EPIC
European Photonics Industry Consortium

Novel Wavelength-Specific UVC Sensors for Space-Based Monitoring of the Herzberg Continuum & its' Impact on Climate Change

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P. Maso (PIT, OVSQ, France)
& many others!

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Sept. 2022

1. Nanovation

Introduction

Oxide Semiconductor Manufacturer

Founded 2001

Situated in “Paris Saclay”

➔Biggest high tech pole in Europe

Lead Product: Optoelectronic Grade Oxide Epiwafers

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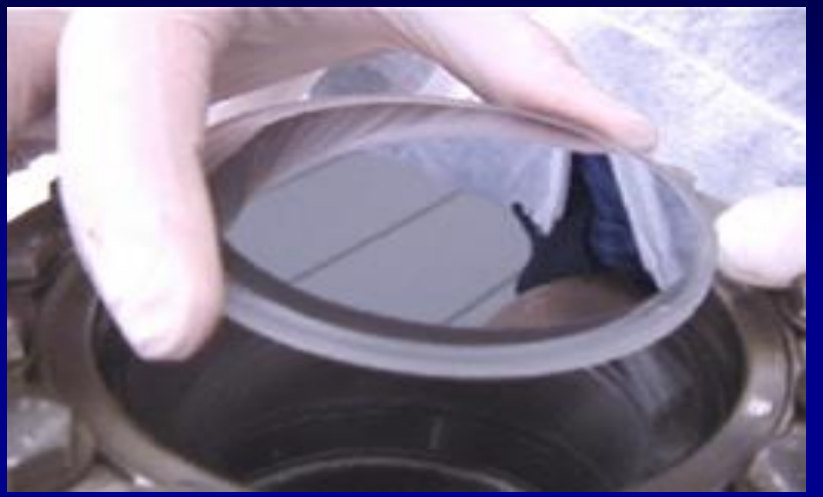
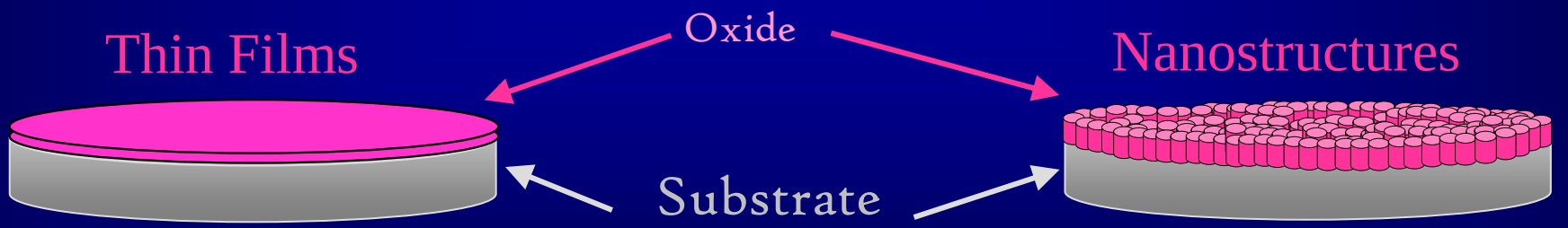
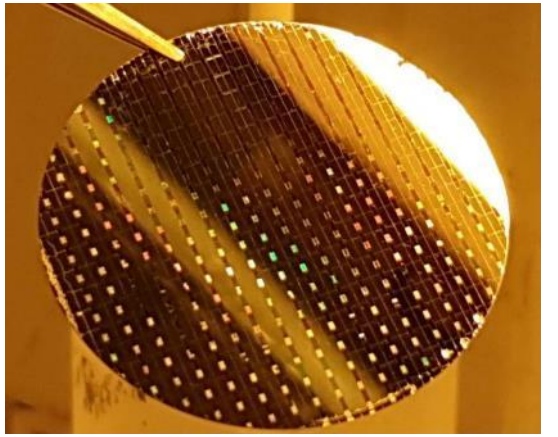
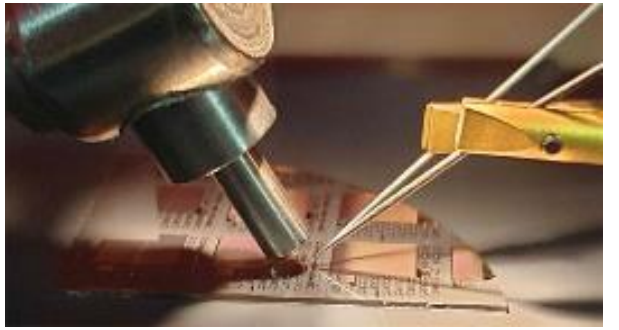




