Electronic Materials and Processing
Room: 210 - Session EM+NC-ThM

Contacts, Interfaces, and Defects in Semiconductors
Moderator: F. Ren, University of Florida

8:40am **EM+NC-ThM3 Point-probe Tunneling Measurements of Sheet Conductance of Metallized Silicon Surfaces**, ***H. Won***, *R.F. Willis*, The Pennsylvania State University

We report measurements of the sheet conductance of Si(111) 7x7 reconstructed surface and its metallization with Ag-overlayer. The experiment employs a STM-tip point tunneling probe coupled to a second spring-contact electrode to evaluate charge-carrier injection and transport via surface states prepared in-situ in UHV. The measurements distinguish a surface-states contribution, a Schottky diode contribution, and a metallic-overlayers dependence on thickness, ranging from submonolayer coverage to 10 monolayers. The thin film conductance shows a dependence on the interface conductance of the semiconductor, which is a function of the surface electron density.

9:00am **EM+NC-ThM4 Photoluminescece Spectroscopy on Near Surface InAs Quantum Dots and Wetting Layers**, ***I. Kamiya***, *K. Fukui*, Toyota Technological Institute, Japan

The electronic and optical properties of self-assembled (SA) InAs quantum dots (QDs) prepared by MBE or MOCVD have been one of the key topics of quantum nanostructures during the past few decades. In contrast to colloidal quantum dots such as CdSe with tri-octylphosphine oxide where the ligands plays a major role in passivating the surface,[1] SA InAs QDs are usually investigated without much concern on their surface/interface properties. However, we have shown that capping on the InAs QDs strongly influence their photoluminescence (PL)[2] or that the conductivity of surface InAs QDs strongly depends on their size.[3] More recently, it has been shown that surface and near surface InAs QDs exhibit features different from those of the well-buried.[4] Here, we have performed PL and PL excitation (PLE) spectroscopies on near surface InAs QDs and wetting layer (WL) to further investigate the influence of surface and interfaces of such structures. While we observed PL features similar to those reported in ref. 4, we have also found those that are different. PL and PLE measurements reveal that the carrier dynamics are stongly influenced by the surfaces and interface structures of the QDs and WL. We will discuss the mechanisms that could be governing such observations.

[1] C. B. Murray, D. J. Norris, and M. G. Bawendi, J. Am. Chem. Soc. 115, 8706 (1993).

[2] I. Kamiya, I. Tanaka, and H. Sakaki, Physica E2, 637 (1998).

[3] I. Tanaka, I. Kamiya, H. Sakaki, N. Qureshi, S. J. Allen, and P. M. Petroff, Appl. Phys. Lett. 74, 844 (1999).

[4] B. L. Liang, Zh. M. Wang, Y. I. Mazur, G. J. Salamo, E. A. DeCuir, and M. O. Manasreh, Appl. Phys. Lett. 89, 043125 (2006).

9:20am **EM+NC-ThM5 Barrier Formation and Transport in Metal Contacts to Nanotubes and Nanowires**, ***A. Talin***, *F. Leonard, B.S. Swartzentruber*, Sandia National Laboratories **INVITED**

The technology of metal-semiconductor contacts has progressed tremendously over the past fifty years. However, as device dimensions shrink well below 100 nm, and as new materials with novel composition and geometry are explored for 'next generation' electronic components, the underlying physics of metal-semiconductor contacts departs substantially from the early models of Schottky, Mott, and Bardeen. Single wall carbon nanotubes, for example, have a quasi-one-dimensional density of states and a relatively inert surface which results in less Fermi level pinning and a strong dependence of the contact barrier height on the metal workfunction. Nevertheless, the simple Schottky model fails to correctly predict the barrier height dependence on the nanotube band gap. The Schottky model is also inadequate for describing metal-nanowire contacts, even in the absence of strong one dimensional character in the band structure. In my talk, I will review recent experimental results for metal contacts to nanotubes and nanowires, and discuss how the dimensions and geometry of these nanostructures affect barrier formation. I will also discuss situations where bulk-limited transport in nanowires leads to non-linear current-voltage characteristics, and which is often, incorrectly, ascribed to contact effects.

