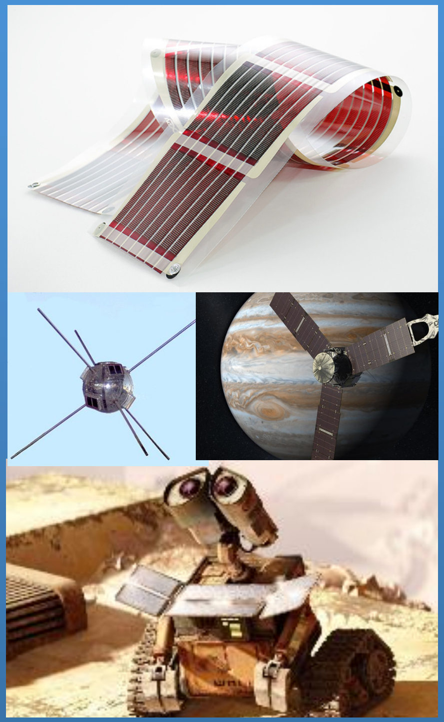
esa
51st eslab symposium "extreme habitable worlds"
04 - 08 december 2017
European Space Agency



Next generation solar cells for powering extreme habitable worlds : light-weight, flexible and printable-on-demand

D. Schreurs, S. Nagels, R. Cornelissen, I. Cardinaletti, T. Vangerven, W. Maes, W. Deferme, and J. V. Manca

OSCAR

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KNOWLEDGE IN ACTION
IMO - IMOMEC
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X-LAB
EXPLORATORY AND FRONTIER CROSS-OVER RESEARCH

Outline

- Exploration of extreme worlds – lessons learned form polar exploration
- Solar energy for the exploration of space - from Vanguard to the photovoltaic Zoo
- Emerging PV : a disruptive PV-technology for space ?
- The OSCAR project
- Conclusions & outlook

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Princess Elisabeth Antarctica Station

- The First "Zero Emission" Polar Research Station

Alain Hubert
Dr.honoris causa UHasselt
Int. Polar Foundation

Prof.em.dr. Tony Van Autenboer
Belgian South Pole Expeditions
1960-1970

INTERNATIONAL
POLAR FOUNDATION

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⇒ **Inspiring model for 'Moon and Mars villages'**

Photovoltaics (PV) for the exploration of space

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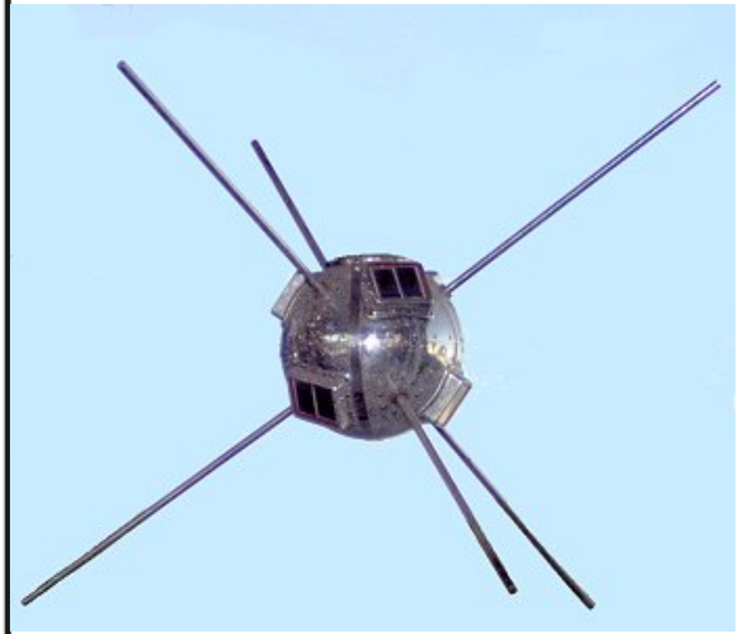

The 1st

Vanguard 1 – 1958-1964 (still flying)
6 **Si-solar cells** (5 cm x 5cm)

The most distant

Juno (Jupiter = 5 AU = 1/25 of light ! – 2016)
19000 **triple junction GaAs-solar cells** (3 x 24 m^2)

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Do go deeper in space:
Solar panels of the future need to be **lighter** and **more efficient**.(Light intensity changes as $1/d^2$: area size increases as the square of the distance)

