Characterization of Perovskite Semiconductors Under Ionizing and Non-ionizing Radiation Exposure

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Introduction

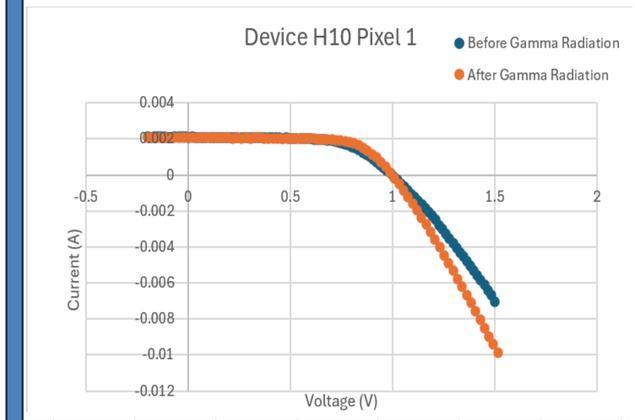
Perovskite semiconductors are promising for space applications due to their adjustable bandgaps and self-healing properties. This research investigates their response to electromagnetic radiation, including non-ionizing UVA radiation and ionizing gamma radiation. Ionizing radiation carries enough energy to remove tightly bound electrons while non-ionizing radiation does not.

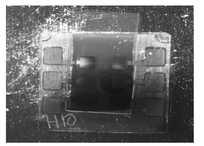
Comparing the effects of these radiation types allows for a greater understanding of how energy level influences material damage and recovery. Post-irradiation changes in elemental composition and optoelectronic performance are characterized to assess stability in space radiation, offering insight into the suitability of perovskites for future space technologies.

Procedure

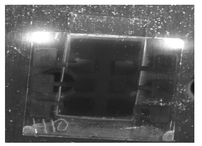
1. Characterize perovskite devices through J-V curve analysis and photoluminescence (PL) mapping to identify power efficiency, and optoelectronic and elemental changes prior to radiation exposure.
2. Expose two devices (H3 & H7) to 3 hours of UVA radiation and two devices (H9 & H10) to 55k Rad (~8 minutes) of gamma radiation.
3. Post-characterize the devices through the same techniques as in step one. Compare the results and analyze the performance of the samples. Note which radiation types were most destructive to the perovskite devices.
4. Analyze damage done to devices. If damage is not seen or is minimal, expose the perovskite devices to further radiation (e.g. now expose devices to 24 hours of UVA radiation).

Measurements/Results

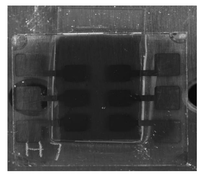




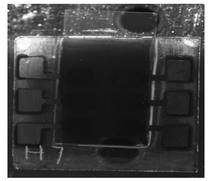
Before Gamma



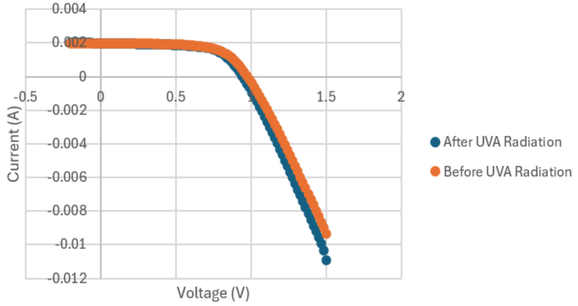
After Gamma



Before UVA



After UVA



J-V Curve Analysis

PL Mapping

Averages	Open-circuit voltage (V)	Short-circuit current density (mA/cm^2)	Fill factor	Power efficiency (%)
Before Gamma	0.989	23.1	68.3	15.6
After Gamma	0.997	22.7	68.1	15.4
Before UVA	0.984	21.9	64.1	13.8
After UVA	0.999	22.1	70.3	15.5

Conclusion

This research focused on the potential impact of simulated space radiation on perovskite semiconductors and the differences ionizing and non-ionizing radiation may pose. From the measurements gathered, both gamma radiation and UVA radiation posed no clear damage to the devices. There were no major differences in the imaging or power efficiency. Although no signs of damage is a great indication that perovskite semiconductors will perform efficiently in space, higher doses of radiation will need to be tested to ensure that these materials will withstand the doses experienced in space.

Future Work

Looking further into the semester, devices H9 & H10 will be exposed to a higher dose of gamma radiation (about 2 hours or ~1M Rad). Devices H3 & H7 will be exposed to 24 hours of UVA radiation. Then, devices H4 & H6 will be exposed to a low dose of X-ray radiation (may be exposed to a higher dose if no damage is visible after the first exposure). More extreme doses of radiation will be important as they will function as more realistic tests of what these kinds of devices would be exposed to in space. It may also reveal damage that occurs after a certain dose of radiation, allowing for a deeper understanding and analysis of the behavior of perovskite semiconductors under space radiation.

FURI

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