Materials Characterization in the Semiconductor Industry Focus Topic
Room: Hall 3 - Session MC-TuP

Materials Characterization in the Semiconductor Industry Poster Session (All areas)

MC-TuP1 Effect of Aromatic Compounds on Semiconducting Boron Carbide Heterojunctions, ***Elena Echeverria***, University of Nebraska - Lincoln, *R. James, F. Pasquale, B. Dong,* University of North Texas, *A. Enders,* University of Nebraska - Lincoln, *A. Kelber,* University of North Texas, *P.A. Dowben*, University of Nebraska - Lincoln

A new class of semiconducting boron carbide devices was fabricated based on a carborane icosahedra ($B_{10}C_2H_{12}$) precursor via plasma enhanced chemical vapor deposition in the presence of aromatic linking units. Our studies have showed that these novel superconducting boron carbide films have excellent rectifying characteristics when deposited on n-type Si, making this heterojunctions extremely promising for neutron detection and other device applications. Films were fabricated by co-deposition of aromatic compounds (pyridine, benzene, diaminobenzene, etc.) with ortho-carborane using plasma enhanced chemical vapor deposition (PECVD). In the case of samples containing pyridine, the characteristic I–V curves for the heterojunction diodes exhibit strong rectification and largely unperturbed normalized reverse bias leakage currents with increasing pyridine content. Similar results are showed when benzene or diaminobenzene are used as linking groups, with a threshold voltage lower for diaminobenzene compared to benzene. These results suggest that modifications to boron carbide may result in better heterojunction diodes, and point the way to a whole family of future studies that may ultimately lead to boron carbides better suited to low power and low flux neutron detection.

MC-TuP2 3 Dimensional Quantitative Composition and Structure Profiling of As Implanted Si USJ and FINFET with TOF-MEIS, ***WonJa Min***, *K.S. Park, K.-S. Yu,* KMAC, Republic of Korea, *S.J. Joo, Y.-S. Kim,* KRISS, Republic of Korea, *D.W. Moon*, DGIST, Republic of Korea

Using a recently developed time-of-flight (TOF) medium energy ion scattering spectrometer (MEIS), we have investigated 3D elemental composition, morphology, and atomic defect structures for As implanted Si ultrashallow junctions (USJs) and As implanted FINFET nanostructures.

As depth profiles in As/Si ultra shallow junctions (USJs) were measured by TOF-MEIS for 2 keV As implantation ion energy before and after annealing. Electrically inactive arsenic (As) complexes in silicon are investigated. In heavily As-doped Si, the As atoms segregated in the interface Si region just below the SiO_2 layer are found to be in interstitial forms (As_i), while the As in the bulk Si region are found to be in the substitutional form (As_{Si}). Despite the substitutional form of As, most of the As are found to be electrically inactive in the bulk region, and we identify that the As forms the <111> oriented As_{Si}-Si-vacancy (As_{Si}-V_{Si}) complex. The As_i's in the interface Si region are found to exist together with Si-interstitials (Si_i). It is suggested that the As_i deactivation centers in the interface Si region possibly accompany Si_i defects.

3D compostional distributions of As implanted FINFET structure were also analyzed with TOF-MEIS. Progresses in TOF-MEIS analysis of other nano-structured materials and devices in various nano & bio technology will be also discussed.

MC-TuP3 Characterization of the Doped Amorphous Carbon Hardmask Film Prepared by Hybrid Plasma CVD Systems, ***Jaeyoung Yang***, *K.P. Park, G.H. Hur*, TES Co. Ltd., Republic of Korea

We investigated the single and laminated stacked doped amorphous carbon film with additive gas as boron and nitrogen, and so on. The film properties was characterized by XPS, SIMS, and FT-IR spectroscope. Boron doped carbon film with B concentration-had > 30 % had the highest selectivity to oxide of over 10:1. In this study we had a choice of hybrid plasma chemical vapor deposition (CVD), and it was very stable plasma condition for a long time process and the specified laminated stacked carbon hardmask films were consisted with nitrogen and boron. We considered our optimised doped carbon films can be applied to use as the hardmask for designing about photolithograph and etching process. We can be easily controlled to dopant ratio by the plasma deposition system with the pulsed source feed-through module. Our new hardmask material prepared by hybrid plasma CVD process will be candidate on future material for advanced logic and memories, including DRAM and 3D VNAND chip integration process. We introduced the several behavior of deposited film' properties with varying the deposition parameters into the hybrid plasma CVD systems.

