Wednesday Afternoon, October 31, 2012

Helium Ion Microscopy Focus Topic
Room: 19 - Session HI+AS+NS-WeA

Basics of Helium Ion Microscopy
Moderator: A. Gölzhäuser, University of Bielefeld, Germany

2:00pm **HI+AS+NS-WeA1 Basics of Imaging with Ions**, ***D. Joy***, University of Tennessee **INVITED**

Imaging with a helium ion microscope (HIM) offers numerous advantages, both fundamental and practical, as compared to a conventional scanning electron microscope (SEM). At the same time, however, many aspects of ion microscopy seem very different to those found in the SEM In this presentation therefore we will examine ;

Why ions are a better choice for imaging than electrons and which ion (or ions) might be the best

In which areas of performance and operation the ion beam image is 'better'

The optimum beam energy for ion imaging for different materials; how typical imaging conditions compare to those for the SEM; and why they are different

The types of signals that are available for imaging in the ion microscope and how they compare with their electron beam counterparts

The problems of specimen charging and beam damage with the ion beams

The options available for microanalysis with the HIM

2:40pm **HI+AS+NS-WeA3 Surface Analysis using Channeling Contrast in NUHV Helium Ion Microscopy**, ***B. Poelsema***, University of Twente, Netherlands **INVITED**

Helium Ion Microscopy, HIM, is a novel high-performance technique to image surfaces and with its high resolution, great surface sensitivity, enhanced material contrast, ability to investigate insulating material and large depth of field, it provides a viable alternative to classical scanning electron microscopy. A number of applications require improved vacuum conditions to achieve ultimate performance. The sharply focused He ion beam is, compared to an electron beam in SEM set-ups, very efficient in decomposing, e.g., hydrocarbons present in the chamber and thus on the sample surface, which may obscure a clear view of the sample. Where this phenomenon is beneficial for high resolution structuring, it may well negate the benefits of small spot size and reduce the acquisition time available for spectroscopy in material analysis. To substantially reduce this problem a Near UHV version of the HIM has been developed in close collaboration between the manufacturer, Carl Zeiss NTS, LLC and our group at the University of Twente [1].

We will report on a number of recent observations with special attention for a new contrast mechanism, i.e. dechanneling of ions that extends the high surface sensitivity – usually achieved in secondary electron images – to backscattered ions. We demonstrate [2-4] how monolayer "thick" organic and inorganic films, as well as self assembled monolayers can be visualized, even when adsorbed on heavier substrates, by changes in the backscatter yield. Normally thin layers of a light element on a heavy substrate are "invisible" in backscattered ion yields. The results can be explained semi-quantitatively in terms of changes of the channelling probability. These results highlight the relevance of proper vacuum conditions for achieving monolayer sensitivity.

[1] R. van Gastel, L. Barriss, C. Sanford, G. Hlawacek, L. Scipioni, A.P. Merkle, D. Voci, C. Fenner, H.J.W. Zandvliet and B. Poelsema: Microscopy and Microanalysis **17(S2)**, 928-929 (2011)

[2] A. George, M. Knez, G. Hlawacek, D. Hagedoorn, H.H.J. Verputten, R. van Gastel and J.E. ten Elshof: Langmuir **28(5)**, 3045-3052 (2012)

[3] G. Hlawacek, V. Veligura, S. Lorbek, T.F. Mocking, A. George, R. van Gastel, H.J.W. Zandvliet, B. Poelsema: submitted

[4] V. Veligura, G. Hlawacek, R.van Gastel, H.J.W. Zandvliet, B.Poelsema: submitted

Acknowledgments: Gregor Hlawacek, Vasilisa Veligura, Raoul van Gastel, Harold J.W. Zandvliet.

