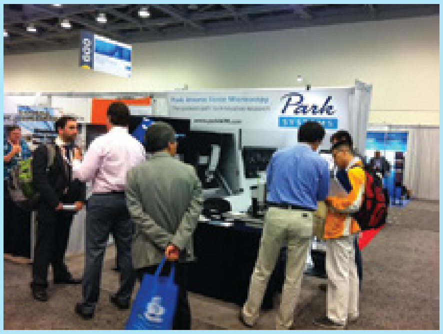


Founder and CEO, Dr. Sang-il Park was a presenter at the MRS Spring Meeting in San Francisco. The presentation titled **Crosstalk Eliminated Atomic Force Microscope and Dimensinal Nanometrology for Inline Manufacturing Control** was given on April 23 at 11am in room 3010, level 3 Moscone West.

Dr. Park's presentation covered Park Systems exclusive innovative AFM platform developed to eliminate cross-talk between the XY and Z scan enabling 3D non contact mode automatic defect review. Park Systems's unique innovative methodology features non-destructive sample scans and longer tip life. The result not only highly reduces costs but also vastly improves productivity, leading to astounding cost savings for manufacturers.

Park Systems recently achieved a commanding market share in the disc storage market through a focused effort on customer needs and performance requirements. It continues to expand into other industries that demand excellence in nanoscale AFM microscopy.

"Park is the only AFM enabling nanoscale advances such as the 3D scanning with rotated head and automated defect review," states Keibock Lee, President of Park Systems.



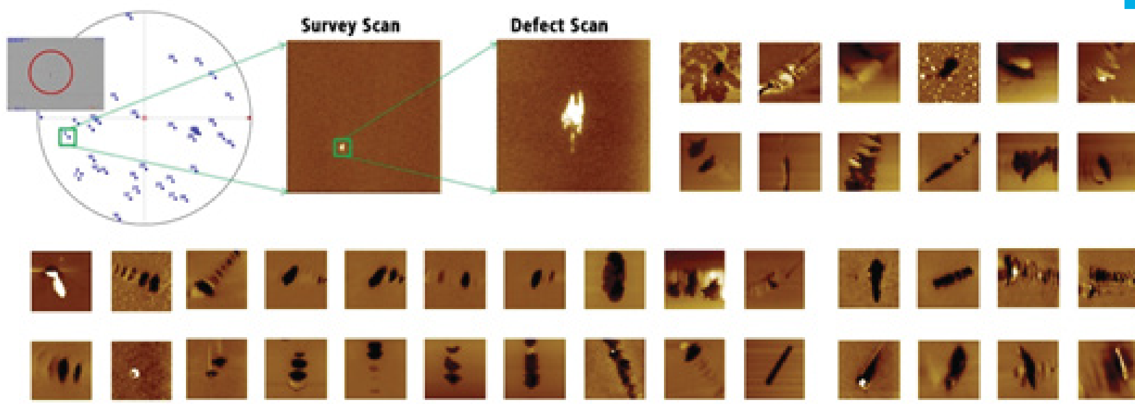
"We have become the leader in nanotechnology design by constantly outperforming our competition, and creating ways to replace or upgrade AFM equipment and technology that align with the customer's objectives of accuracy and productivity."

Read more.

PARK SYSTEMS INTRODUCES AUTOMATIC DEFECT REVIEW FOR SEMICONDUCTOR WAFERS - AN ASTOUNDING 1,000 % THROUGHPUT INCREASE

Park Systems, a leading manufacturer of atomic force microscopy (AFM) products, proudly introduces the new NX-Wafer Automatic Defect Review (ADR), for 300mm bare wafer a fully automated process that improves throughput by up to 1,000 %. Park NX- Wafer ADR is a new process for identifying defects designed specifically for the semiconductor market without the need of reference markers. In terms of accuracy and productivity, Park's new ADR process speeds up and improves the way defects are imaged and analyzed compared with more traditional manual methods of defect review on the market. Furthermore, it is able to do this without the laborious and often damaging reference marks created. Additionally, this new Park ADR offers a significantly longer tip life than competitors by 10x~20x thanksto Park Systems patented True Non-Contact™ Mode AFM technology.

"This new advanced Park ADR is designed specifically for Semiconductor engineers and researchers to replace the old process of identifying nanoscale defects which was time consuming and greatly hindered throughput", comments Sang-il Park, Chairman and CEO Park Systems.



"We used our highly successful AFM model widely accepted as the industry standard in the hard disk market to create a product to improve ADR for the Semiconductor Wafer industry with the clear goal of improving accuracy and productivity for our customers."

