Processing at the Nanoscale
Room 308 - Session NS+MI-TuA

Nanoscale Patterning and Lithography

Moderator: B.D. Terris, IBM Almaden Research Center

2:00pm **NS+MI-TuA1 Patterning Magnetic Recording Media by Imprinting**, ***G.M. McClelland***, *M.W. Hart,* IBM Almaden Research Center*; M.E. Best,* Hitachi San Jose Research Center*; C.T. Rettner, K.R. Carter,* IBM Almaden Research Center*; G. Hu, B.D. Terris, M. Albrecht,* Hitachi San Jose Research Center **INVITED**

Patterning magnetic media is a promising strategy for increasing magnetic recording density beyond the current value of 15 Gbit/sq. cm. As proposed by Chou, imprinting is an attractive means for generating the small structures required. This application is not affected by some difficult aspects of imprinting: overlay is not required, long range distortion is accommodated by positioning of the recording head, and defects can be corrected by error correction during read out. We have developed a complete, cost effective process for patterning of 30-nm-dia. single-domain magnetic islands over a 65 mm disk. The process steps are: forming a flexible stamp from a master, imprinting a replica in resist, reactive ion etching SiO2 pillars into the substrate, and depositing a magnetic film by evaporation. To accommodate the roughness and curvature of the substrate, a 10-micon-thick polymer stamp on an acrylic backing plate is used. The stamp is formed by photocuring an acrylate mixture in contact with an SiO2 master made by e-beam lithography. The resist is formed from a 15-nm-thick prepolymer liquid acrylate film spun onto the glass substrate. The film is viscous, so that non-flatness in the substrate is accommodate by stamp deformation, rather than by flow of the resist. After UV exposure, the stamp is removed to leave 30-nm-high resist pillars on a 10-nm-thick base layer. A dozen repeated imprints show a defect rate of about 1 in 10,000 pillars. A CF4/CH4 etch transfers the resist pattern into 30-nm-high, 30-nm-dia. SiO2 pillars with a period of 60 nm. To form a magnetic film, a 10-nm CoPt multilayer is deposited by e-beam evaporation at 300 K. This method shows promise for large-scale manufacturing, because the stamp-making process can be repeated indefinitely from a single master, and many replicas can be formed from each stamp.

2:40pm **NS+MI-TuA3 Buffer Layer Assisted Laser Patterning of Metals at the Nanometer Scale**, ***G. Kerner***, *M. Asscher,* The Hebrew University of Jerusalem, Israel

Spatial patterning of thin films on surfaces is of great importance for basic physical sciences and technology. An innovative method is presented for a single pulse, macroscopic scale laser patterning of metallic thin film to form nanometer range variable width conducting wires. Employing laser induced thermal desorption (LITD) via interfering split low power beams- metallic gold and potassium coverage grating on top of multilayer Xe is formed over Ru and Si at 20K as a demonstration. Upon annealing to 80K, the Xe layer desorbs and the metallic pattern softly lands and strongly attaches to the substrate. This is a highly versatile patterning technique that can be employed with practically any element and chemical species. It may readily be utilized to prepare millimeters long, 30nm wide conducting wires using current laser technology. The structure and thermal stability of the metallic pattern has been studied by means of AFM, STM, optical second harmonic and linear diffraction. The metallic structures are composed of nanometer size clusters, their size and distribution depend on the buffer layer thickness. The technique presented here is potentially an attractive alternative method for the deposition of periodic and more complex spatial patterns of conducting wires at widths well below the current limits.

3:00pm **NS+MI-TuA4 Low-Temperature Nanolithography using Energetic Neutral Atoms**, ***E.A. Akhadov***, *A.H. Mueller, M.A. Hoffbauer,* Los Alamos National Laboratory

Neutral atomic beams with kinetic energies of a few eV are exploited for etching of nanoscale features in polymeric materials and for epitaxial thin film growth on substrates held near ambient temperature. A unique low temperature etching and thin film growth technique, called Energetic Neutral Atom Beam Lithography (ENABL), has been recently developed at LANL. Using a collimated atomic beam with a small de Broglie wavelength permits the fabrication of high-aspect-ratio (>25:1) nanoscale features in polymeric substrates without undesirable defects (undercutting, tapering etc.) common to conventional etching. The high flux (~10@super17@ atoms/cm@super2@sec) and high kinetic energies (1 to 5 eV) of reactive atomic species (O and N) allow etching of sub-100nm features at high rates and the growth of high-quality oxide films at ambient temperatures. The use of ENABL for etching and film growth opens new frontiers for materials synthesis and processing at the nanoscale at ambient temperatures. Future prospects and challenges for low-temperature ENABL-based nanoscale fabrication will also be addressed.

