Radiation tolerance of $GaAs_{1-x}Sb_x$ solar cells: A candidate III-V system for space applications

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Outline:

- ➢ Space Industry powered by solar energy
- ➢ Radiation-induced degradation mechanisms
- ➢ GaAsSb based solar cell structure and spectroscopic properties
- ➢ Effect of electron-irradiation on the solar cell performance
- ➢ Improvement of carrier extraction under LILT conditions
- ➢ Conclusions and future work

Space Industry and Space Exploration

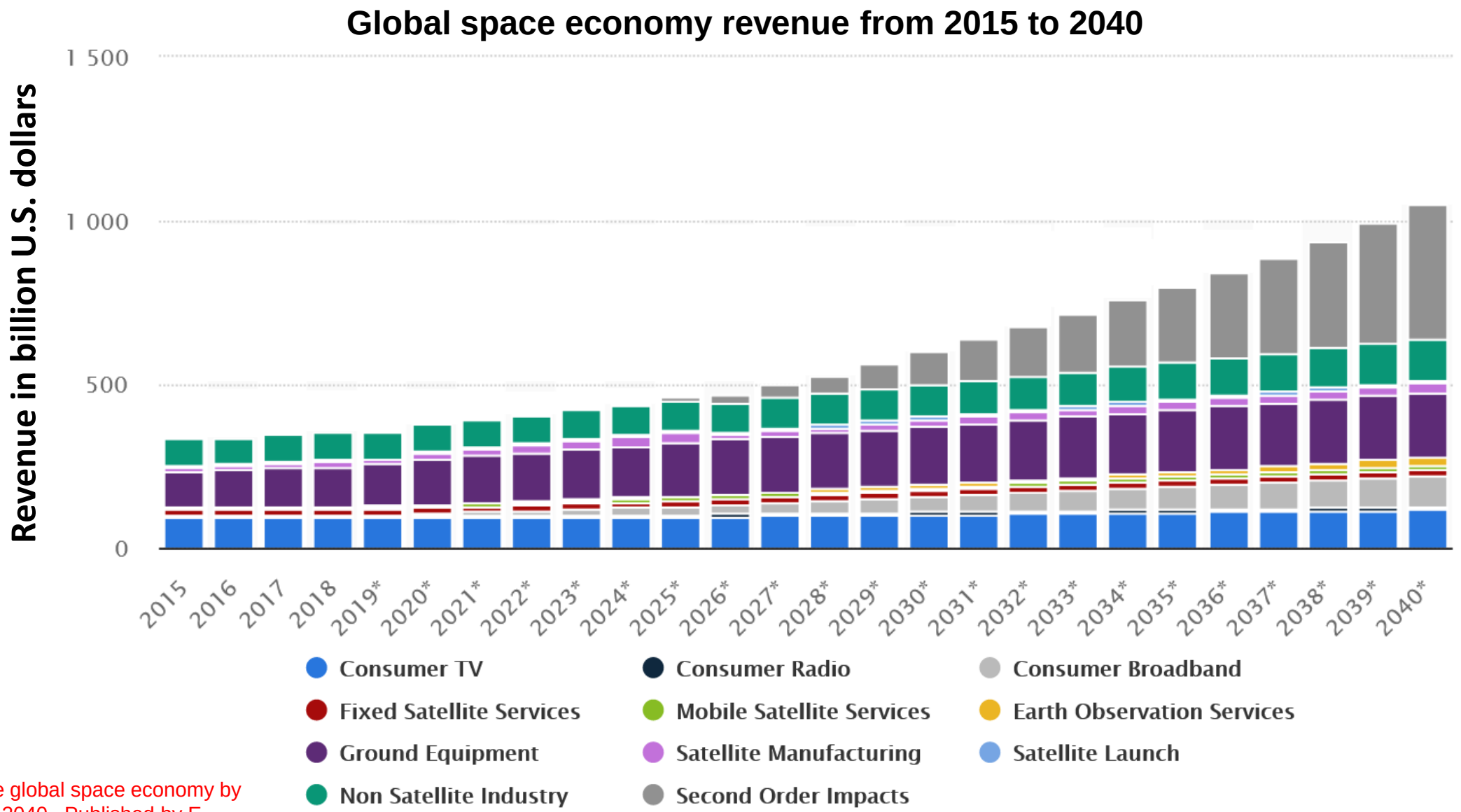
➢ An emerging and rapidly growing industry
➢ Solar Energy as the main source of power
➢ GaAs and multijunction systems have dominated the space solar panels, With issues regarding the cost of the solar panel and irradiation hardness.
➢ Studies are focusing on improving radiation tolerance of space solar panels

