SunPartner TECHNOLOGIES

Im2np

Emilie BIALIC, *Advanced R&D Division*

Optical Communication & Passive optical Sensor

PROGRAM

- **SunPartner Technologies**
- **LiFi Technology**
- **Video demonstration**

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SUNPARTNER TECHNOLOGIES

PRESENTATION

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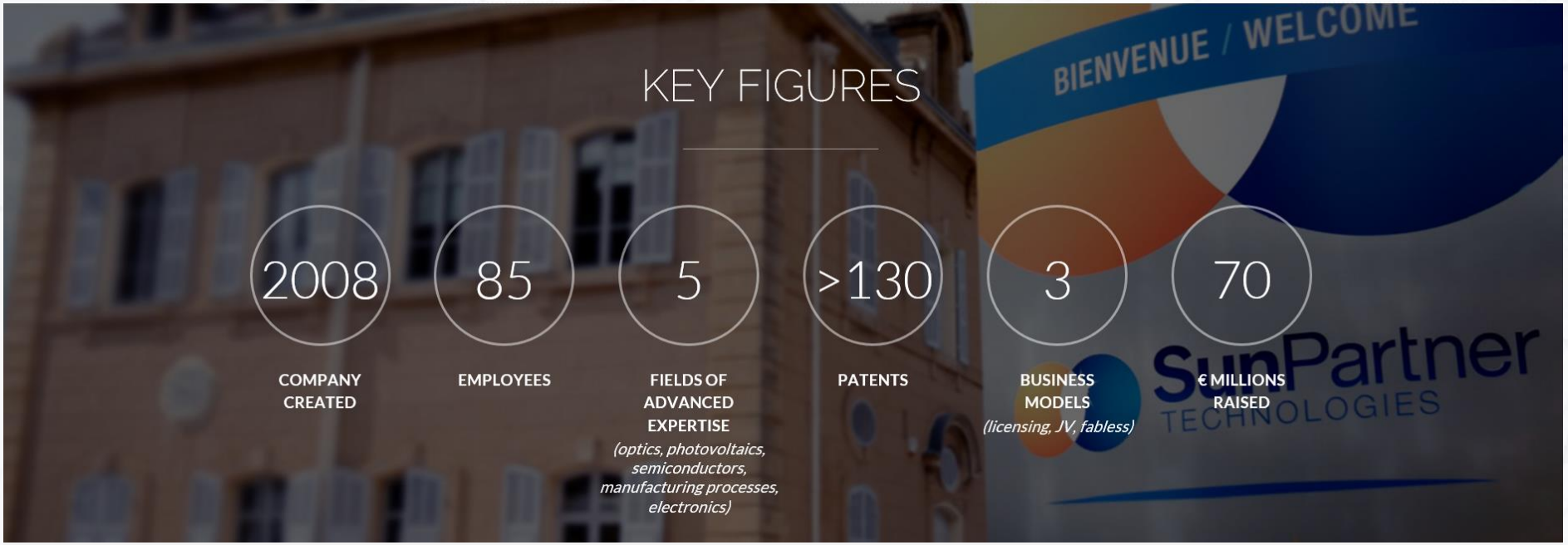
SUNPARTNER Technologies's Vision

SMART SURFACES EVERYWHERE TO PRODUCE OFFGRID ENERGY
& ENHANCE USER EXPERIENCE, USING SOLAR ENERGY

Innovative solutions for mobile devices,
displays, transportation, smart buildings & cities

SUNPARTNER Technologies

SUNPARTNER Technologies' s Company



wysips® GLASS
BUILDING & TRANSPORTATION
smart glazing

wysips® CRYSTAL
CONSUMER
emissive screens

wysips® GRAPHICS
CONSUMER
aesthetic surfaces

wysips® REFLECT
CONSUMER
any surfaces and reflective screens

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CONSUMER PRODUCTS

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wysips® REFLECT for Watches

PERFORMANCES

> Available for sizes up to 6”
> Up to 85% transparency
> From 1mW/cm² to 3mW/cm²
depending on display and transparency requirement @ 1 SUN

APPLICATIONS

WATCHES
(DIAL, DISPLAY OR COVER LENS)

ADDED VALUE

> Extended autonomy of 30% to 50%
> Standard quartz watches: no more battery change
> Analog watch « slightly » connected :
adding value & features with enhanced connectivity
> Smartwatches: moving to higher autonomy
and get closer to traditional watches with Wysips®

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wysips® CRYSTAL for Displays

PERFORMANCES

> Available for sizes up to 6''

> Up to 85% transparency

> From 2.5mWp/cm² to 4mWp/cm²
depending on transparency requirement @1 SUN

APPLICATIONS

EVERY DEVICE WITH EMISSIVE DISPLAY
(SMARTPHONE, WEARABLE)

ADDED VALUE

> Emergency power reserve:
Last call, last picture, last alert

> IoT connectivity: Geo-localization , tracking, access control, mobile paiement

> Invisible & embedded light sensor:
ALS, Li-Fi/VLC reception

> Bring autonomy to low power consumption displays

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BUILDING

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Products dedicated to the building sector

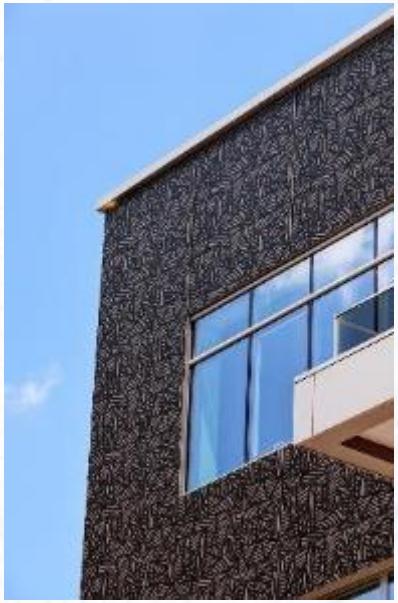
wysips® VISION-GLASS

Transparent photovoltaic glass

wysips® DESIGN-GLASS

Semi-transparent photovoltaic glass
+
power management

wysips® CAMELEON



Aesthetic photovoltaic glass

Oline
SOLUTIONS AUTONOMES & CONNECTÉES

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Consumer & Glass Production Lines

Consumer production line

Rousset

Pilot line: pre-series

Shanwei, China

Production under license with Truly Semiconductors Ltd.

Glass production line

Rousset

Photovoltaic glass products

Capacity: 150 000 m²/year

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TRANSPORTATION

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Transportation Applications

APPLICATIONS

CARS

AIRCRAFTS

TRAINS

MARINE

ADDED VALUE

> Improve autonomy of electrical vehicles
> CO_2 regulation
> Solar protection system: user comfort
> Power electronic devices or functions: off-the-grid dimmable windows, power pre-ventilation / pre-start operations

Under development with key players of the market

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VISIBLE LIGHT COMMUNICATION

LIFI

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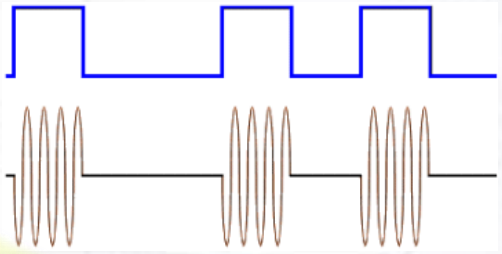
VLC & LiFi

Modulated Light



OLEDCOMM

LVX System

lucibel Lighting innovation

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SIEMENS

pureLiFi

SAMSUNG

cea

PHILIPS

LUCIOM For light communication

Fraunhofer

VÕLMENNI

GLOBAL LIFI TECH

TOSHIBA

CASIO

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The Best LiFi Receiver

Only few papers :

[1] H. Haas et al., *Towards Self-powered Solar Panel Receiver for Optical Wireless Communication*, Optical Networks and Systems (2014), p.3348 – 3353. **(Multicrystalline silicon module)**

[2] E. Bialic et al., *Specific innovative semi-transparent solar cell for indoor and outdoor LiFi application*, Applied optics vol.54 No.27 (2015), p.8062 – 8069. **(Semi-transparent amorphous Si module)**

[3] H. Haas et al., *Organic solar cells as high-speed data detectors for visible light communication*, Optica vol.2 No.7 (2015), p.607 – 610. **(OPV PTB7:$PC_{71}BM$ & PEDOT:PSS module)**

[4] W. Shin et al., *Self-reverse-biased solar panel optical receiver for simultaneous visible light communication and energy harvesting*, Optics Express vol.24 No.22 (2016), p.1300 – 1305. **(Monocrystalline silicone module)**

Omni-Directionnal

Thin & Integrable

Universal Receiver

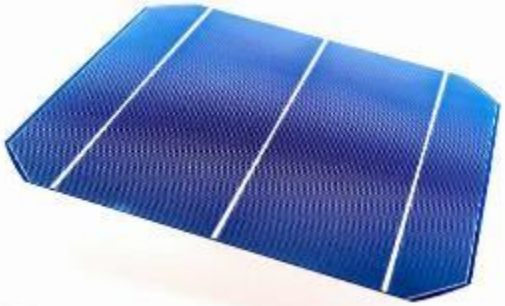
Energy Sufficient

No outdoor solution

High Data Rate

Self Adaptive

Why not ?



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COLLABORATION

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Collaboration Team

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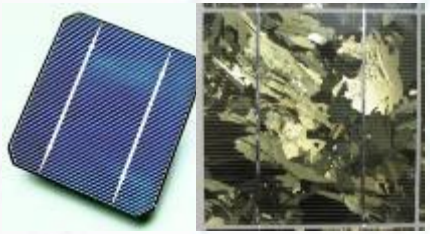
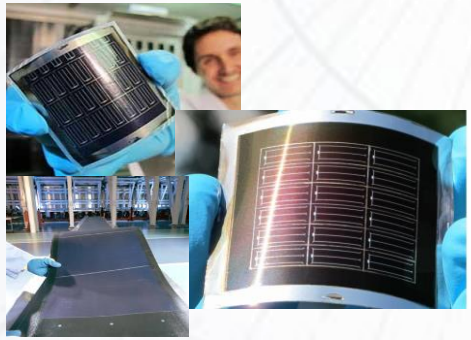
IM2NP Lab.

Optoelectronic and Photovoltaic Team (OPTO-PV)

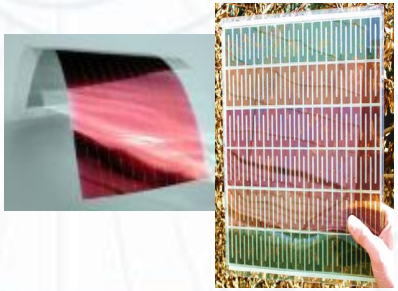


Silicon

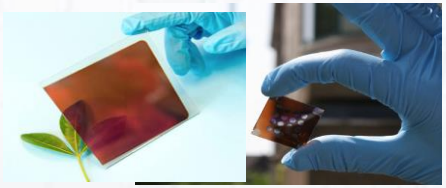


Inorganic thin film solar cells

OPV / DSSC



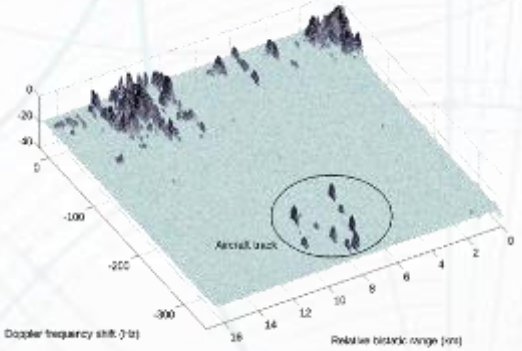
Nanostructure pérovskite

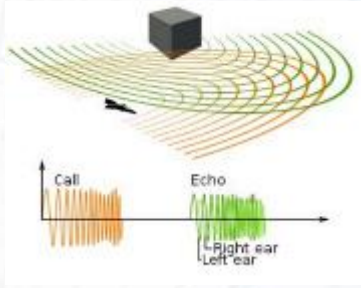


Signal & Tracking Team

Signals from
Environment : Biological ...
Acoustic : Sonar …
Telecom : OFDM …
Domestic : consumption …
2D : Images

Signal Analysis
Signal Modeling
(Maths - Proba Stat)





