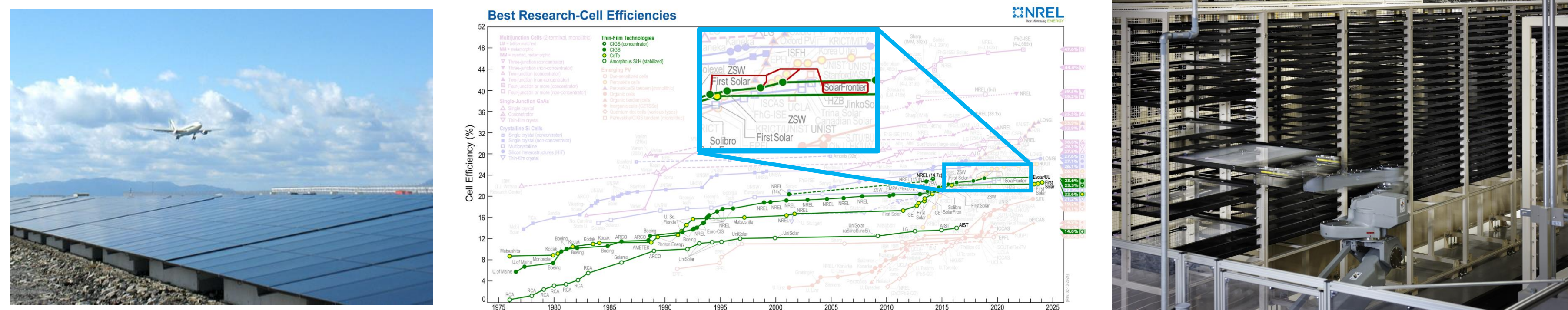


Abstract

Cu(In,Ga)(S,Se)₂ (CIGS) solar cells are widely used in terrestrial applications so far. However, CIGS solar cells will also be promising candidates for space applications because of their high radiative tolerance properties. Here we will show our cover-glass-less ultra-light CIGS solar cells which can present more cost-efficient options for space solar cells. Our ultra-light CIGS solar cells exhibited 16% (AM0) efficiency and high tolerance properties for protons and electrons. Also, ultra-light CIGS solar cells exhibited recovery from radiative damage by post light-soaking.

1. About CIGS Solar Cell

Cu(In,Ga)(S,Se)₂ (CIGS) solar cells are thin film solar cells that are widely used in terrestrial. We Idemitsu Kosan and our subsidiary Solar Frontier developed world-recording cells in lab scale and manufactured Giga Watt scale CIGS solar cells in the past.



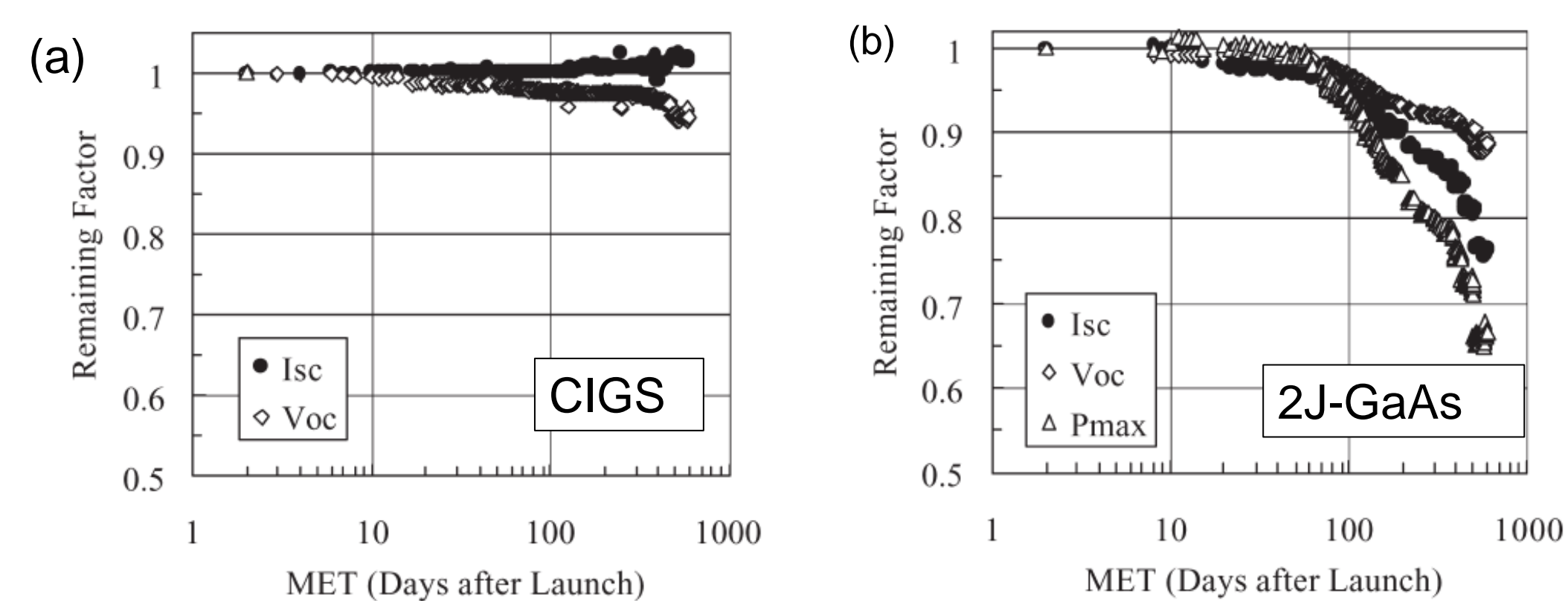
CIGS solar cells at Kansai Airport (KIX) Best Research-Cell Efficiencies table by NREL¹⁾ Manufacturing plant of Solar Frontier