Opportunity Mars rover

CubeSats orbiting earth

Juno spacecraft orbiting Jupiter

Space Economy

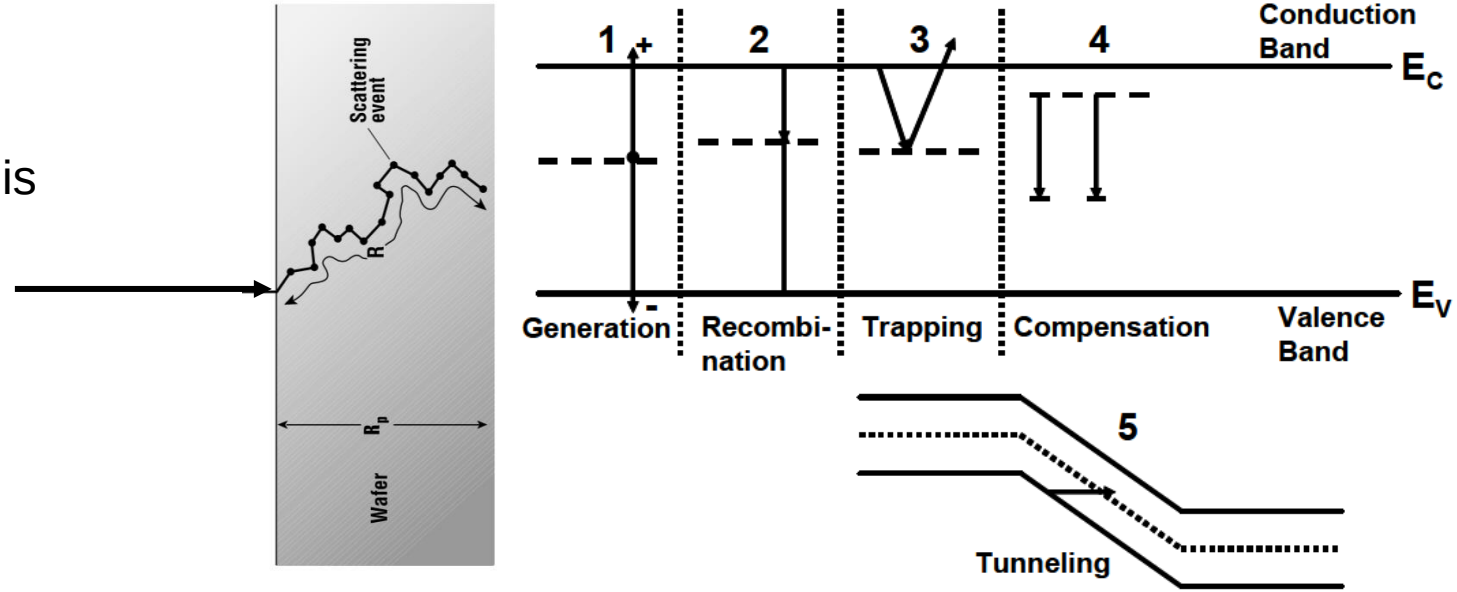


Revenue of the global space economy by segment 2015-2040 , Published by E. Mazareanu, Dec 11, 2019, www.Statista.com

Radiation-induced degradation mechanisms are similar in different technologies

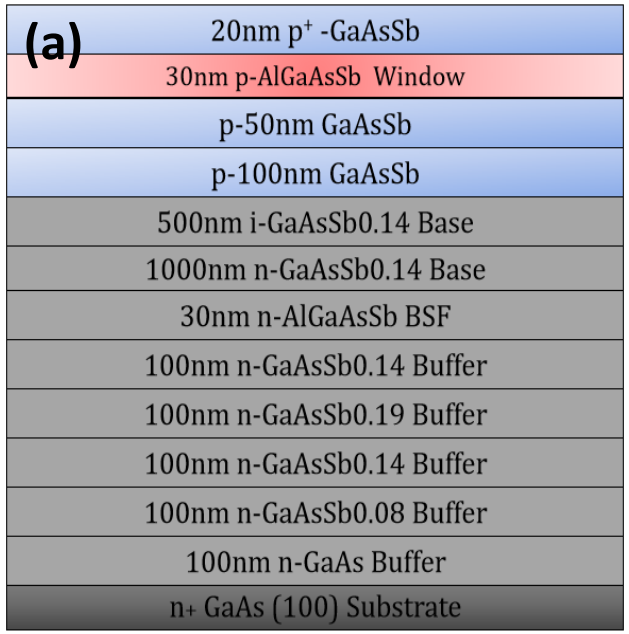
- Electronic Interaction
- Nuclear Interaction

