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A Systematic Study of Metallic and Semiconductor Heterojunction 2-terminal Lateral Nanoscale Vacuum Field Emission Devices

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In the last 15 years there has been renewed interest in vacuum field effect transistors (VacFETs) with nanoscale feature sizes for their potential to transcend performance limitations associated with solid state transistors while maintaining some of the benefits of complex scaling and large-scale batch fabrication common to integrated circuits. Specifically, the vacuum channel of a VacFET offers potentially superior device operation for high temp and radiation hard environments, faster switching for high power/high frequency applications, and can be a surface for sensitive gas adsorbate sensing [1]. Employing wide bandgap semiconductor materials for VacFETs is of practical interest because their high covalent bond strength offers robustness for long-term reliable operation and the potential for hybrid on-chip integration with solid-state circuitry.

Our team has successfully demonstrated repeatable DC operation (< 30 V) of AlGaN/GaN heterojunction based nanoscale vacuum field emission diodes that emit from the edge of the two-dimensional electron gas (2DEG). Specifically, we have demonstrated the first 2DEG cathode / 2DEG anode variant and a 2DEG cathode / Metallic anode variant that performed at the largest current (~600 µA) reported to date for this class of device [2]. The team has also developed a computationally efficient and capable 3D modeling and simulation approach suitable for lateral metallic field emission devices [3]. On-going examination of 2-terminal metallic (Au/Cr) lateral nanoscale vacuum devices has been central towards its development, particularly for the consideration and inclusion of practical leakage effects that could occur [4]. This presentation will share an overview of these efforts and our projected posture towards extending our computational tools to accommodate nanoscale semiconductor field emission [5] and demonstration of 3-terminal VacFET devices.

References:

[1] N. Hernandez, et al, JVST-B, (2022); 40(5), 053201 doi:10.1116/6.0001959
[2] N. Hernandez,et al J. Appl. Phys. (2024); 135 (20): 204305 doi:10.1063/5.0204235
[3] J. Ludwick, et al. J. Appl. Phys., (2021). 130, 144302, doi: 10.1063/5.0065612
[4] J. O'Mara, et al, (2023) IEEE IVNC 2023, doi: 10.1109/IVNC57695.2023.10189015
[5] N.Hernandez et al J. Appl. Phys. (2024); 136 (15): 155704 doi:10.1063/5.0234885

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Field emission

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