2. Ultra-light CIGS solar cells by Idemitsu

We are currently developing ultra-light CIGS solar cells that will present more cost-efficient options for space missions. The features of our cells are described below.

• High radiative tolerance properties for higher End of Life efficiency

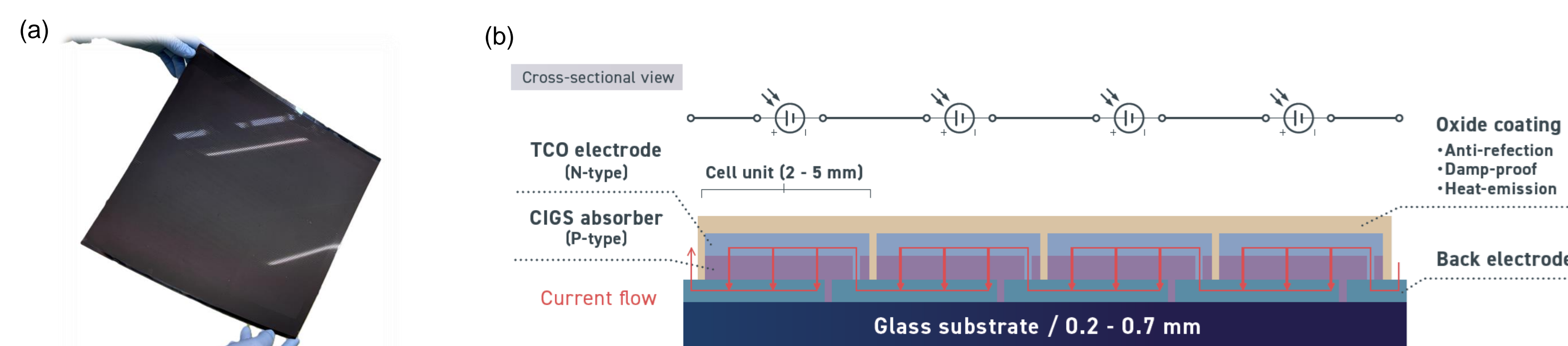
Space demonstration by JAXA (MDS-1)²⁾ and the University of Tokyo (Cubesat XI-V)³⁾ showed that CIGS solar cells exhibit high durability in space.