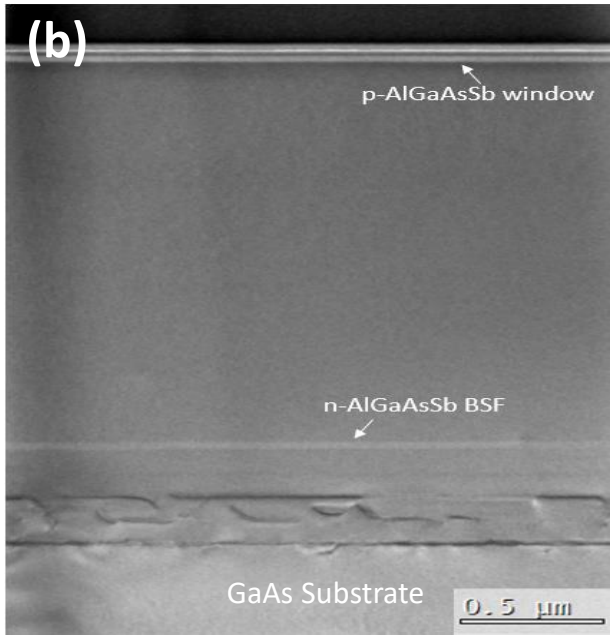
New defect states within the band gap.
The main effects of defect states in the band gap is degradation of minority carrier diffusion length.



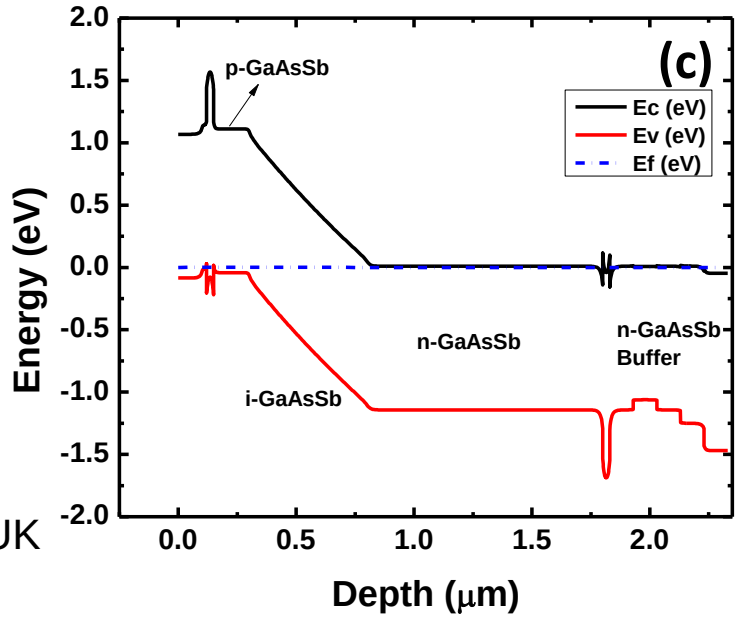
Modeling of Radiation Induced Defects in Space Solar Cells, R. J. Walters, S. messenger, J. H. Warner, C. D. Cress, M. Gonzalez and S. Maximenko Proc. of SPIE Vol. 7933 79330P-1

