ULTRA LIGHTWEIGHT PEROVSKITE SOLAR CELLS FOR SPACE APPLICATIONS

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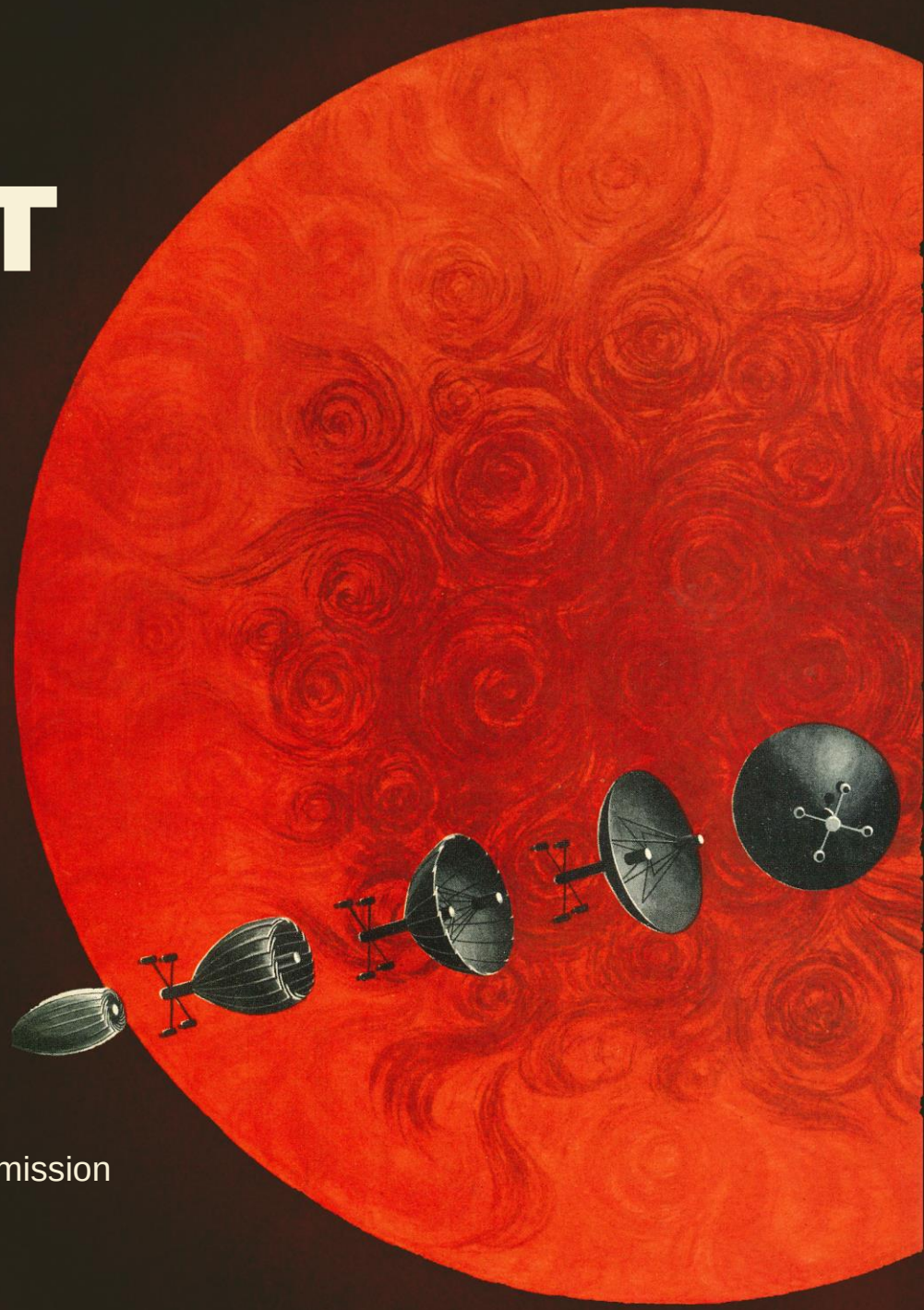
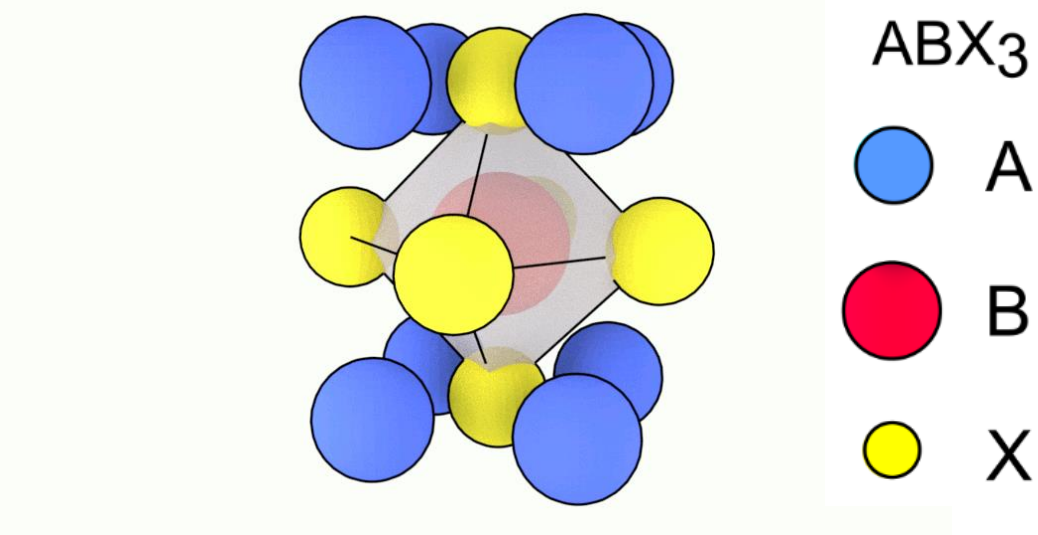


Image from Golec MJ. Another Science Fiction: Advertising the Space Race 1957–1962 by Megan Prelinger.