Degradation trend of I_{sc} and V_{oc} of the (a) CIGS (b) 2J-GaAs cell²⁾

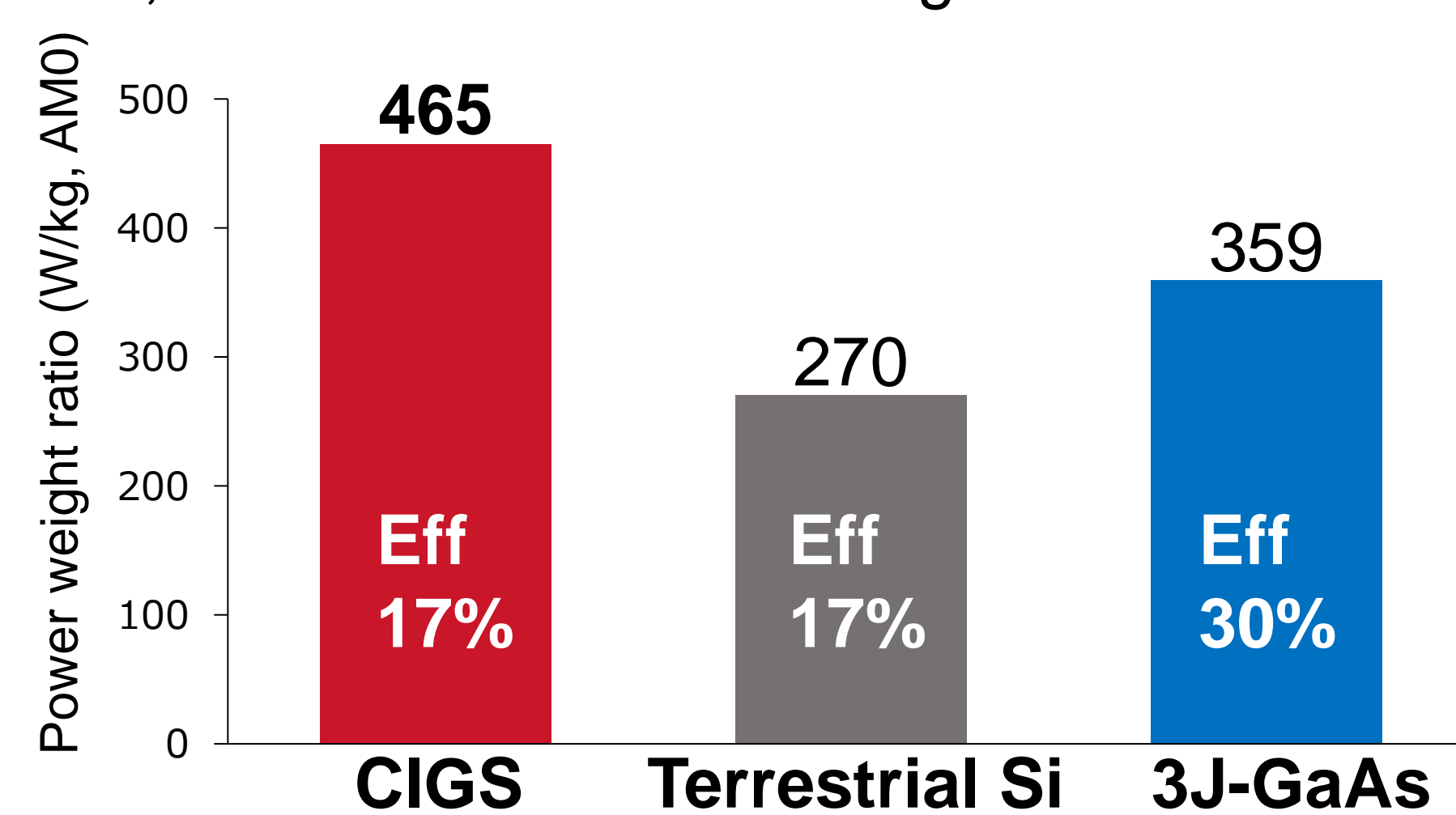
• Ultra-light weight for reducing launching costs

Idemitsu-CIGS solar Cells use 0.2 mm substrate glass and does NOT need any cover glass.