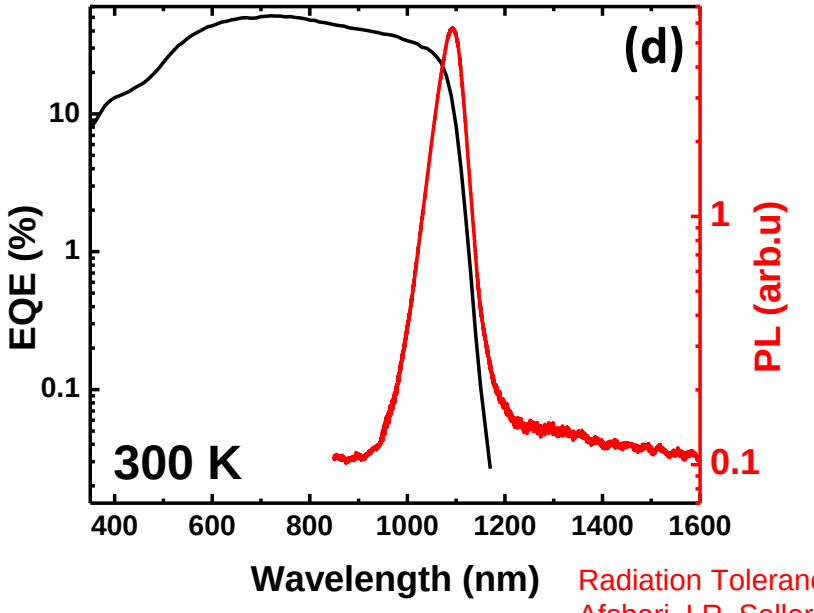
GaAsSb based solar cell





solar cells were grown using molecular beam epitaxy at University College London, UK