3:20pm **NS+MI-TuA5 Self-Assembling Circuits?**, ***K.W. Guarini***, *C.T. Black,* IBM **INVITED**

The aggressive dimensional and performance targets for future technology generations place severe demands on lithography, not only for feature size scaling but also pattern integrity, density, line edge roughness, and process control. Already today many process "tricks" are routinely employed to shrink the dimensions of lithographically-defined features, such as resist trim and sidewall image transfer, but there are limitations on the extendibility of such approaches. While the great potential of various so-called "next generation" lithography techniques has been well touted, these solutions are inherently complex, require new tooling infrastructure, and present throughput challenges. Self organizing materials offer an exciting prospect for overcoming many of these hurdles. The simplicity, reproducibility, and dimensional control inherent in self-assembling materials make them attractive for silicon nanofabrication. In the grandest vision, we might imagine integrated circuits that one day "organize themselves"-yielding the ultimate sizing and positional control, but this vision is still in the realm of science fiction. However, already today we can implement self-organizing materials for selective unit processes to complement or enhance conventional semiconductor processing. For instance, self-assembling polymer films provide an appealing alternative to photoresists for certain types of patterning at nanometer-scale dimensions. In particular, diblock copolymer thin films self assemble into uniform, densely-spaced nanometer-scale features over wafer-scale areas. These films are compatible with standard semiconductor fabrication processes, enabling their integration into device and circuit fabrication. Such self-organizing materials provide novel nanofabrication capabilities and may enable solutions to some challenges confronting integrated circuit fabrication.

4:00pm **NS+MI-TuA7 Fabrication and Electrical Characterization of 2D Dopant Nanostructures in Si**, ***J.S. Kline***, *J.C. Kim, S.J. Robinson, K.-F. Chen, R. Chan, M. Feng, J.R. Tucker,* University of Illinois at Urbana-Champaign*; J.-Y. Ji, T.-C. Shen,* Utah State University*; C. Yang, R.-R. Du,* University of Utah

Lithography and contact with external leads are the two major challenges in nanoscale electronic device fabrication. We attempt to address both of these issues by using an integrated approach. STM lithography on H-terminated Si surfaces routinely achieves 1nm resolution. P donors can be selectively deposited onto the H-desorption area by dosing phosphine gas onto the STM patterned device template. Subsequent Si low-temperature deposition and annealing allows epitaxial overgrowth and the dopant atoms are completely activated. The sheet resistance of the P-delta layer is in the range of 1-4k@Omega@/square and can be controlled by phosphine surface coverage. External contacts to the device are fabricated by As ion implantation. We present a method whereby differences in surface features and tunneling spectroscopy between the contact and device region allow the registration of the STM. Low temperature electrical measurements of nanowires and other more complex structures are currently in progress and will also be reported. This work is supported by NSF, ARO, and DARPA.

4:20pm **NS+MI-TuA8 Polymer Patterning using a Soft Inkpad**, ***Y.P. Kong***, Institute of Materials Research and Engineering, Singapore*; L. Tan, L.-R. Bao,* University of Michigan, Ann Arbor*; X.D. Huang,* Institute of Materials Research and Engineering, Singapore*; S.W. Pang,* University of Michigan, Ann Arbor*; A.F. Yee,* Institute of Materials Research and Engineering, Singapore