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LIFI CHARACTERIZATION TOOL

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LiFi Test Bench

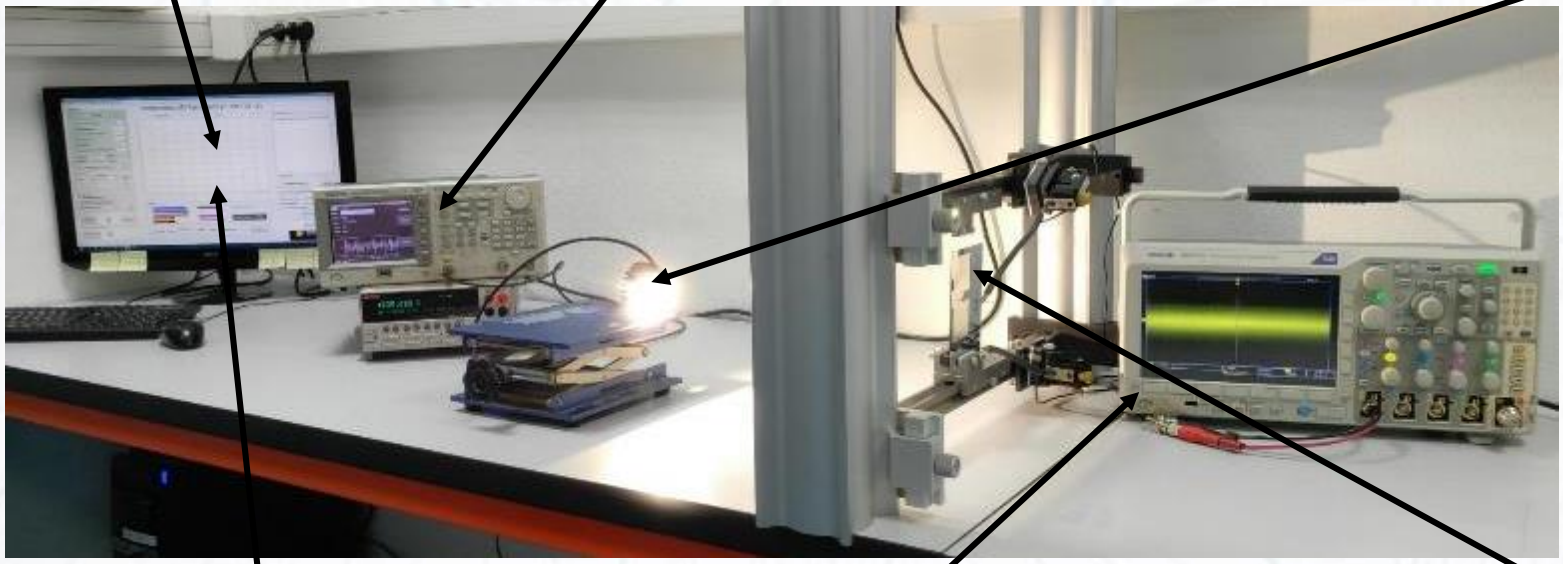
Current generator
Keithley 2440
Bias generation

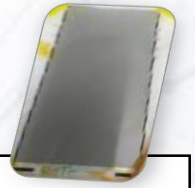
BiasTee
Tektronix PSPL5580
AC + DC modulation

Matlab 2016b
HP Z800
Data → OFDM signal

Arbitrary function generator
Tektronix AFG3021
Sent OFDM signal

LED
Philips Lumileds Luxeon CoB Gen3
Luminous signal transmission





Matlab 2016b
HP Z800
OFDM signal demodulation → Data

Oscilloscope
Tektronix MSO3034
Recording received signal

PV module
Sunpartner technologies
Luminous modulation detection

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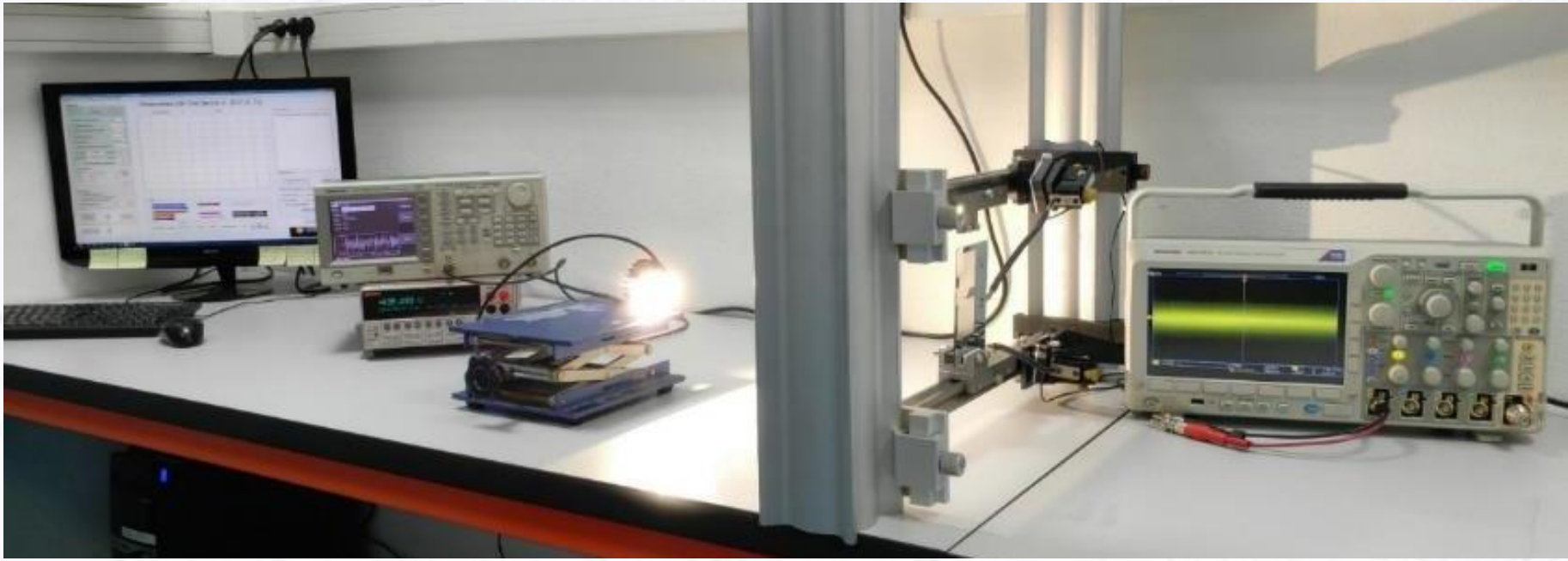
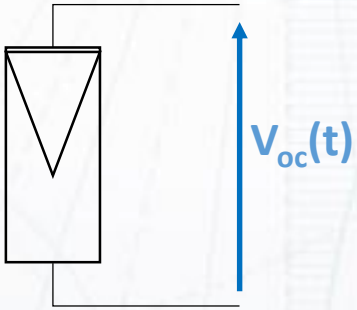
LiFi Test Bench



PV module



Working range:

- **E/R distance**: 1cm → 2m
- **Luminous intensity** AC+DC: 100lx → 400000lx
- **Frequency modulation**: 50 KHz (Bias Tee) → 25 MHz (LED)
- **Calibration**: Hamamatsu APD photodiode
- **Modulation type** : DCO-OFDM
  (IM2NP internal software development)

LiFi Modulation : DCO-OFDM

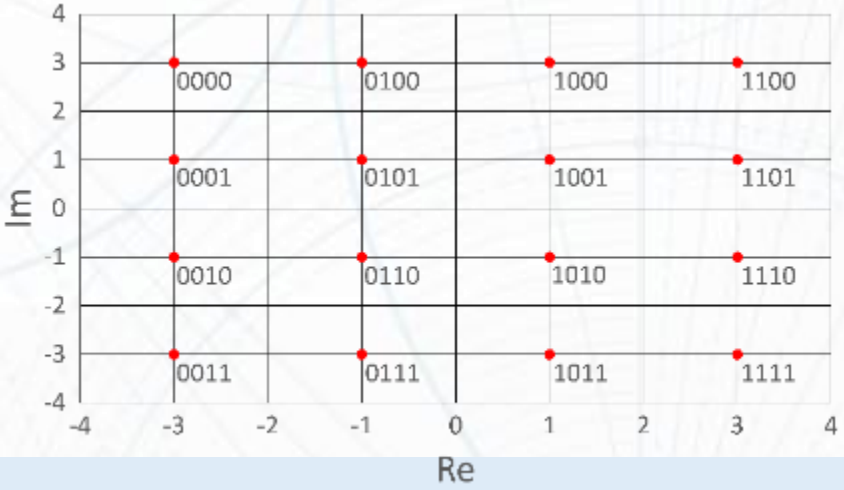
DCO- OFDM :

- DC biased Optical – Orthogonal Frequency-Division Multiplexing

Principle :

- Send multiple frequency at same time without interferences
- Send set of bits on each frequency (by using some amplitude level on signal)

Constellation map example
for 4 bits on each frequency



Interest of OFDM modulation :

- Increase data rate
- Measure channel on all selected frequency at same time

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LiFi Bench validation

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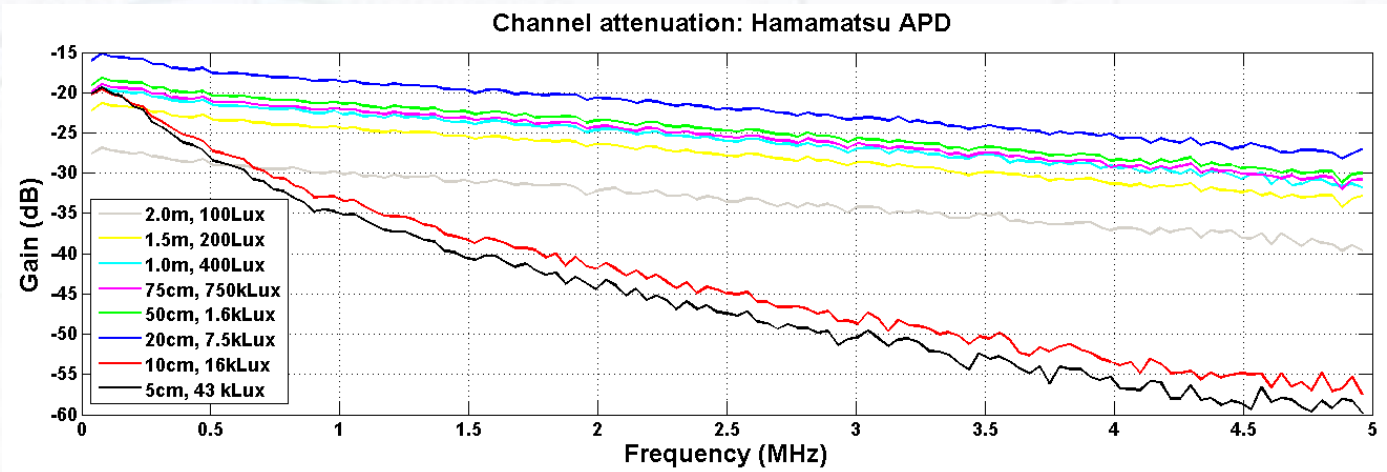
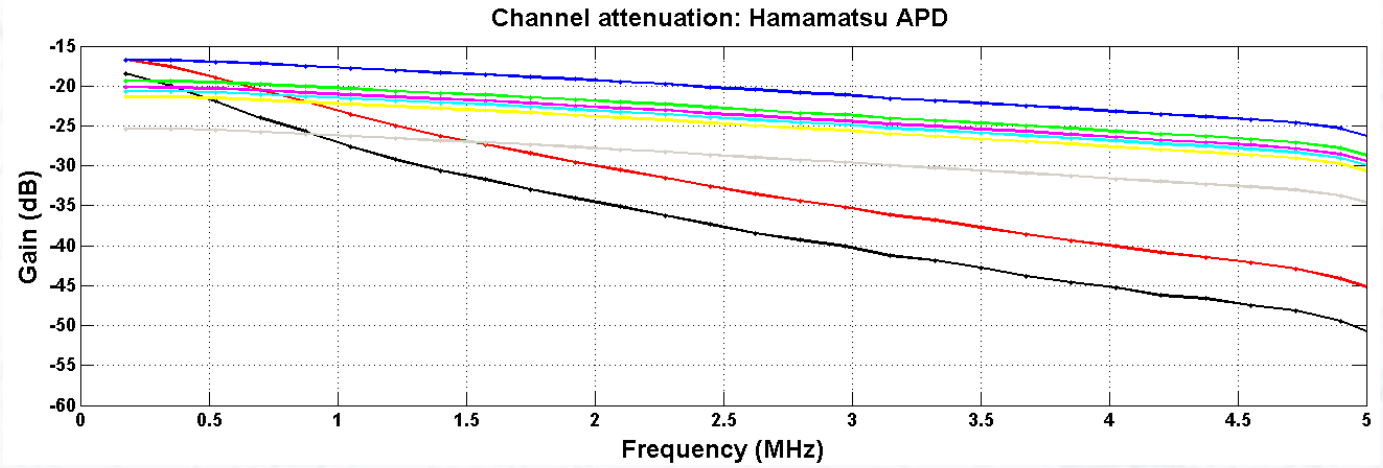