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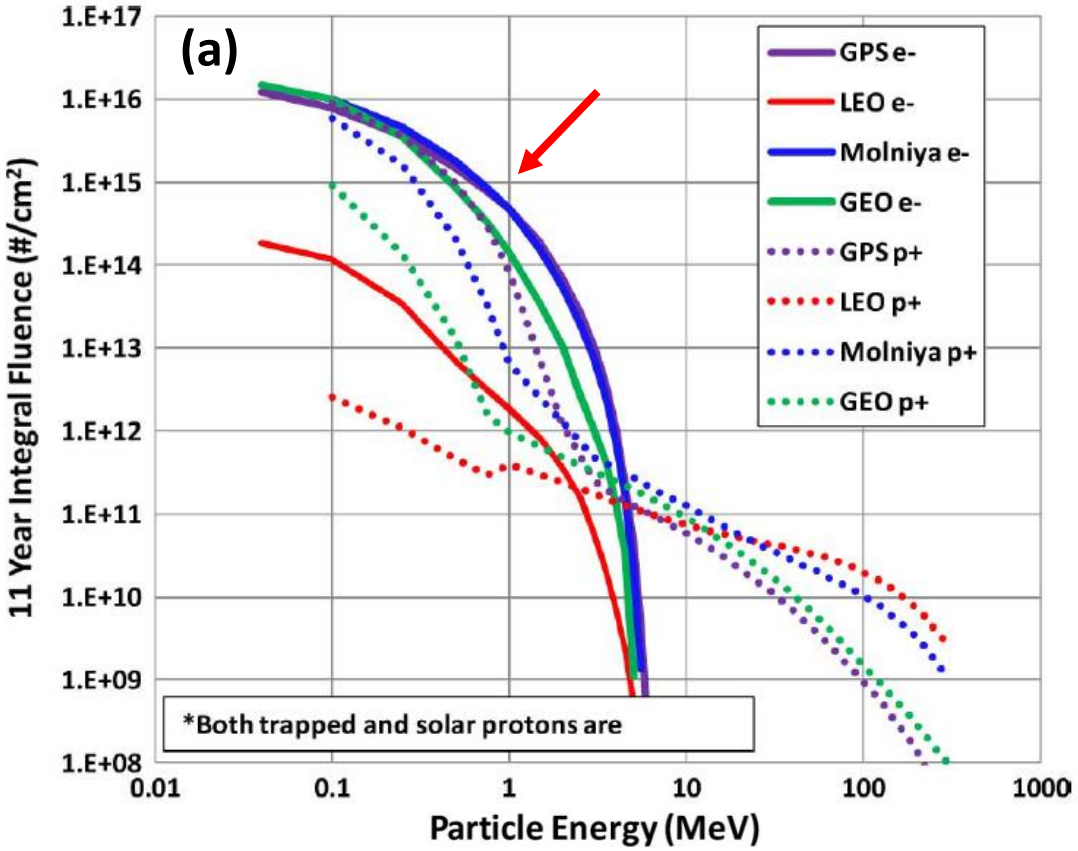
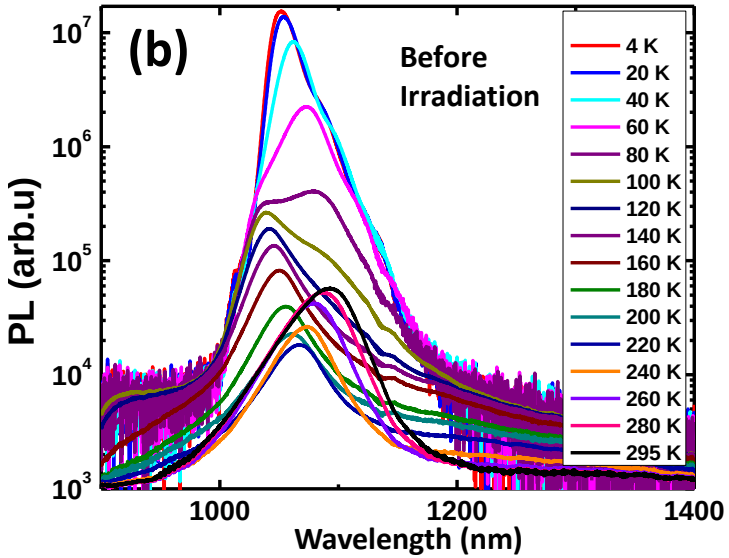
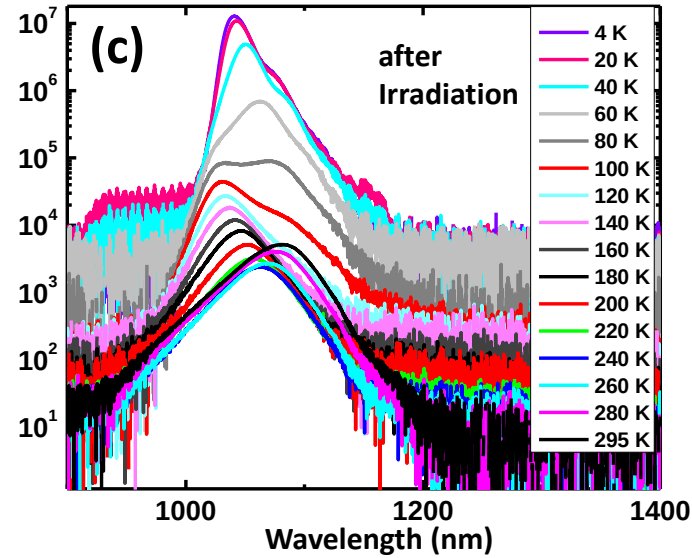
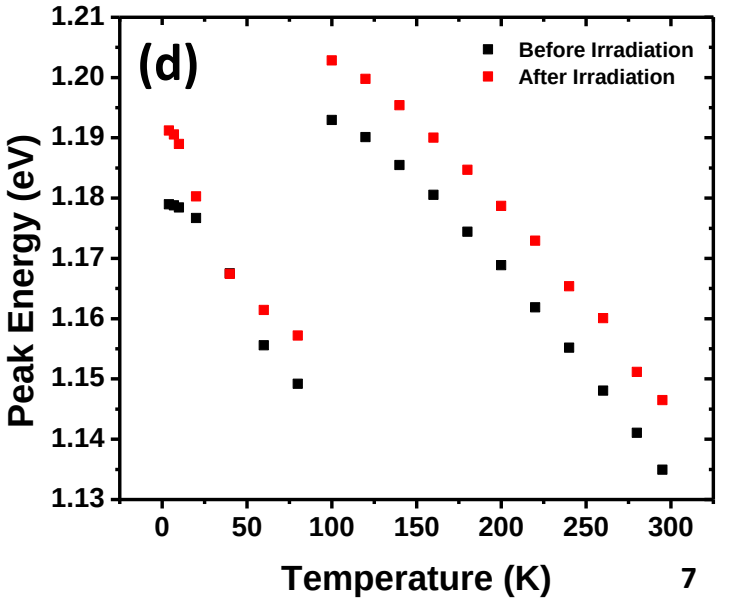
Electron Irradiation of the solar cells
Energy of 1 MeV, Fluence of 10^{15} 1/cm^2