4:00pm **HI+AS+NS-WeA7 Evaluation of W(111) Gas Field Ion Sources Based on Single Atom Tips**, ***R. Urban***, University of Alberta and The National Institute for Nanotechnology, Canada, *J.L. Pitters,* National Institute for Nanotechnology, NRC Canada, *R.A. Wolkow*, University of Alberta and The National Institute for Nanotechnology, Canada

Atomically defined tips gained significant attention over the past decade because they serve as high brightness electron and ion sources. The success of the Scanning Helium Ion Microscope is dependent on the development of an appropriate Gas Field Ion Source (GFIS) to generate the helium ion beam. Single atom tips (SATs) represent a unique subgroup of atomically defined tips where emission only occurs from a single atom at the tip apex. Small virtual source size makes these tips attractive candidates for advanced scanning imaging applications such as SEM, TEM, and scanning ion microscopy (SIM) as well as for non-staining ion beam writing applications.

In this study SATs were fabricated from single crystal W(111) wire using a gas and field assisted etching process. By carefully controlling etching parameters SATs with extraction voltages between 5 and 17 kV were formed for various tips. During tip formation, we also used neon as an imaging gas to evaluate a W(111) tip shape during nitrogen-assisted etching. The neon image allows for the observation of atomic structure not available while imaging with helium and helps to elucidate the atomic structure of the tip during and after the etching to a single atom. The field ion microscopy (FIM) patterns (intensity maps) from SAT were fitted with 2D Gaussian curve to evaluate ion beam divergence and amplitude. The divergence of helium beam with respect to helium pressure and applied voltage will be discussed for various SATs.

Angular current density of various SATs was evaluated from their FIM patterns recorded by a microchannel plate and ion current measurements using a Faraday cup. The volume under the 2D Gaussian surface was found to be directly proportional to total ion current carried by an ion beam. The ion current was found to be linearly proportional to He pressure. However, comparing various tips it was found that the ion current increased faster than the extraction voltage. This suggests improved He capture by a broader tip base. The effect of the shape of the base of the tip was also evaluated and it was found that the beam opening angle varied with the size of the tip base leading to a forward focussing effect. The relative angular current densities from SATs supported on different tip curvatures were also evaluated and found to increase at a faster rate than current, also indicating that a forward focusing effect was in effect. This indicates that SATs on large bases would prove optimal for ion current generation in a scanning ion microscope.

4:20pm **HI+AS+NS-WeA8 Single-atom Tip as an Emitter of Gas Field Ion Sources**, ***I.-S. Hwang***, *H.-S. Kuo,* Academia Sinica, Taiwan, Republic of China, *T.-Y. Fu,* National Taiwan Normal University, Taiwan, Republic of China, *J.-L. Hou, C.-Y. Lin, Y.-H. Lu, W.-T. Chang, T.T. Tsong*, Academia Sinica, Taiwan, Republic of China

Thermally and chemically stable single-atom tips (SAT) or nanotips are highly desirable for emission of high-brightness gas field ion beams. In 2001, Fu et al. demonstrated a Pd-covered W(111) SAT through vacuum deposition of an ultra-thin Pd film on a clean W tip surface followed by thermal annealing [1]. Later, Kuo et al. further simplified the preparation process by replacing the tip cleaning and the vacuum deposition with electrochemical processes and successfully prepared several different types of noble metal-covered W(111) SATs [2]. This type of SATs is thermally stable and chemically inert, and thus can be regenerated through a gentle annealing if the apex is contaminated.

We have successfully generated hydrogen, helium, argon, and oxygen ion beams using a Ir/W SAT and characterized these ion sources [3]. The first two lightest ions provide the lowest sputtering rates, which is beneficial for scanning ion microscopy. The argon ion has a large mass and can provide a high sputtering rate, suitable for ion milling. Due to the high secondary ion yields, an oxygen ion beam may be applied to secondary ion mass spectrometry. The ion beam profiles indicate that the half opening angle is ~0.5°. This single spot indicates that emission occurs only from the topmost atom. This small source size and the small opening angle are particularly favorable for achieving high angular intensity, high brightness, and low spherical aberration, which are important characteristics for a focused ion beam system. The ion current of these gas ion beams are very stable and the tip does not show any degradation under fields above 5 V/Å after a total operation time of 80 hours. Since the SAT can be regenerated for more than 50 times, therefore its lifetime is long enough for most practical applications.