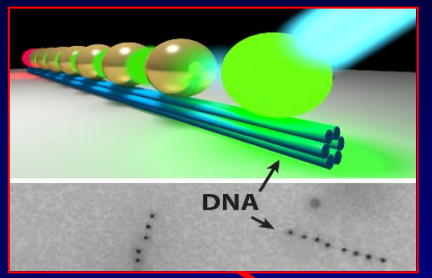
ZnO, NiO, CuO, Cu_2O, Ga_2O_3

Nanovation Facilities



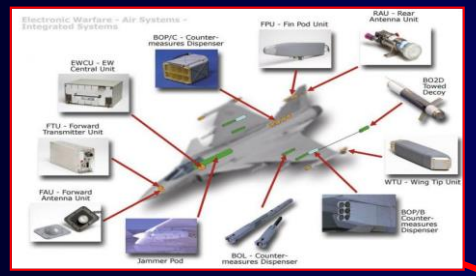


Plasmonics

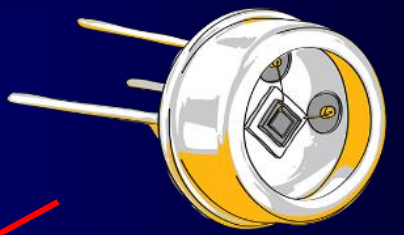


SAW Filters

Transparent/Flexible Electronics



Extreme Electronics



UV Sensors/Detectors

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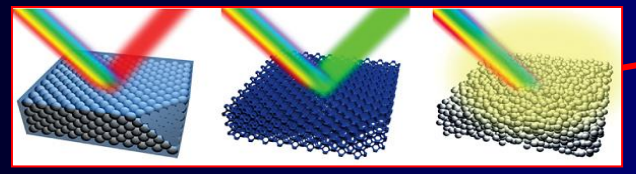
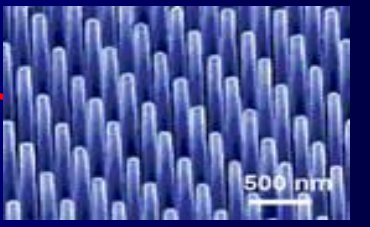


Photonic Crystals

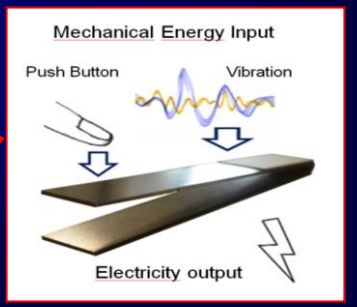


Nano-Arrays

Biomedical

Solar Cells

LEDs & Lasers



Piezo Energy

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Some Customer References

2. UVC Photodetectors

Solar Blind (UVC) Photodetectors only see λ < 280 nm

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Sensing/imaging

- flame detection
- microscopy
- oil leaks
- space astronomy
- military (flash/fire/missile detection)
- gas
- corona discharge

Non-line-of-sight Communications

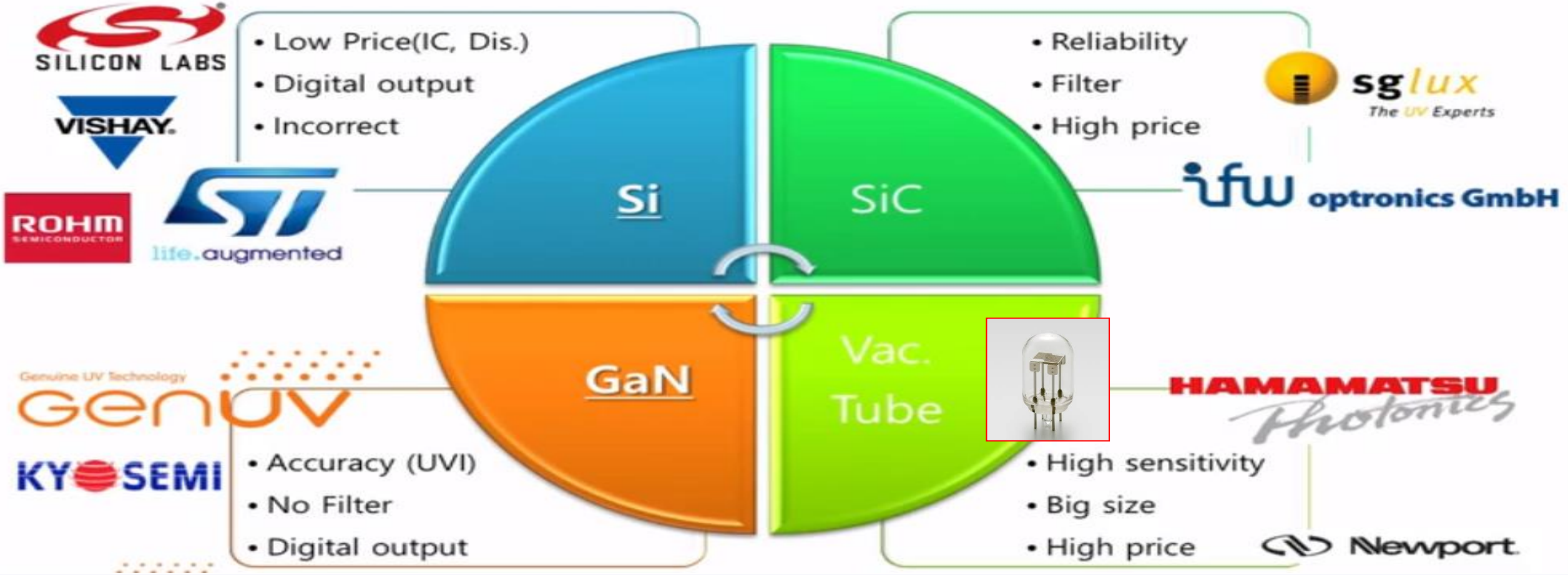
Monitoring

- medical/water/air sterilisation

Commercial UVC Detectors

❖ Commercial suppliers

Source: J. Son, *UV and Higher Energy Photonics: From Materials to Applications 2018*