The Photovoltaic Zoo

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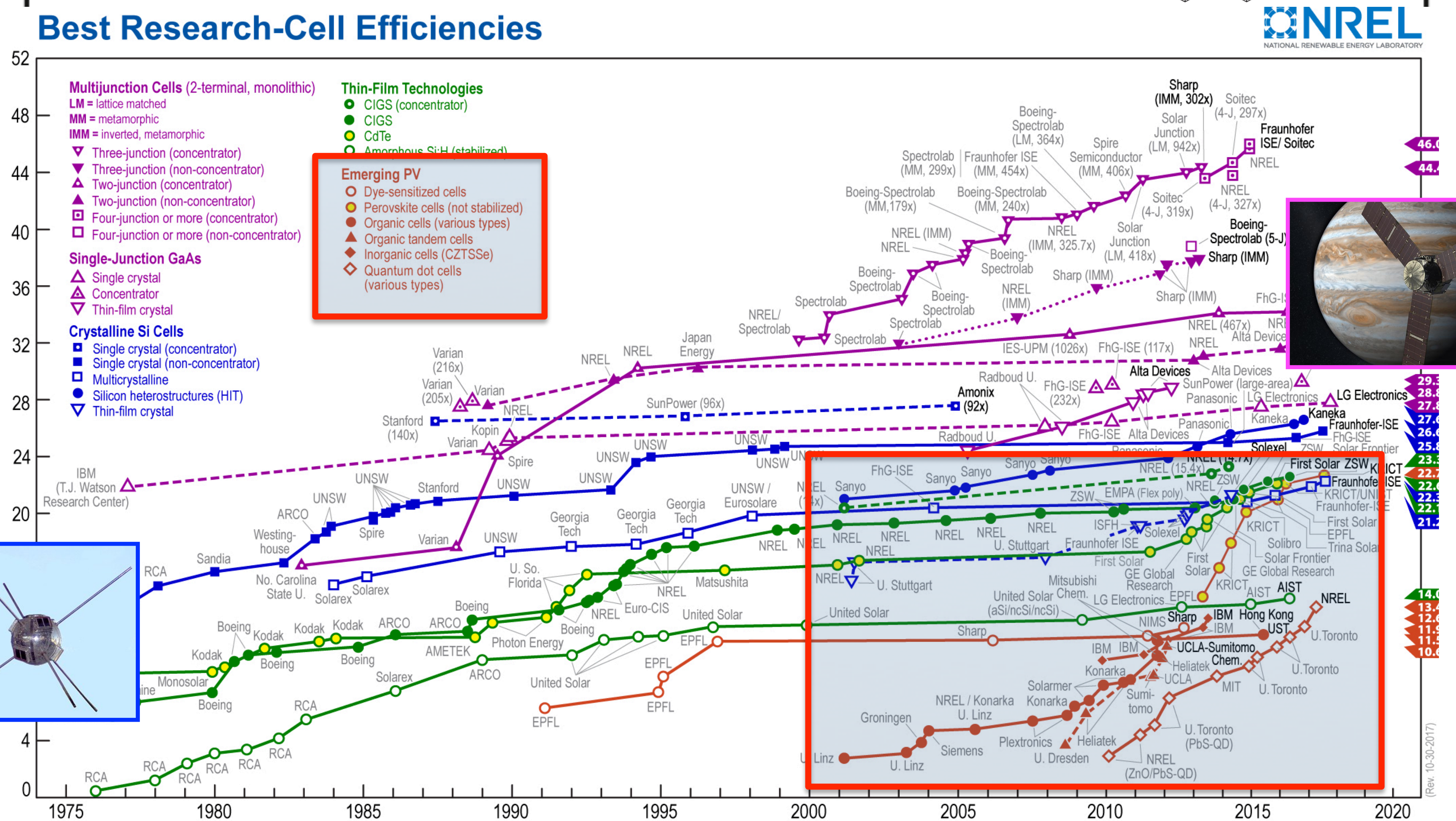

Organic solar cells (OPV)