In addition, we have also prepared a pure iridium SAT based on oxygen-induced crystal faceting of the Ir(210) [4]. We have shown that the Ir-SAT can be a good field ion emitter, capable of emitting a variety of gas ion beams, including He^+, H_2^+, N_2^+, and O_2^+, with high brightness and stability. In particular, nitrogen is a very corrosive gas for metal tips under strong positive electric fields. If we can achieve a stable emission of nitrogen ion, it also means many other gas field ion beams may also be emitted from this Ir-SAT. This may greatly broaden the application of focused ion beam technology.

[1] T.-Y. Fu et al., Phys. Rev.B **64** (2001), 113401.

[2] H.-S. Kuo et al., Nano Lett. **4** (2004), 2379.

[3] H.-S. Kuo et al., Appl. Phys. Lett. **92** (2008), 063106.

[4] H.-S. Kuo et al., Nanotechnology **20** (2009), 335701.

4:40pm **HI+AS+NS-WeA9 Helium Ions for Imaging and Nanofabrication on the nm Scale**, ***E. Van Veldhoven***, *H.H.P.Th. Bekman, F.T. Molkenboer, N.B. Koster, D.J. Maas*, TNO Technical Sciences, The Netherlands

The Helium ion microscope (HIM, Zeiss Orion Plus™) has unique features. This microscope unravels a new application area for imaging sensitive and charging surfaces with (sub) nm resolution [1]. The beam-sample interaction generates secondary electrons with low energy and a low quantity of backscattering ions. These properties are very interesting for using the microscope not just for imaging only, but for nanofabrication too [2]. To explore all the capabilities for nanofabrication, the HIM is equipped with a pattern generator (Raith Elphy Multibeam™) and a gas injection system (Omniprobe Omnigis™) to explore direct write, lithography and gas induced applications.

In this contribution we would like to focus on imaging charging materials and our latest results for using the HIM for developing new applications for mainly the Semiconductor Industry. We consider a few HIM-based methods for TEM sample preparation. It is possible to use the HIM for making a thin wedge without significant artifacts like bubble formation and amorphization. With the gas injection system we develop new recipes for very local deposition and etching. These recipes are used for feasibility studies for mask repair and circuit editing. The helium ion microscope offers a novel way for nanofabrication and imaging on the nm scale.

5:00pm **HI+AS+NS-WeA10 Towards Secondary Ion Mass Spectrometry on the Helium Ion Microscope**, *T. Wirtz*, ***N. Vanhove***, *L. Pillatsch, D. Dowsett,* Centre de Recherche Public – Gabriel Lippmann, Luxembourg, *S. Sijbrandij, J. Notte*, Carl Zeiss

The ORION Helium Ion Microscope (HIM) has become a well-established tool for high-resolution microscopy [1]. The high brightness ALIS gas field ion source can operate with helium and, after special prototype modifications, with neon [2]. However, the detection of backscattered atoms can provide only limited specimen composition information. By contrast, Secondary Ion Mass Spectrometry (SIMS) is an extremely powerful technique for analyzing surfaces due to its excellent sensitivity, high dynamic range, very high mass resolution and ability to differentiate between isotopes. In order to get chemical information with a higher sensitivity and a high lateral resolution, we have investigated the feasibility of performing SIMS on the HIM.

Therefore, the secondary ion formation process under He^+ and Ne^+ bombardment has to be investigated and optimized. To investigate secondary ion formation an experimental study was performed; to investigate sputtering effects on resolution and practical implementation aspects a simulation approach was taken.