CEA



Bench calibration have been made compared to SunPartner / CEA-Leti publication

SPECIFIC LIFI APPLICATION

SPECIFIC LIFI RECEIVER

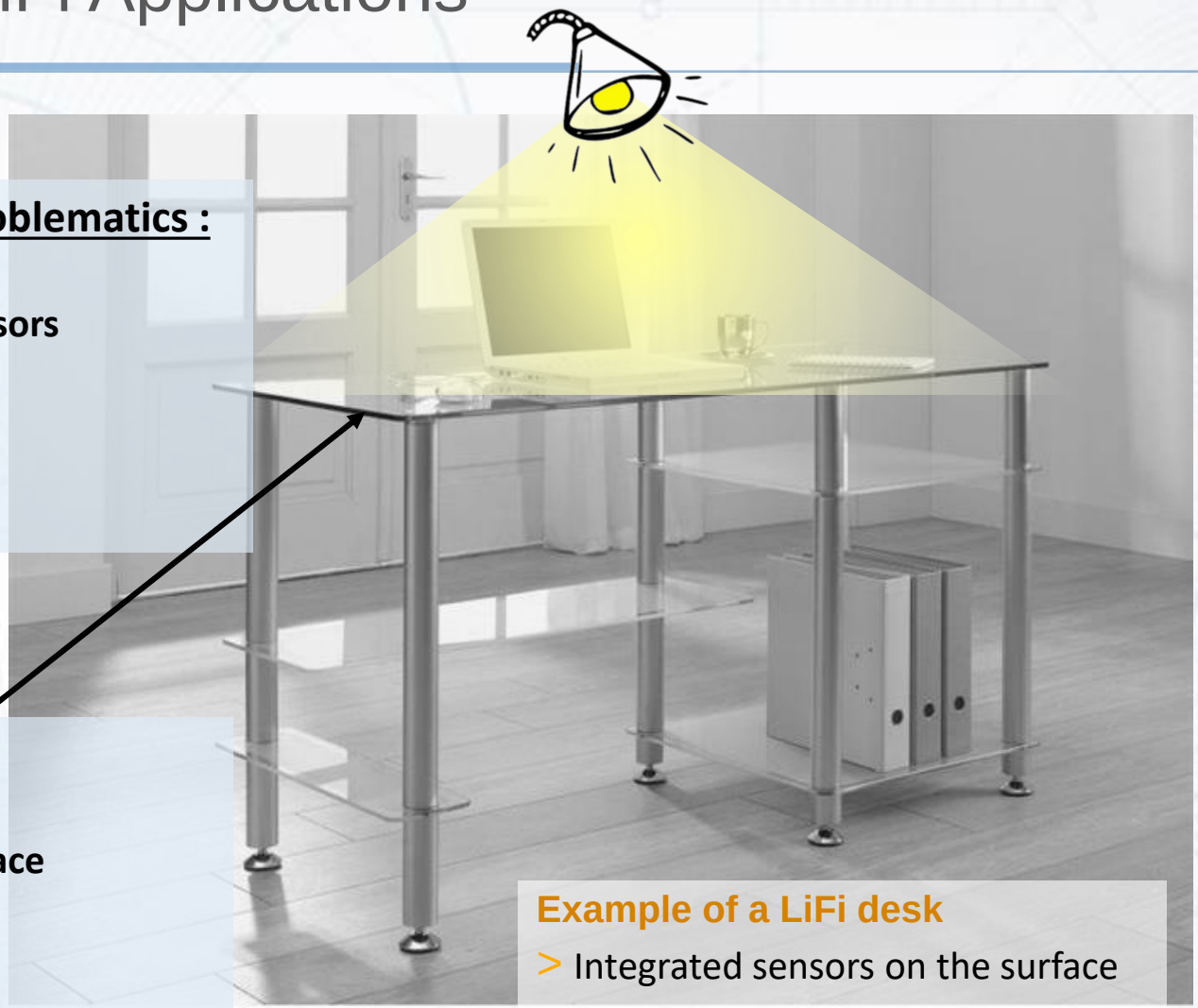
Specific indoor LiFi Applications

Conventional reception problematics :

- **Small sensors, opaque sensors**
  - Not well integrated
- **Need to be powered**
- **Strong shading effect**
- **Directional reception**

Photovoltaïc solution :

- **Large semi transparent surface**
  - Well integrated
- **Optical passive sensor**
- **Weak shading effect**
- **Omni-directional receiver**
- **Could be used as energy harvester**



Example of a LiFi desk

> Integrated sensors on the surface

> USB connection to smart object

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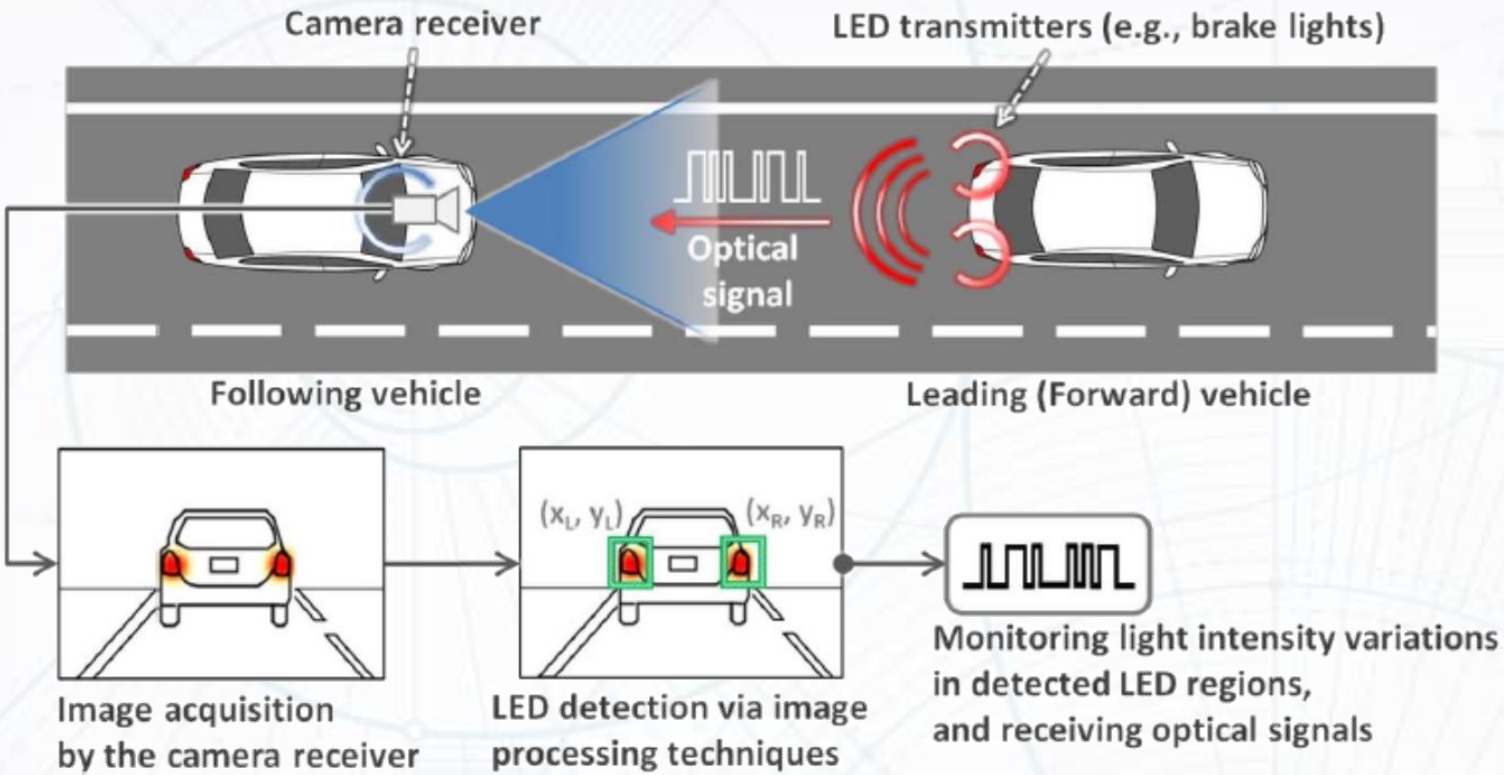
Specific outdoor LiFi Applications



Source : Isamu Takai *et al,* « optical Vehicle-to-Vehicle Communication System Using LED Transmitter and Camera receiver », IEEE Photonics Journal, 2014

Conventional reception problems:

- **Ambient Lighting saturation effects**
- **Sensor location**
  - Not well integrated
- **Need to be powered**
- **Directional reception**

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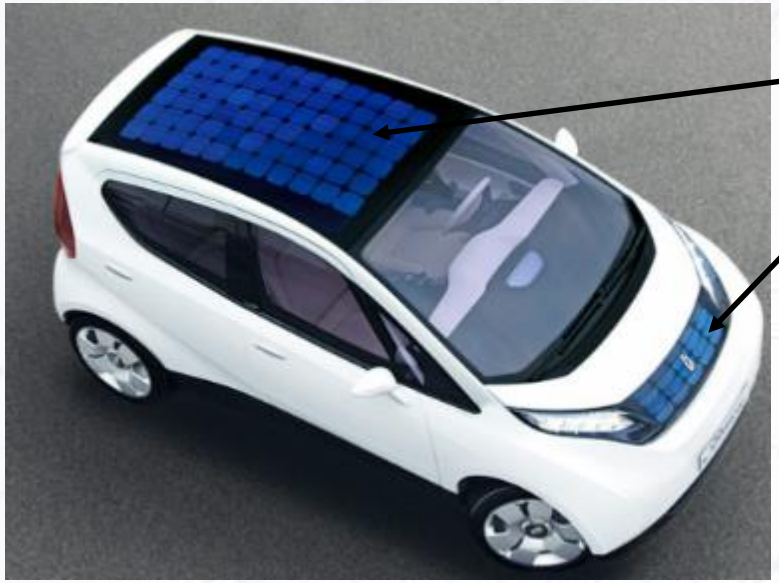
Specific outdoor LiFi Applications



Photovoltaïc solution :

- **Large surface**
  - Well integrated
- **Optical passive sensor**
- **Weak shading effect**
- **Omni-directional receiver**
- **Could be used as energy harvester**

Source : http://www.voiture-electrique-populaire.fr/tag/panneaux-solaires-photovoltaiques