(a) External and (b) cross-sectional images of our CIGS solar cells

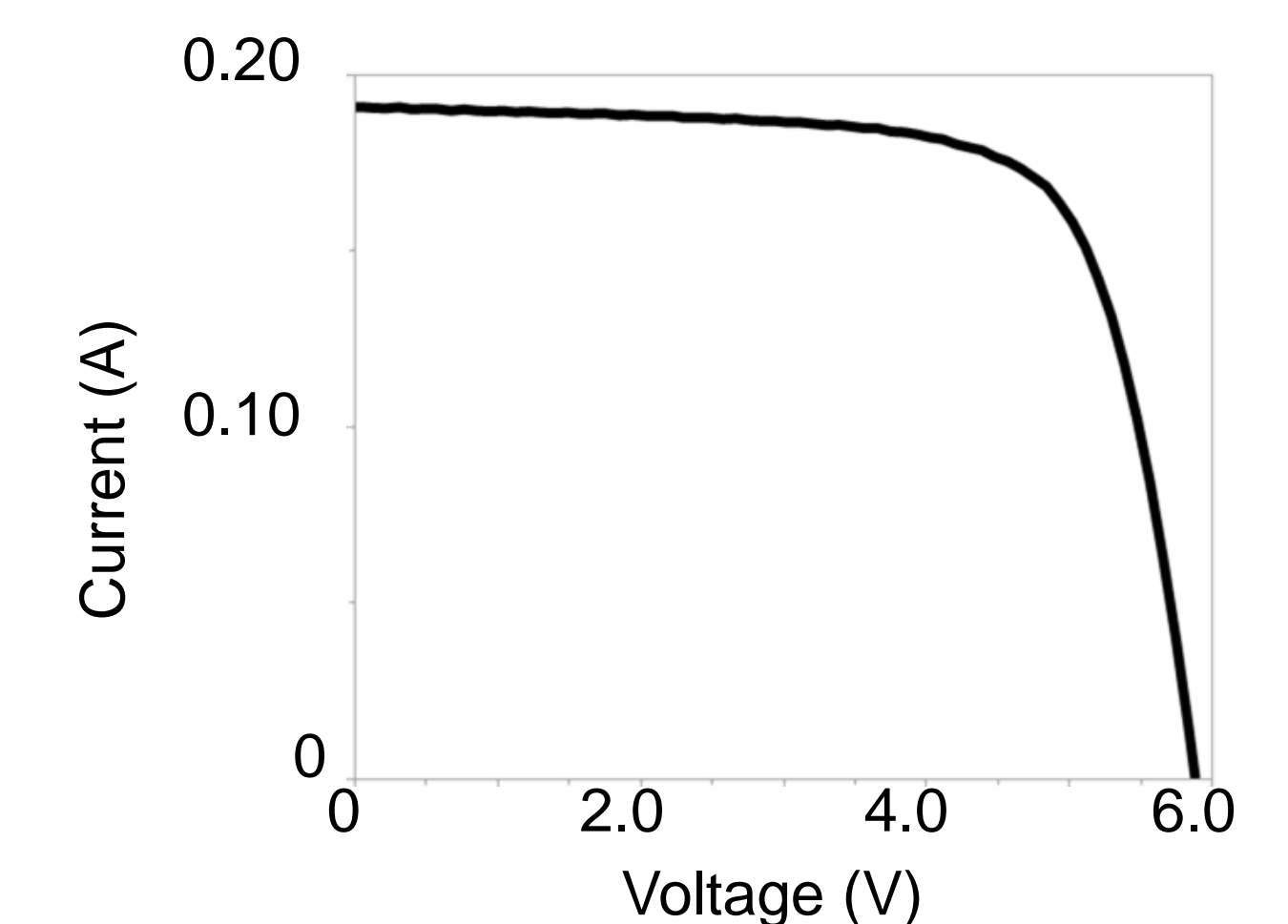
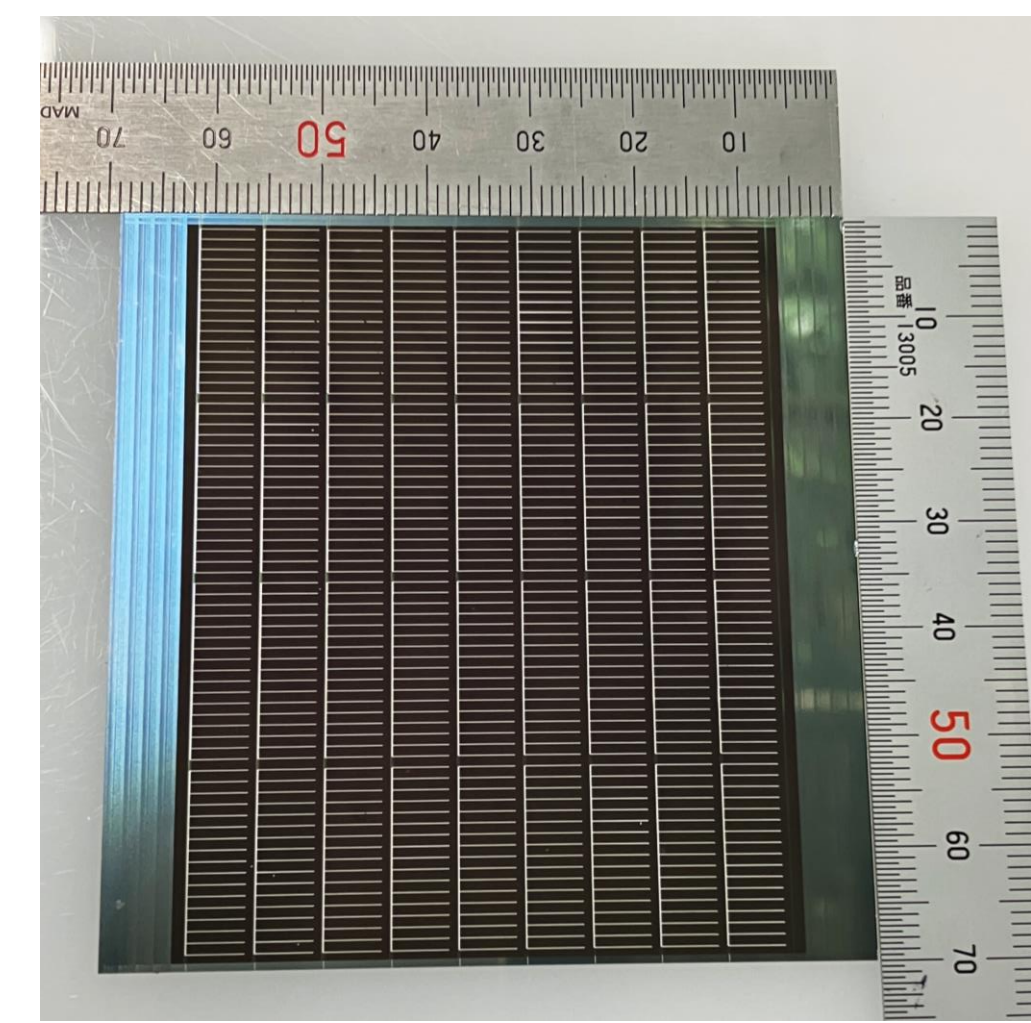
Therefore, our ultra-light CIGS solar cells show higher power weight ratio than terrestrial Si and 3J-GaAs solar cells, that will reduce launching cost.



