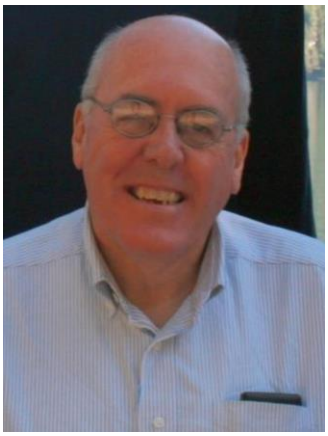
Reliability and Performance Limiting Defects in 4H SiC Metal Oxide Semiconductor Field Effect Transistors



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Abstract:

Enormous progress has been made in the development of metal oxide semiconductor (MOS) technology based upon 4H SiC. However, this promising technology is significantly limited by reliability and performance limiting defects. The most important defects are at and very near the SiC/SiO_2 interface. Fairly extensive electron paramagnetic resonance studies (EPR) have developed an extensive but not yet complete understanding of the atomic scale structure of defects responsible for these problems. Most of the EPR studies have utilized extremely sensitive electrically detected magnetic resonance (EDMR) detection. These EDMR studies clearly demonstrate links between processing chemistry and the densities of at least some of these defects. In addition, EDMR results elucidate the role they play in limiting device performance and, to some extent, device reliability. Because EDMR directly involves measurements of device currents, they provide direct and completely unambiguous links between defect chemistry and device performance. These studies show that the SiC/SiO_2 interface/ near interface defects are far more complex than is the case for the much better understood Si/SiO_2 system. In the Si/SiO_2 system, interface silicon dangling bond defects called

P_b centers usually dominate interface traps. Oxide silicon dangling bond centers called E' centers (often associated with oxygen vacancies) usually play dominating roles in oxide charge trapping. In the 4H SiC/SiO_2 system near interface SiC silicon vacancies, nitrogen complexed defects, and carbon and possibly silicon dangling bond centers can, depending on processing parameters, play significant roles in interface trapping. Near interface E' defects can also play important roles in the SiC/ SiO_2 system, in a manner somewhat similar to the roles they play in the Si/SiO_2 system.

Biography:

Patrick Lenahan is Distinguished Professor of Engineering Science and Mechanics and Co-Chair of the Inter-College Graduate Program in Materials Science and Engineering at Pennsylvania State University. He earned his B.S. degree from the University of Notre Dame and his Ph.D. from the University of Illinois at Urbana –Champaign. After completing his Ph.D. at Illinois, he did a post-doc at Princeton University. Following the post-doc, in 1980, he joined Sandia National Laboratories, Albuquerque, NM, where he served as a member of the technical staff for five years. Since 1985 he has been with Pennsylvania State University. Patrick and his students have investigated reliability and materials physics problems in systems including the interfaces of silicon and silicon carbide with silicon dioxide, hafnium oxides, silicon nitrides, and a variety of low-dielectric constant materials. The work has focused upon developing a fundamental understanding of the role of point defects in the operation of solid state electronic devices. In recent years, his group has worked to develop various electrically detected magnetic resonance techniques to explore the structure and electronic properties of point defects in fully processed devices. The work has resulted in approximately 230 journal articles, about 45 conference proceedings articles, about 400 conference presentations, and 4 patents. Patrick has been technical program chairman and general program chairman for the IEEE International Integrated Reliability Workshop and has also served on the technical program committee of the IEEE Semiconductor Interface Specialists Conference, the IEEE Nuclear Space Radiation Effects Conference, and the Rocky Mountain Conference on Magnetic Resonance; he has also served as either an invited or elected organizer of the MRS Electronic Materials Conference for many years. He is a fellow of the IEEE.