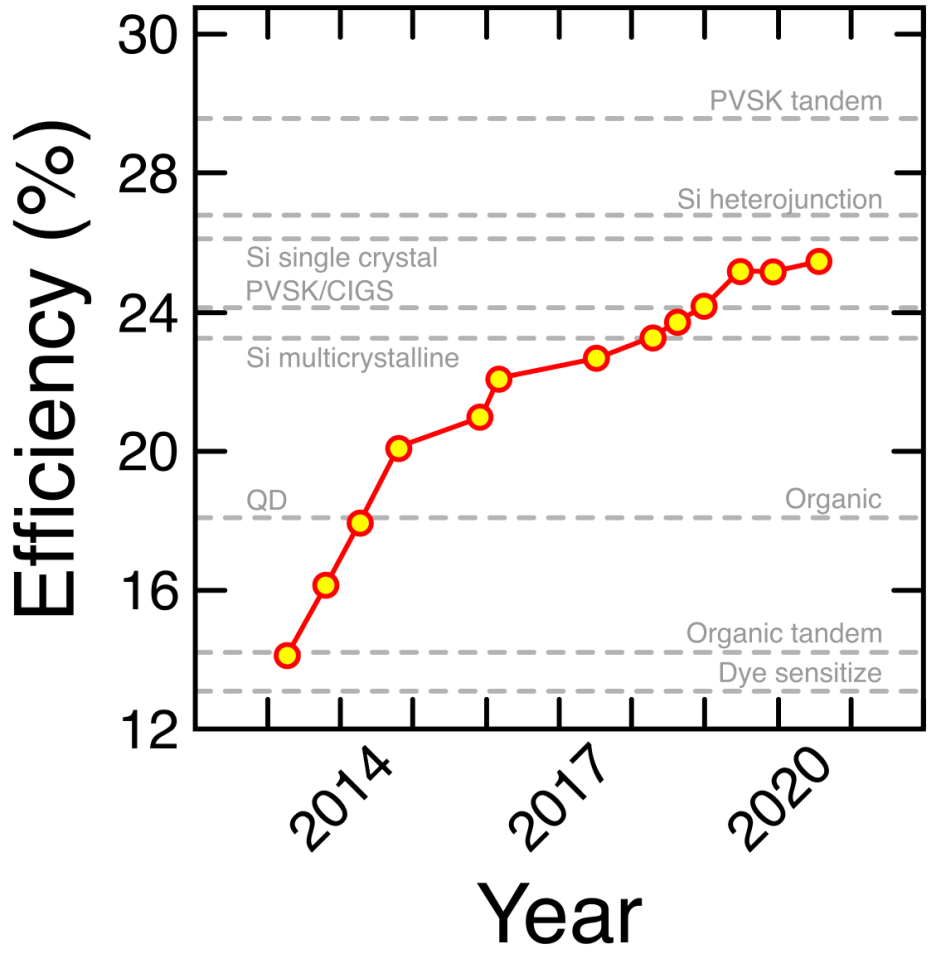
BACKGROUND

JOHANNES KEPLER
UNIVERSITÄT LINZ

PEROVSKITES

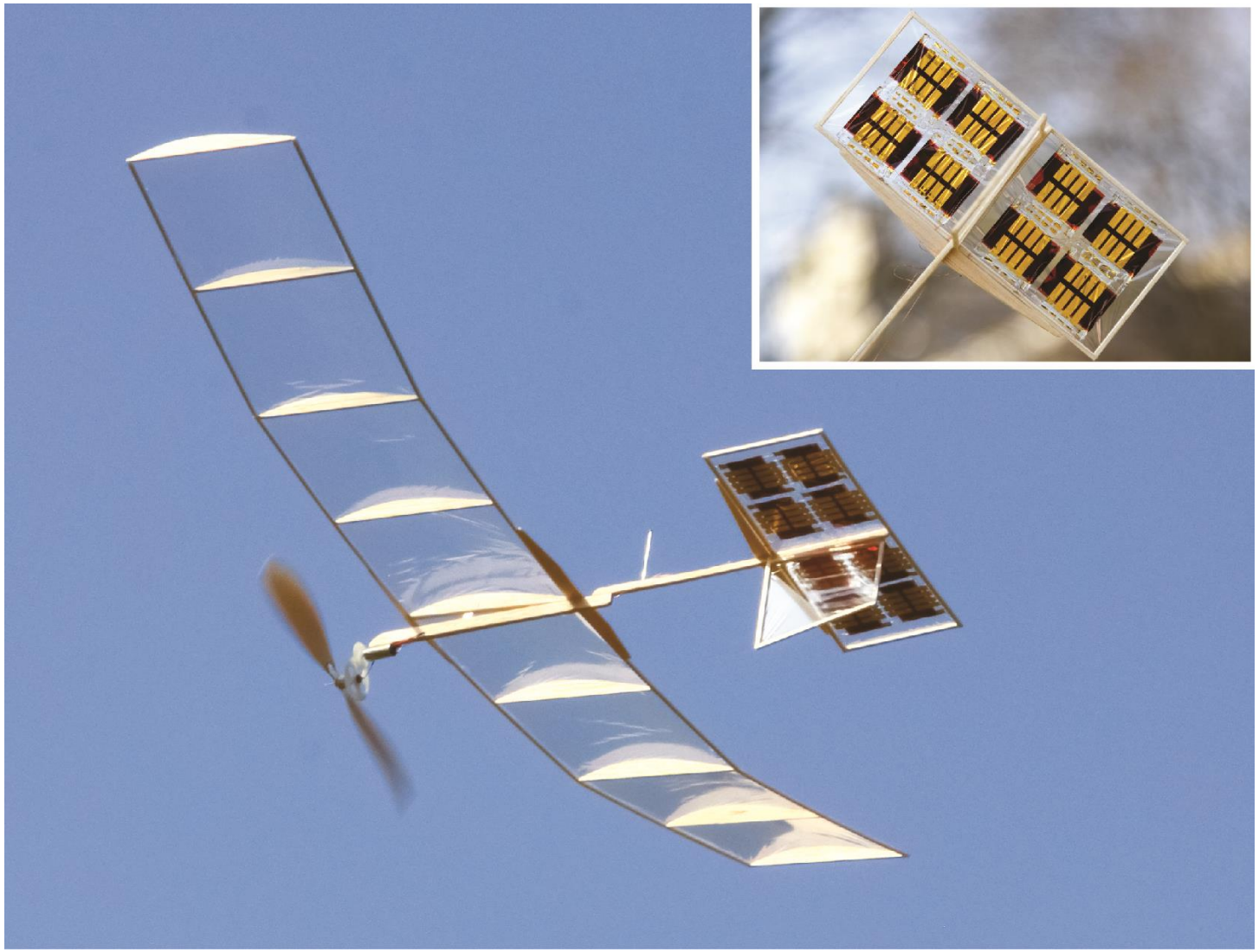


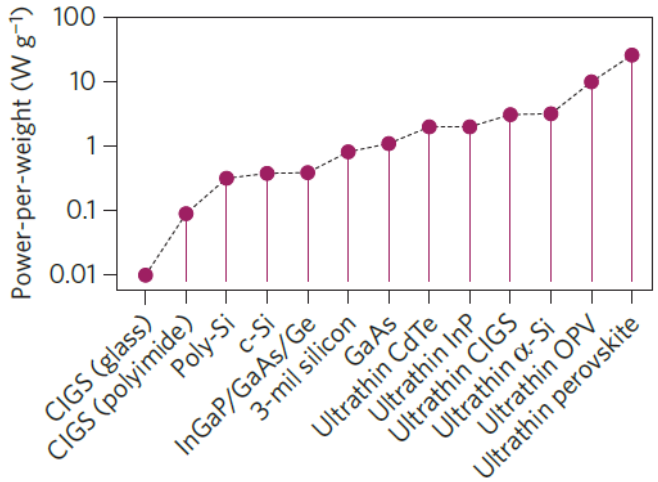
- Ease of processing (solution techniques)
- Defect tolerance (large carrier diffusion, suppressed recombination)
- Low cost
- High efficiency