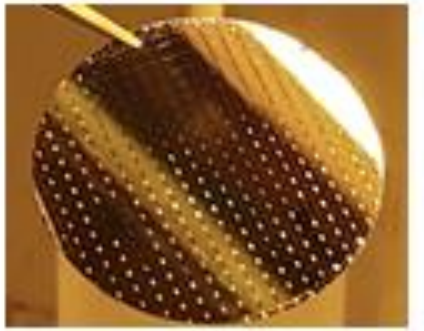


3. New Oxide Paradigm for Solar Blind UV Sensors

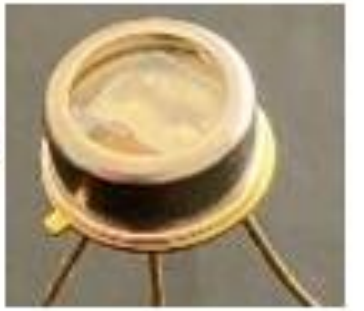
Photodetector Fabrication Chain

Substrate

Active layer coatings



Unpackaged Sensors



Packaged Individual Sensors

Ga_2O_3 Spectral Response Engineering Through Al Addition

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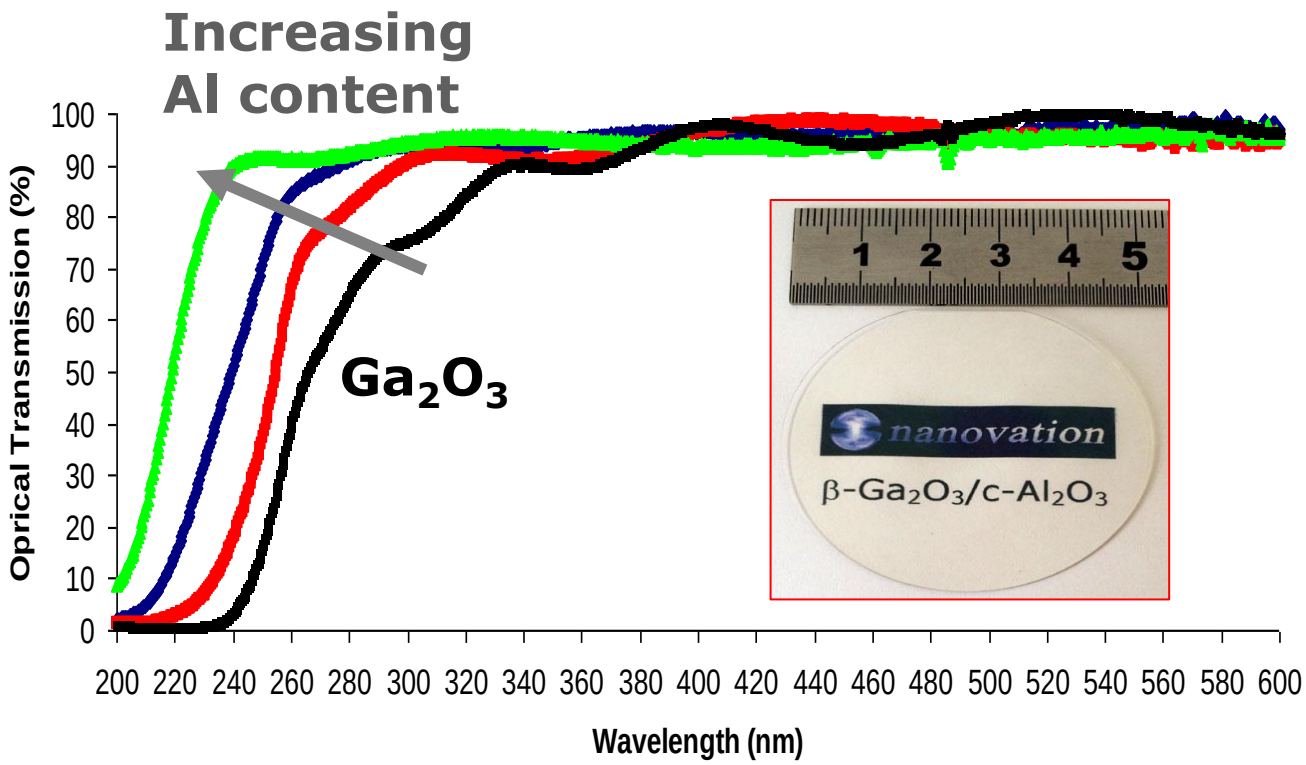
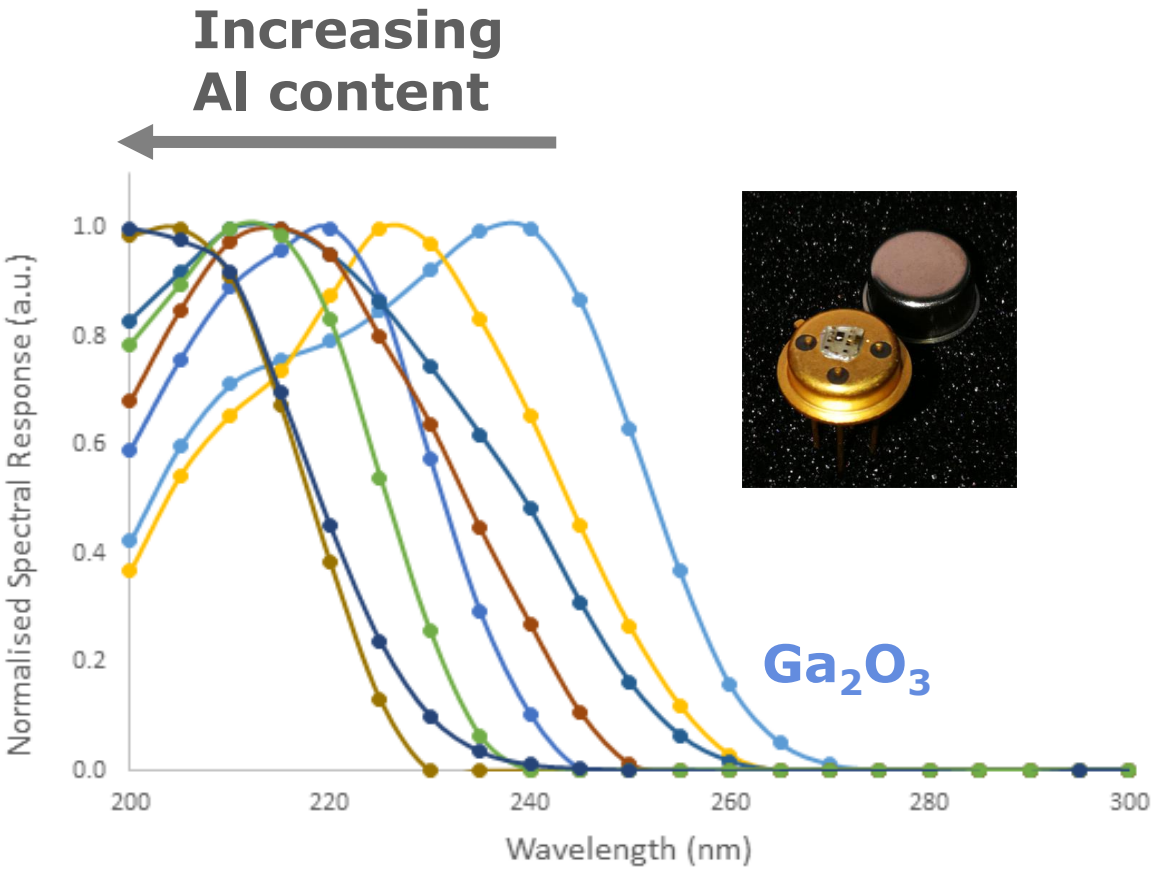
Wafer