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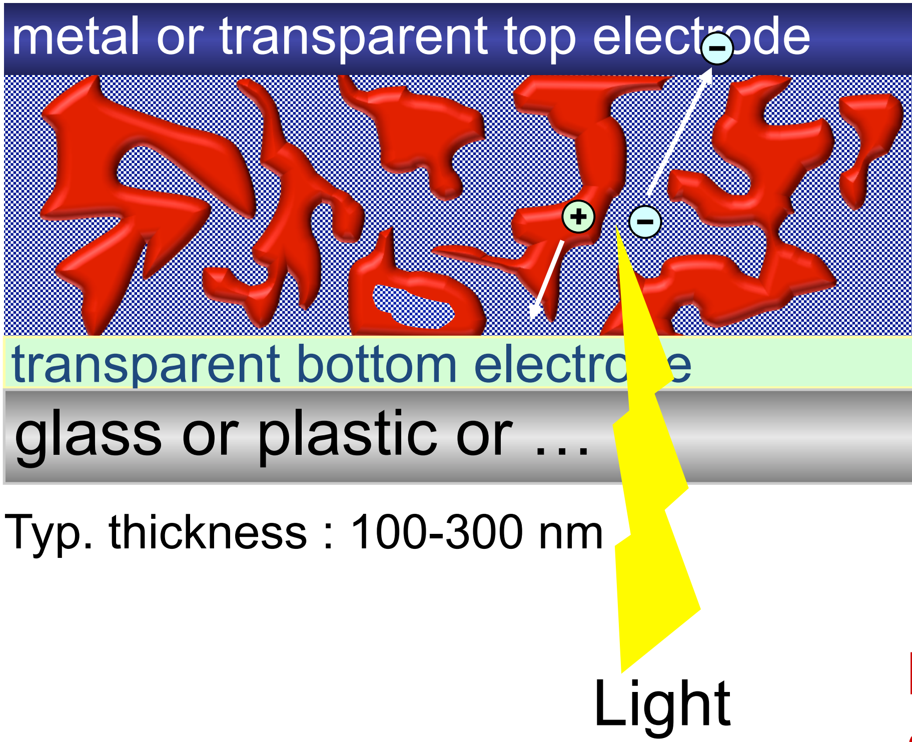
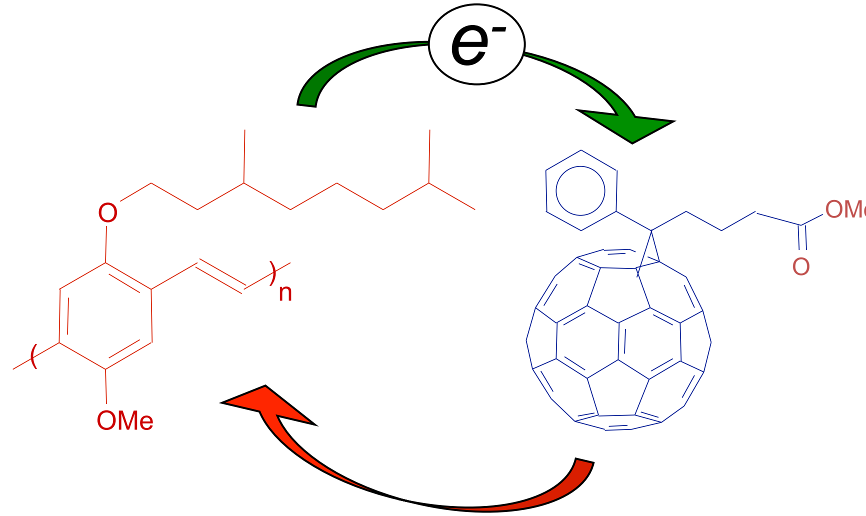


Typ. thickness : 100-300 nm



MDMO-PPV
as donor (D)

PCBM
as acceptor (A)

Record cell efficiency
2017
11.5%

N.S. Sariciftci *et al.*, *Science*, **1992**, *258*, 1474
C.J. Brabec *et al.*, *Chem. Phys. Lett*, **2001**, *340*(*3,4*), 232