We present a method of producing micrometer and submicrometer patterns of polymer on substrates. A patterned hard mold is pressed onto an 'inkpad' coated by a polymer. The inkpad consists of a polydimethylsiloxane (PDMS) layer backed by a hard substrate. The function of the PDMS layer is twofold. Oxygen plasma treatment of the PDMS layer allows a polar polymer solution to be spun coated on it. The hydrophobic recovery of the PDMS layer then lowers its surface energy and this allows the transfer of the polymer to the hard mold that has a higher surface energy. Secondly, the deformation of the PDMS layer during the pressing induces a large stress field gradient at the edges of the mold protrusions. It is this stress that leads to a localized rupture of the polymer layer. The pressing is carried out at temperatures close to the glass transition temperature of the polymer and under relatively low pressures

to transfer the polymer onto the protrusions of the hard mold. After the hard mold is separated from the inkpad, it is brought into contact with a substrate under a suitable temperature and pressure to produce a positive replica of the mold. At the same time, a negative image of the mold is left on the inkpad and this negative pattern can be transferred to a substrate. With a 700 nm period silicon grating mold, we are able to produce both positive and negative polymeric gratings. We also demonstrate the transfer of multiple layers of polymer onto the protrusions of the mold thereby increasing the aspect ratio of the patterns. Transferring of different polymer layers leads to the possibility of making high-resolution polymer light emitting displays and organic circuits. The advantages of our patterning method over nanoimprint lithography are: lower process temperatures and pressures, no material transport related problems, absence of a residual layer that needs removal, and the possibility to create both negative and positive replicas of the mold.

4:40pm **NS+MI-TuA9 Influence of Stoichiometry and Structure on the Local Oxidation of Metal Films***, **N. Farkas**, G. Zhang, K.M. Donnelly, E.A. Evans, R.D. Ramsier,* The University of Akron*; J.A. Dagata,* National Institute of Standards and Technology

Oxidation growth kinetics of sputter-deposited Zr and ZrN thin-films are studied on the local scale by atomic force microscope (AFM) -assisted lithography. The growth kinetics are found to depend strongly upon the nitrogen content of the deposition plasma. Mass transport of subsurface O, H, and N species also plays an important role in the growth of nanometer-scale oxide structures, producing feature heights up to an order of magnitude greater than those observed in other material systems such as silicon and titanium. The stoichiometric and structural differences in the films are investigated by X-ray photoelectron spectroscopy (XPS), secondary ion mass spectrometry (SIMS) and X-ray diffraction (XRD) techniques to account for solid-state reaction and transport mechanisms involved in oxidation driven by a highly localized electric field. These results demonstrate the potential of AFM lithographic techniques for characterizing oxidation kinetics in the presence of the rich chemical behavior exhibited by reactive metal films.

Processing at the Nanoscale
Room 317 - Session PN-ThA

Molecular Monolayers

Moderator: P.S. Weiss, The Pennsylvania State University

2:00pm **PN-ThA1 AFM-Based Lithography and Conductive Probe Measurements with Substituted Oligo(phenylene ethynylene) Molecular Wires on Au(111)***, **J.C. Garno**, J.D. Batteas,* National Institute of Standards and Technology

AFM-based lithography is combined with conductive probe AFM (CP-AFM) measurements to characterize the surface structure and conductive properties of designed test platforms comprised of substituted oligo(phenylene ethynylene) molecules within a matrix of alkanethiol self-assembled monolayers (SAMs). Oligo(phenylene ethynylene)s on Au(111) are excellent candidates for molecular electronics, due to their rigid, planar structure and pi-conjugated backbone. When substituents are attached to oligo(phenylene ethynylene)s, electronic properties such as negative differential resistance and molecular scale switching behavior have been reported. Nanopatterned test platforms may provide a means to obtain a highly reproducible contact area in which the alkanethiol matrix of the test platforms serves as a boundary and provides an insulating frame of reference in the areas surrounding test elements. In CP-AFM, the probe is placed directly on the surface of the fabricated nanostructure, at a certain applied force. The alkanethiol matrix may be used as an internal calibration for CP-AFM measurements, with direct side-by-side comparisons of the alkanethiol matrix versus test molecule. Nanopatterns generated using AFM-based nanofabrication furnish local measurements of the thickness of molecular wire SAMs, using matrix alkanethiols as a height reference. By systematically varying certain parameters, such as the size, composition, geometry, and arrangement of test elements, we anticipate that changes can be correlated with measured conductivity, to shed light on predicting how electrical properties vary with molecular structure. Useful design parameters for molecular electronics which could be gained from this approach include the critical geometry and size thresholds for functional device elements, differences in electrical conductivity of materials, and the structural motifs best suited for devices.