Device



Rogers et al. Proc. SPIE 11687 (2021)

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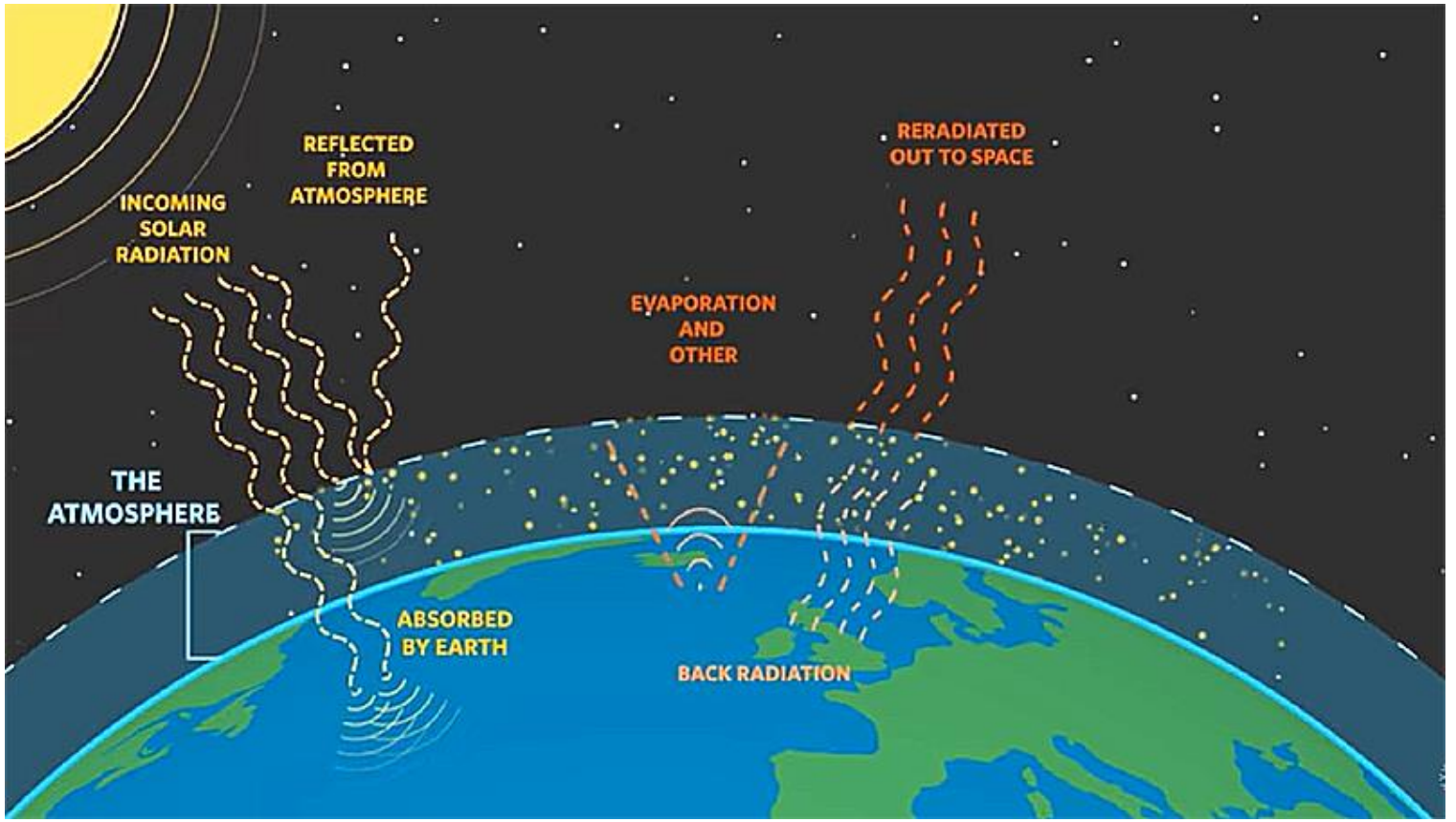
4. UV Space Astronomy