Park Systems new 300mm bare wafer ADR solution if a fully automated ADR AFM review process from transfer and alignment of defect maps to the survey and zoom-in scan imaging of defects that uses a unique remapping process and enhanced vision that does not require any reference marker on a sample wafer. Unlike SEM which leaves destructive irradiation marks, square-shaped, on defect sites after its run, the Park ADR enables advanced coordinate translation with enhanced vision that uses the wafer edge and notch to automatically enable the linkage between a defect inspection tool and Park AFM. Since it is fully automated, it does not require any separate step to calibrate the stage of the targeted defect inspection system, increasing throughput by up to 1,000 percent. Read more.

"CONDUCTIVE AFM IS AN IMPORTANT TOOL FOR DEVICE RESEARCH AND FAILURE ANALYSIS AND WITH THE INTRODUCTION OF PINPOINT CONDUCTIVE AFM TECHNOLOGY, PARK SYSTEMS HAS SUCCEEDED IN SOLVING ALL OF THE SHORTCOMINGS OF CONVENTIONAL CONDUCTIVITY AFM"

KEIBOCK LEE, PARK SYSTEMS PRESIDENT

"IN TERMS OF THE SCOPE AND THROUGHPUT OF THE AUTOMATION, THE 300MM BARE WAFER ADR IS THE ONE AND ONLY AFM SOLUTION FROM PARK" WITHOUT ANY MATCH IN THE MARKET

RYAN (YK) YOO, VICE PRESIDENT OF GLOBAL SALES AND MARKETING.

"WE HAVE BECOME THE LEADER IN NANOTECHNOLOGY DESIGN BY CONSTANTLY OUTPERFORMING OUR COMPETITION, AND CREATING WAYS TO REPLACE OR UPGRADE AFM EQUIPMENT AND TECHNOLOGY THAT ALIGN WITH THE CUSTOMER'S OBJECTIVES OF ACCURACY AND PRODUCTIVITY."

DR. SANG-IL PARK, CEO & FOUNDER PARK SYSTEMS

"OUR RECENT SUCCESSES, WHICH INCLUDE CAPTURING A DOMINANT MARKET SHARE OF THE HARD DISC INDUSTRY MARKET, WERE ACCOMPLISHED BY SIMPLY OUTPERFORMING OUR COMPETITION. THE CONVENTIONAL AFM TECHNOLOGY STILL EMPLOYED BY OUR MAJOR COMPETITORS HAS BEEN RIDDLED WITH PROBLEMS AND LIMITATIONS RELATED TO FUNDAMENTAL ASPECTS OF INSTRUMENT DESIGN.

TO REMEDY THESE ISSUES, PARK CREATED A NEW ARCHITECTURE, AND PERFECTED THE NON-CONTACT MODE, WHICH HAS DRASTICALLY INCREASED ACCURACY AND USABILITY WHILE BRINGING DOWN THE TOTAL COST OF OWNERSHIP OF AFM TOOLS. THE PERFORMANCE OF OUR NON-CONTACT TECHNOLOGY HAS MADE OUR INSTRUMENTS VERY ATTRACTIVE TO HARD DISK MANUFACTURERS."

PARK SYSTEMS FEATURED IN SOLID STATE TECHNOLOGY MARCH 2014

FAILURE ANALYSIS AND THE INNOVATIVE PINPOINT CONDUCTIVE AFM

By Keibock Lee, Park Systems Inc.

