Our activities in this area employ an interrelated three-pronged approach, with the aim not just of rationalising the spatial resolved distribution of the ion and neutral fluxes generated by the discharge. A time resolved triple Langmuir probe was also employed to measure the plasma parameters such as electron temperature and density and scanning in a three dimensional map.

References:

8:40am PS+2D+SE-WeM3 Probing the Plasma Chemistry that Underpins Diamond Chemical Vapour Deposition. Michael Ashfold, University of Bristol, United Kingdom Great Britain and Northern Ireland. M.W. Kelly, B.S. Truscott, University of Bristol, UK, United Kingdom Great Britain and Northern Ireland. Y.A. Mankelewich, Moscow State University, Russia, Russian Federation

Most diamond chemical vapour deposition (CVD) employs microwave (MW) activated C/H (typically C:H/H) gas mixtures. Many previous studies have sought to explore (and optimise) radical formation in such activated gas mixture, and the ways in which these radicals add to, and are accommodated on and in, the growing diamond surface.

Our activities in this area employ an interrelated three-pronged approach, i.e.

i) electronic spectroscopy methods (cavity ring down absorption and optical emission spectroscopies) to determine the spatial distributions of selected species (e.g. H atoms, CH and C: radicals) as functions of process variables like the process gas mixing ratio, flow rate and total pressure, and MW power.

ii) complementary 2-dimensional (2-D) modelling of the plasma chemistry and composition with the aim not just of rationalising the spatial resolved column density data obtained in (i), but also enabling prediction of the concentrations of other key gas phase species (e.g. CH radicals, which are generally regarded as the dominant growth species) that are not amenable to spectroscopic detection, as functions of process condition, and

iii) quantum mechanical (QM) and QM-molecular mechanics (MM) calculations of the energies of the elementary steps involved in radical addition to, migration on, and eventual accommodation on, a growing diamond surface.

This invited presentation will summarise the current understanding of diamond CVD from traditional C/H gas mixtures and results of recent studies designed to explore and explain the significant growth rate enhancements that can be achieved by adding trace amounts of nitrogen to such gas mixtures.

9:20am PS+2D+SE-WeM5 Ionization Zones and the Deposition of Thin Films in the Transition Region from Non-Reactive to Reactive Magnetron Sputtering including dc, HiPIMS, and Burst-HiPIMS Modes. Yuchen Yang, X. Zhen, A. Anders, Lawrence Berkeley Lab, University of California, Berkeley

Research has been done for copper and chromium targets in conventional non-reactive HiPIMS, revealing the disappearance of localized ionization zones when operating at high power due to high metal neutral supply from the target. However, relatively little research has been done for reactive HiPIMS. In this work we investigate the existence of ionization zones in various forms of reactive magnetron sputtering: direct current (dc) and HiPIMS for conventional pulse patterns and in burst mode. Copper and chromium targets are selected with nitrogen as reactive gas because (i) in the non-reactive regime Cu and Cr can be operated with or without ionization zones, and (ii) these target materials form application-relevant compound films, e.g. of interest in wear and corrosion-resistant applications, medical implants, metallization layers, etc.

Work at LBNL is supported by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.
evidence for MoS radicals. Wavelength specific plasma imaging and mass/energy spectroscopy studies demonstrated that the applied magnetic field mostly affects excited and ionized Ar generated in background gas collisions with electrons trapped by the magnetic field lines, while the trajectories of Mo and S species generated from the target surfaces are influenced to a much lesser degree. The imposed magnetic field intensity was adjusted to selectively filter Ar species from reaching the substrate and to find a balance between reducing unnecessary Ar bombardment and preventing shifting energy distributions of all arriving ions above 8 eV, where point defect generation is expected for hexagonal MoS₂. Plasma studies were used to select optimum growth conditions for 2D MoS₂ synthesis on SiO₂ surfaces at 700 °C. Film thickness uniformity was verified by producing 2-3 monolayer layer thick hexagonal polycrystalline MoS₂ films over 25-50 mm scale area sizes as confirmed by in-situ Raman spectroscopy and TEM microscopy.


11:40am PS+2D+SE-WeM12 Molybdenum Nitride Formation by N₂ Plasma Exposure on Molybdenum Disulfide: In-situ Surface Study. Angelica Azcatl, X. Qin, Q. Wang, N. Lu, M.J. Kim, C.L. Hinkle, R.M. Wallace, The University of Texas at Dallas
Two-dimensional molybdenum disulfide (MoS₂) is currently considered as a potential channel material for CMOS applications. Electron mobilities on the order of 470 cm²/Vs [1] have been reported for few-layer MoS₂ based FETs. Such promising results have fueled the efforts on synthesis of large area and high quality mono and few-layer MoS₂. Yet, the development of MoS₂ processing techniques of interest for device fabrication (i.e. doping, etching, functionalization) is still in an early stage.

Recently, it has been reported that when MoS₂ is exposed to SF₆, CF₄ or CHF₃ plasma treatments, fluorine can be introduced in the MoS₂ structure as an acceptor dopant, resulting in p-type doping. In parallel, due to the weak van der Waals interlayer forces, layer etching occurred as a side effect after these fluorine-based plasma exposures. [2]

Following the exploration of the effect of plasma exposures on MoS₂, in this study nitrogen plasma exposures on MoS₂ were performed, while the surface chemistry was monitored by in-situ by X-ray Photoelectron Spectroscopy. Theoretical studies have shown that substitution of sulfur with nitrogen in MoS₂ leads to p-type doping. [3,4] Here, the chemical analysis obtained by XPS indicates that nitrogen will covalently interact with molybdenum to generate molybdenum nitride. It was found that the nitrogen content in MoS₂ can be controlled with exposure time. The thermal stability of MoNₓ formed due to sulfur replacement with nitrogen will be discussed. Finally, Raman Spectroscopy studies and Scanning Transmission Electrons Microscopy imaging on the MoNₓ/MoS₂ structure will be presented to discuss the impact of the Mo-N bonding environment on the MoS₂ structure. This work will give an important insight for the understanding of the interaction of MoS₂ with a non-metal dopant atom, nitrogen, which has implications on the electrical properties of MoS₂.

This work is supported in part the Center for Low Energy Systems Technology (LEAST), one of six centers supported by the STARnet phase of the Focus Center Research Program (FCRP), a Semiconductor Research Corporation program sponsored by MARCO and DARPA, and by the SWAN Center, a SRC center sponsored by the Nanoelectronics Research Initiative and NIST.

References


12:00pm PS+2D+SE-WeM13 Low Temperature Synthesis of AlYB₁₄ by High Power Pulsed Magnetron Sputtering Oliver Hunold, Y.T. Chen, D. Muster, RWTH Aachen University, Germany, P.O.A. Persson, Linköping University, Sweden, J.M. Schneider, RWTH Aachen University, Germany

The influence of ion bombardment on the structure evolution of AlYB₁₄ was studied by using high power pulsed magnetron sputtering (HPPMS). The structure was analyzed by X-ray and electron diffraction. The diffraction data are consistent with the formation of crystalline AlYB₁₄ domains in an amorphous matrix. As the growth temperature was 675 °C synthesis was conducted at 725 °C below the bulk synthesis temperature. It is reasonable to assume that this decrease in the growth temperature is facilitated by bombardment of ions formed in the HPPMS discharge resulting in enhanced surface diffusion and hence higher adatom mobility. This work may be relevant for synthesizing other boron rich solids with low symmetry crystal structures at temperatures well below their bulk synthesis temperature.
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