R. H. Friend *et al.*, *Nature*, **1995**, *376*, 498
A. J. Heeger *et al.*, *Science*, **1995**, *270*, 1789

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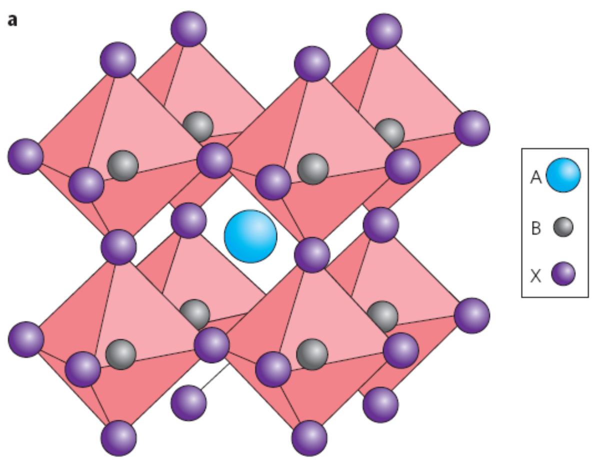
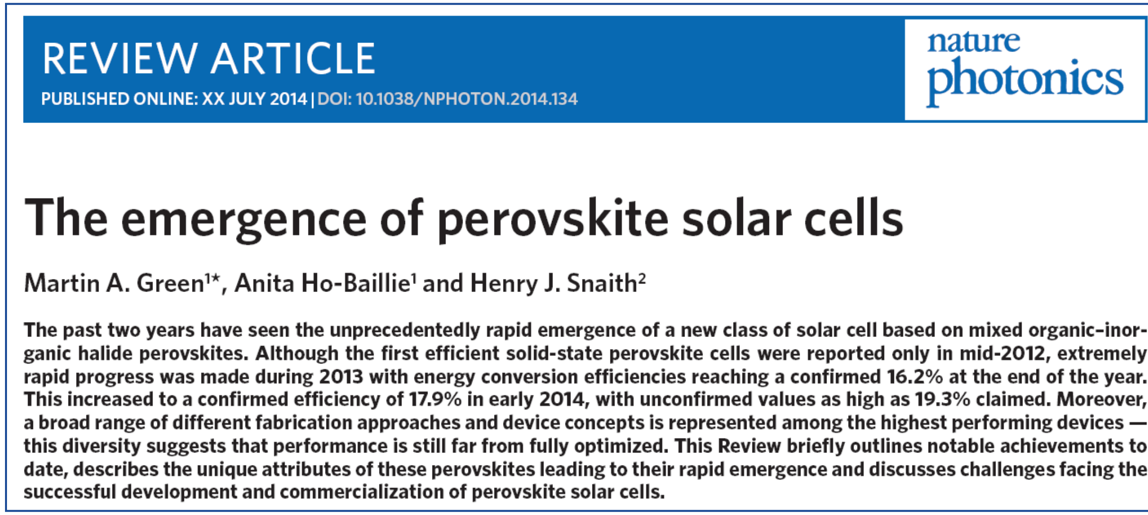
Perovskite solar cells (OPV)



A : usually the methylammonium ion (CH_3NH_3),
B : small cation B is Pb
X : anion, a halogen ion
(usually I, or Cl and Br)


REVIEW ARTICLE

PUBLISHED ONLINE: XX JULY 2014 | DOI: 10.1038/NPHOTON.2014.134

nature photonics

The emergence of perovskite solar cells

Martin A. Green[1]*, Anita Ho-Baillie[1] and Henry J. Snaith[2]

The past two years have seen the unprecedentedly rapid emergence of a new class of solar cell based on mixed organic–inorganic halide perovskites. Although the first efficient solid-state perovskite cells were reported only in mid-2012, extremely rapid progress was made during 2013 with energy conversion efficiencies reaching a confirmed 16.2% at the end of the year. This increased to a confirmed efficiency of 17.9% in early 2014, with unconfirmed values as high as 19.3% claimed. Moreover, a broad range of different fabrication approaches and device concepts is represented among the highest performing devices — this diversity suggests that performance is still far from fully optimized. This Review briefly outlines notable achievements to date, describes the unique attributes of these perovskites leading to their rapid emergence and discusses challenges facing the successful development and commercialization of perovskite solar cells.