2:20pm **PN-ThA2 Chemical Nanostructures as Templates for the Fabrication of Laterally Patternend Polymer Brushes***, **A. Paul**, A. Küller,* Universität Heidelberg, Germany*; U. Schmelmer, R. Jordan,* TU München, Germany*; A. Ulman,* Polytechnic University*; M. Grunze, W. Eck,* Universität Heidelberg, Germany*; A. Gölzhäuser,* Universität Marburg, Germany

Chemical Nanolithography@footnote 1@ utilizes electron beams for the controlled modification of self-assembled monolayers (SAMs). E-beam irradiation of SAMs of nitrobiphenylthiol causes a lateral cross-linking reaction of the biphenyl mesogen along with a simultaneous conversion of the terminal nitro groups to the amine.@footnote 2@ Consecutive reactions such as chemical coupling of chromophores or surface-initiated polymerization can be performed in predefined (irradiated) areas.@footnote 3@ We show the fabrication of polymer brushes with lateral dimensions down to 50 nm by utilizing chemical nanolithography templates for surface-initiated polymerization. Limits of resolution and potential applications will be discussed. @FootnoteText@ @footnote 1@ A. Gölzhäuser et al., Adv. Mater. 13, 806, (2001)@footnote 2@ W. Eck et al., Adv. Mater. 12, 805, (2000)@footnote 3@ U. Schmelmer et al., Angew. Chem. Int. Ed. 42, 559 (2003)

2:40pm **PN-ThA3 Reactions of Silicon and Gold Nanostructures on Surface-Templated Molecule Corrals***, **Y. Liu**, Z Zhang, M. Wells, A.V. Teplyakov, T.P. Beebe, Jr.,* University of Delaware

Semiconductor and metal nanostructures display novel size-dependent properties as a result of quantum confinement. New concepts and new challenges evolve with regard to the potential applications of these nanostructures in molecular electronics, sensors, biological interfaces and biomedical applications, advanced material design, charge storage, light-emitting diodes, energetic materials, and other applications that remain unknown at present. Semiconductor and metal nanostructures on surface-templated molecule corrals are unique because large numbers of these nanostructures with controlled size, height, shape, surface density, and position or pattern can be produced quickly and efficiently with a narrow size dispersion in a parallel process that takes only minutes. In this work, the formation and modification of silicon and gold nanostructures templated on the highly oriented pyrolytic graphite (HOPG) basal plane will be discussed. Molecule corrals are typically formed with a high degree of control by a simple bench-top process in an oven operating at approximately 650 Â°C in the ambient air from the preexisting natural defects or manmade (ion-beam bombardment) defects on the surface. Silicon and gold nanostructures are vacuum evaporated onto these size- and shape-controlled molecule corrals. These nanostructures are then functionalized with a number of reagents, including organosilanes and organothiols. Scanning tunneling microscopy, atomic force microscopy, time-of-flight secondary ion mass spectrometry, Fourier-transform infrared spectroscopy and X-ray photoelectron spectroscopy are used to characterize the degree of chemical modification of surface-templated nanostructures before and after modification.

3:00pm **PN-ThA4 Molecular Monolayers for Interfacing Organic and Biological Molecules to Group IV Semiconductors***, **R.J. Hamers**,* University of Wisconsin-Madison **INVITED**

The burgeoning fields of organic electronics, molecular electronics, and bio-electronics are all placing increased emphasis on electrically interfacing inorganic materials such as silicon and diamond with organic and biological materials. Over the last several years we have been exploring new methods for fabricating and patterning hybrid interfaces on silicon and diamond surfaces, and understanding how the specific chemical chemical bonds and nanometer-scale structures control the resulting electrical properties of the interfaces. In ultrahigh vacuum the reactions of C=C bonds, S-H bonds, and O-H bonds can be used as the basis for preparing covalently-bonded layers that exhibit specific reactive and/or non-reactive functional groups, which can in turn be used for linking more complex films (pentacene) and structures (DNA) to the surfaces . Essentially identical reactions are used to link organic molecules with H-terminated silicon and diamond under ambient (atmospheric pressure) conditions, using ultraviolet light to initiate the reactions. We have been assessing the molecular conductivity on an atomic level via STM measurements of the apparent height, and on more macroscopic scales by measuring interfacial impedance after the molecular monolayers are covered with conductive materials such as the pentacene or after they are linked to biological molecules such as DNA. In this talk I will summarize what we have learned about how to use organic monolayers as electrical interfaces to pentacene films, DNA molecules, and other nanometer-scale structures of interest.

