Diamond Gammavoltaic Cells for Biasless Gamma Dosimetry

Research area: Monitoring

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Project website: https://bit.ly/2YdG8id

The Challenge

Diamond dosimeters are reliable and well-characterised, with significant development having been undertaken within the SWNH [1]. Simple and radiation hard, they have no measured upper limit for dose rate and will continue to operate after other dosimetry technologies have saturated. This is possible due to some of the extreme properties of diamond, but those same properties necessitate the use of a high operating bias: 300 – 500 V over a diamond thickness of 0.5 mm. This creates a need for greater complexity in the measurement apparatus, introduces a shock hazard, and imposes size constraints on deployments.

The Solution

By careful modification of the design of a diamond dosimeter, it has been possible to create a device that powers itself in high-dose environments, from the ambient gamma flux. It is thus acting as a gammavoltaic. Gammavoltaics is a nascent field with no properly published devices at time of writing – this ought to be the first!

In lower-dose environments, where generative mode is not possible, the device can be operated in the same biased mode as a standard diamond dosimeter. However, the required voltage is much lower, being a sliding scale starting at 2 V.

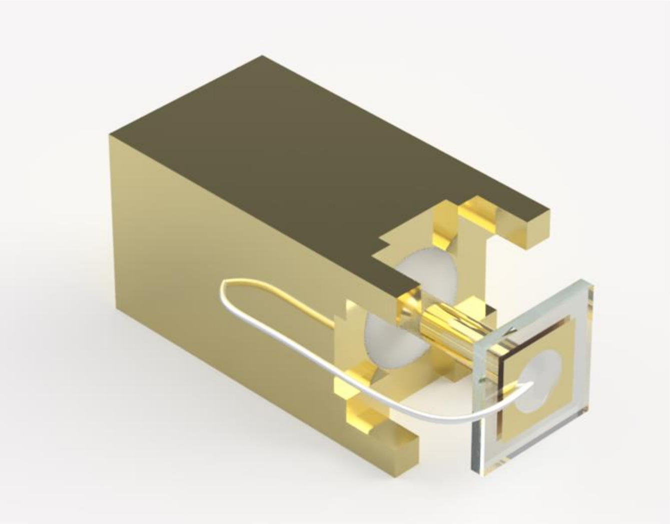

Figure 1*: A render of the as-constructed diamond gammavoltaic, mounted on an SMA head for testing, and here reproduced for monte carlo simulation purposes.*

[1] *Diamond-based Dosimetry for Measurements in Highly-Radioactive Nuclear Environments,* C. Hutson (2018)

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The Impact

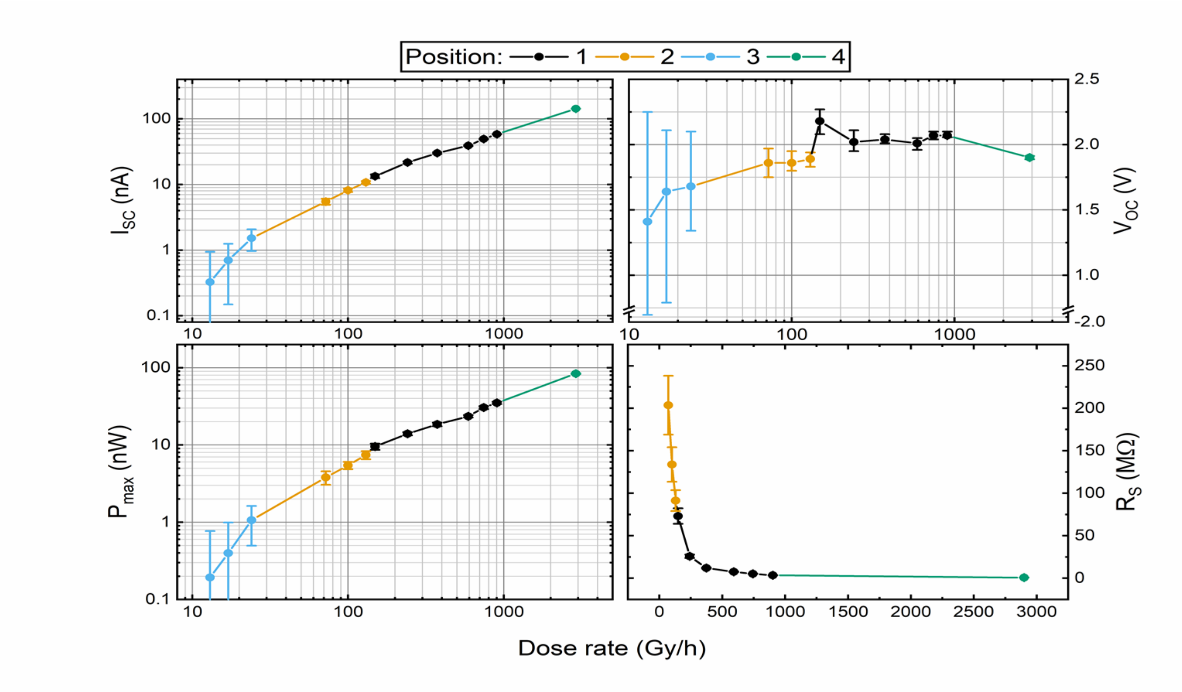

***Figure 2**: Diamond gammavoltaic device properties over widely varying fluxes of Co-60 gamma radiation. The short circuit current, I_{SC}, is the parameter most useful for dose rate measurement. The open circuit voltage, V_{OC}, and maximum power output, P_{max}, are both suggestive that in the near-term, a diamond gammavoltaic may even be able to power the apparatus used to make and transmit measurements. The change in series resistance, R_S, is believed to be a novel result for voltaic devices.*

At the moment, the device is still in the calibration phrase, being tested against dose rates measured with a standard dosimeter. It has currently been validated over 3 orders of magnitude with Co-60 radiation. The lack of bias and associated savings in space have allowed consideration of CubeSat deployment, for measurement of highly radioactive regions of space.

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