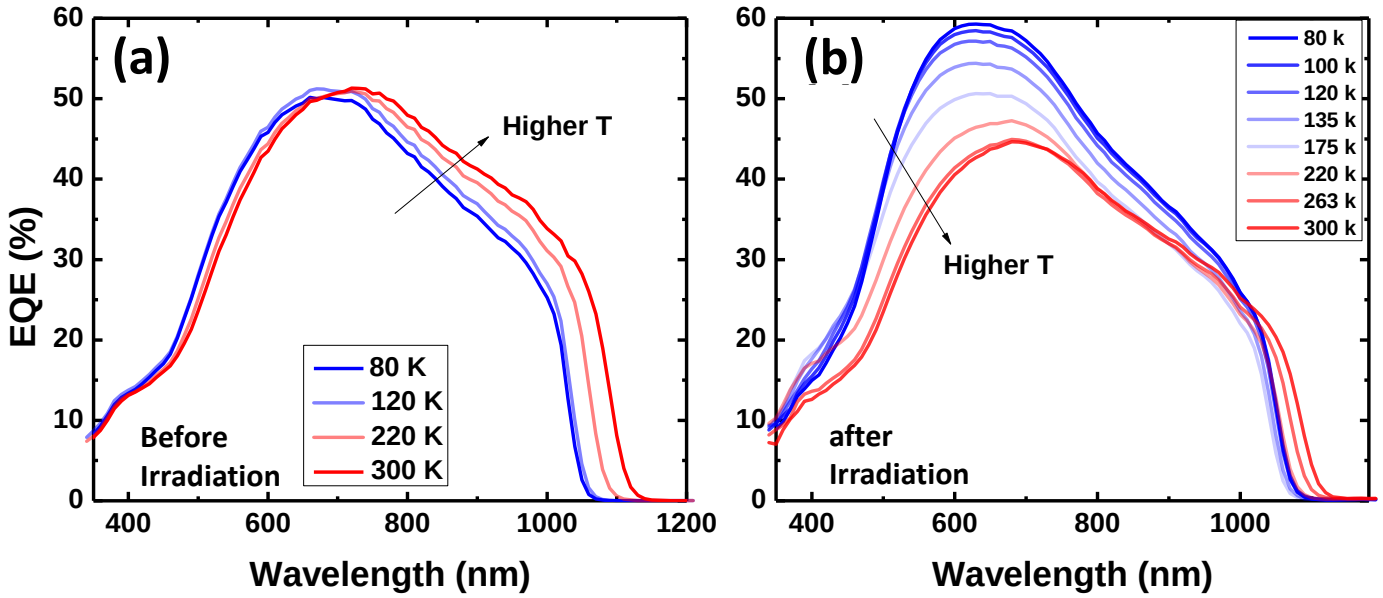


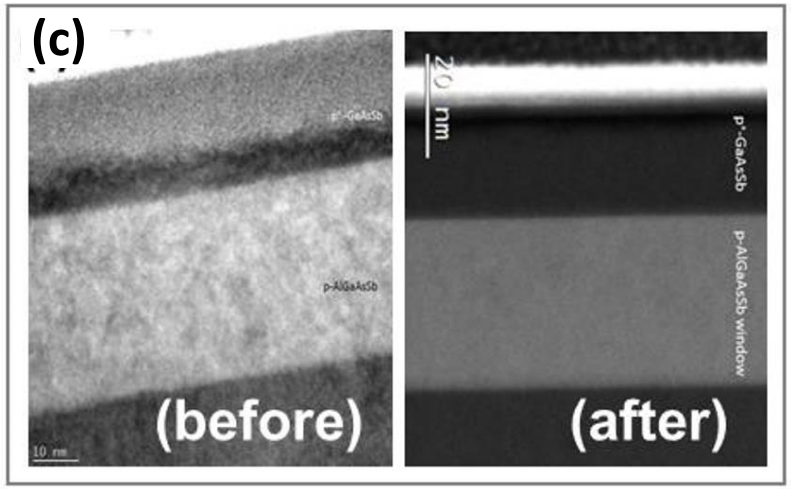
Energy of 1 MeV and fluence of 10^{15} exceeds the electron radiation levels that satellites at GPS, LEO, Molniya and Geo orbits experience in 11 years. It is also equivalent to irradiation levels at Jovian atmosphere

Electron Irradiation was performed in collaboration with NASA Glenn Research center, Ohio, USA

C. Inguimbert and S. Messenger, IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 59, NO. 6, 2012

Improvement in carrier extraction at low temperature





Irradiated solar cells have significantly higher quantum efficiency at low temperatures

TEM image of the cross section of the cell near the window layer shows before irradiation is more amorphous and after irradiation is more crystallin