M. Green et al., Nature Photonics, July **2014**, vol. 8, DOI: 10.1038/NPHOTON.2014.134

Record cell efficiency
2017
22.7%

PV-for-space : Power-to-mass-ratio

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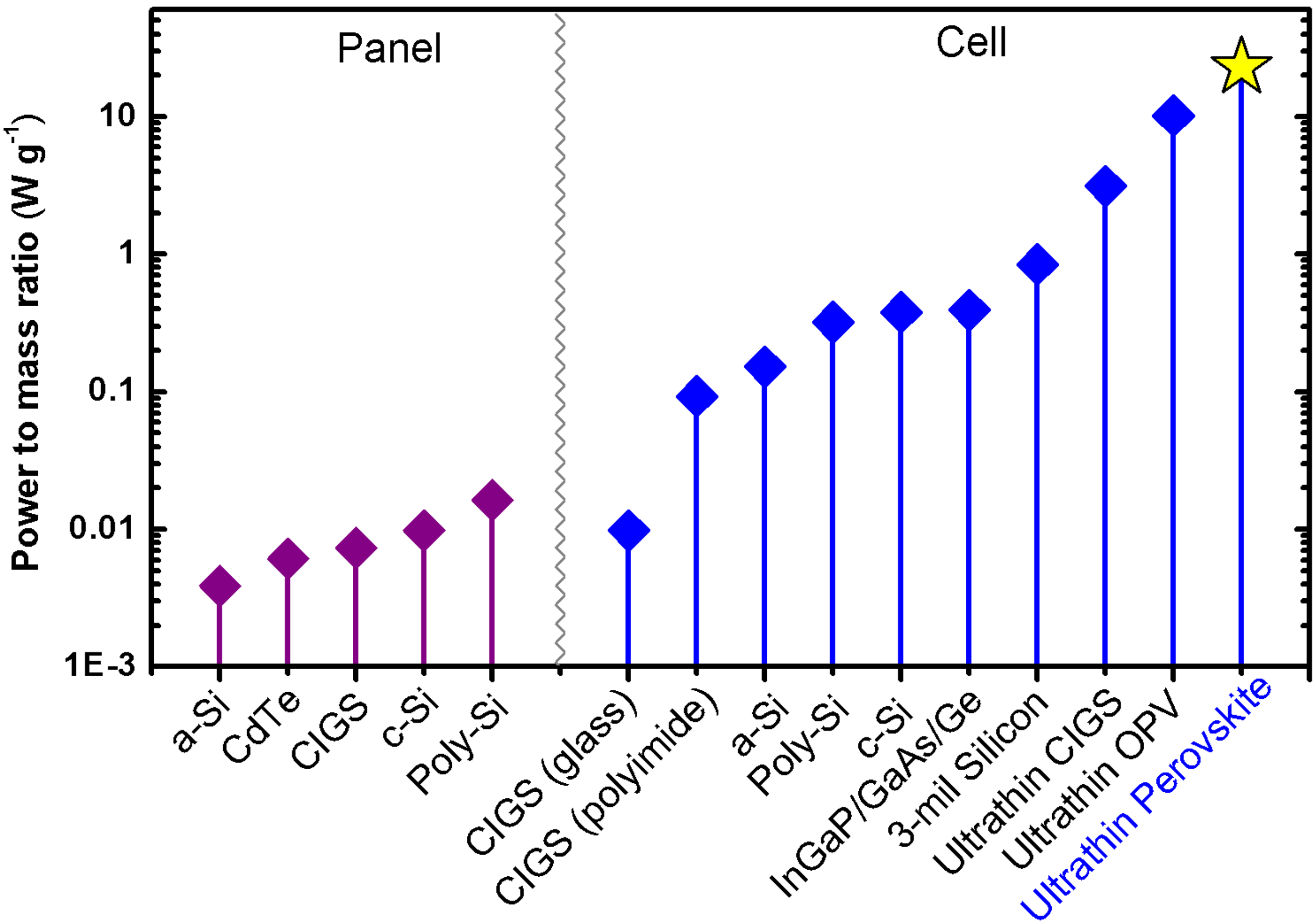

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$10,000 to put a pound of payload in Earth orbit. (Nasa)