LED Transmitter

⇌

Bi-directional link

PV module receiver

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AMBIENT LIGHTING EFFECT

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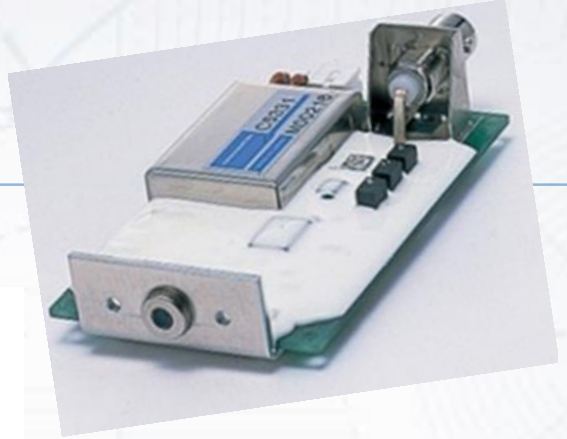
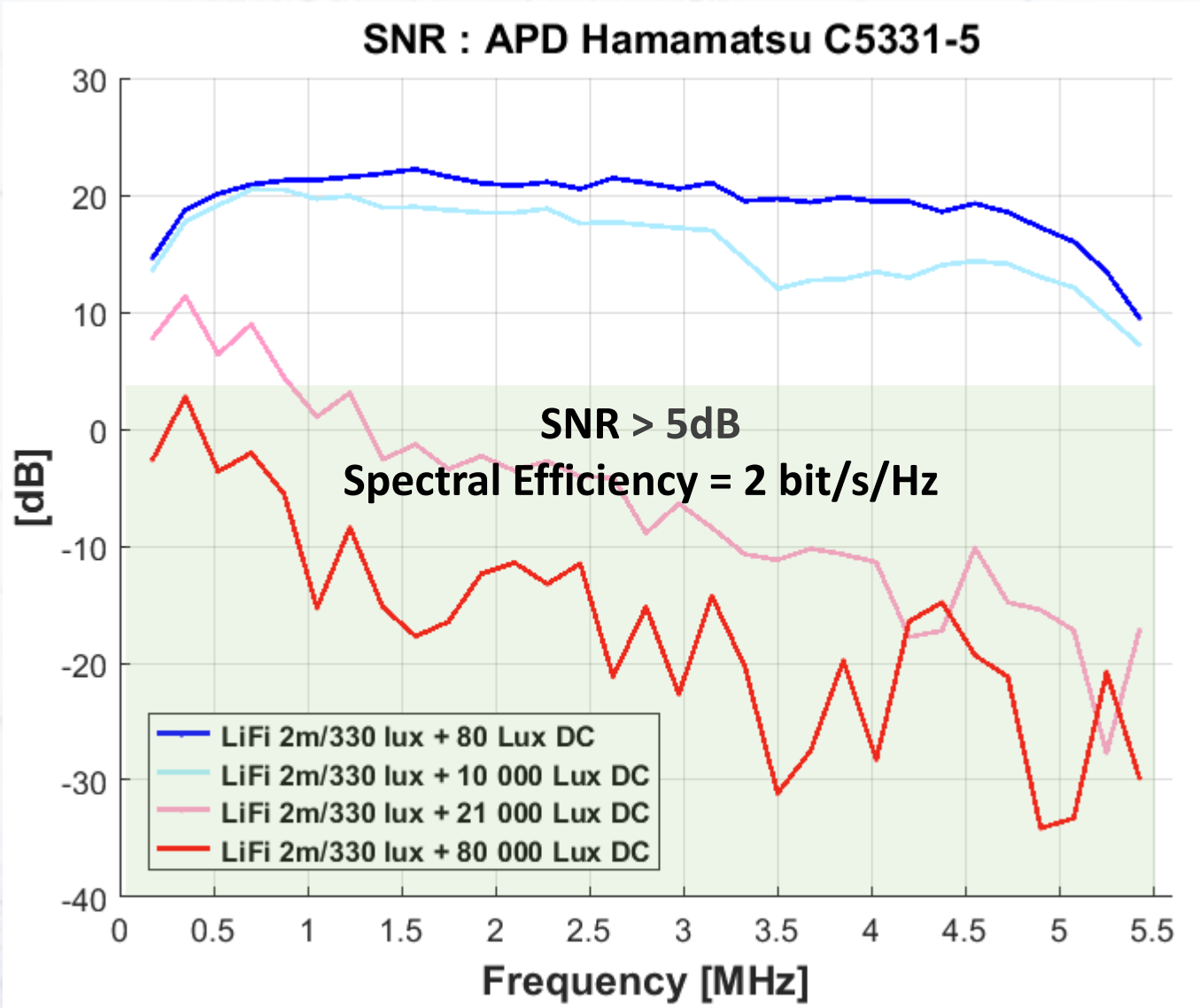
Conventional LiFi effects





Indoor Ambient Lighting Conditions

> 11 Mbit/s

Outdoor Ambient Lighting Conditions

0 Mbit/s

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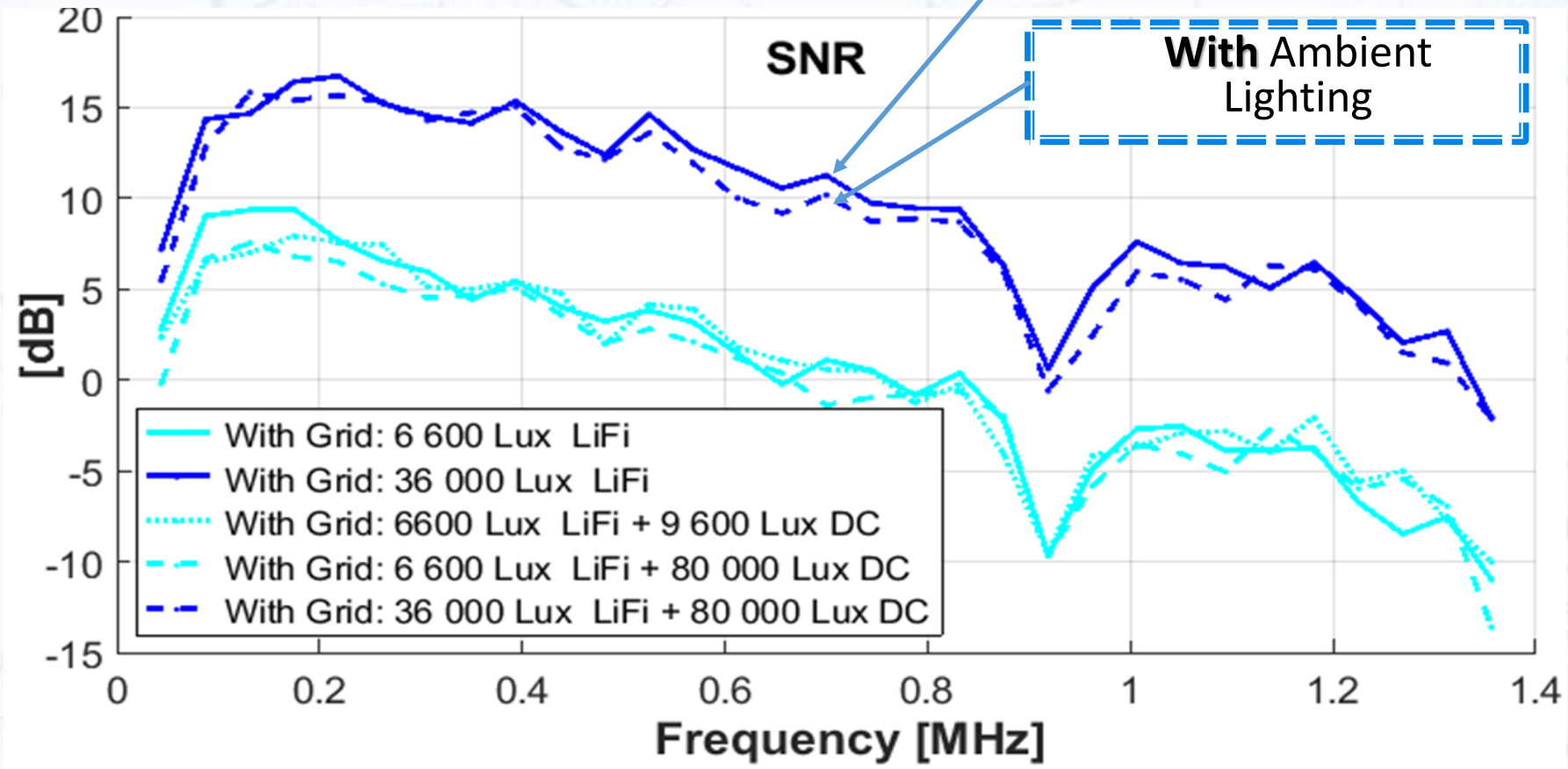
Saturation stability LiFi effects



Indoor Ambient Lighting Conditions & Outdoor Ambient Lighting Conditions

Same performances

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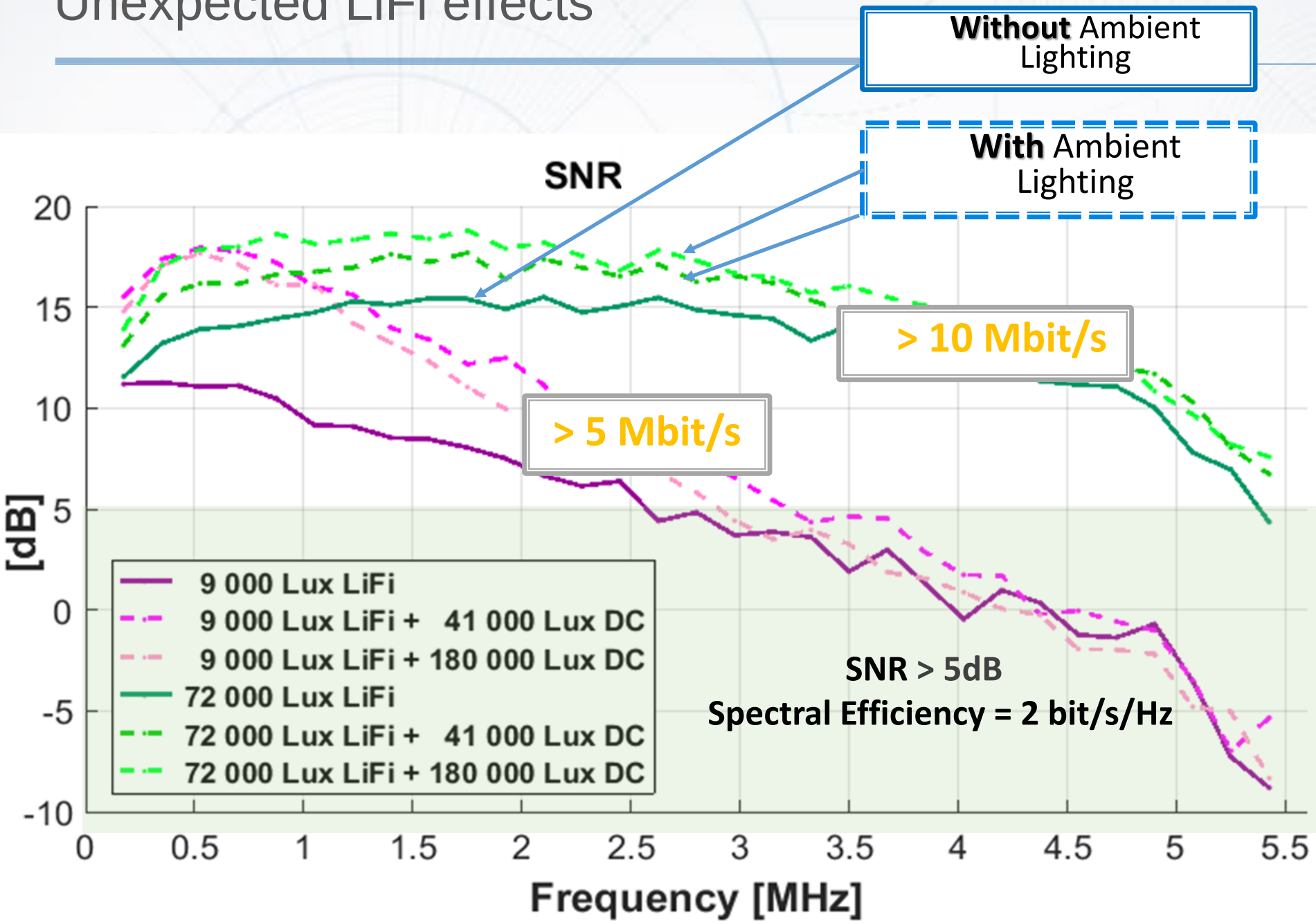
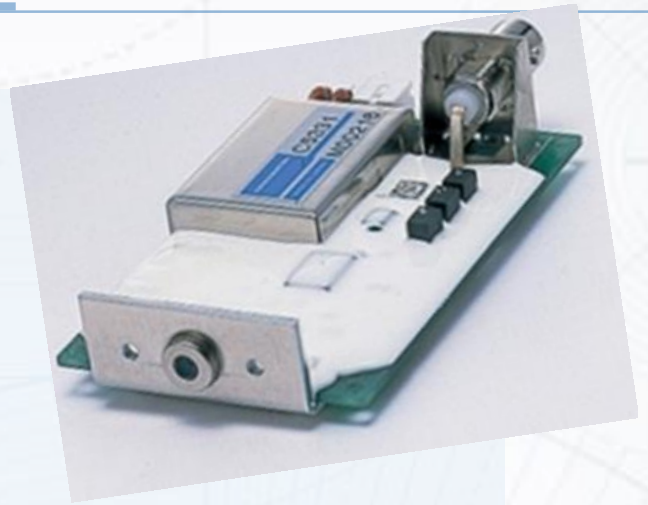
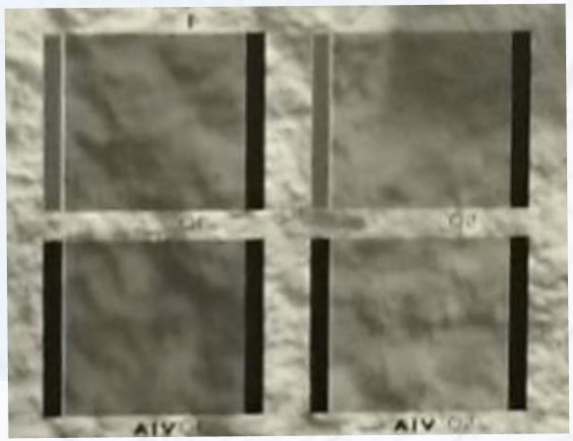
Unexpected LiFi effects