First, secondary ion yields for different elements sputtered from different materials exposed to helium and neon ion beams were experimentally determined on a test set-up. The basic yields could be increased by several orders of magnitude by using reactive gas flooding (i.e. O_2 and Cs^0 [3,4]). Afterwards, detection limits have been calculated taking into account the experimentally obtained useful yields. Depending on the dwell time, ppm sensitivity can be obtained for Ne^+ bombardment on silicon with oxygen flooding. Second, a detailed study of the sputtering phenomena using TRIM simulations was carried out in order to determine the effect of the collision cascade on the lateral resolution. The diameter (FW_{50}) of the area from which sputtered atoms originate has been determined for 10 keV He^+ and Ne^+ bombardment on different materials. While the obtained results are very encouraging, the practical instrumentation aspects have to be investigated as well in order to obtain a high secondary ion transmission and maintain the excellent primary beam characteristics. Therefore, the practical limitations imposed by adding an extraction system to the HIM have been studied in detail with respect to the extraction geometry.

In general, the combination of high-resolution microscopy and high-sensitivity chemical mapping on a single instrument will lead to a new level of correlative microscopy.

[1] L. Scipioni *et al.*, J. Vac. Sci. Technol. B **27**, 3250 (2009)

[2] F. Rahman *et al.*, Scanning **33**, 1 (2011)

[3] K. Franzreb *et al.*, Surf. Sci. **573**, 291 (2004)

[4] P. Philipp *et al.*, Int. J. Mass Spectrom. **253**, 71 (2006)

Helium Ion Microscopy Focus Topic
Room: 19 - Session HI+AS+BI+NS-ThM

Imaging and Lithography with the Helium Ion Microscope
Moderator: A. Gölzhäuser, University of Bielefeld, Germany, V.S. Smentkowski, General Electric Global Research Center

8:40am **HI+AS+BI+NS-ThM3 Helium Ion Microscopy of Photonic Structures in Biological Systems**, ***S.A. Boden***, *A. Asadollahbaik, H.N. Rutt, D.M. Bagnall*, University of Southampton, UK **INVITED**

The natural world is replete with examples of biological systems that have developed complex micro- and nano-scale structures to interact with light. Such structures, which include thin film multilayers, diffraction gratings, graded index layers and 2D and 3D photonic crystals, acting alone or in combination, allow the realization of a range of optical effects that would be impossible through the use of pigmentation alone. These effects range from the vivid iridescence observed on the skin of some species of bird, through the vibrant metallic sheen of some beetle species, to the dramatic interference patterns seen on the transparent wings of some species of fly. Lepidoptera (an order of insects that includes butterflies and moths) also provides a rich seam of examples of structural color ranging from the antireflective nipple arrays found on the eyes and wings of some species of moth to the photonic crystal structures producing vivid coloration on the wings of some butterfly species.

As these optical effects are a result of the scale of these structures being at or below that of visible light wavelengths, scanning electron microscopy (SEM) is often used to explore their form and to offer insights into their function. Recently, helium ion microscopy (HIM) has emerged as a surface imaging technique, similar to SEM but with the benefits of higher resolution and a larger depth of field. Here, HIM is used to probe the structures responsible for a number of optical effects observed in Lepidopterans. Images will be presented showing the fine details of the ribs and cross-ribs found on the highly-absorbing black ground wing scales of *Papilio ulysses* (Blue Mountain Butterfly) and the complex gyroid 3D photonic crystal structure observed underneath the top lamina on vividly green wing scales from *Parides sesostris* (Emerald-patched Cattleheart). Other examples will include the antireflective close-packed nipple array on the wings of *Cephonodes hylas* (Pellucid Hawk Moth), and cross-sections of the multilayer structures that make up the various colored wing scales of *Chrysiridia rhipheus* (Madagascan Sunset Moth).

The integrated electron flood gun on the helium ion microscope is employed to neutralize charge build-up, allowing samples to be imaged without the need of a conductive coating. This ensures that the natural surface itself is imaged at high resolution and details are not obscured by coating artefacts. In addition, by taking advantage of the large depth of field available with HIM, stereo pairs are generated to extract information on the three-dimensional nature of these structures.