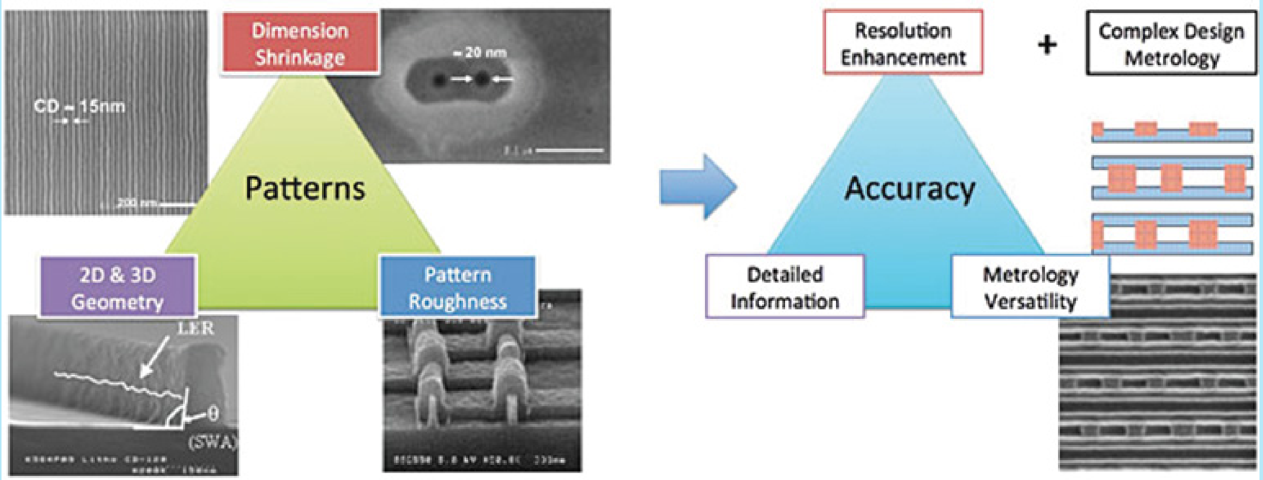
Introduction

One of the most challenging issues in the semiconductor industry is the failure analysis (FA) investigation of devices with enduringly shrinking geometries down to single digit nanometer trench widths. The complexity of such semiconductors means that the task of identifying sources of failure is extremely refined, sophisticated and difficult to perform. The most utilized current systems, such as scanning electron microscopes (SEMs) and focused ion beams (FIBs),have a limited measurement and property characterization modes beyond imaging of the sample, and destructive in high resolution. Therefore, the alternate solution of higher spatial resolution that can provide electrical property information has been more of a necessity than an option. The powerful conductive atomic force microscopy (AFM) is one of the technological advances in the field of AFM and provides an effective solution to the respective FA problems. However, the conventional conductive AFM technique requires a tradeoff between the spatial resolution and the current signal. Therefore, there was a need for the introduction of an innovative method that would allow FA engineers to overcome the disadvantages of conventional Conductive AFM. The introduction and the subsequent implementation of PinPoint Conductive AFM (PinPoint iAFM)by Park Systems offers frictionless conductivity scanning and excellent high spatial resolution and sensitivity with a very high signal-to-noise ratio. In this paper, I will explain how Conductive AFM can solve the FA problems faced by engineerswith respect to SRAM (static random access memory) cells as one of application examples. Subsequently,I will discuss the limitations of the conventional Conductive AFM and how the novel PinPoint iAFM effectively solves those issues, thereby providing the optimum solution for the FA engineers. Read more.

Park Systems Featured in Jan 2014 Issue Quality Magazine

INNOVATIVE 3D AFM TECHNOLOGY FUELS SEMICONDUCTOR, RESEARCH AND INDUSTRIAL QUALITY CONTROL

One of the most essential issues in the semiconductor industry is the fabrication and the subsequent implementation of integrated circuits (ICs) with enduringly smaller feature sizes. The manufacturing of circuits with continuous shrinking critical dimensions (CD), not only expands the existing applications of semiconductors but also propels the demand for designs at the nanoscale level in the respective markets. However, they simultaneously call for novel apparatuses that need to cope with metrology requirements including high resolution, accuracy, and cost-effective precision. The traditional metrology tools such as CD-SEM, scatterometry, and optical lithography have proved to be inadequate and inaccurate at such low scales. Therefore, there has been a need for developing new, refined, and easy-to-use apparatuses that will ultimately overcome the intrinsic limitations of the existing metrology techniques. This article unfolds the principles of the new Park 3D atomic force microscopy (AFM) developed by Parks Systems. It is based on Park's unique AFM architecture with independent flexure XY scanner and Z rotating head, its True Non-Contact™ technology and advanced electronics which allows for the acquisition of high-resolution images of sidewalls and undercut features.



EXISTING METROLOGY TOOLS AND THEIR LIMITATIONS

The major technological necessity in the semiconductor industry is the development of circuits that have been shrinking critical dimensions continuously. Consequently, the respective metrology requirements for the development of such advance nodes need to be strict, and focus on precision, enhanced accuracy, and high resolution. Hence, the characterization of various parameters such as the Line Edge Roughness (LER), Line Width Roughness (LWR) and Sidewall Roughness (SWR) is of upmost importance due to the fact that they underline and define the device performance.

The current metrology tools cannot keep pace with the challenges imposed by lowering the CDs. Optical lithography was initially used for the creation of patterns in the manufacturing of semiconductors. However, as the dimensions of the circuits get smaller, this technique is limited in resolution. Moreover, an additional apparatus for measuring such parameters involves the scanning electron microscope (SEM). This method can provide automation and compatibility with low critical dimensions. However, it cannot offer the user with the acquisition of high resolution LER data (its resolution reaches it limits). Therefore, the demand for an innovative and cost-effective system that can fully characterize all critical parameters while it can simultaneously image all surfaces of the pattern has emerged.

PARK SYSTEMS NON CONTACT 3D AFM AND ITS INNOVATIVE FEATURES

The basic principle of Park non-contact 3D-AFM is that the cantilever rapidly oscillates just above the surface of the sample under investigation. One of its unique features is the implementation of an independent Z-scanner that is decoupled from the respective XY scanner. Therefore, and by using a very high performing Z-servo feedback, this method deters any physical contact between the surface of the sample and the tip of the cantilever (true non-contact AFM). In fact, the mechanical response of the Z-scanner must be very fast to track the respective changes (tip-sample interactions) and, hence prevent the tip from contacting the sample surface.

Furthermore, the implementation of the independent Z scanner offers the advantage of incredibly high Z-linearity while at the same time improving its Z-scan bandwidth. Read more.