3:40pm **PN-ThA6 Covalent Linkage of Hydrocarbon Moieties and Addition of Organic Functional Groups on Si(111)***, **T. Yamada**, H.S. Kato, K. Shirasaka, M. Noto, M. Kawai,* RIKEN, Japan

Deposition of unsaturated hydrocarbon moieties (CH@sub 2@=CH- etc.) on H-terminated H:Si(111)(1x1) surface was performed by Grignard reaction, and addition of boranes and halogens to the C=C double bond was attempted by the methods of wet chemical organic synthesis. The adsorbates formed on Si(111) were investigated by HREELS, AES, etc. in ultrahigh vacuum. Treating H:Si(111) in a tetrahydrofuran (THF) solution of CH@sub 2@=CHMgCl) resulted formation of adsorbates with a major amount of -CH@sub 2@- and a minor amount of CH@sub 2@=, detected by HREELS. The formation of saturated -CH@sub 2@- seems to be due to inter-adsorbate bonding of vicinal CH@sub 2@=CH-groups right after deposition. This parasitic reaction was avoided by using a 1:3 - 5 mixture of CH@sub 2@=CHMgCl and CH@sub 3@MgBr in THF to insert inactive CH@sub 3@- groups among CH@sub 2@=CH- adsorbates. HREELS revealed the ratio of CH@sub 3@:CH@sub 2@=CH in the adlayer was approximately equal to that in the Grignard solution. This sort of CH@sub 2@=CH- moieties diluted in CH@sub 3@- can be useful in reactions with bulky reagents. To realize the terminal hydration of CH@sub 2@=CH:Si(111) into OH-CH@sub 2@-CH@sub 2@:Si(111), hydroboration reaction with a borane reagent 9-BBN was attempted in THF. Deposition of boron was detected by AES, indicating that 9-BBN was bonded by breaking CH@sub 2@=CH bonds. Further attempt to complete the hydration by H@sub 2@O@sub 2@ solution was made, and we are trying to distingish the OH group on the -CH@sub 2@-CH@sub 2@- moiety from OH attached on surface SiO@sub 2@ impurities by HREELS. Addition of HBr on CH@sub 2@=CH:Si(111) was performed by a moderate reaction with HBr in organic solvents. Our goal is to gain a freedom of terminating Si surface with desired functional groups. This is a key technology in grafting polymers and biomolecules such as DNA and peptides to construct intelligent chemically functional system on silicon.

4:00pm **PN-ThA7 Templated Growth of One-dimensional Molecular Wires on Si(100) Using Multi-step Feedback Controlled Lithography**, ***R. Basu***, *N.P. Guisinger, M.C. Hersam,* Northwestern University

This study demonstrates the fabrication of one-dimensional molecular wires on the Si(100) surface with atomically precise control over the position and length of each wire. Specifically, styrene molecules, which are known to experience self-directed growth on Si(100) surface along dimer rows, have been induced to grow from individual dangling bonds that have been created on the hydrogen-passivated Si(100)-2x1 surface through feedback controlled lithography (FCL) using a room temperature ultra-high vacuum (UHV) scanning tunneling microscope (STM). The site-specific creation of individual dangling bonds allows control over the position of the styrene wires whose growth is confined along a dimer row. FCL has also been used to create an additional pair of dangling bonds at two different positions within the same dimer row to allow for controlled chemisorption of the organic free radical, 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO). The presence of the bounded TEMPO molecules physically restricts the growth of the styrene chain beyond the specified length along the dimer row and thus allows unprecedented control over the length of the molecular wires. Current-voltage spectroscopy has been performed on the styrene and TEMPO molecules. Based on the spectroscopic data, bias dependent STM conductance images of the molecular wires have been obtained.

4:20pm **PN-ThA8 UHV Characterization of Adsorbates Deposited in Ambient from Solution onto Si(001):H-(2x1)**, ***L.A. Baker***, *A. Laracuente, L.J. Whitman,* Naval Research Laboratory

The marriage of nanoscale organic components with semiconductor devices for molecular electronics and sensing applications requires new approaches to fabrication. For example, whereas most device fabrication occurs in an ultra-high vacuum (UHV) system, organic materials chemistry often begins in a solution-filled beaker. We are using H-terminated Si(001) prepared in UHV as a robust substrate for ambient surface chemistry that can subsequently be characterized in UHV by STM. As demonstrated by Hersam, et al.,@footnote 1@ Si(001) terminated with H in UHV can be removed to an ambient environment for hours and still appear as a relatively clean, well-ordered Si(001):H-(2x1) surface upon return to UHV. We now find that this surface can be exposed in ambient to chlorinated solvents (e.g., CHCl@sub 3@) with minimal surface modification observed following reintroduction to UHV. In addition, we will present results showing that organic molecules, such as porphyrins, can be deposited in this way and subsequently characterized in UHV with STM. @FootnoteText@@footnote 1@M. C. Hersam, et al., Appl. Phys. Lett. 78, 7 (2001).