3 differents ambient lighting effects

- **Conventional LiFi effects** :
  - If the ambient lighting ↗ Then the SNR ↘
- **Saturation stability effects** :
  - If the ambient lighting ↗ Then the SNR →
- **Unexpected LiFi effects** :
  - If the ambient lighting ↗ Then the SNR ↗





Sources

1. E. Bialic, L. Maret, D. Ktnénas, « Specific innovative semi-transparent solar cell for indoor and outdoor LiFi Applicatio
2. E. Bialic, presentation at WISEE 2016

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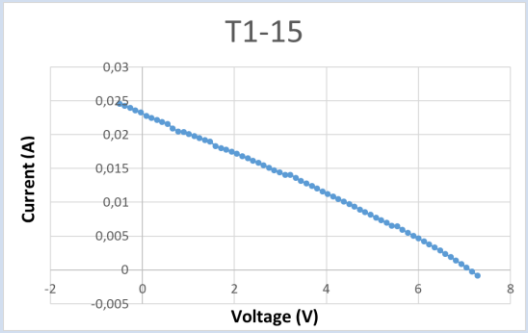
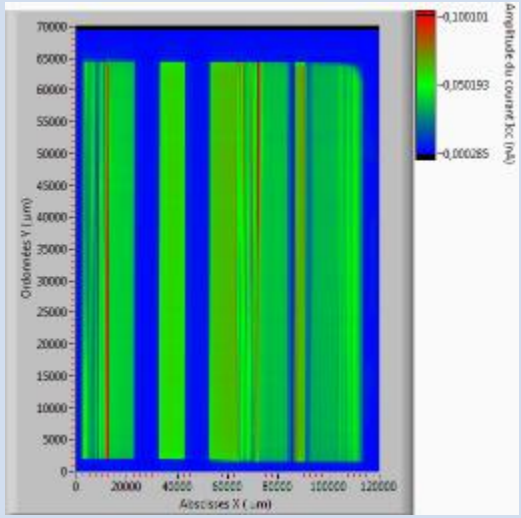
SHADING EFFECTS

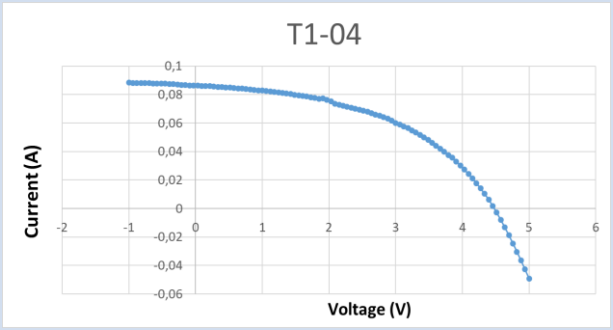
T1-15 & T1-04 : I(V), LBIC (Light Beam Induced Current)

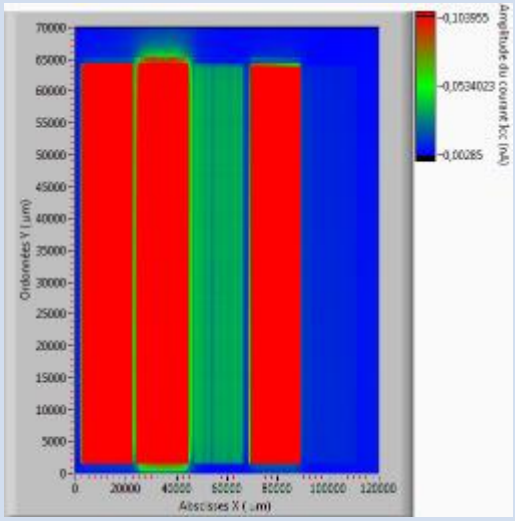
T1-15 : 11 cells, 33% PV





T1-04 : 5 cells, 33% PV





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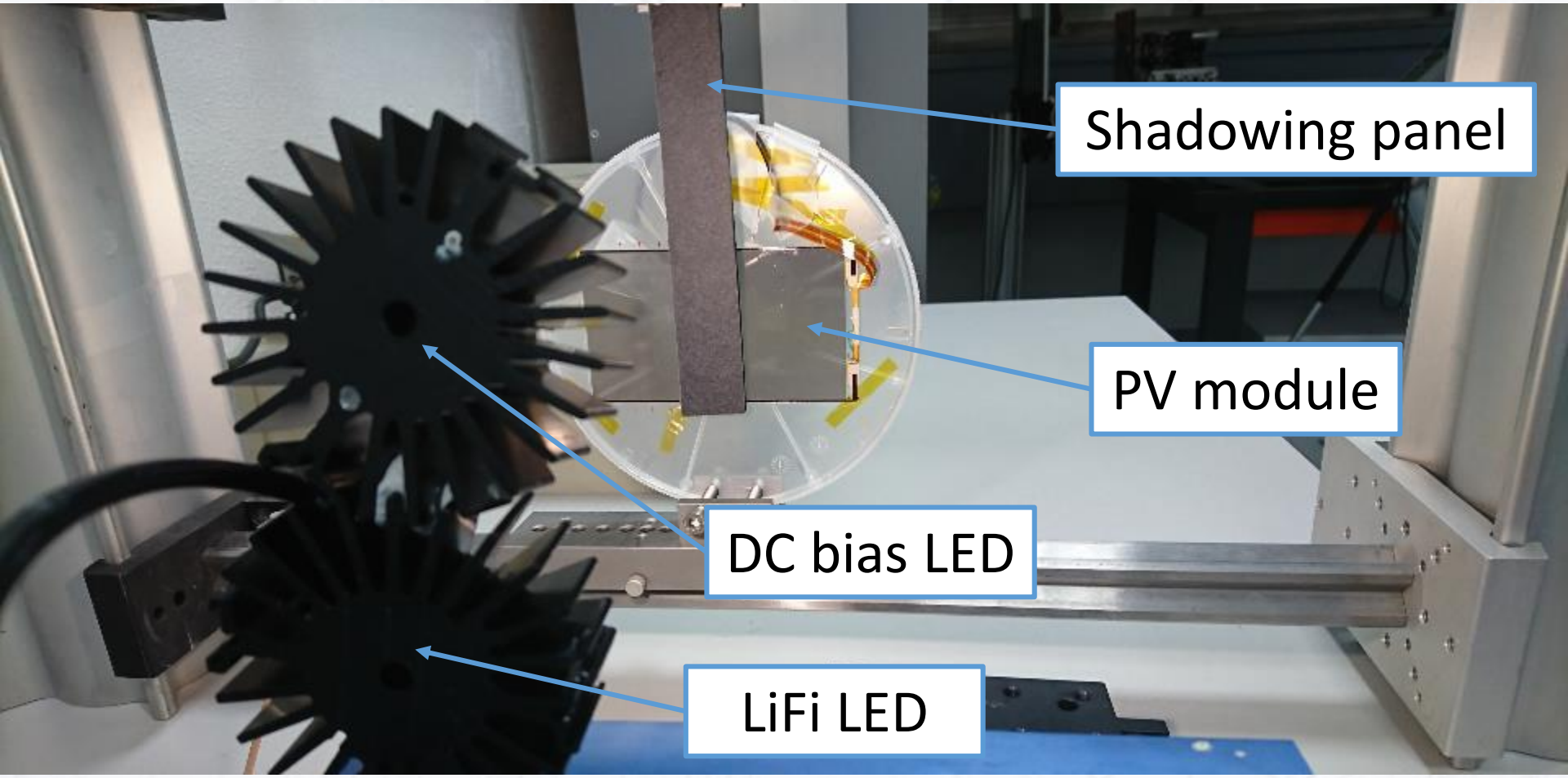
Shading Effect Test Bench



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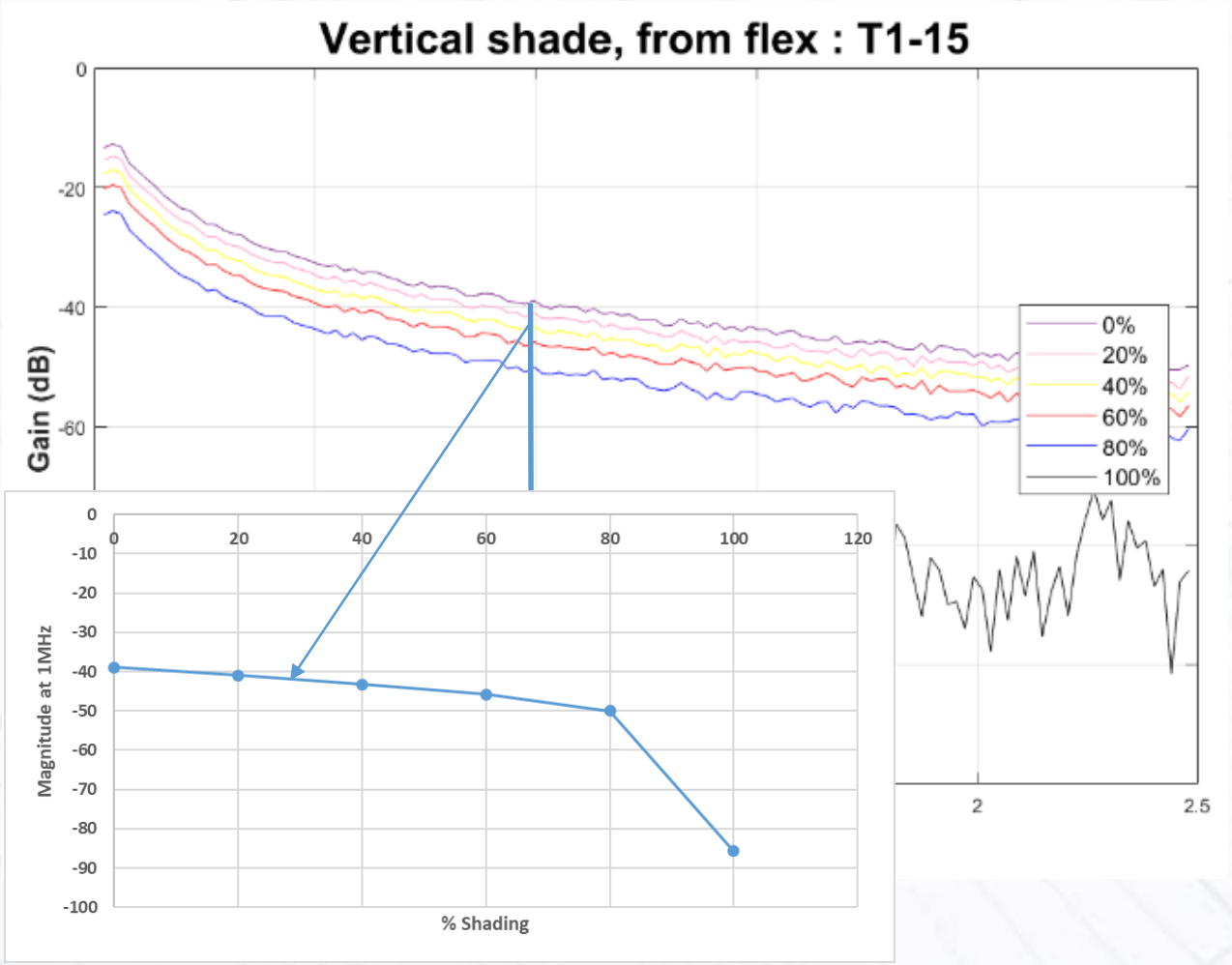
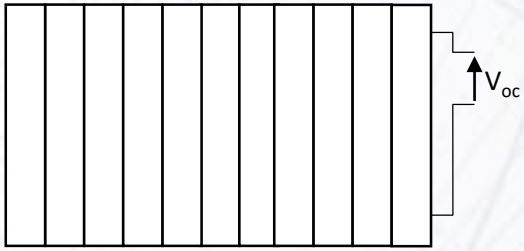
Vertical shade