Comparison of power weight ratio for typical space solar cells

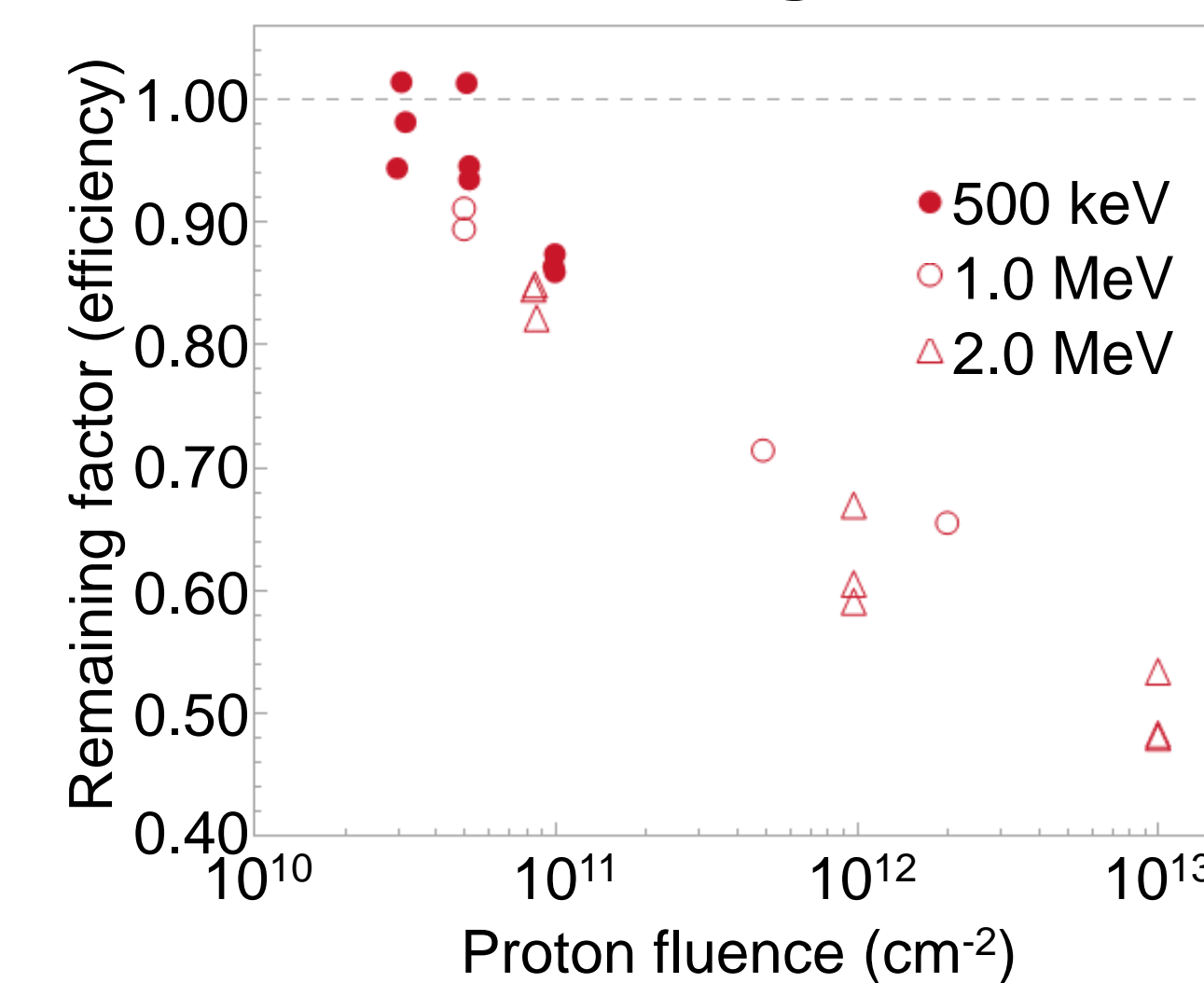
3. Our recent results

• Current BoL efficiency : 16 % (AM0, in-house).