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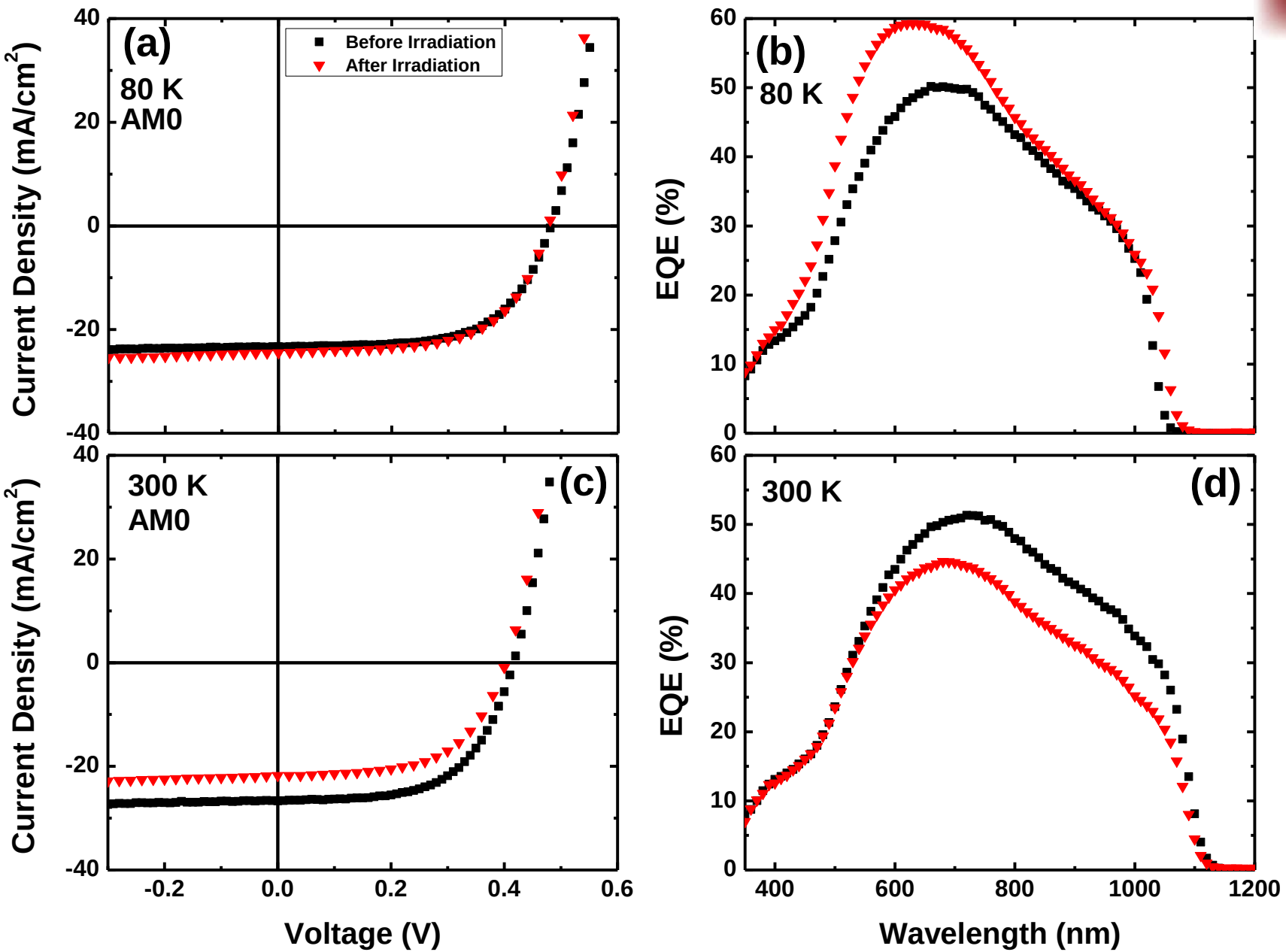
Radiation tolerance of GaAsSb solar cell specifically at low T

➢ Irradiated solar cell performs better than reference cell at 80 K
➢ Photocurrent produced by the cell is more than reference cell, reflected in higher EQE as well
➢ FF is un-affected

➢ V_{OC} of the cell is almost un-affected at all temperatures
➢ Photocurrent produced by the irradiated cell is less than the reference cell, reflected in higher EQE as well
➢ FF is almost un-affected