LiFi detection operational up to 80% shading

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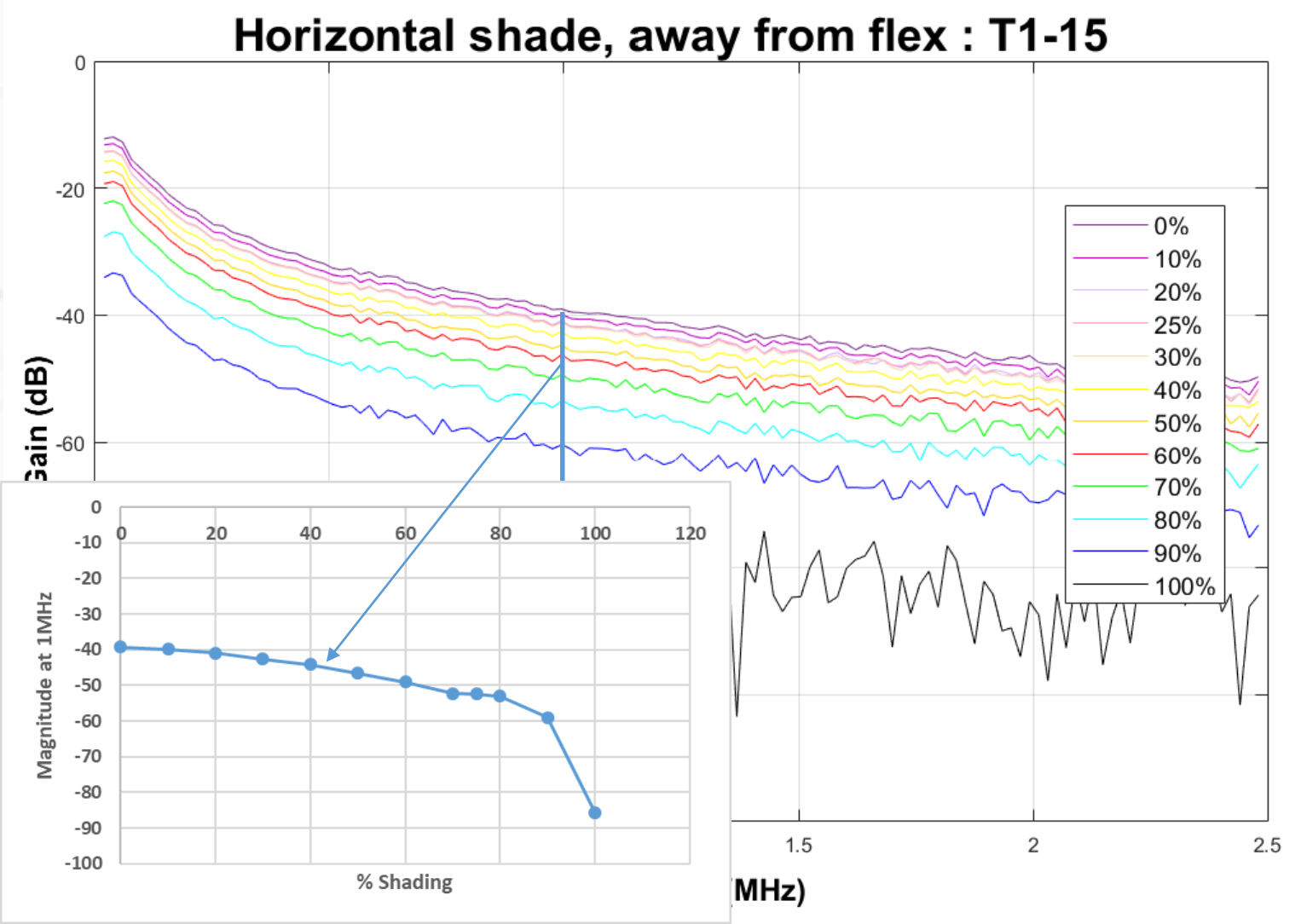
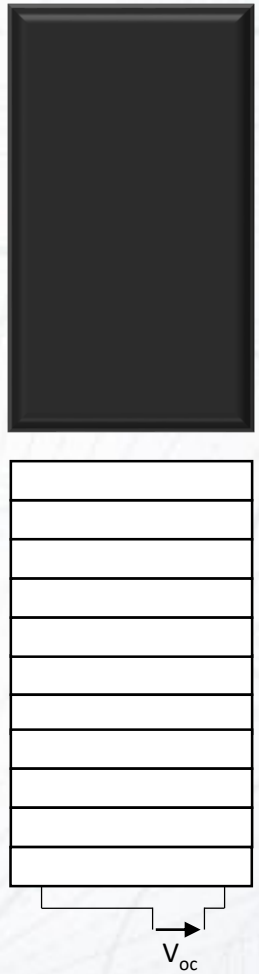
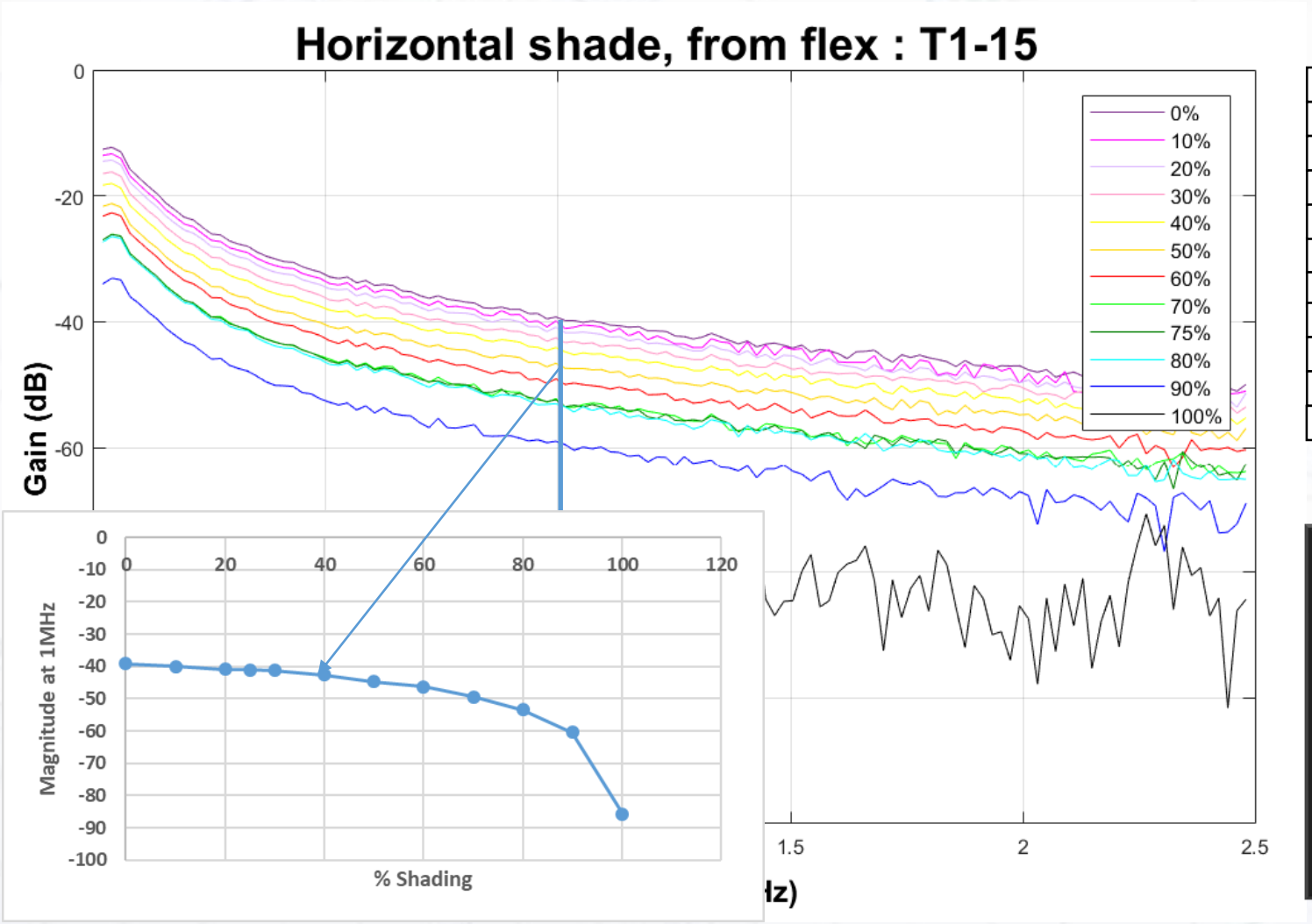
Horizontal shade

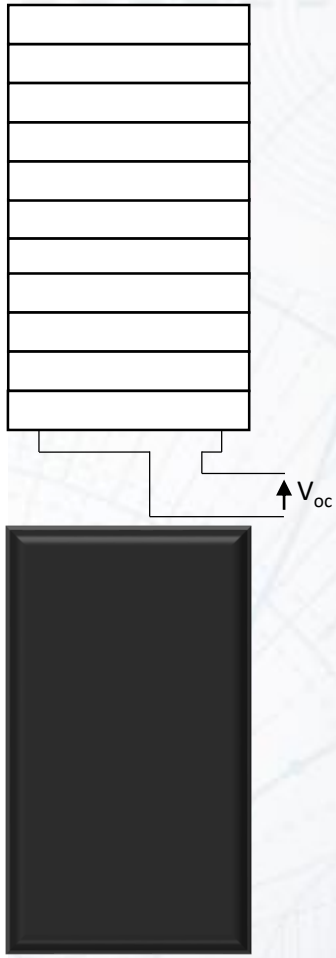




LiFi detection operational up to 60% shading

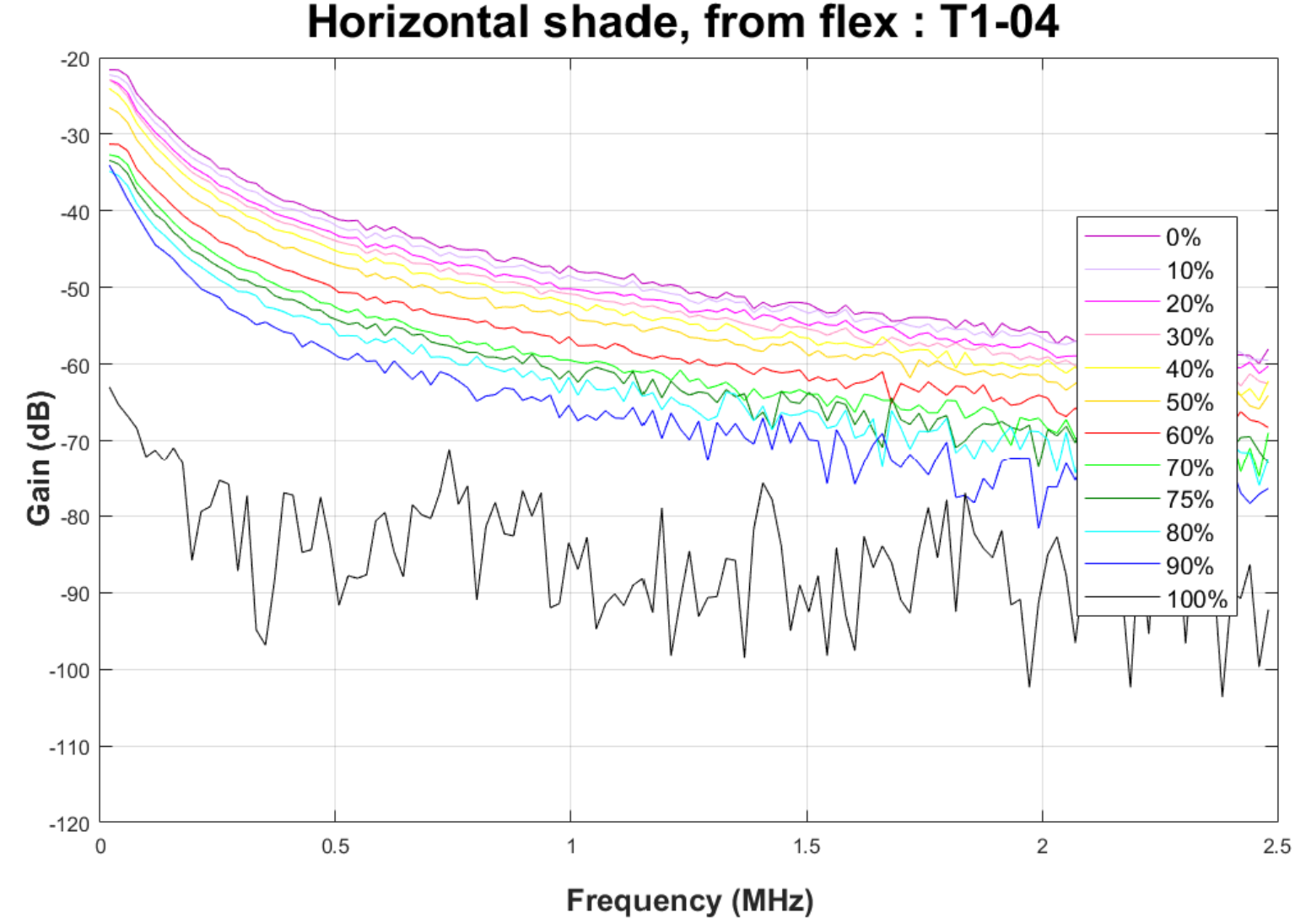
Horizontal shade





LiFi detection operational up to 60% shading

Horizontal shade

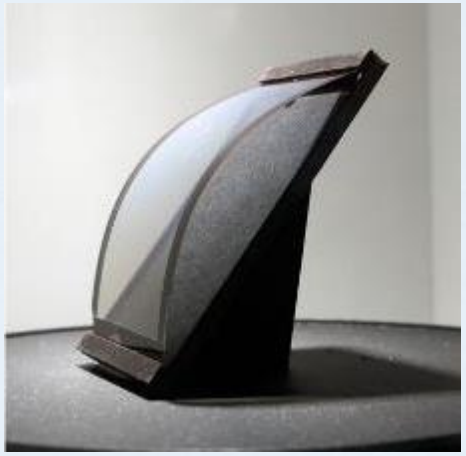


Same effects as T1-15

Conclusion

Photovoltaic receiver: a good solution for specific LiFi applications

- **Large surface**
  - Well integrated
  - Semi-transparent or design solution
  - Glass or flexible solution
- **Passive optical sensor**
- **Compatible with outdoor environment**
- **Weak shading effect**
- **Omni-directional receiver**
- **Could be used as energy harvester**