Kaltenbrunner et al.,
Nat.Comm. – 3 April 2012 / Nat.Mat. - 24 Aug. 2015

PV-for-space : Flexible & Foldable

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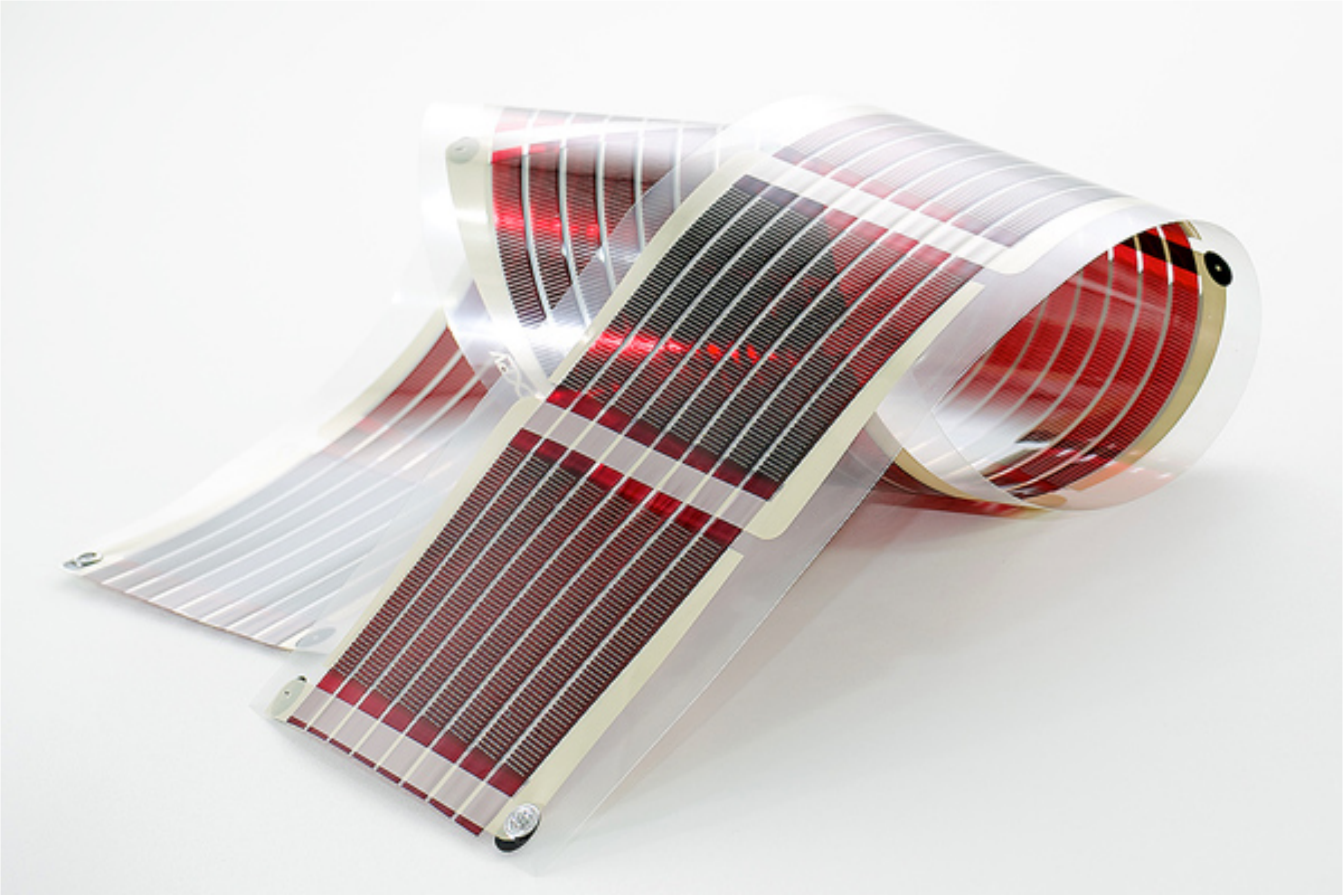
- 'Flexible solar cells'



Infinity PV printed foil

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PV-for-space : Printing-on-demand