UV Astronomy for Climate Monitoring



CALIFORNIA ACADEMY OF SCIENCES

Solar UV cycle

IR cycle

Earth energy budget

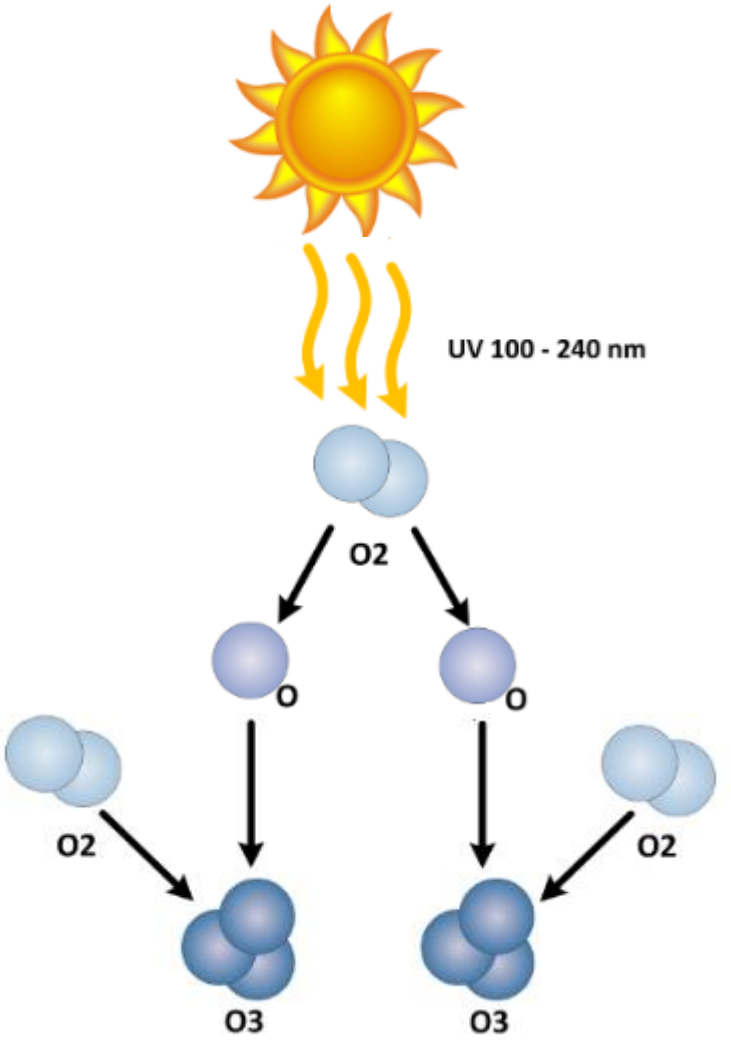
Ozone hole

Ozone layer

Ozone Layer Creation by UV Light < 240nm from Sun

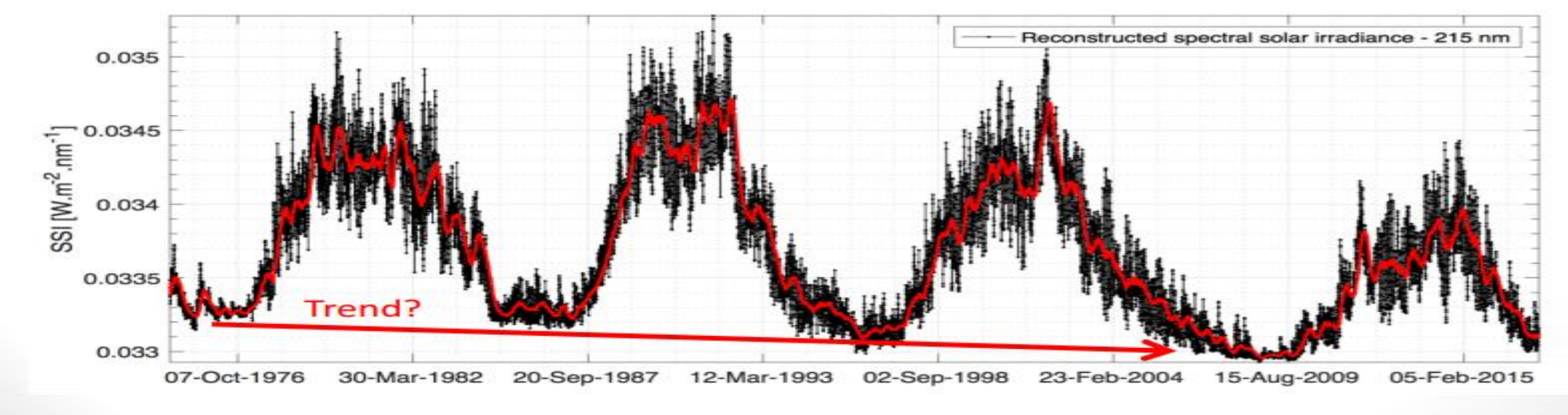
1. UV Light < 240 nm cracks molecular O_2 to form O radicals