Adapted from NREL Best Research-Cell Efficiency Chart

ULTRA LIGHTWEIGHT PVSK PV

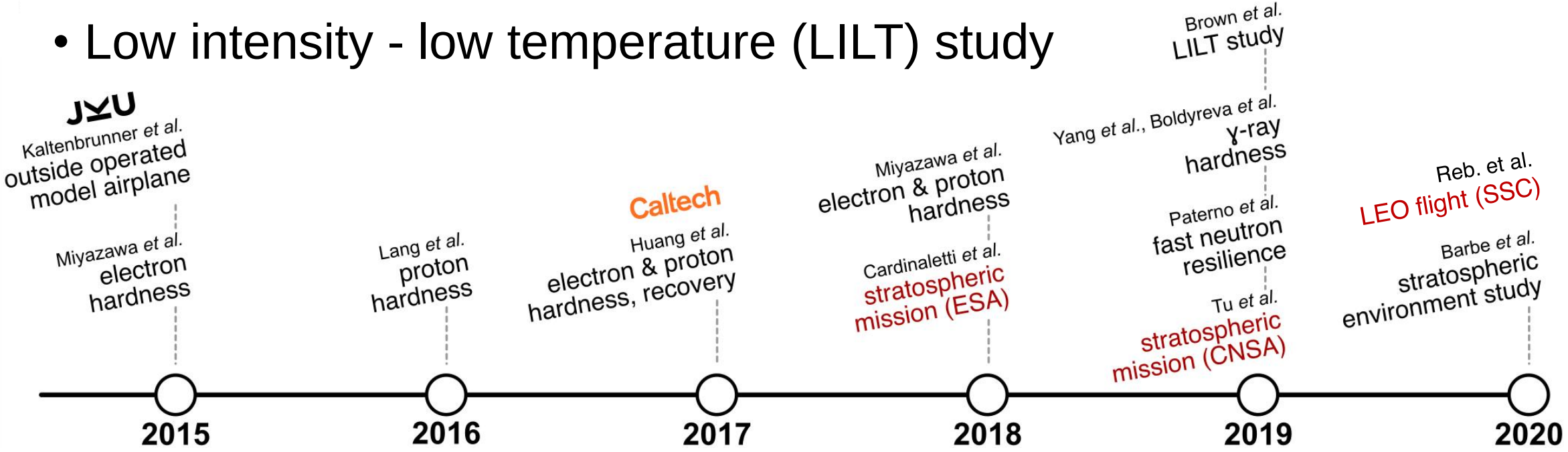




Kaltenbrunner M, *et al*. 2015

PEROVSKITES IN SPACE

- Stability to proton & electron radiation
- γ-ray hardness
- Fast neutron resilience
- 2 stratospheric missions (EU & China)
- Low intensity - low temperature (LILT) study



DEVICE ARCHITECTURE

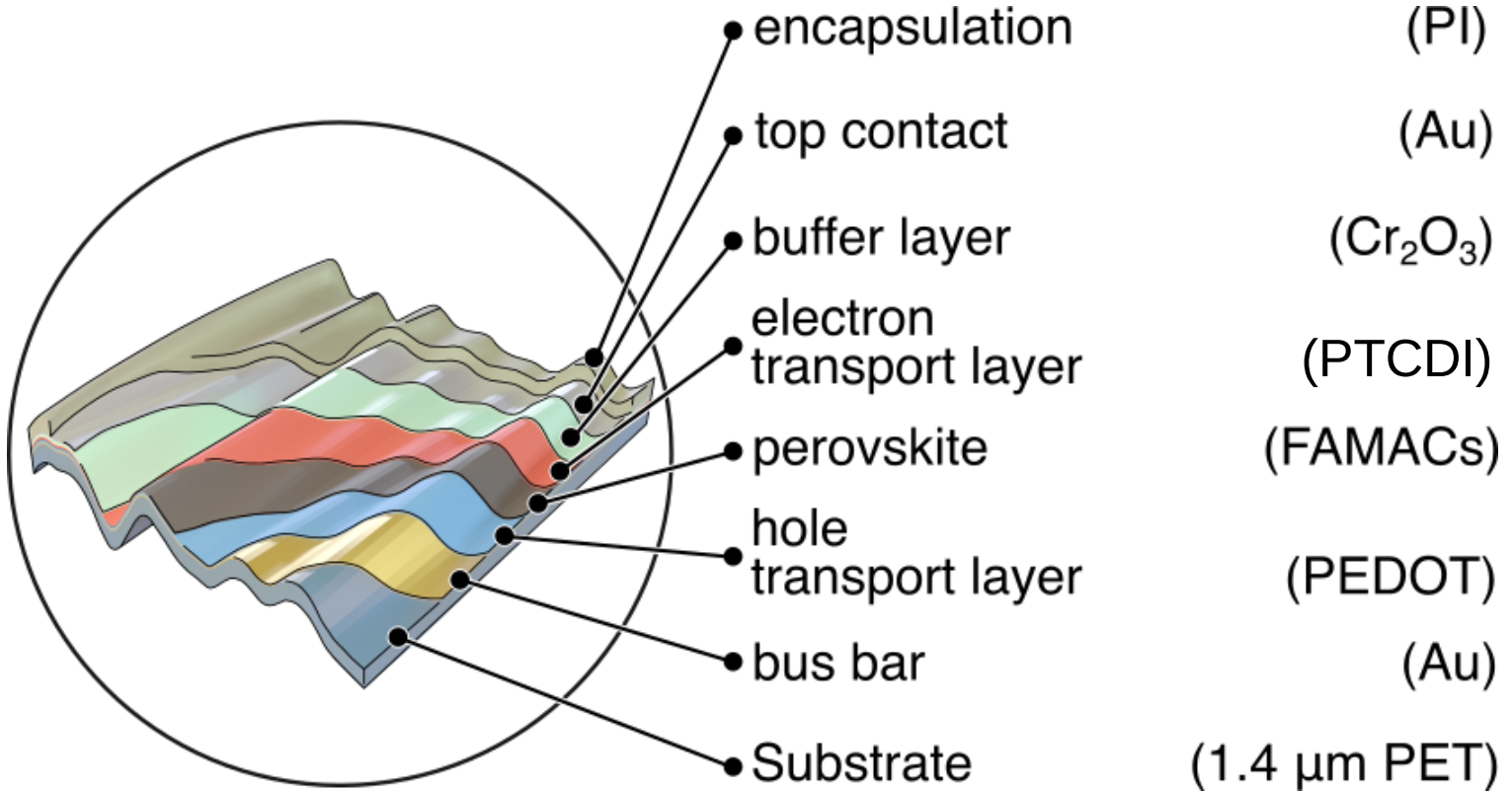
Perovskite active material:

