

Researchers show that the sun's energy can repair solar cell defects in the vacuum of space

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Anita Ho-Baillie and Shi Tang wear protective gloves while examining perovskite solar cell prototypes. Credit: University of Sydney

Australian researchers have demonstrated that perovskite solar cells

damaged by proton radiation in low-Earth orbit can recover up to 100% of their original efficiency via annealing in thermal vacuum.

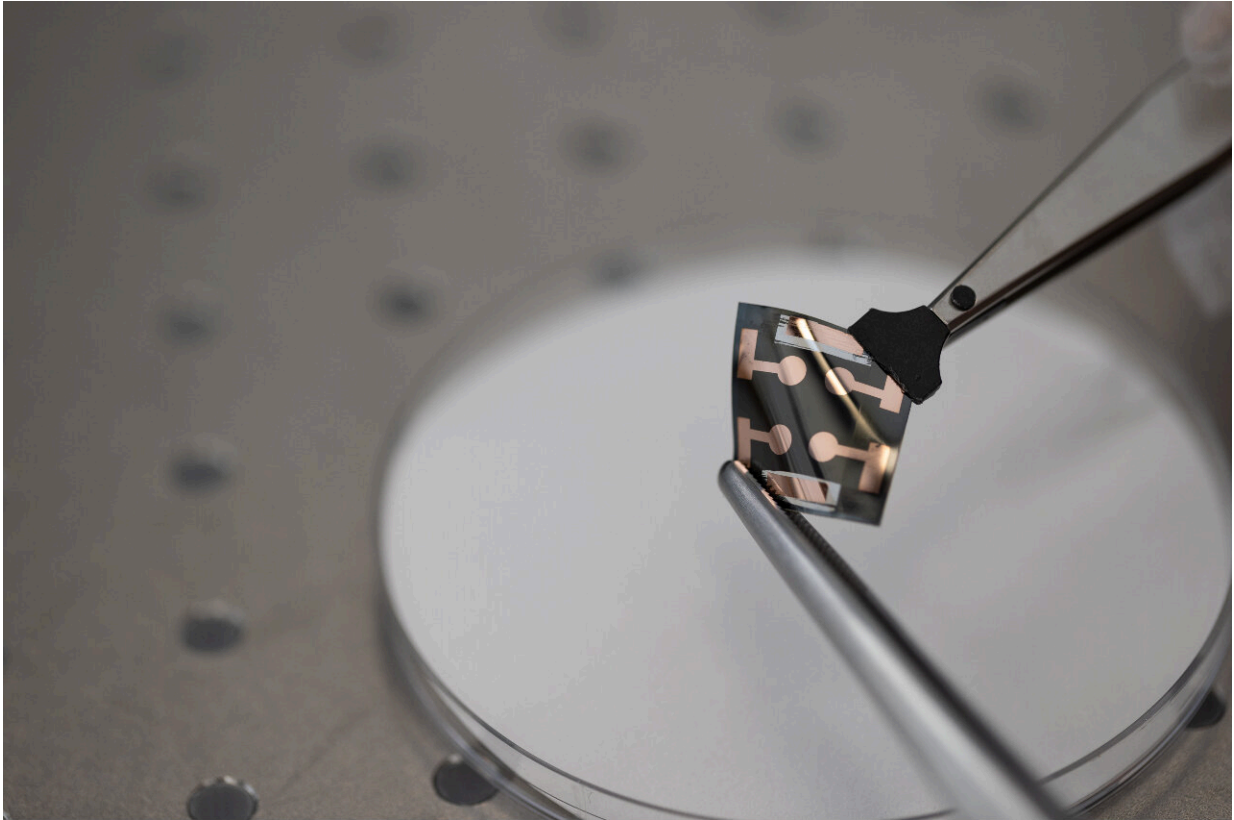
This is achieved through careful design of the hole transport material (HTM), which is used to transport photo-generated positive charges to the electrode in the cell.

The multidisciplinary project is the first to use thermal admittance spectroscopy (TAS) and deep-level transient spectroscopy (DLTS) to study the defects in proton-irradiated and thermal-vacuum recovered [perovskite solar cells](#) (PSCs). It is also the first study to use ultrathin sapphire substrates with the high power-to-weight ratios suitable for commercial applications.

The results have been published in the journal *Advanced Energy Materials*.

Light-weight PSCs are a strong candidate for powering low-cost space hardware thanks to their low manufacturing cost, [high efficiency](#) and radiation hardness.

All previous proton irradiation studies of PSCs took place on heavier substrates thicker than 1mm. Here, to take advantage of high power-to-weight ratios, ultrathin radiation resistant and optically transparent sapphire substrates of 0.175mm were used by a team based at the University of Sydney. The project was led by Professor Anita Ho-Baillie, who is also an Associate Investigator with the ARC Center of Excellence in Exciton Science.



A perovskite solar cell is examined using laboratory equipment. Credit: The University of Sydney

The cells were exposed to rapid scanning pencil beam of seven mega-electron-volts (MeV) protons using the [high energy](#) heavy ion microprobe at the Center for Accelerator Science (CAS) at ANSTO, mimicking the proton radiation exposure that the solar cell panels would undergo while orbiting the Earth on a satellite in low-Earth orbit (LEO) for tens to hundreds of years.

It was found that the type of cells featuring a popular HTM and a popular dopant within its HTM are less radiation tolerant than their rivals. The HTM in question is the compound 2,2,'7,7'-Tetrakis[N,N-di(4-methoxyphenyl)amino]-9,9'-spirobifluorene (Spiro-OMeTAD),

while the dopant is lithium bis(trifluoromethanesulfonyl)imide (LiTFSI).

Through [chemical analysis](#), the team found that fluorine diffusion from the LiTFSI induced by proton radiation introduces defects to the surface of the perovskite photo-absorber, which could lead to cell degradation and efficiency losses over time.

"Thanks to the support provided by Exciton Science, we were able to acquire the deep-level transient spectroscopy capability to study the defect behavior in the cells," lead author Dr. Shi Tang said.

The team was able to ascertain that cells free of Spiro-OMeTAD and free of LiTFSI did not experience fluorine diffusion related damage, and degradation caused by proton-radiation could be reversed by heat treatment in vacuum. These radiation-resistant cells had either Poly[bis(4-phenyl) (2,5,6-trimethylphenyl) (PTAA) or a combination of PTAA and 2,7-Dioctyl[1]benzothieno[3,2-b][1]benzothiophene (C8BTBT) as the hole transport material, with tris(pentafluorophenyl)borane (TPFB) as the dopant.

"We hope that the insights generated by this work will help future efforts in developing low-cost light-weight [solar cells](#) for future space applications," Professor Ho-Baillie said.

More information: Shi Tang et al, Effect of Hole Transport Materials and Their Dopants on the Stability and Recoverability of Perovskite Solar Cells on Very Thin Substrates after 7 MeV Proton Irradiation, *Advanced Energy Materials* (2023). [DOI: 10.1002/aenm.202300506](https://doi.org/10.1002/aenm.202300506)

Provided by ARC Centre of Excellence in Exciton Science

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