2. O radicals react with molecular O_2 to form ozone (O_3)



Solar Cycle in the UVC (~215 nm)

45 years of UVC Solar Irradiance



Variability in solar UV flux is much higher than other spectral ranges…

Meftah, Rogers et al. Remote Sens. 12, (2020) 92

Satellite Self-Contamination Challenge

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Outgassing (particularly from solar panels) trails satellite in slip-stream vacuum

Hydrocarbons deposit on cold surfaces… & polymerise

➔ Cooled silicon photodiodes have functional lifetimes of only several weeks

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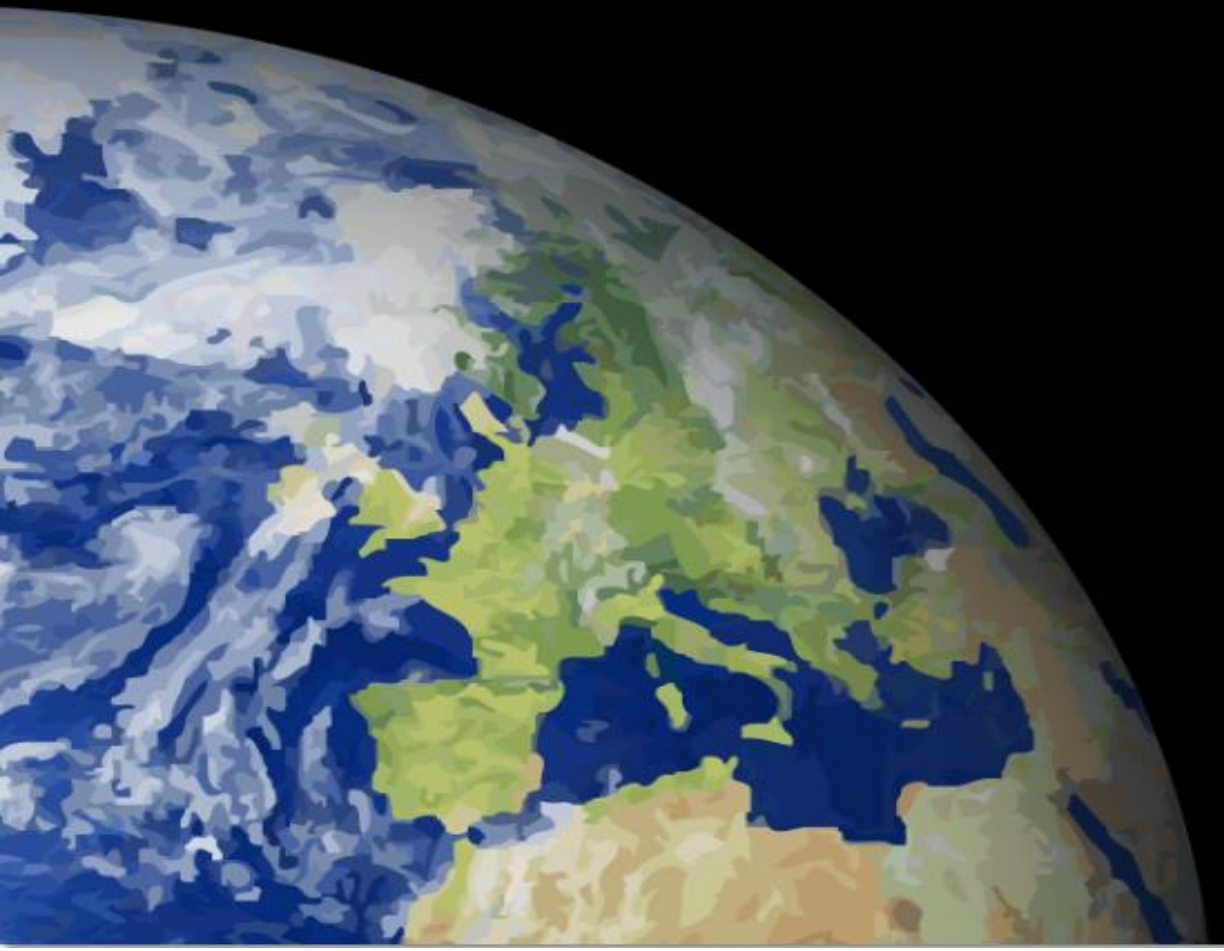
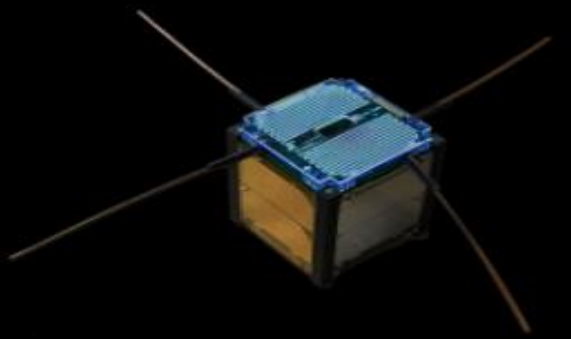
"NEW SPACE"