$MA = CH_3NH^{3+}$

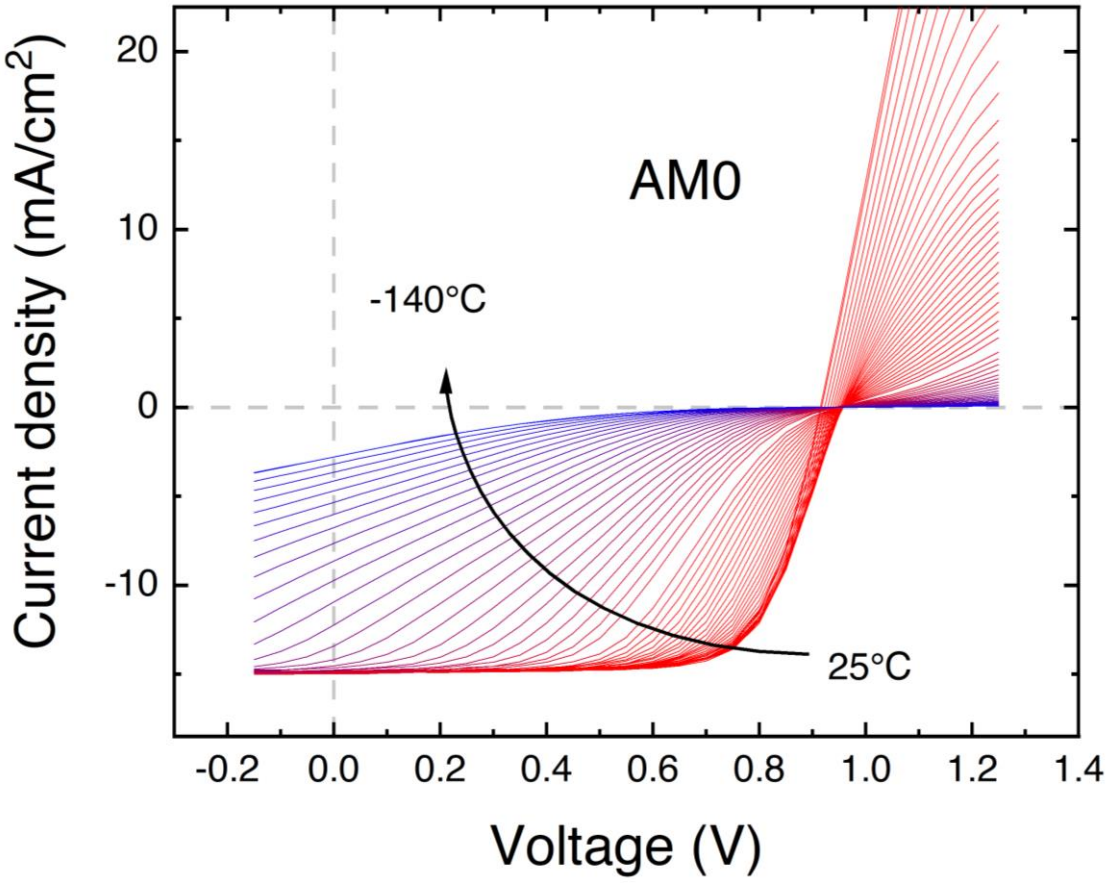
$FA = CH(NH_2)^{2+}$

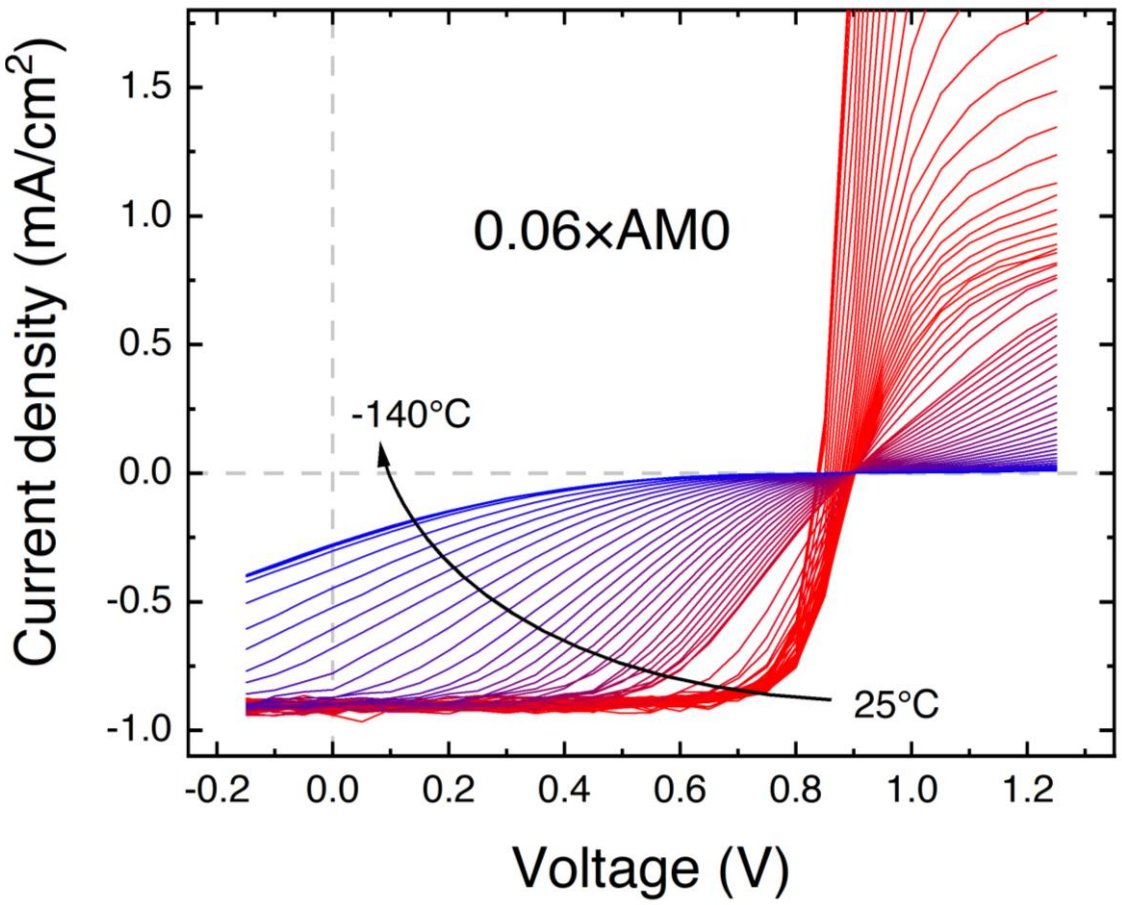
FAMACsPbI_xBr_{3-x}

- Improved efficiency (up to 15 %)
- Improved stability

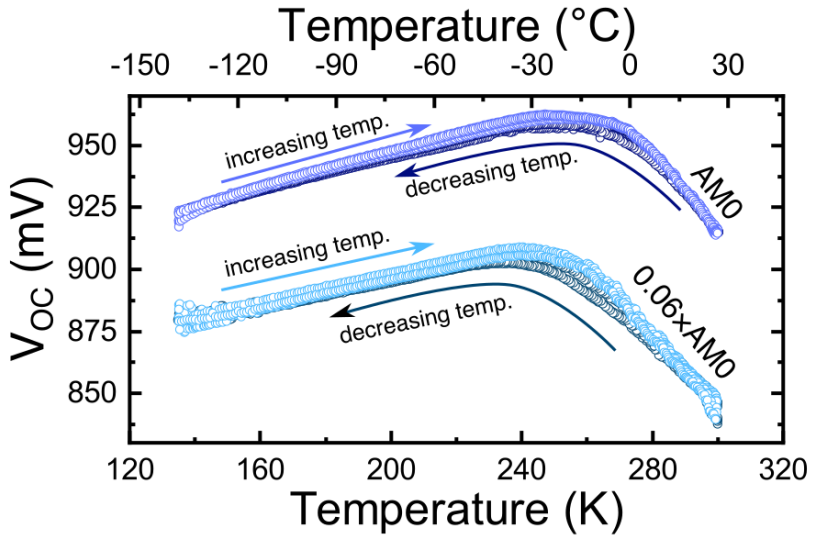