4:40pm **PN-ThA9 Nanoscale Fabrication and Characterization of Chemically Modified Silicon Surfaces Using Conductive Atomic Force Microscopy in Liquids**, ***C.R. Kinser***, *D.E. Kramer, M.W. Such, P. Bertin, H. Jin, S.T. Nguyen, M.J. Bedyzk, M.C. Hersam,* Northwestern University

Self-assembled monolayers of terminal alkenes on hydrogen passivated silicon provide an attractive route for covalent organic functionalization of silicon surfaces. This talk addresses two important experimental issues that improve the applicability of these surfaces for potential device applications: (1) Means of verifying the conformation of terminal reactive groups; (2) Strategies for patterning these monolayers down to the nanometer length scale. The first issue is addressed using X-ray reflectivity and X-ray standing wave techniques at the monolayer level. X-ray characterization of a bromine tagged analog of ethyl-undecylenate on Si(111) show that the monolayer coverage is 0.59 and the bromine lies 14.6 Å above the silicon surface. This data illustrates that the molecule is reacted to the surface via the terminal alkene, thus presenting the bromine functionality for post-chemistry. In this manner, the effectiveness of subsequent chemical reactions on functionalized silicon surfaces can be efficiently forecasted. The remainder of the talk describes a novel strategy for nanopatterning monolayers on hydrogen passivated silicon directly from the liquid phase. In Liquid Phase Nanolithography, hydrogen desorption is induced by applying a bias across a conductive atomic force microscope tip-sample junction submerged in an organic solvent. Appropriately chosen molecules suspended in the solvent directly chemisorb on the depassivated lines. We will present results for patterning neat undecylenic acid methyl ester on H:Si(111) with 50 nm spatial resolution using this technique and suggest approaches for utilizing this scheme to fabricate biomedical nanosensors.

5:00pm **PN-ThA10 Imaging of Monomolecular Lithographic Patterns by X-ray Photoelectron Spectromicroscopy and X-ray Absorption Spectromicroscopy**, ***M. Zharnikov,*** Universität Heidelberg, Germany; *R. Klauser,* National Synchrotron Radiation Research Center, Taiwan; *A. Paul, A. Gölzhäuser,* Universität Heidelberg, Germany; *A. Scholl,* Lawrence Berkeley National Laboratory

The development of novel approaches for the fabrication of nanostructures and, in particular, chemical and biological patterns is an important technological and scientific issue. One of perspective methods applies electron-beam patterning of chemisorbed monomolecular films (so-called self-assembled monolayers - SAMs), with the major advantage to tailor the resist properties through the exact architecture and packing of the molecular constituents. We have utilized scanning soft X-ray photoelectron and X-ray absorption spectromicroscopy to image and characterize different electron-beam patterned SAMs on gold substrates. Both techniques rely on characteristic spectroscopic features, which makes them chemically sensitive. The XPM measurements have been performed with a scanned zone-plate-focused X-ray beam and a 16 channels photoelectron spectrometer while the XAM images were collected with a X-ray PEEM working in a total electron yield (TEY) acquisition mode. The lateral structures in all SAM-based patterns could be clearly distinguished by both XPM and XAM. Chemical and physical changes in some of the resists could be directly monitored. The strength and limits of XPM and XAM to image monomolecular lithographic patterns are discussed. The major constrains of XPM are a strong inelastic background at the position of characteristic emissions and a rather limited (at present) lateral resolution. The major constrain of XAM is a rather poor surface sensitivity due to a large probing depth in the TEY acquisition mode. Ways to overcome the experimental constrains are considered, along with the issue of X-ray damage, which might be relevant at an X-ray exposure required for the acquisition of high-quality XPM and XAM images.

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