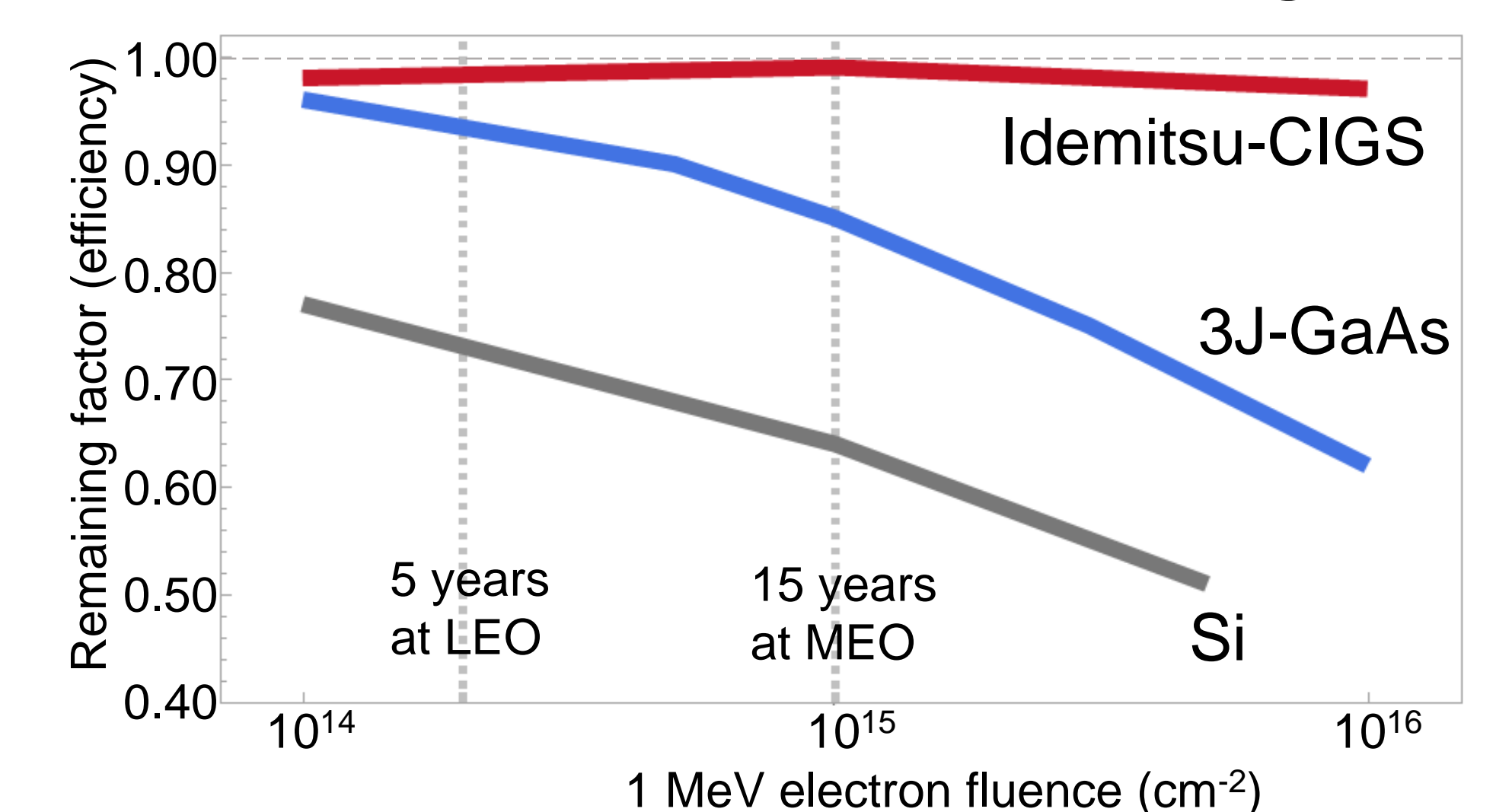


Eff(AM0) (%)	V_{oc} (V)	J_{sc} (A)	V_{pm} (V)	J_{pm} (A)	FF (%)
16.0	5.88	0.191	4.82	0.169	72.6

• Idemitsu-CIGS solar cells exhibited higher durability for protons and electrons even without cover glass than terrestrial Si and 3J-GaAs solar cells with cover glass.