10cm x 10cm x 10cm

1.2kg

650km high orbit

2W total power

5V operation

Constellation planned

5. Space Qualification

Reproducibility/Stability/Robustness Testing

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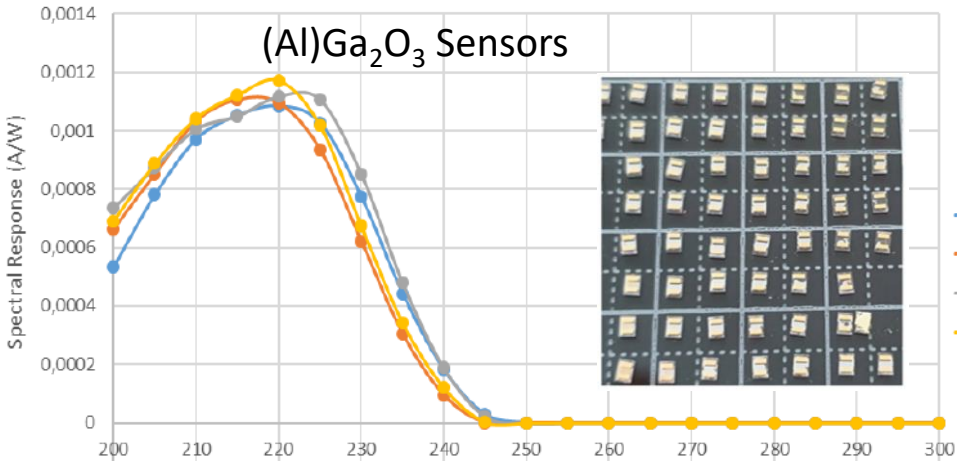
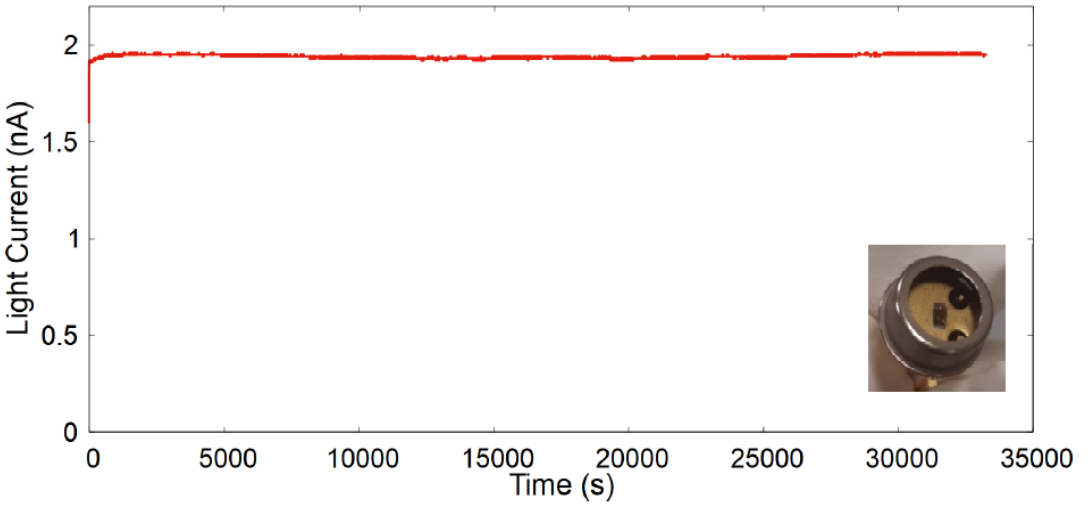
Herzberg Continuum Spectral Response