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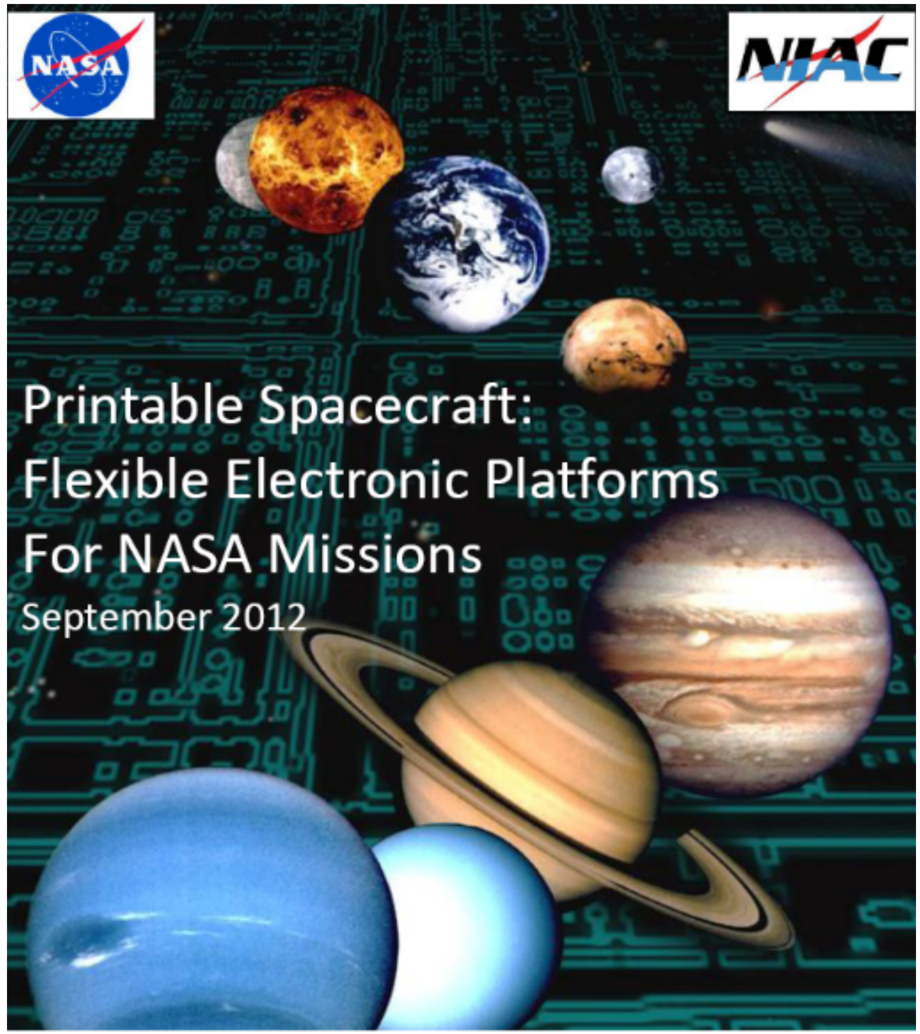
- 'Printing of PV and electronics in space'



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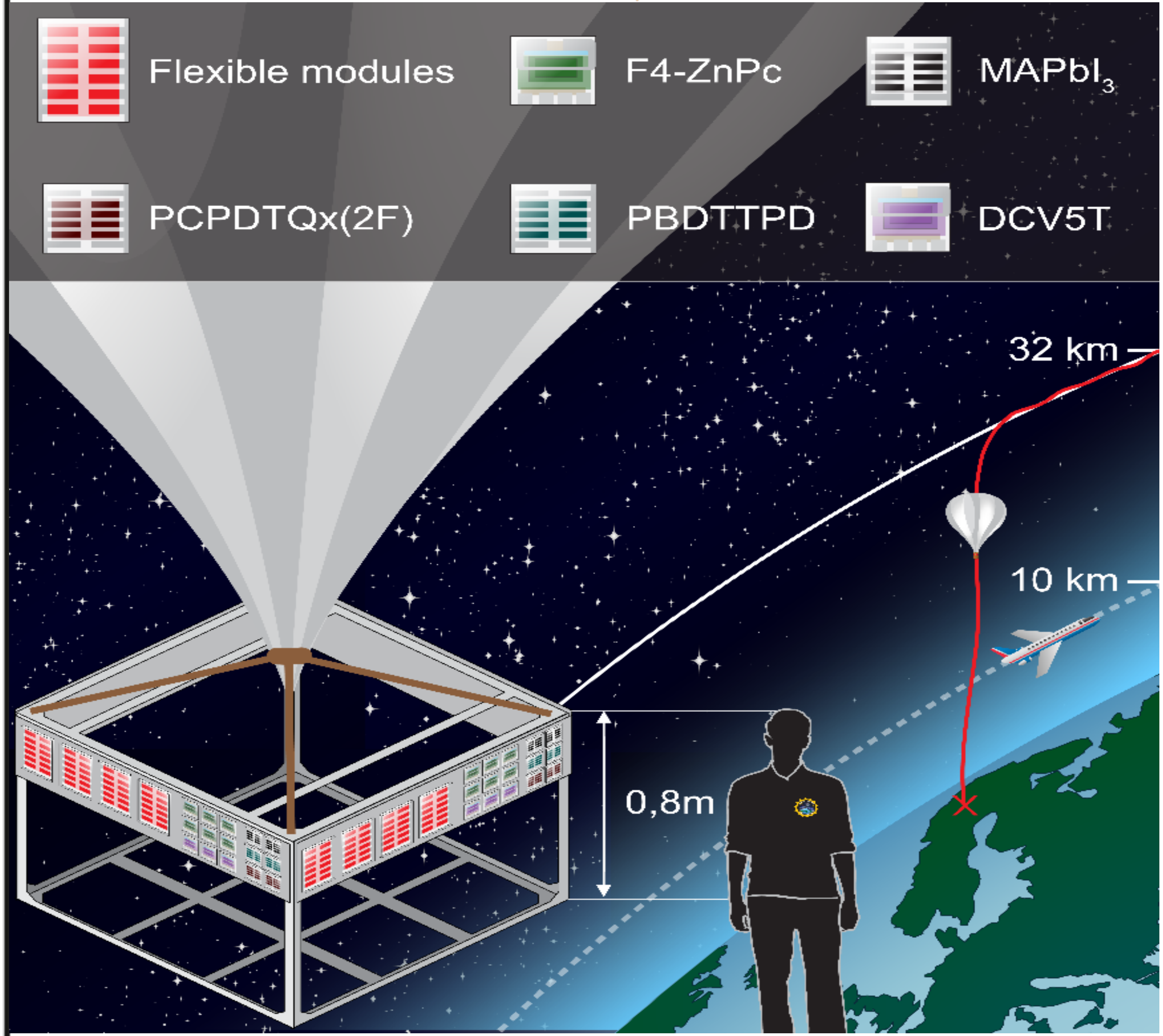
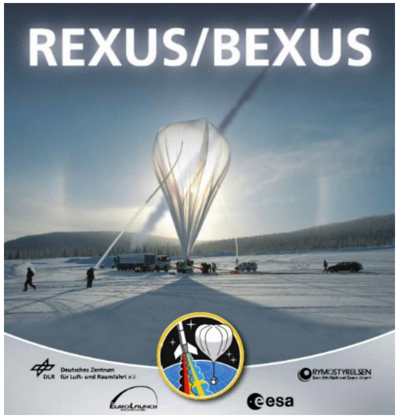
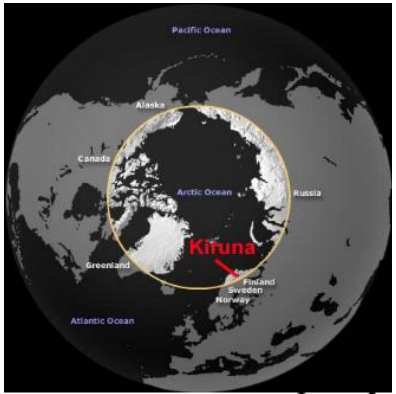
OSCAR project