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Thanks for your attention – Let’s Go to the demonstration

240 Avenue Olivier Perroy - 13790 Rousset - France
+33 (0) 4 42 39 86 44

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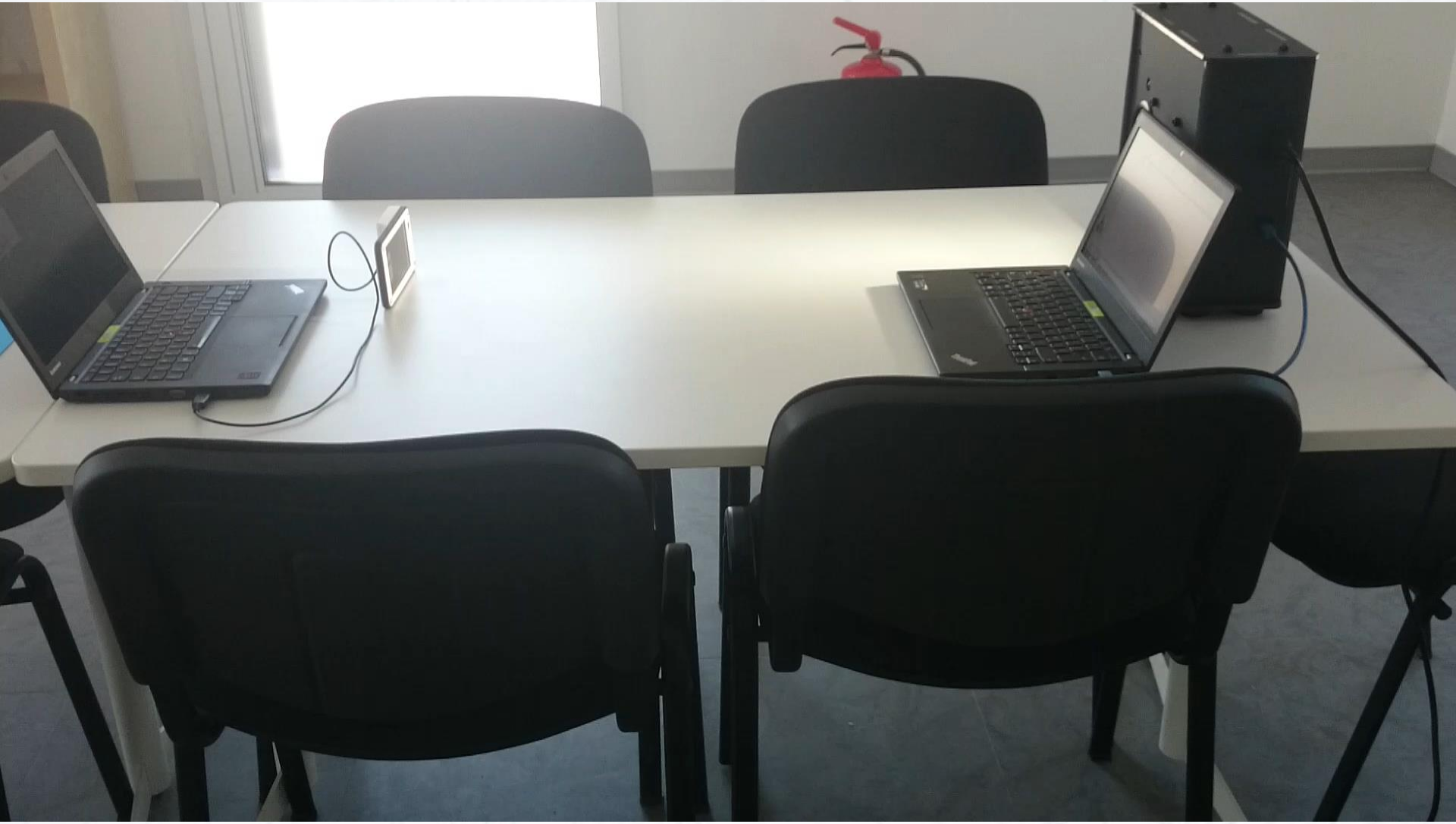
www.sunpartnertechnologies.com



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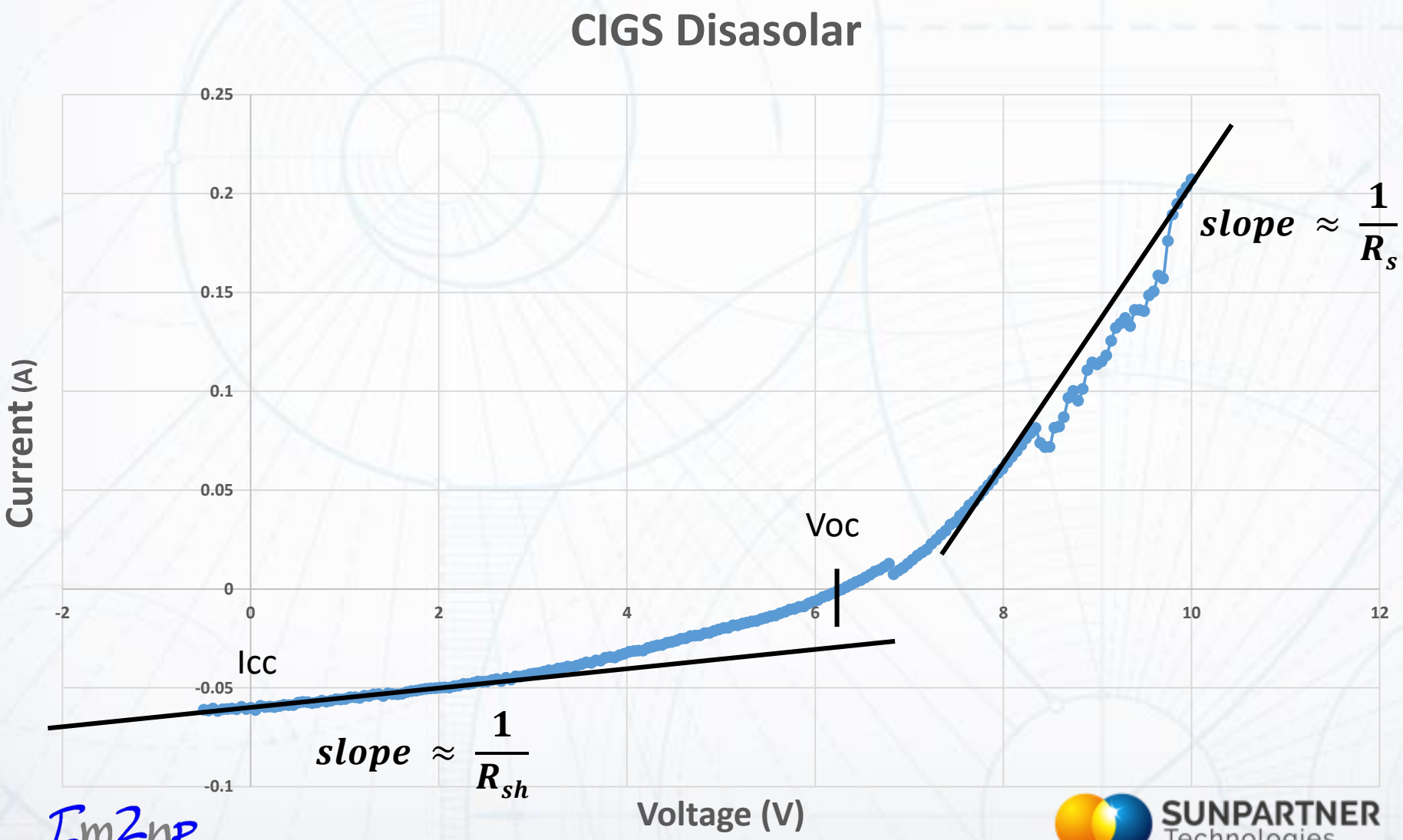
ANNEXES

STATIC CHARACTERIZATION

TOOLS

I(V)



Im2np

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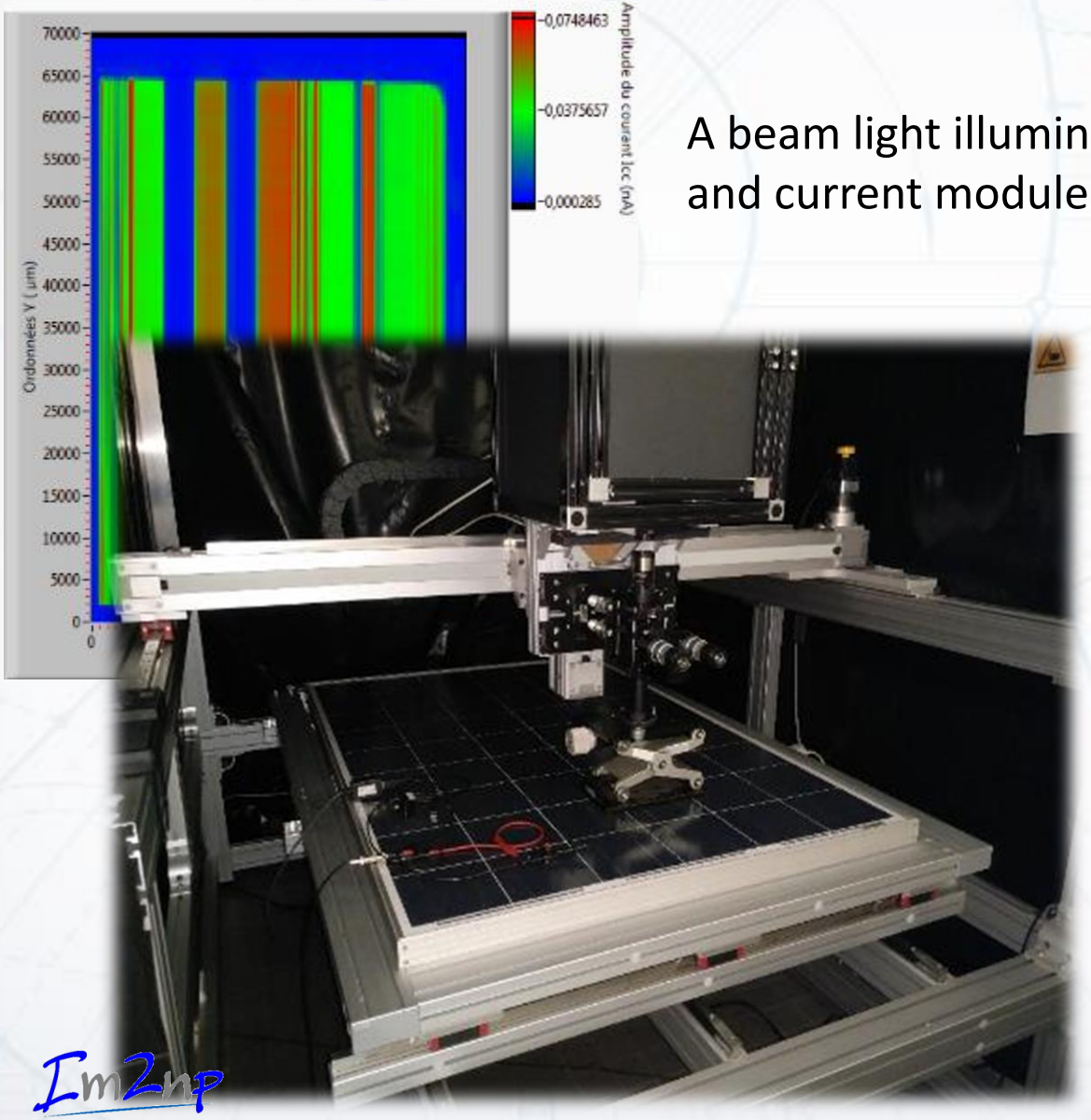
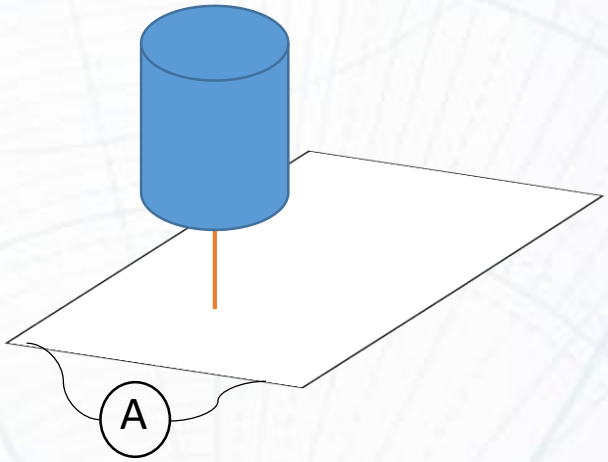
LBIC : Light Beam Induces Current



A beam light illuminate the module point by point and current module is measured.