MC-TuP4 Surface Structure and Morphology of GaAs Nanowires Grown by Aerotaxy, ***Sofie Yngman***, *S. McKibbin, J. Knutsson, F. Yang, E. Lundgren, M. Magnusson, R. Timm, A. Mikkelsen*, Lund University, Sweden

III-V semiconductor nanowires (NWs) continue to show promising results as components in energy saving devices. GaAs NW arrays recently beat the record for photovoltaic solar cells presenting a conversion efficiency of 15.3% [1]. Given the large surface to volume ratio of NWs, performance in such devices may be strongly determined by surface characteristics for example, morphology, the presence of various oxide species and surface structure. We study GaAs NWs grown by using the novel growth technique aerotaxy [2]. In aerotaxy growth the NWs are catalyzed from Au aerosol nanoparticles floating freely in a continuous N_2 flow mixed with group III and V precursor gases. The growth rate of NWs using aerotaxy is much faster than for epitaxially grown NWs and the absence of expensive crystal substrate allows large scale economic production. A detailed understanding of the surface properties of these aerotaxy NWs is highly relevant in order to optimize device performance.

We compare surface structure and morphology of GaAs aerotaxy NWs to GaAs NWs grown epitaxially on a substrate. We obtain images of the NWs from microns to the atomic scale using both Atomic Force Microscopy (AFM) and Scanning Tunneling Microscopy (STM). Comparing this to chemical information obtained via X-ray Photoemission Spectroscopy (XPS) we find that the different growth techniques results in NWs with very different morphology. Using in air AFM phase measurements we show that the aerotaxy NWs exhibit a rounder cross section with few or no large facets in comparison to the hexagonal geometry of epitaxially grown NWs. XPS measurements show that by annealing the NWs in the presence of atomic hydrogen, we can remove the native oxides which form on them when exposed to air as previously observed for the expitaxially grown NWs[3][4]. From the XPS studies we can identify the different oxides present in the aerotaxy NWs before cleaning. We examine clean NWs using STM in Ultra High Vacuum. The morphology of the NWs is similar to as what is found in the AFM studies, however by direct atomic resolved imaging we can identify that even the round shaped aerotaxy NWs contain a considerable fraction of small unreconstructed patches of the {110} surface.

[1] http://www.solvoltaics.com/news.shtml (2015-05-01).

[2] M. Heurlin, et al. "Continuous gas-phase synthesis of nanowires with tunable properties", Nature 492, 90-94 (2012).

[3] E. Hilner, et al. "Direct atomic scale imaging of III-V nanowire surfaces", Nano Letters 8, 3978 (2008).

[4] M. Hjort, et al. "Direct imaging of atomic scale structure and electronic properties of GaAs wurtzite and zinc blende nanowire surfaces", Nano Letters 13, 4492 (2013).

MC-TuP5 Characterization of Si/Ru and Si/B_4C/Ru Multilayers using X-ray Reflectivity, X-ray Diffraction and Synchrotron-based EUV Reflectometry, ***Mohammad Faheem***, GLOBALFOUNDRIES Inc., *P. van der Heide,* GLOBALFOUNDRIES, Inc., *O. Wood, Y. Liang, A. Kumar Kambham, K. Wong, V. Park, P. Mangat*, GLOBALFOUNDRIES Inc.

Future photomasks for extreme ultra violet lithography (EUVL) would be improved with broader bandwidth reflective multilayer coatings especially below the 7 nm technology node. Owing to its lower index of refraction, higher numerical aperture and contamination resistance Ruthenium (Ru) is a potential candidate for use on future generation EUVL masks. We characterized 20 layer stacks of Si/La, Si/Ru and Si/B_4C/Ru on Si (100) substrates. X Ray Reflectivity (XRR) and Atom Probe Tomography (APT) were carried out on a Si/La stack for period comparison. Si/Ru and Si/B_4C/Ru were prepared for phase comparison using XRR and X Ray Diffraction (XRD). Four samples of Si/B_4C/Ru multilayers with less than 1 Å period difference were compared using synchrotron-based EUV reflectometry.

XRR measurements were carried out using a Bruker D8 Discover with Cu K-alpha (λ = 1.542 Å) and a scintillator detector. Measurements were made at small detector angles, 2θ = 0-10º. For texture and crystallite size, locked coupled scans were carried out using 0.2 mm beam slit and Lenxeye detector in 1D mode along 2θ = 10-110º. Bruker's Eva software was used to measure the peak positions and the ICDD PDF-4 data base was used to identify the Ru peaks. The APT measurements were performed by LEAP 4000X-Si instrument under UV laser illumination.

The result indicates the close agreement between XRR and APT for a 20 layer La/Si stack. XRR spectra of Si/Ru and Si/B_4C/Ru showed the

multilayer period of ~ 7nm with sharp peaks which indicate the uniformity of deposited multilayers. Ru and B_4C showed polycrystalline behavior compared to amorphous Si. XRD results demonstrate that Ru layers tend to have (002) texture both in Si/Ru and Si/B_4C/Ru samples. Ru crystallite size in Si/Ru was observed to be larger than in Si/B_4C/Ru. The difference in crystallite size can be due Ru film thickness and its deposition on Si and B_4C. In the case of four Si/B_4C/Ru samples, the change in period was found to be correlated to changes in bandwidth and shifts in the position of peak EUV reflectivity. These results are not only of fundamental importance but also beneficial for improving the performance of Ru-based EUVL reflectors.

Key words: EUVL, XRR, XRD, APT, Synchrotron

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