Signal Stability

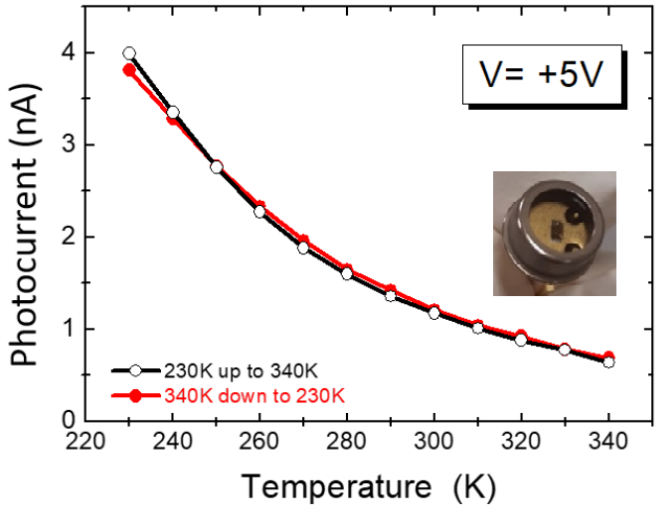


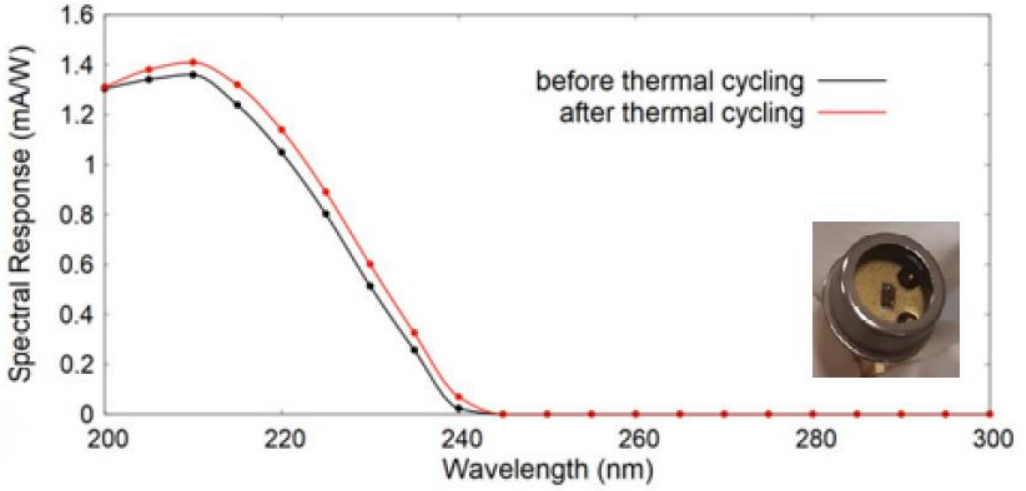
Pull-tests

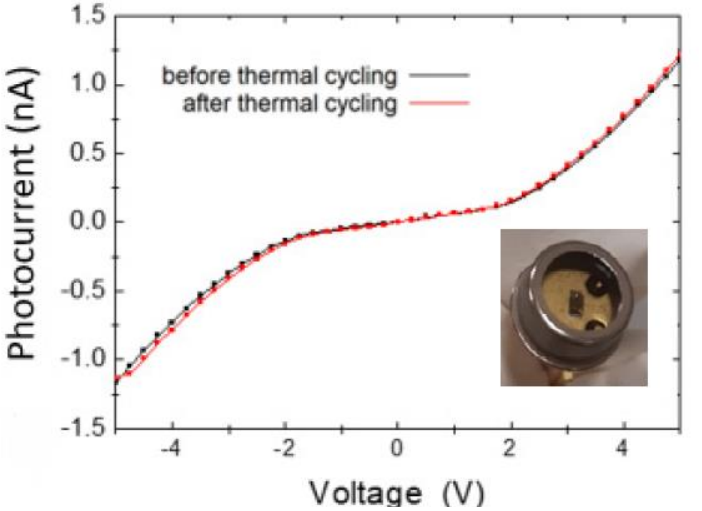
10.26gf

(MIL-STD-883 norm: >3gf)

Temperature Cycling





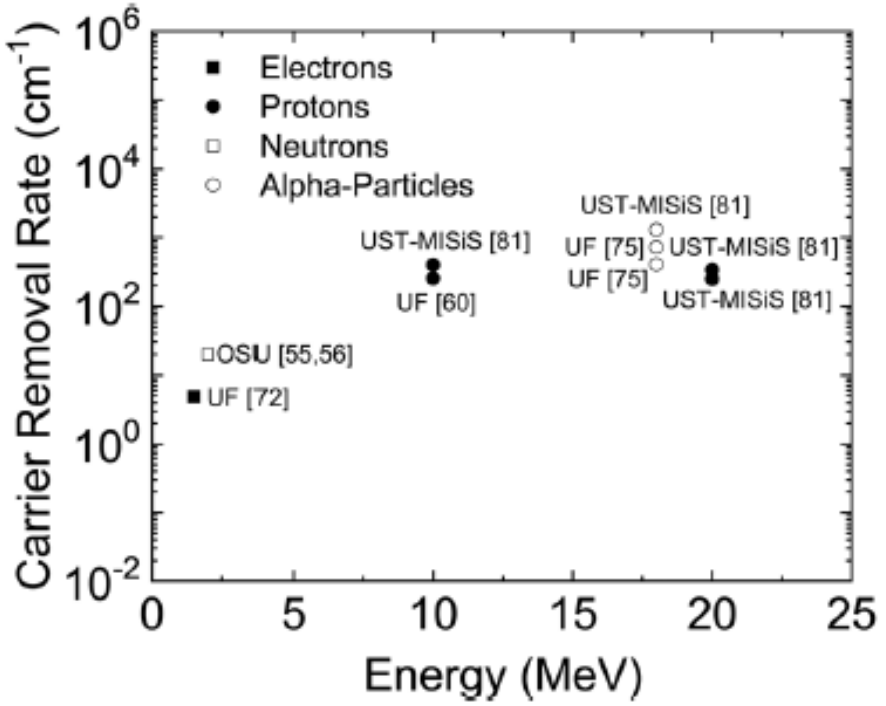


Ghorbel, Rogers et al. Proc SEIA 2021

Arrateig, Rogers et al. Proc SPIE 2021

Ga_2O_3 Radiation Hardness

We review the effect on the material properties and device characteristics of proton, electron, X-ray, gamma ray and neutron irradiation of β-Ga_2O_3 electronic and optoelectronic devices under conditions relevant to low earth orbit of satellites



Carrier removal rate in Ga_2O_3 as a function of energy for different types of radiation. Data is either from University of Florida (UF),[60,72,75] National University of Science and Technology (UST-MISiS) or Ohio State University (OSU).[55,56]

CONCLUSION

"The carrier removal rates for Ga_2O_3 are comparable to GaN"

Kim et al. J. Mater Chem C 2019, 7, 10

Sensors now Space Qualified

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Questions?

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Acknowledgements

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