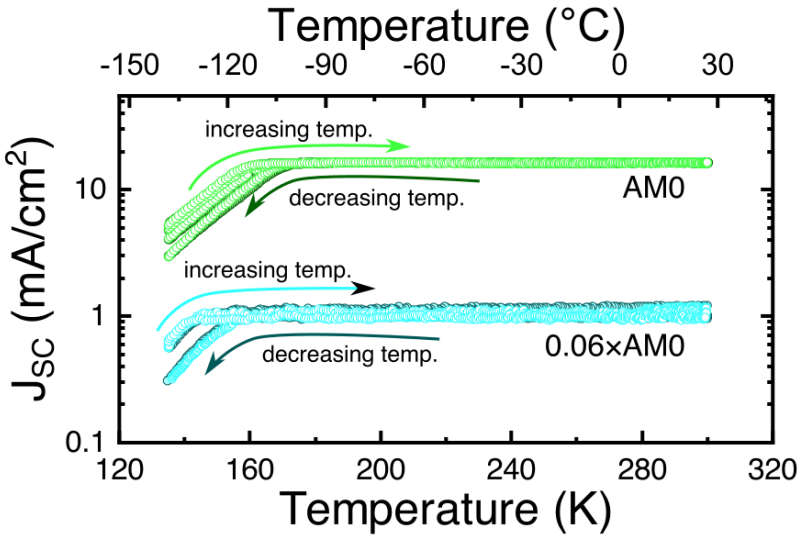
LOW INTENSITY LOW TEMPERATURE

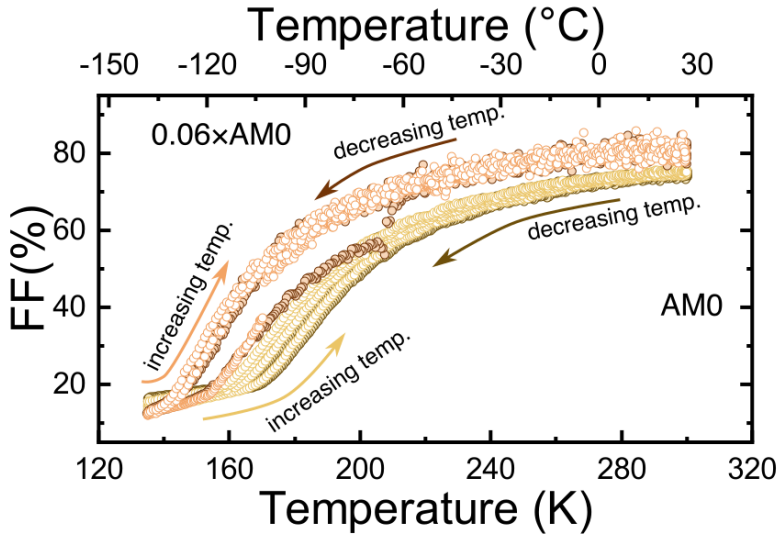


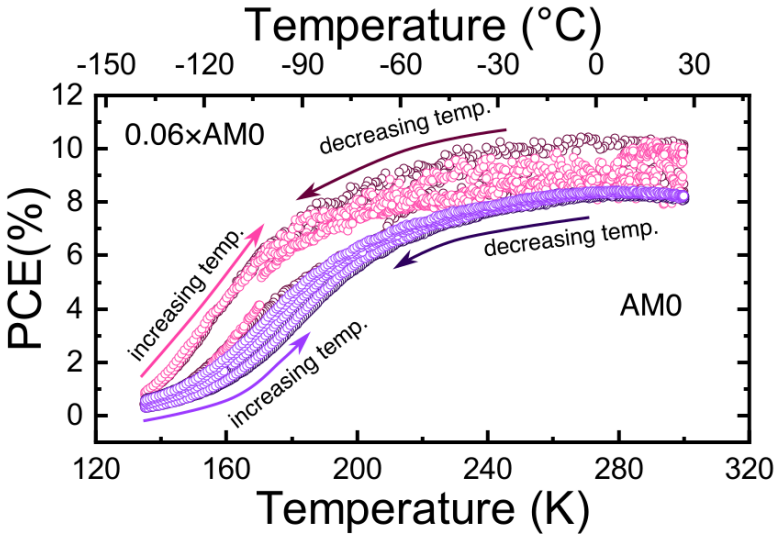


SAMPLE COOLING

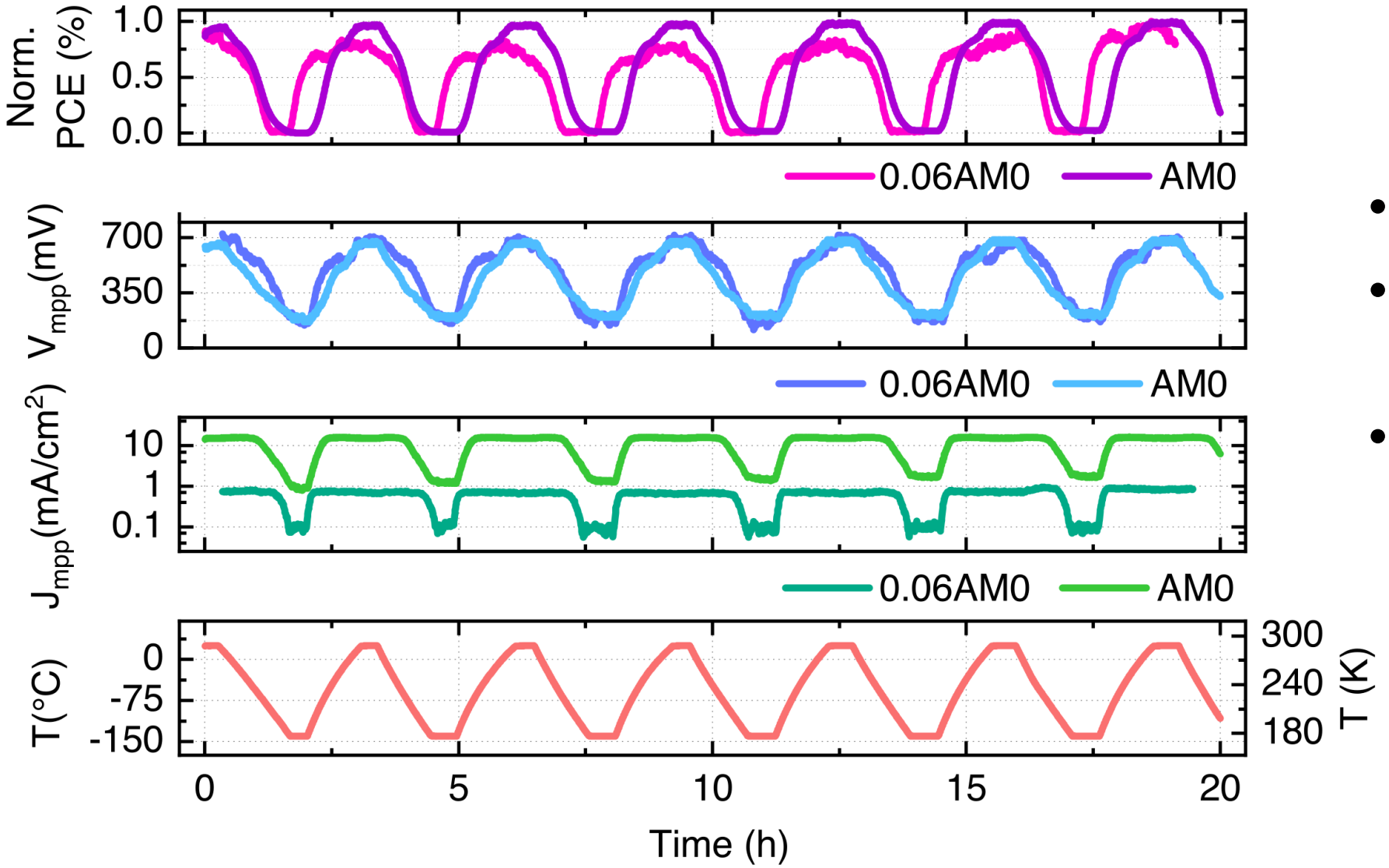






