SI-IMS/MANA Joint Seminar

Title : **Nano-electronics of high κ dielectrics on exotic semiconductors for science and technology beyond Si CMOS**

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Abstract

The dimensional scaling in the transistors, which in the past has simultaneously provided high-density,low-cost, and high-performance ICs in Si-based system, does not give device performance advantages. New materials of high κ dielectrics and high carrier mobility channel materials, along with novel device architectures are beginning to play important roles for improving the required performance. Looking ahead beyond the 16 nm node ICs, the general consensus is that new high mobility channels such as III-V's (InGaAs) and Ge will have to be integrated onto Si as "hybrid" chips for future devices; this may occur in 2017-2020. The intensive quest since early 1960's in identifying electrically and thermodynamically stable insulators on InGaAs with a low interfacial density of states (Dit) and low leakage current densities, required for the self-aligned inversion-channel InGaAs MOSFET, has finally been answered by our discovery of UHV-deposited Ga2O3 (Gd2O3) [GGO] [1] and Gd2O3 [2] films on GaAs surfaces, and later by atomic layer deposited (ALD) oxides. The first inversion-channel GaAs and InGaAs MOSFETs were demonstrated with GGO as a gate dielectric. With these achievements, the problem puzzling the researchers for the past 35 years has finally been solved. Moreover, the discovery has opened up an entirely new field for the IC industry – III-V MOSFET. We have successfully extended high κ dielectric growth using MBE to that using ALD, on the III-V's, Ge, and GaN. Furthermore, we have achieved world-record device performance in self-aligned inversion-channel InGaAs MOSFET, much more superior than those of Si devices in the same gate length, [3,4] as well as a CET of ≤ 1 nm and high-temperature thermal stability withstanding >850°C RTA in GGO and a CET of ≤ 1 nm in ALD-HfO2 on InGaAs. [5,6] *In-situ XPS analysis was used to determine the energy-band parameters at* interfaces of high κ oxides on InGaAs, and showed that absence of arsenic oxide and elemental arsenic was a principal mechanism responsible for Fermi level unpinning at the dielectric oxide/GaAs interface, thereby leading to effective passivation of the InGaAs surfaces. [7,8] Self-aligned, inversion-channel Ge MOSFET using MBE-GGO without any interfacial layers have shown remarkable device performances. [9] Inversion-channel and accumulation type GaN MOSFET's with high κ's as gate dielectrics have exhibited remarkable device performance due to excellent high κ's/GaN interfaces and high κ values, even the device designs are simple.

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