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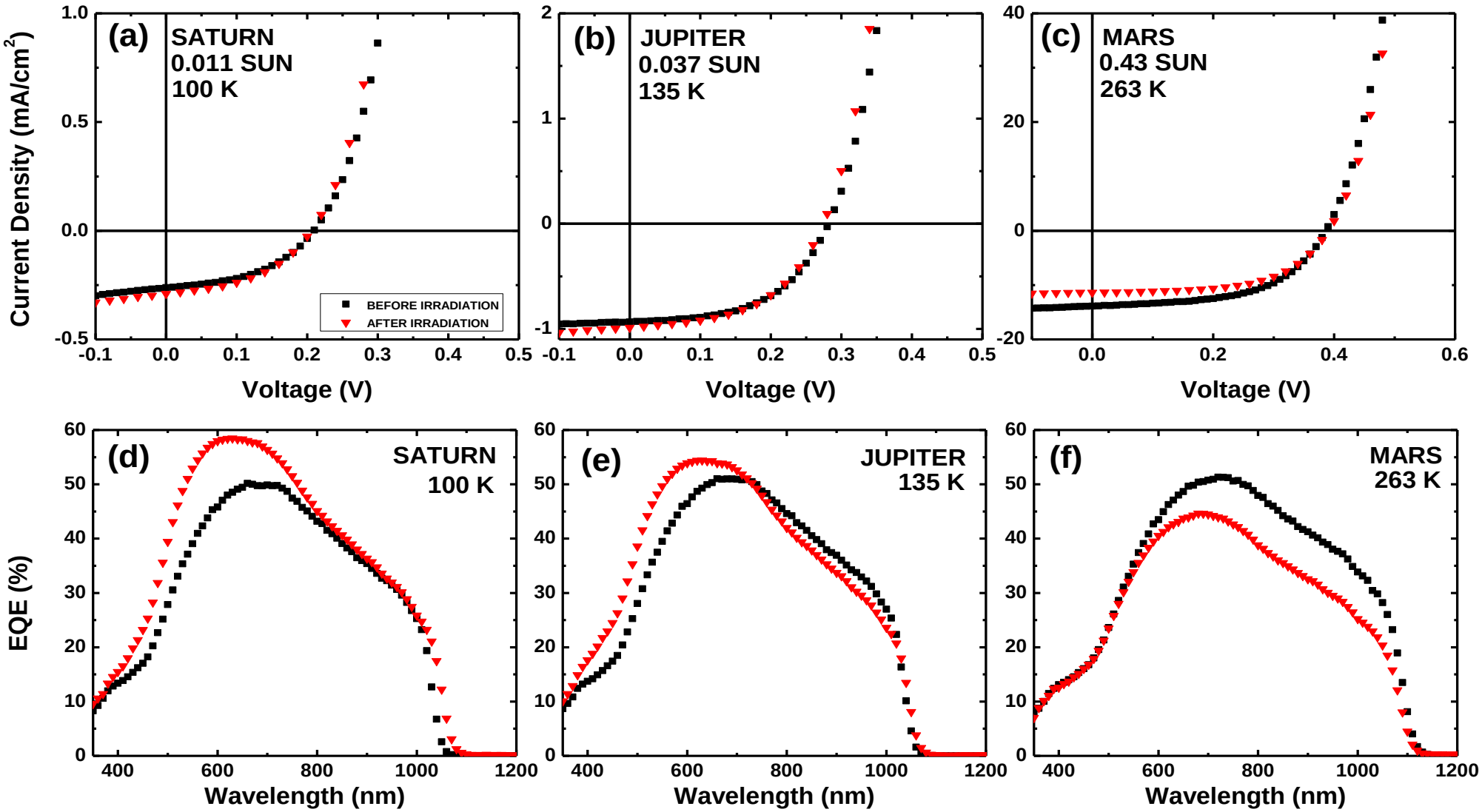
Excellent tolerance at LILT conditions



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Conclusion:

➢ Meticulously designed GaAsSb solar cell shows excellent electron-radiation tolerance
➢ V_{OC} is un-affected by the irradiation
➢ Radiation tolerance is specifically high at low temperature suited for LILT conditions
➢ Photogenerated current is improved at low T and LILT
➢ Electronic ionization and change in doping profile are potential reasons for improved photocurrent
➢ A wide spectrum of energy for electron irradiation can target different parts of the solar cell providing valuable information

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Oklahoma Center for the Advancement of Science and Technology

The Oklahoma Photovoltaic Research Institute

Thank you for your time and attention