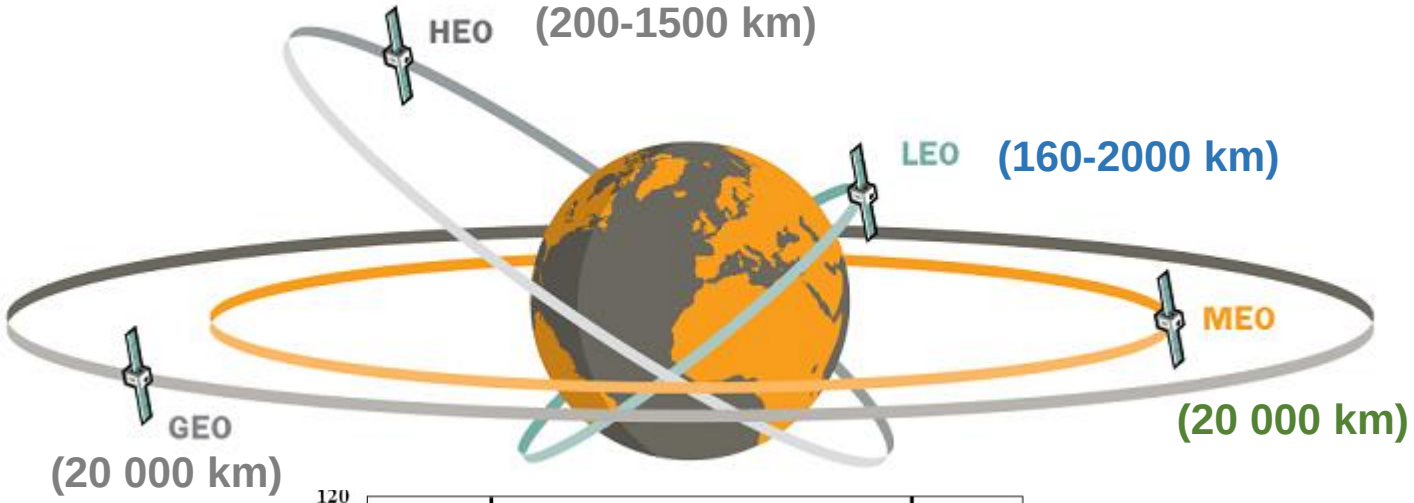


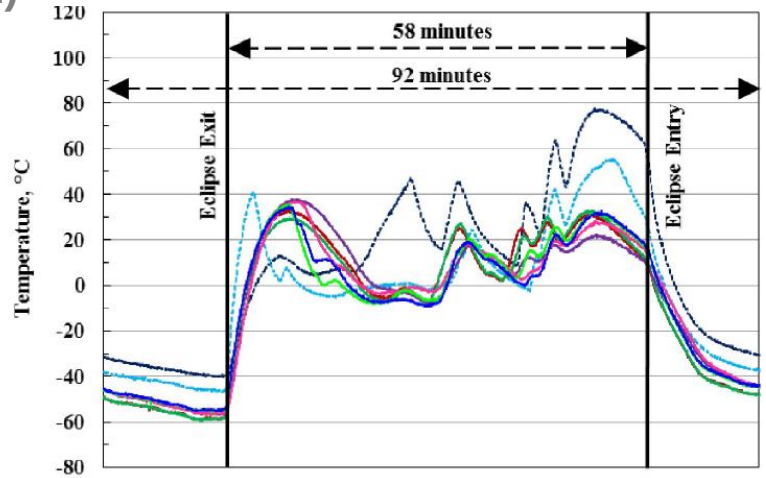
MPPT CYCLING

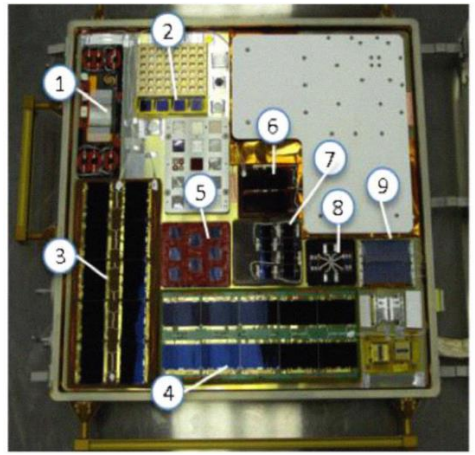


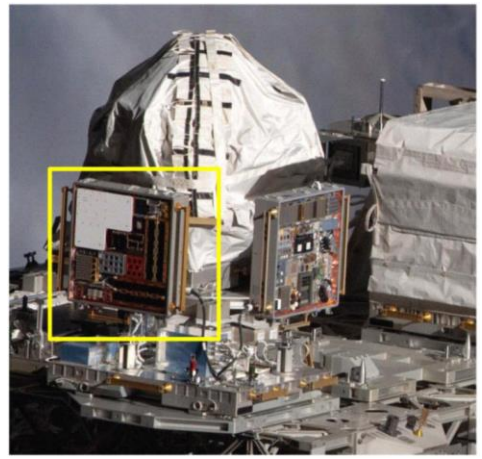
- 10^{-6}-10^{-7} Torr
- No considerable degradation
- 6 cycles (20 h)