9:20am **HI+AS+BI+NS-ThM5 Imaging of Carbon Nanomembranes (CNM) and Graphene with Helium Ion Microscopy**, ***H. Vieker***, *A. Beyer, A. Polina, A. Willunat, N.-E. Weber, M. Büenfeld, A. Winter, X. Zhang, M. Ai, A. Turchanin, A. Gölzhäuser*, Bielefeld University, Germany

We present a Helium Ion Microscopy (HIM) study of carbon nanomembranes (CNMs). CNMs are extremely thin (~1 nm) nanolayers consisting only of surface. They are made via cross-linking of self-assembled monolayers (SAMs) with large-area exposures of electrons, photons or helium ions and a subsequent transfer to suitable substrates. Patterned radiation exposures allow the fabrication of perforated nanomembranes, e.g., nanosieves. After annealing at temperatures above 800K, CNMs become conductive and eventually transform into graphene. HIM images of CNMs with different precursor molecules are shown, and images of graphene from SAMs are compared with the CVD grown graphene. Capabilities of the HIM imaging of freestanding CNMs and graphene will be discussed.

10:40am **HI+AS+BI+NS-ThM9 Dopant Contrast in Helium Ion Microscopy**, *Y. Chen, H. Zhang,* ***D. Fox****, C.C. Faulkner, J. Wang, J. Boland, J. Donegan*, Trinity College, Ireland **INVITED**

Innovation in metrology is crucial to the future of semiconductor industry, since the miniaturization of transistors demands novel characterization technologies at and beyond the nanometre scale. Recent research has demonstrated that dopant contrast in the Helium-ion Microscope (HIM) is plausible and the HIM is a competitive platform for quantitative secondary-electron (SE) dopant mapping in terms of throughput, sensitivity, and resolution. However, the contrast mechanism of SE imaging is still debatable and it hinders further development of the technique. In this research, quantitative HIM dopant contrast of gallium-doped silicon samples has been investigated and compared with the contrast observed in a scanning electron microscope (SEM). Beam-sample interaction, signal general, as well as detection configuration have been considered via using a range of detectors in the two microscopes. It has been found that the Everhart-Thornley (E-T) secondary electron detector attached to HIM provides similar contrast to the images acquired from the InLens detector attached to SEM, while contrast reversal is observed with the SEM E-T detector. The contrast reversal also depends on the Dwell time. We have confirmed that the HIM is more sensitive to type-I SEs and a capacitance model based on charging effect has been proposed to explain the contrast reversal. Our results indicate that quantitative dopant contrast in the HIM is promising, while charging effect and imaging conditions must be carefully considered.

11:20am **HI+AS+BI+NS-ThM11 High Resolution Patterning of Carbon Nanomembranes and Graphene via Extreme UV Interference Lithography: A Helium Ion Microscopy Study**, ***A. Winter****, A. Willunat, A. Beyer*, University of Bielefeld, Germany, *Y. Ekinci*, Paul Scherrer Institute, Switzerland, *A. Gölzhäuser, A. Turchanin*, University of Bielefeld, Germany

Two-dimensional (2D) carbon materials like graphene, graphene oxide, carbon nanomembranes (CNMs) or ultrathin polymeric films have recently attracted enormous interest due to their potential use in electronics, chemical and biological sensors, nanofilters, hybrid materials, etc. Most of these applications require lithographic patterning of these 2D carbon materials with the nanoscale resolution. In this respect, Extreme UV Interference Lithography (EUV-IL) provides both large-scale pattering and high resolution with an ultimate limit in the sub-10 nm range. We employ EUV-IL to generate nanopatterns in ~1 nm thick CNMs and graphene. We characterise these nanopatterns with a Helium Ion Microscope (HIM). Its high surface sensitivity and lateral resolution provide excellent conditions for imaging of the topographic and chemical features in CNMs and graphene. The possibility to routinely fabricate and characterize the nanopatterns via EUV-IL and HIM on various technologically relevant insulating substrates (e.g., oxidized silicon wafers, glass, and quartz) and with the resolution below 20 nm shows high potential of both techniques for applications in carbon-based nanotechnology.