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Ilaria Cardinaletti – PhD 2017 (Universiteit Hasselt), Manuscript submitted

Conclusions

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Emerging class of solar cells – disruptive potential for space applications & new paradigms :

- High power-to-mass ratio
- Flexible & foldable
- Printed-on-demand in space
- Tunable band gap => tuning to local light conditions
- Improved possibilities for diffuse light
- Promising radiation hardness
- First demonstration with ESA-BEXUS-mission : OSCAR

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OSCAR-team :

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R. Cornelissen, J. Hruby, S. Nagels,
J. Vodnik, K. Wouters, M.A. Beynaerts
M. Nesladek, M. De Roeve

Solar cell devices :

- Perovskites : IMEC-Leuven (B)
- Flexible OPV : InfinityPV (DK)
- Small molecule OPV : IAPP (D)
- Polymer OPV : DSOS/UHasselt (B)

Funding :

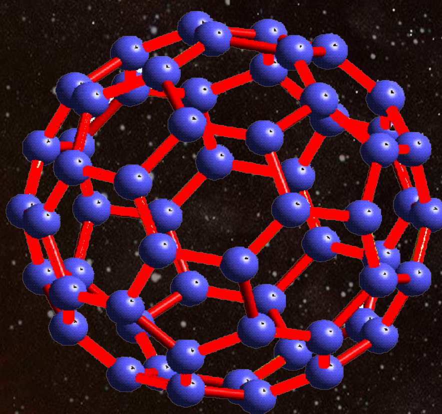
- UHasselt & funding agencies :

Analysis : Hercules TOF-SIMS

- Stijn Meuris – Lyrics "*Satelliet Suzy*"
- Alain Hubert – Princess Elisabeth Antarctica Station

ThanX for your attention !

The energy of the future is positive energy…



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Satelliet Suzy
Telkens als ik u zie
Schijnt jouw licht over mijn planeet
Hoe hoger je staat, hoe mooier je heet
Oh, Suzy (Stijn Meuris)