Resolution: 50µm x 50µm (light spot)
Wavelenght: 400 to 1100nm or white light
Largest module acceptable: 1.5m x 1m

Im2np

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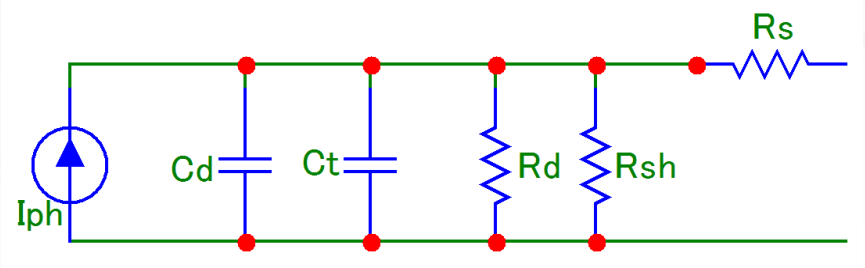
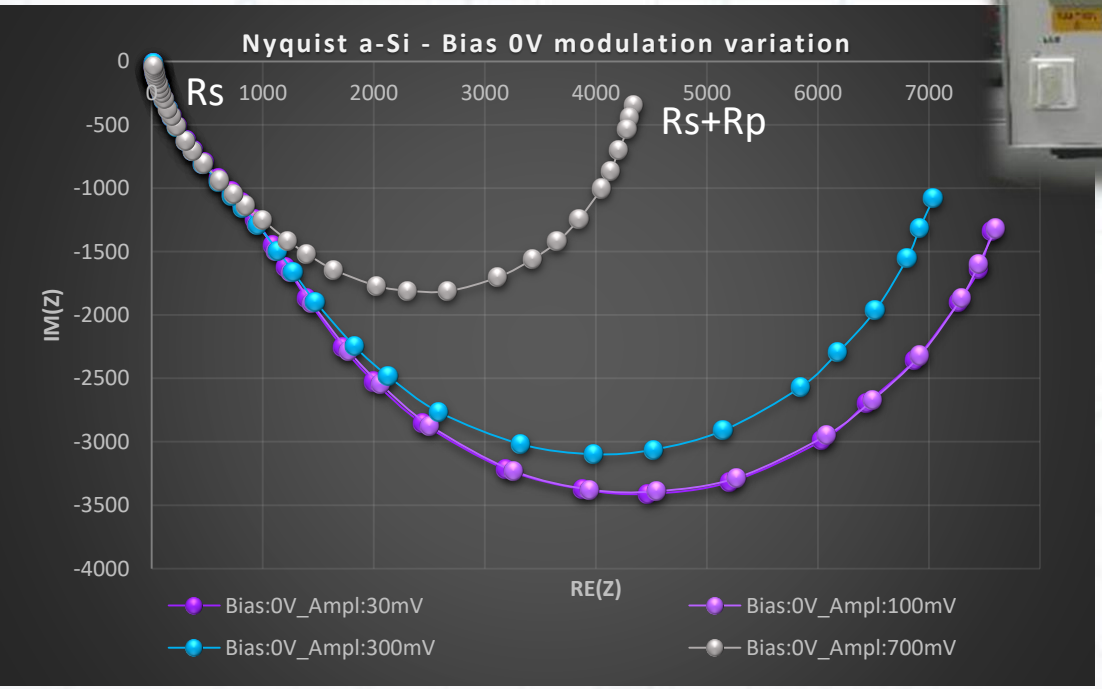
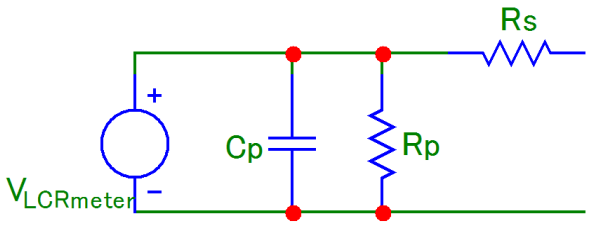
DYNAMICAL CHARACTERIZATION TOOLS

Impedance spectroscopy







AC+DC voltage is sent to the DUT and current fluctuation is measured.

$$U = Z.I$$

Reverse bias: Rp ~ Rsh | Cp ~ Ct
Forward bias: Rp ~Rd | Cp ~ Cd

$$C_p = \frac{1}{\omega R_p}\sqrt{\frac{|Z|^2 - (R_s + R_p)}{-|Z|^2 + R_s^2}}$$

Im2np

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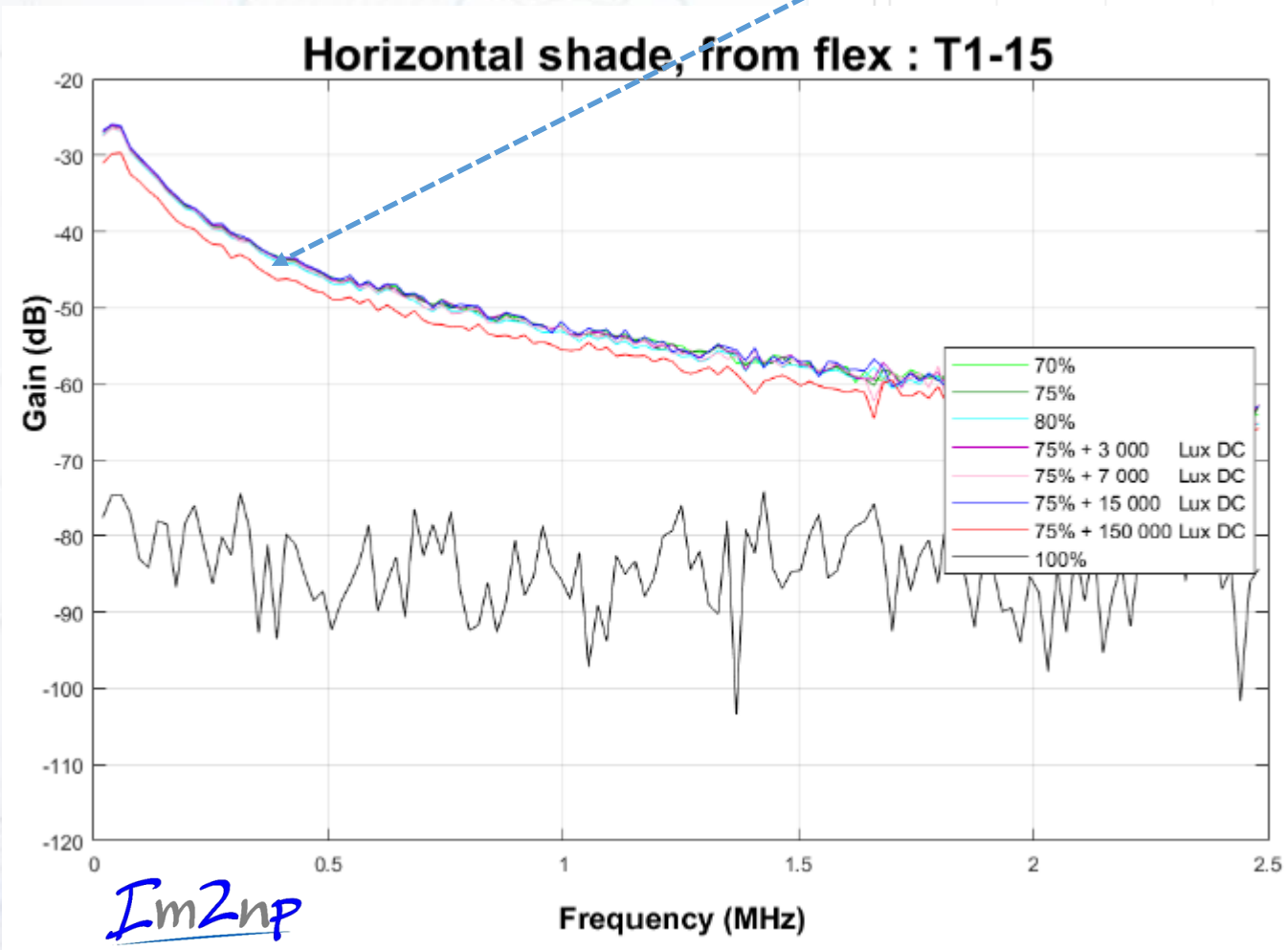
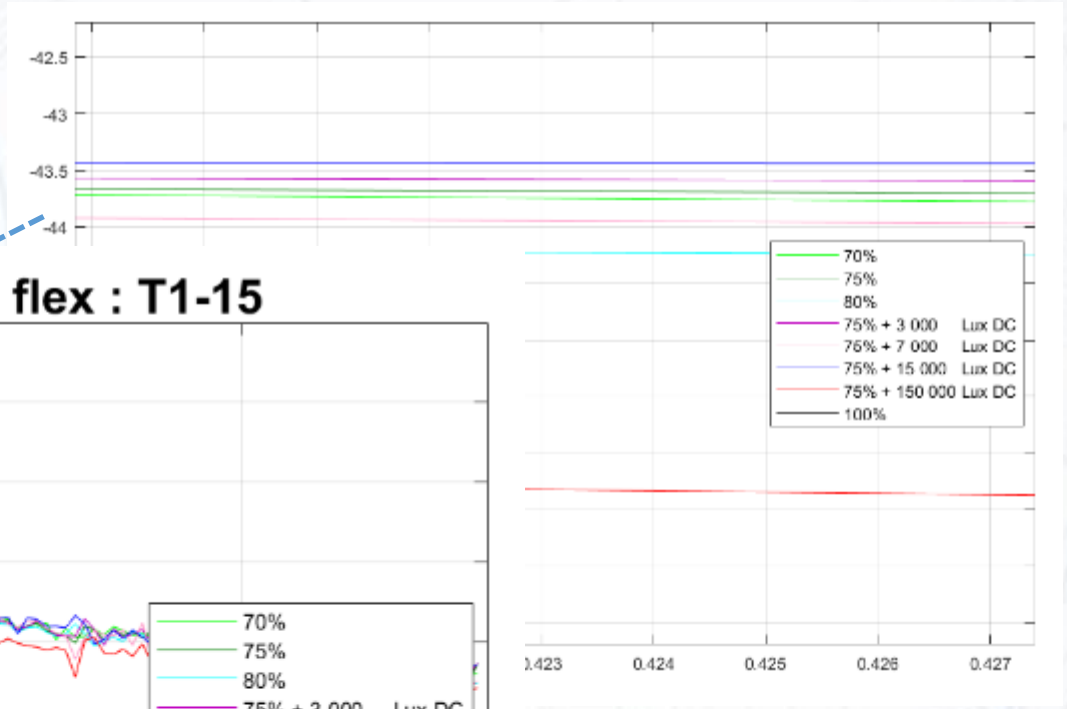
Horizontal shade & bad cell : **no lighting effects**





Im2np

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DIGITAL PLATFORM

Smart window

> Tintable glass control
> Integrated sensors*
> Wireless communication (Bluetooth & LoRa)
> Battery management

Real time control

> Automatic or manual mode
> Precise control

* presence, temperature, outdoor luminosity, Intrusion detection, Open window detection system