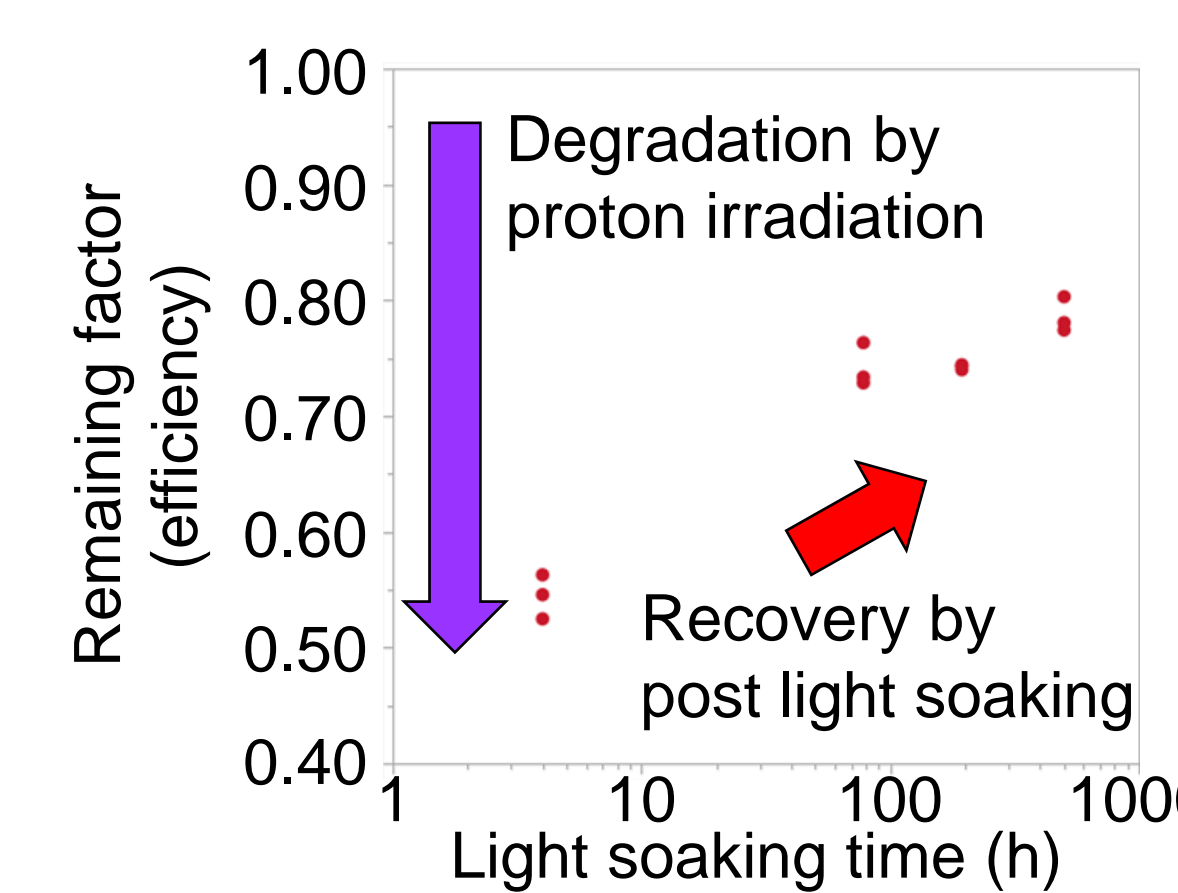


Degradation trend for proton irradiation of Ultra-light CIGS without post light-soaking for several proton energies.

