Electronic Materials and Devices
Room 310 - Session EM+SC-TuA

50th Anniversary Sessions: Electronic Materials
Moderator: L.J. Brillson, Ohio State University

2:00pm **EM+SC-TuA1 Electronic Materials Growth: A Retrospective and Look Forward*, C.W. Tu,*** University of California, San Diego **INVITED**

This article reviews the development of electronic materials, primarily III-V compound semiconductors, from substrates to epitaxy and in situ monitoring to heterostructures, quantum wells and superlattices, that are important to various device applications. As the current research direction leads to the immediate future, the article then summarizes some of the recent advancement in quantum wires, nanowires, and quantum dots.

2:40pm **EM+SC-TuA3 Electronic Materials Theory: Interfaces and Defects*, C.G. Van de Walle,*** Palo Alto Research Center **INVITED**

The experimental advances in electronic materials over the past decades have been accompanied by a remarkable increase in the ability to predict structural and electronic properties from first principles. Basic theory, along with modeling and simulation, has always been instrumental in understanding materials. Only recently, however, has the capability emerged to accurately predict properties based solely on the composition of the material, without any fitting to experimental quantities. Such a description must be based on a quantum-mechanical treatment, i.e., a solution of the Schrödinger equation for the system of atomic constituents. The seemingly impossible task of solving this vast many-body problem was rendered feasible by the development of density functional theory (DFT), an achievement for which Walter Kohn received the Nobel Prize in Chemistry in 1998. Other important developments that have greatly enhanced the ability to tackle large systems include pseudopotentials, the simultaneous optimization of electronic and atomic degrees of freedom as embodied in the Car-Parrinello method, and the tremendous increase in available computer power. In this talk I will focus on two areas in which these theoretical and computational advances have had a major impact, namely heterojunction interfaces and defects in semiconductors. Both are intimately connected to the high-quality growth techniques that have enabled a host of novel electronic devices. In the area of defects I will describe the effects of point defects and impurities on doping, specifically highlighting the role of hydrogen. A recently discovered universal alignment for the electronic level of hydrogen in semiconductors and insulators reveals a surprising link with the problem of heterojunction band lineups.

3:20pm **EM+SC-TuA5 Progress in Electronic Materials Characterization*, P.H. Holloway,*** University of Florida **INVITED**

Progress in characterization of electronic materials over the past 50 years will be illustrated by selected examples of determination of the atomistic reconstruction and formation of electronic states at surfaces and interfaces of semiconductors using surface sensitive characterization techniques. The same techniques have been used to characterize reactions at interfaces and determine the mechanisms by which charge carrier transport is changed from that controlled by Schottky rectifying to contacts with ohmic characteristics. Seconday ion mass spectrometry (SIMS) has been used to measure dopant profiles over dimensions <10 nm below the surface, and optical characterization techniques have been used for real time control of semiconductor growth. Finally, areas of future development in electronic materials characterization techniques will be the subject of speculation.

4:00pm **EM+SC-TuA7 Making Contact - The Evolution of Materials for Silicon Device Contacts and Interconnections*, J.M.E. Harper,*** University of New Hampshire*; S.M. Rossnagel, F.M. d'Heurle, L. Clevenger, C. Lavoie, C. Cabral, Jr.,* IBM T.J. Watson Research Center **INVITED**

The evolution of silicon device technology during the 50-year history of the AVS required not only the constant miniaturization of the transistor, but the concurrent miniaturization of contact metallurgy and interconnection structures. With decreasing area and thickness came a series of materials challenges related to deposition processes, interdiffusion, compound formation and phase stability. These challenges were overcome with a steady stream of innovations in alloy metallurgy, deposition methods, diffusion barriers and understanding of phase formation that apply far beyond the field of microelectronics. Many of these advances were developed by active AVS members and award winners, since the AVS has provided a fertile professional arena for bringing together the necessary scientific and engineering perspectives. Examples will be taken from the development of aluminum-copper and copper interconnections and from the evolution of titanium, cobalt and nickel silicide contact metallurgy.

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