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Title: Wide bandgap electronics and sensors for nuclear fuel cycle monitoring

Abstract:

Radiation sensors for nuclear fuel cycle processes monitoring are often found in harsh environments where the silicon-based sensors and electronic components would not function well, demanding wide bandgap microelectronic and sensors. We are developing 4H-SiC diodes with ink printed Ag, Au, and Pt Schottky metals for alpha radiation detection. The averaged energy resolution is 1.89% and the best achievable resolution is 0.51%, both at 5.486 MeV, compared to 0.29% using cleanroom fabricated SiC devices. Neutron sensitive boron carbide layer were also printed on the top of the metal contacts, enabling them as neutron detectors. Parallel to this effort, we are developing pixelated 4H-SiC sensor for position sensitive neutron detector. Gallium oxide stands as another wide bandgap material for possible usage as radiation detectors. We have developed low leakage gallium oxide based Schottky diodes using a recently developed metal/$BaTiO_3$/Ga_2O_3 structure for alpha radiation sensor applications. This has enabled the first demonstration of alpha particle detectors based on β-Ga_2O_3. Traps in GaN and β-Ga_2O_3 have been characterized and identified to enable ultra-low leakage with highly controllable low doping for high-sensitivity radiation sensors. Results so far have already demonstrated methods to reduce compensating and deep donor trap concentrations by more than an order of magnitude and are approaching requirements for controllable doping in the low 10^{15} cm^{-3}, which is expected to further leap the progress for their radiation sensor applications. On the front of electronics, radiation-tolerant monolithic GaN-based logic integrated circuits using the p-GaN/AlGaN/GaN high electron mobility transistors were designed and demonstrated. These have enabled the first demonstration of GaN-based logic gate circuits with excellent tolerance to gamma irradiation.