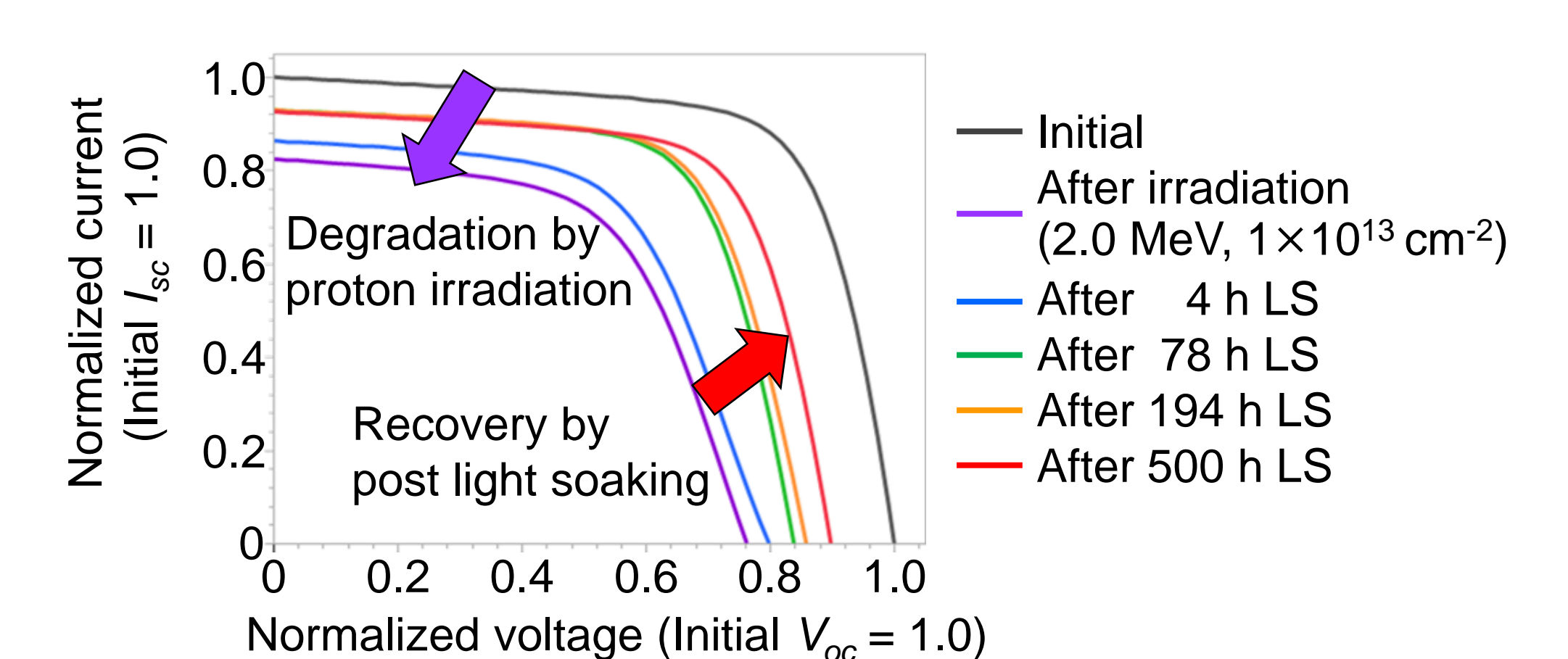


Degradation trend for 1MeV electron irradiation of Ultra-light CIGS (red), terrestrial Si (blue) and 3J-GaAs (green)

• Idemitsu-CIGS solar cells recovered from radiative damages after light-soaking.



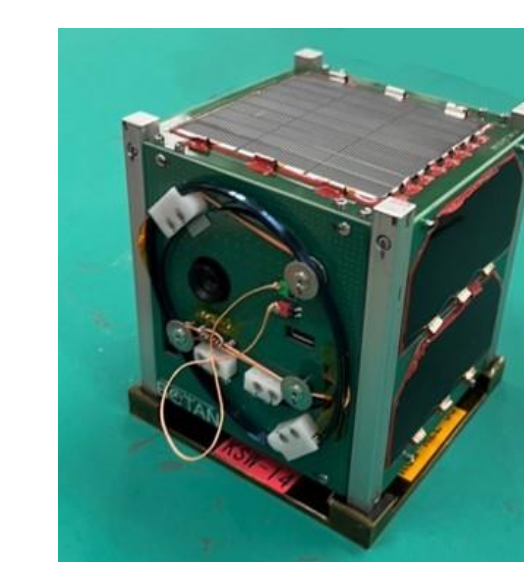
Recovery trend from proton irradiation damage by post light-soaking in N₂ atmosphere under metal-halide lamps (~ 60 mW/cm²),



Transition of IV curves during post light soaking in N₂ atmosphere under metal-halide lamps (~ 60 mW/cm²).

4. Future Work

- Reliability tests of Idemitsu-CIGS solar cells for space applications (thermal cycling, thermal vacuum, UV, atomic-oxygen, etc.).
- Space demonstration on a cubesat with Chiba Institute of Technology in 2025 (planned).



External appearance of the cubesat with Idemitsu-CIGS solar cells on top



- Mass production with an annual output of 1MW or more in 2026.
- Cell samples for your evaluation are available upon your requests after NDA.