Experimental Demonstration of Ga_2O_3 as a Radiation Sensor and Its High Temperature Resistance

Jarod Remy (1), Thomas Blue (1), Parans Paranthaman (2), Lei R. Cao* (1)
(1) The Ohio State University, (2) Oak Ridge National Laboratory
remy.56@buckeyemail.osu.edu, *cao.152@osu.edu
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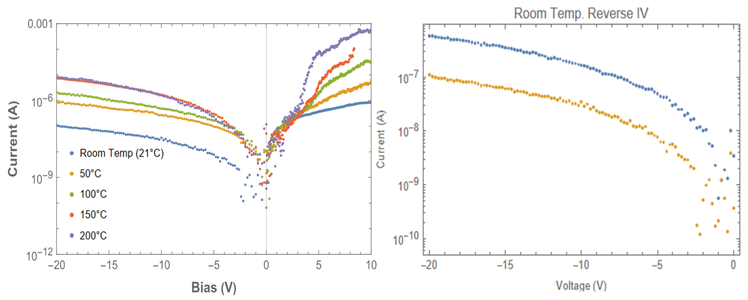
Introduction

Molten salt reactors and pyro-processing environments contain alpha particle emitting actinides. By deploying a detector sensitive to alpha particles, the ratio of the actinides may be determined. Devices in the molten salt environment will be subjected to high temperatures, high radiation fluences, and corrosion. Schottky barrier diodes made from wide bandgap semiconductors, such as 4H-SiC, have already been shown to be able to measure alpha spectra at high temperatures, but have been limited to 450 ºC. Ultrawide bandgap semiconductor, β-Ga_2O_3 is being investigated for deployment in environments of 550-750 ºC.

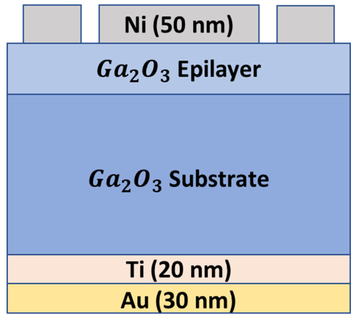
Thermal Investigations



- Temperature dependent measurements were performed on a Signatone S-1060RH high temperature hot chuck
- Following pthermal cycling of device, a reduction in leakage current at room temperature was noticed
- Current-voltage sweep was performed while being held at temperatures at 50 ºC intervals
- Contact failure occurred at 250 ºC

Goals and Objectives

- To fabricate Schottky barrier diodes from β-Ga_2O_3 as alpha particle detectors.
- Demonstrate sensitivity to alpha particles
- Determine electrical performance and sensitivity dependence on temperatures up to 750 ºC.



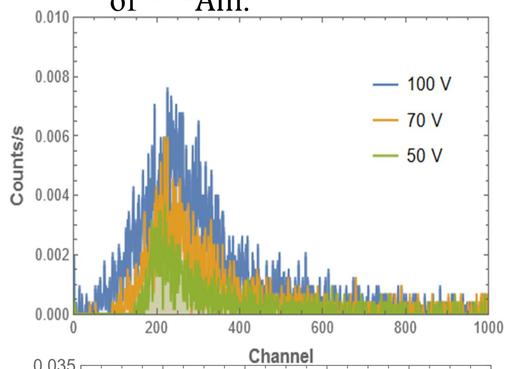
Schottky Contact with Guard Ring Structure

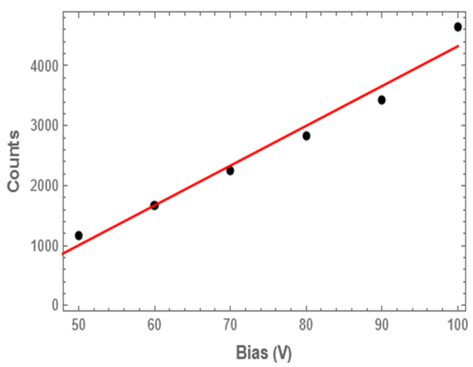
Contact Size: 0.785 mm^2
Epitaxial Layer Thickness: 11.0 μm
Dopant Concentration: 3.7×10^{16} cm^{-3}
Substrate Thickness: 640 μm

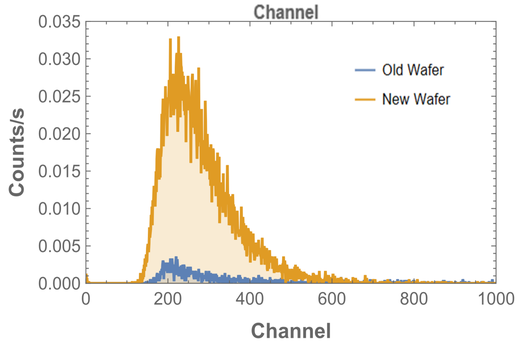
Epilayer grown by Hydride Vapor Phase Epitaxy

Results

- Sensitivity to alpha particles were demonstrated by collecting spectra of 5.486 MeV alpha particles from a 1 μCi button source of ^{241}Am.





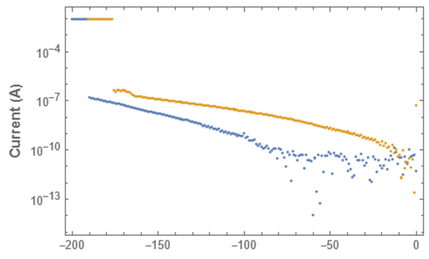


A second wafer has been procured from NCT, Japan. The new wafer has an average doping concentration of 7×10^{15} cm^{-3}

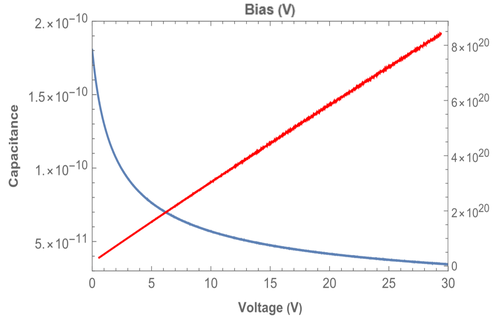
An increase in count rate ~14x while utilizing the same design

Electrical Characterization

- Current-voltage sweeps were performed to determine reverse bias leakage current and device breakdown
- Capacitance-voltage measurements were also performed to determine built in voltage and to view dopant profile



Breakdown occurring around -180 V



Inverse capacitance squared shows a uniform doping profile near the surface

$V_{bi} = 1.385\ V$

Conclusions

- Preliminary alpha spectra was achieved from a Ga_2O_3 Schottky barrier diode without the use of a passivation layer
- It will be necessary to extend the breakdown voltage to achieve the desired charge collection
- Thermal experiments have shown the necessity for more robust temperature resistant contacts

Acknowledgments

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