Abstract for an Invited Paper
for the MAR12 Meeting of
The American Physical Society

Metropolis Prize Talk: Defects in Al_2O_3 and their impact on III-V/Al_2O_3 MOS-based devices

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As the dimensions of conventional silicon devices continue to shrink, novel approaches are required to achieve increasing performance demands. Recently Intel announced the implementation of a 3-D MOSFET geometry known as the tri-gate transistor for their 22 nm technology. In addition to different geometries, new materials will also be needed for future technologies. In this talk, we will consider the use of III-V channel materials, and novel gate dielectrics. Al_2O_3 is a promising dielectric for III-V devices. However, the presence of deep levels and fixed charge in the Al_2O_3 layer is a concern, with native defects being a potential source of traps, leakage, and fixed charge. We will present the results of hybrid density functional calculations for such defects. The energetic positions of defect-induced levels will be discussed in the context of the III-V/ Al_2O_3 interface. We find that native defects are a source of border traps, and fixed charge in the dielectric. We will also discuss the interaction of hydrogen with such defects, in the context of passivation. Our results indicate that hydrogen is effective at removing border traps, and helps to alleviate the problem of fixed charge. This work was performed in collaboration with A. Janotti and C. G. Van de Walle.