11:40am **HI+AS+BI+NS-ThM12 Application of Helium Ion Microscope on Processing and Characterization of Nano Wires**, ***H.X. Guo****, S. Nagano, K. Onishi, D. Fujita*, National Institute for Materials Science (NIMS), Japan

Scanning helium ion microscope (SHIM) is advanced in high resolution and high focal depth of secondary electron imaging and Rutherford backscattered ion imaging.[1] It also employed in the nano pattern or fabrication on surface and other various structures, such as 2D materials, graphene.[2] It is an excellent candidate for the naon processing of 1D nano structures, such as nanowires and nanotubes.

Rhenium trioxide (ReO3) is an unusual transition metal oxide with high electrical conductivity close to that of metals. It is well investigated for the applications of photovoltaics[3], catalyst[4],and tip for scanning tunneling microscope[5]. Various ReO3 nano structures such as nano paticles[3,6], nano wires[7], and core-shell structures have been synthesized and characterized by different methods.

In this research, ReO3 nanowires were synthesized by a physical vapor deposition method. Etched by the helium ion beam, the diameter of part of the nanowire was decreased. During this processing, the structure and transport properties of the ReO3 nanowire were modified with a controllable method. In this presentation, we will show the structure and properties characterization of the etched nanowires by using scanning probe microscope (SPM) , transmission electron microscope (TEM) and other methods. An *in-situ* transport properties measurement system with SHIM will also be introduced in the presentation.

[1] J. Morgan, J. Notte, R. Hill, and B. Ward, *Microsc. Today,* **14**, 24(2006)

[2] D. C. Bell, M. C. Lemme, L. A. Stern, J. R. Williams, and C. M. Marcus, *Nanotech.*, **20,** 455301(2009).

[3] S. V. Bhat, S. B. Krupanidhi , and C. N. R. Rao, *Appl. Phys. Express*,**3**, 115001(2010)

[4] E. Cazzanelli, M. Castriota, S. Marino, N. Scaramuzza, J. Purans, A. Kuzmin, R. Kalendarev, G. Mariotto, and G. Das,; *J. Appl. Phys.,* **105**, 114904 (2009)

[5] S. I. Ikebe, D. Shimada,T. Akahane, and N. Tsuda,; *Jpn. J. Appl. Phys.,* **30**, L405(1991)

[6] K. Biswas and C. N. R. Rao, *J. Phys. Chem. B,***110**, 842, (2006).

[7] D. Myung, Y. Lee, J. Lee, H. K. Yu, J. L. Lee, J. M. Baik, W. Kim, M. H. Kim, *phys. status solidi-R*, **4**, 365 (2010)

Helium Ion Microscopy Focus Topic
Room: Central Hall - Session HI-ThP

Aspects of Helium Ion Microscopy Poster Session

HI-ThP1 Fabrication of Carbon Nanomembranes by Helium Ion Lithography, *X. Zhang, H. Vieker, A. Beyer,* ***A. Gölzhäuser***, University of Bielefeld, Germany

A helium-ion microscope (HIM) is capable of creating nanoscale patterns and its beam can perform ion milling as commonly done in focused ion beam (FIB) systems. Here we use a helium ion beam as direct writing tool to cross-link 4'-nitro-1,1'-biphenyl-4-thiol (NBPT) SAMs with arbitrary patterns. The cross-linked SAMs were transferred to either silicon substrates with an oxide layer for optical characterization or transmission electron microscopy (TEM) grids for preparing free-standing carbon nanomembranes (CNMs). The required dose for the complete cross-linking with helium ions is quite similar to the dose earlier established with electrons. To determine the feature resolution limit, we prepared dot arrays of CNMs at various doses and 5 nm feature sizes have been achieved. Proximity effect and sample damage on the nanoscale patterns were also investigated. Furthermore, we use the ion beam to form nanopores in the CNM with an attainable feature size of 5 nm.