10:40am **EM+NC-ThM9 Reliability of III-N Electronic Devices**, ***M. Shur***, Rensselaer Polytechnic Institute **INVITED**

III-N materials system has a much larger dislocation and defect densities than more conventional semiconductors, such as silicon or III-V materials, and III-N field effect transistors operate at much higher voltages and/or current densities. As a consequence, device reliability is one of major concerns for III-N semiconductor technology. In GaN-based field effect transistors, reliability mechanisms are linked to hot electron trapping, trap creation in high electric fields at the gate edges (especially at the gate edge closer to the drain), and to the gate leakage current. The electric field activated carrier trapping in the gate-to-drain spacing of AlGaN/GaN HFET is primarily responsible for the current reduction at RF frequencies (so-called current collapse, or RF dispersion. The defect states creation at the gate edges and in the drain-to-gate spacing depends on the device temperature. At relatively low temperatures, these defect states are created due to impurity anneal. At higher temperatures, crack and dislocation creation becomes the dominant mechanism leading to the permanent device failure. As a consequence, an extrapolation of high temperature accelerated reliability tests to lower temperatures might be inaccurate. Except for the failure mechanism related to the gate leakage current, other failure and performance degradation mechanisms are related to a high electric field at the drain edge of the device channel and in the drain-to-gate spacing adjacent to the gate. (Therefore, GaN-based RF switches operating at zero DC drain bias and having insulated gate structure (MOSHFETs and MISHFETs) do not have reliability problems.) Field plates and dual field plates diminish the maximum electric field in the device channel improving reliability. Another approach, still to be explored, is based on using Field Controlled Electrode at the drain, which a kind of a field plate attached to the drain, rather than to the gate or source. Leaky passivation helps discharging the trapped charge diminishing the current collapse. Optimization of buffer doping also improves reliability. These design approaches, using better quality substrates, and improving materials quality of III-N epitaxial films will allow to achieve long life times and stable performance for high power and high frequency GaN-based field effect transistors.

11:20am **EM+NC-ThM11 The SiC Surface: A Surface of Growing Technological Importance**, ***C.R. Eddy, Jr.***, *D.K. Gaskill, M.A. Mastro, R.T. Holm, B.L. VanMil, R.L. Myers-Ward, M.E. Twigg, Y.N. Picard*, U.S. Naval Research Laboratory, *P.G. Neudeck, A.J. Trunek, J.A. Powell*, NASA Glenn Research Center

Silicon carbide has become a highly versatile substrate providing a foundation for device technologies based on III-V nitrides, silicon carbide and graphene materials. In each of these systems, the starting silicon carbide surface plays a pivotal role in determining the properties and qualities of the material. The importance of surface orientation and preparation to each materials system will be discussed in terms of step morphology and contributions of extended defects in the substrate. For III-V nitride heteroepitaxy, basal plane SiC is preferred and surface morphology plays a critical role in the defectivity of films. Engineered SiC substrate surfaces are used to create localized regions of the surface with widely varying step densities including areas nearly free of surface steps. Experiments show that surface steps are directly responsible for extended defects in the heteroepitaxial layers. Nearly step-free surfaces are used to demonstrate drastically reduced extended defect concentrations ($\leq 10^7$ cm^{-2}) in GaN epilayers. In regard to SiC homoepitaxy, the key elements are the control of polytype deposition, the removal of surface imperfections arising from the substrate, and the reduction or elimination of extended defects arising from the substrate or during the epitaxial nucleation process. Substrates are prepared oriented slightly away from the basal plane to promote single polytype epitaxy and off-cut toward <11-20> to promote the smoothest films. Although modification of the surface is an unavoidable first step to epitaxy due to the reactive nature of hydrogen at growth temperatures near 1600°C, the best epitaxy occurs when the surface is controllably etched to remove unwanted polishing damage. And with the desire to fully exploit the properties of SiC for high power devices, it is necessary to initiate the epitaxy in such a way as to greatly reduce or eliminate extended defects. In the new field of graphene formation through sublimation of SiC surfaces, key elements are the removal of surface imperfections from the substrate and the control of surface properties, i.e., steps that may be used advantageously for specialized devices. Key aspects of surface properties and preparation will be discussed in terms of surface structure and extended defect intersection with the surface as characterized by atomic force microscopy, electron channeling contrast imaging, and transmission electron microscopy.

11:40am **EM+NC-ThM12 Investigation of Negative Electron Affinity in Hydrogen Complex Deactivated Surface of InP:Zn (100)**, ***M.D. Williams***, Clark Atlanta University

Ultraviolet photoemission spectroscopy is used to investigate the development of negative electron affinity at the surface of hydrogenated Zn doped InP (100). Hydrogen injected into the material electronically passivates the local carrier concentration. Reverse-biased anneals of the InP under ultra-high vacuum show a dramatic change in the work function of the material within a set annealing temperature range suggesting the establishment of negative electron affinity at the surface. The strength of the negative electron affinity is 1.08 eV for a reverse bias field strength of approximately 1875 V/m . This value is consistent with the deactivation energy of the H-Zn complex (1.14 eV) determined previously. Spectral features are also shown to be sensitive to sample temperature. Hydrogen retrapping at the surface limits the effect and it is dependent on surface conditions.

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