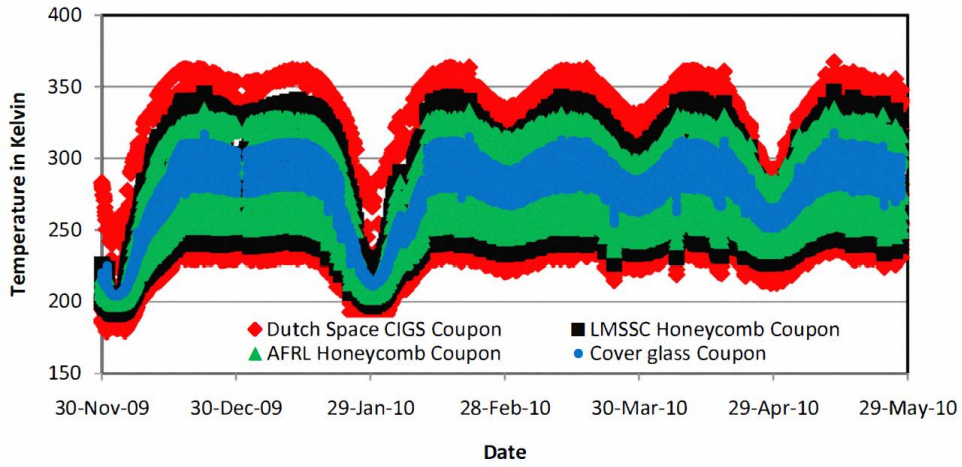
LOW EARTH ORBIT (LEO)







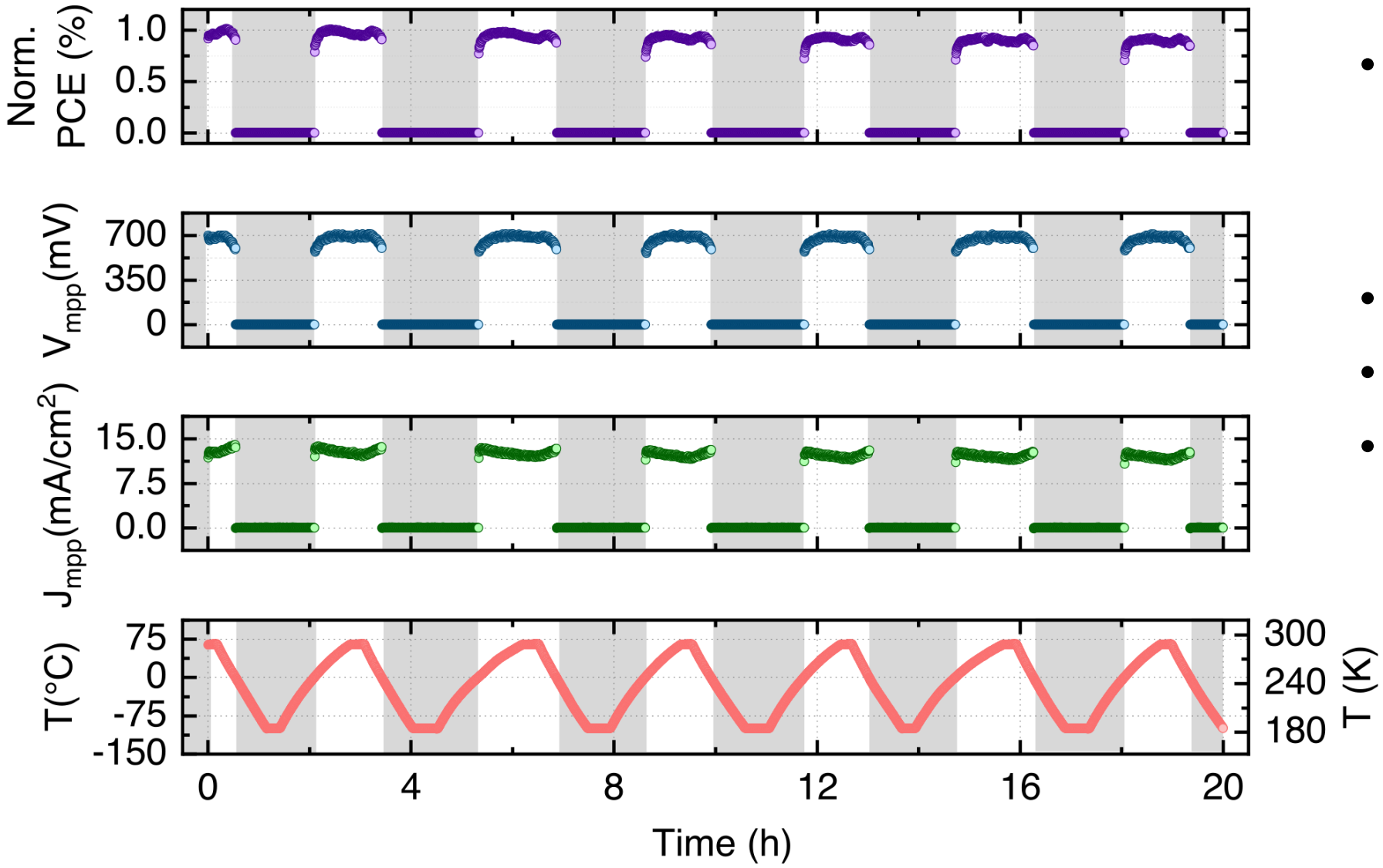




Banik J, *et al.*, On-orbit validation of the roll-out solar array. 2018 IEEE Aerospace Conference

Jenkins PP, *et al.*, Initial results from the second forward technology solar cell experiment. 2010, IEEE Photovoltaic Specialists

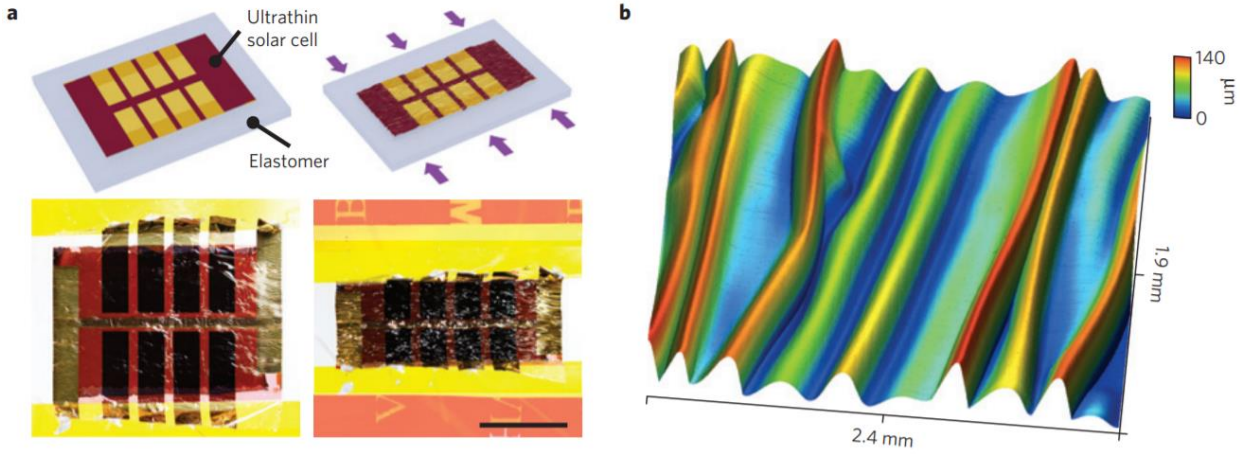
LOW EARTH ORBIT



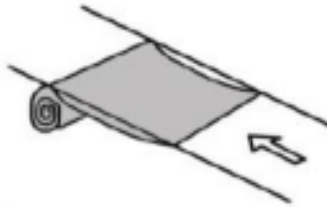
- Based on information available from previous missions (ISS, ROSA, Nimbus 2, *etc.*)
- AM0, vacuum
- 65 → -100 → 65 °C
- 6.5 satellite day/night cycles