HI-ThP2 Site Specific He Ion Irradiation Damage Studies in Nanolayerd Thin Films, ***V. Shutthanandan****, A. Devaraj, R.S. Vemuri, C.M. Wang, T. Varga, C.H. Henager Jr, S. Thevuthasan*, Pacific Northwest National Laboratory

Over recent years materials with a high density of nanoscale interfaces are finding increasing attention due to their improved radiation tolerance in comparison to their bulk form. The efficient trapping and recombination of radiation induced point defects such as vacancies and interstitials at such interfaces are proposed to be the fundamental reason for their increased radiation tolerance. Several different ODS steels, nanostructured ceramic materials and nanolayered thin films have been recently investigated to understand the fundamental mechanism of radiation damage. In many of these investigations high energy He ion irradiations were carried out in a large area over the entire specimen followed up with characterization of radiation damage. The spot size of ion irradiation beams from conventional sources was in the order of 100s of microns or larger preventing a site specific irradiation damage investigation of individual microstructural features. In such cases often the overall irradiation damage evolution in the material would be a cumulative response of the entire material microstructure (grain boundaries, interphase-interfaces, second phase precipitates and other preexisting defects) to the ion beam irradiation. A nanoscale site specific He ion irradiation method, if made possible can aid in decoupling and individually analyzing the He ion irradiation response of different microstructural features in a mutually exclusive manner. He ion microscopy (HIM) developed in recent years offer such a capability for obtaining coherent He ion beams that can be precisely controlled and directed to areas as small as few nanometers. In EMSL, a DOE national user facility in PNNL, efforts are underway to look at irradiation response of nanoscale microstructural features in nanolayered metallic thin films by cross coupling site specific He ion irradiations with site specific TEM and Atom probe tomography (APT) sample preparation methods made possible by Focused ion beam system. Proof of principle experiments are being conducted in nanoscale PVD synthesized Ti/Al nanolayer thin films using He ion irradiation doses ranging from 1E14 to 1E17 ions/cm2 and subsequent analysis by TEM and APT. Recent results from this study will be presented in this paper.

HI-ThP3 Helium and Neon Ion Beams Induced Platinum Deposition, ***H. Wu****, D. Ferranti, D. Xia, W. THompson, L.A. Stern,* Carl Zeiss*, P.D. Rack, C.M. Gonzalez,* The University of Tennessee*, M.W. Phaneuf*, Fibics Incorporated

Gallium focused ion beams (Ga-FIB) have been used by the semiconductor industry to provide nanoscale deposition or milling. However, Ga ion implantation and limited spatial resolution capability encourage people to explore other ion sources for nanofabrication. Helium and Neon ion beams have been studied for many years as good alternative ion sources to replace Ga ion beams. The GFIS (gas field ion source) microscope is able to provide both He and Ne ion beams. Because of the mass difference of He and Ne ions, the interactions of ions with precursor molecules result in different sputtering rates, implantation and deposition yields. In this study, we use methylcyclopentadienyl trimethyl platinum (PtC_9H_{16}) as the precursor, and the metal deposition is induced by He and Ne ion beams respectively. To optimize the deposition process, beam current and dwell time have been studied. Compared with Ga ions, both He and Ne ion beams have smaller probe sizes, cause less surface damage and results in deposited material with superior properties without gallium contamination. The Pt nanowires using Ne ion beam exhibit lower resistivities, as low as 600 μΩ-cm, than those nanowires using He ion beam. Composition analysis by EDX shows the higher Pt: C ratio of Pt deposition by Ne ion beam than that by He ion beam, which is consistent with the resistivity results.

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