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Integration of Oxides with Widebandgap Semiconductors : A New Platform for Electronic Devices

Yoon Soo Park
Seoul National University, School of Physics, Seoul 151-742 Korea
E-mail: yoonsoopark@msn.com

Recent surge of interest in Widebandgap Semiconductor (WBG) is attributable to demonstration of blue laser diodes which paves the way for many applications such as displays, solid state lighting, and optical storage. Not only the materials have many favorable optical properties but also they have attractive electronic, mechanical and thermal properties for high temperature, power and frequency applications. The most attractive properties of WBG as a semiconductor are its bandgap, large exciton binding energy, a very efficient radiative recombination process and a high saturation velocity. Through the development and exploitation of the material, device, and circuit properties of widebandgap semiconductors, many new exciting applications and capabilities can be envisioned. Pursuit of widebandgap semiconductor materials research will revolutionize semiconductor industry in the fields of displays, lighting, high power electrical energy. In addition multifunctional structures involving ferroelctronic materials are promising areas of exploration for the future.

ONR launched the program "Epitaxial Multifunction Materials and Applications (EMMA)." The objective of this program is to develop revolutionary techniques for single-crystal epitaxial complex-oxide thin films and multi-layer hetero-junctions (each layer performing a different active function) on semiconductors. A primary goal is to investigate hetero-junctions, superlattices, and quantum wells between various functional crystal films as far as possible on SiC, nitride semi-conductors, GaAs, InP and Si devices and applications.

Widebandgap semiconductors integrated with Lithium-Metal Oxides are promising family of materials for a variety of applications. For examples, III-N HEMTs on Lithium Niobate MZ modulators are "the low hanging fruit" with new applications, cost reductions and possible new markets. Non-linear Optics can now enter its epitaxial design phase. High Frequency Magnetic Tuning elements are now very likely. Ferroelectric power transistors may be possible. An entirely new set of "Multi-functional" devices are within our grasp.

Potential for improved device design exists by integration of widebandgap semiconductors with crystalline oxides. Applications include:

- SiC Power Transistors
- Surface Charge control on III-Nitrides
- Various Optical Devices
- Integrated Optics and Electronics

Epitaxial oxides, and in particular, lithium niobate/tantalate materials are a promising material set that could lead to advanced multifunctionality. Using plasma assisted growthand novel chlorinated metal sources, MBE can be used to epitaxially grow Lithium Niobate on SiC. Future efforts will involve epitaxy of variations of the metallic cations and applying these new films for new device structures. Integration of WBGS with Crystalline Oxides is illustrated.