OUTLOOK: MECHANICAL STABILITY

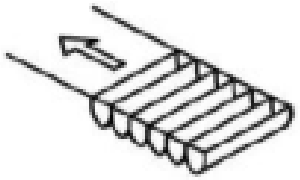
- Mechanically robust
- Thin structures - small bending radius (sin folds λ ~100-300 μm)
- Ideal for deployable structures



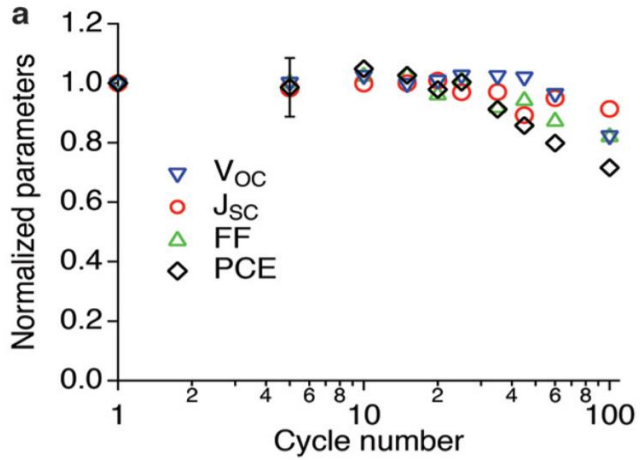
Umbrella type



Rolled membranes



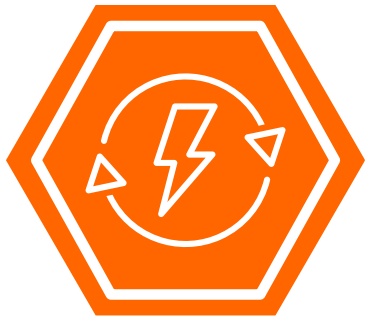
Foldable structures



Otto et al., 1972

Kaltenbrunner et al., 2015

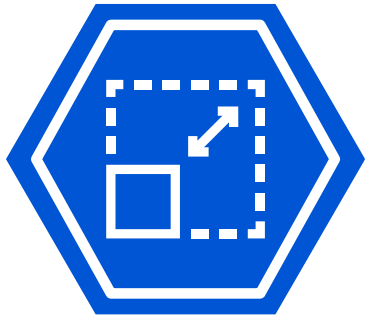
NEXT STEPS



Improved performance

(~17-18%)

Radiation testing



Larger scale (cm^2)

Powering more

ACKNOWLEDGEMENT

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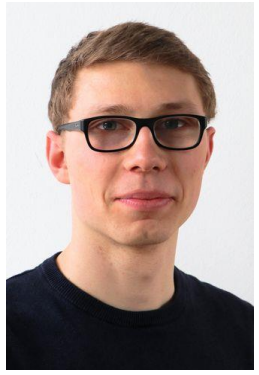

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European Research Council
Established by the European Commission

Caltech
Space Solar Power Project

SOLAR CELLS INSPIRATION

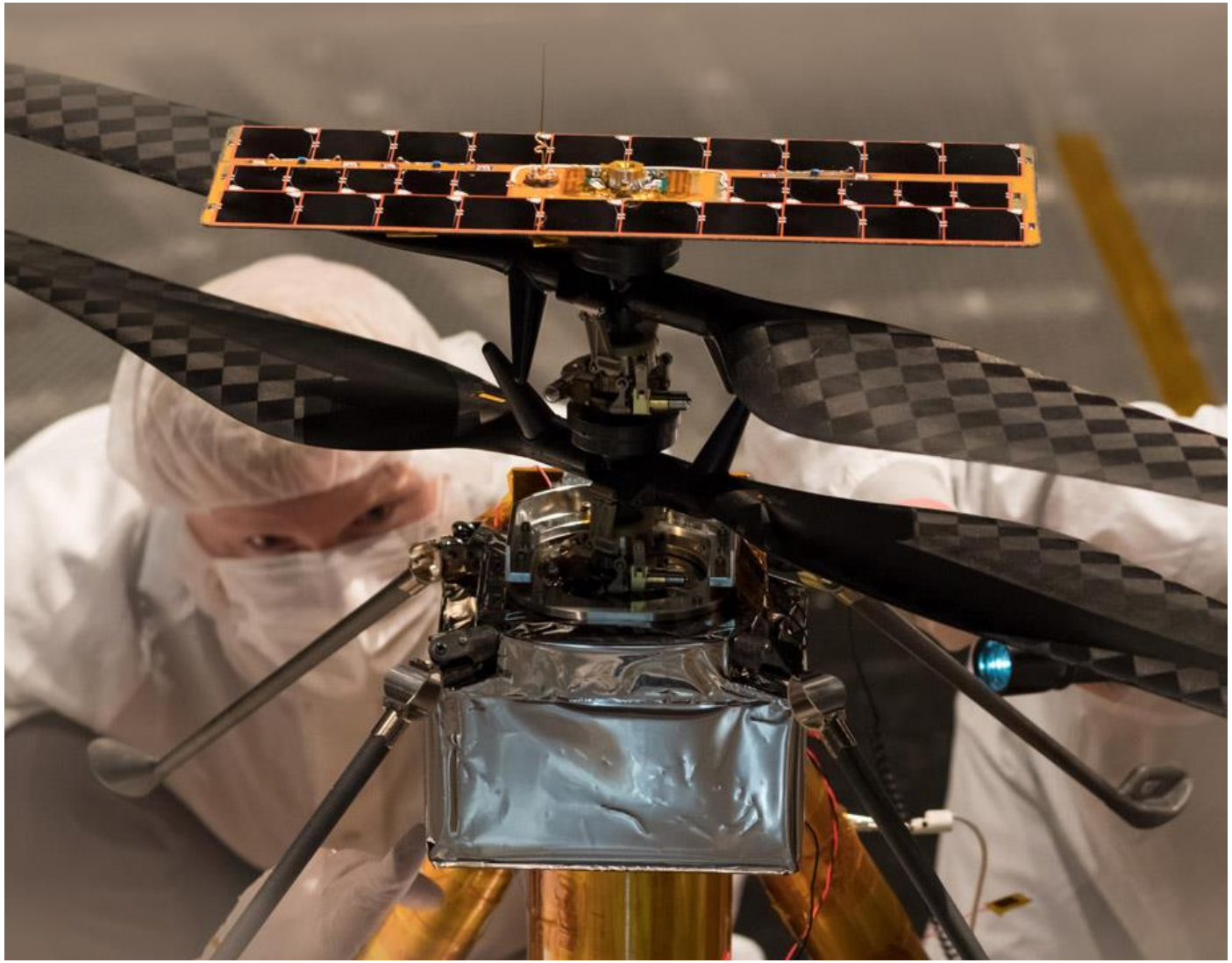

Image credit: NASA/JPL-Caltech