MICROSYS

Laboratory, University of Liege
www.microsys.ulg.ac.be

Autonomous Micro-platform for Multi-sensors integration and wireless monitoring

Cohesi event, June 13, 2013

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Presented by: Dr. Serguei Stoukatch

Agenda

- Brief description of Microsys
- Introduction: Autonomous Micro-platform for Multi-sensors (AMM)
- AMM realization
- Conclusions and outlook

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Microsys Description

- MICROSYS is a laboratory of the University of Liege (part of EMMI) created in 2006
- Main research fields:
  - Micro-assembly and Packaging for microsystem
  - Energy harvesting for autonomous and wireless microsystem
  - Bio and Organic chip packaging, harsh environment applications
- 9 projects: ERDF (European Regional Development Fund) funding, industrial (Walloon Region funding) total budget of 4 M€
- Team: 1 Professor, 3 senior researchers, 4 research engineers, 1 technician, 1 PhD student
- 1 spin-off company : TAIPRO Engineering (created in 2009), for packaging and microsystem engineering service for industrial needs

Microsys Expertise

Design office

Clean room

4 Core Competences

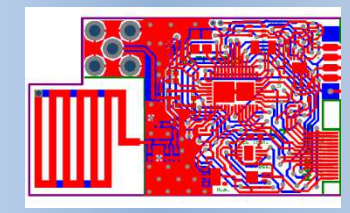
Design and development

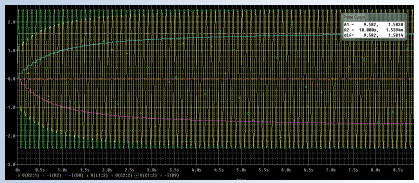
Multiphysics modeling and simulation

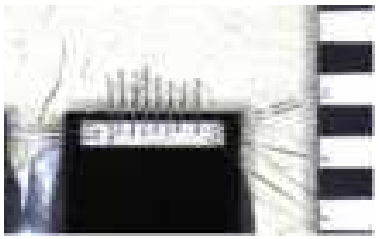
Micro-assembly, interconnection and packaging

Test and characterization

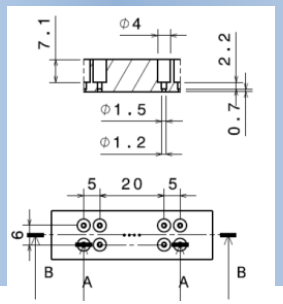
Electronics

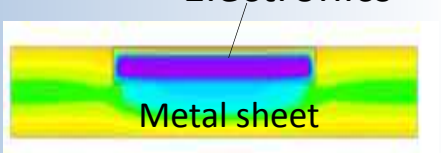




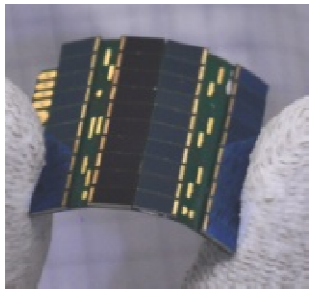


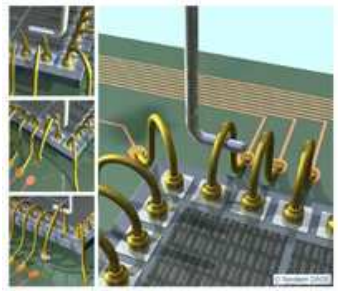
Mechanics





Zinc melted (800°C)





Facilities

- 200 m² certified clean room class 10.000 (ISO7)
- 4 separate rooms (2 for packaging, 1 bio, 1 chemical)
- Fully ESD equipped infrastructure (rooms, furniture, clothes,…)

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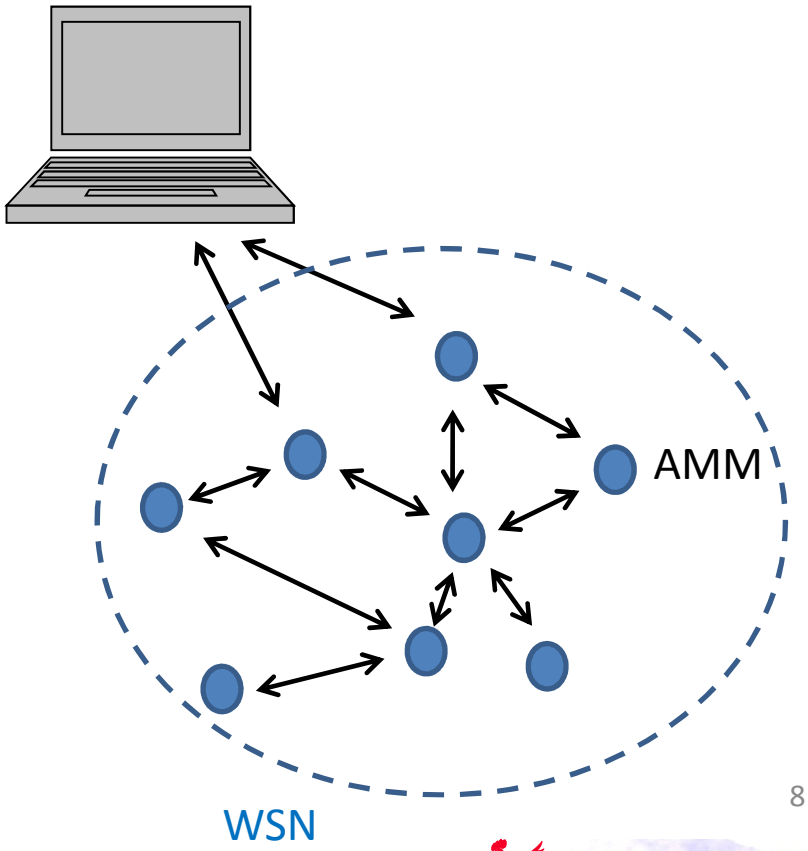
Concept

- The Autonomous Micro-platform for Multi-sensors (AMM) consists in a node for Wireless Sensor Network (WSN):

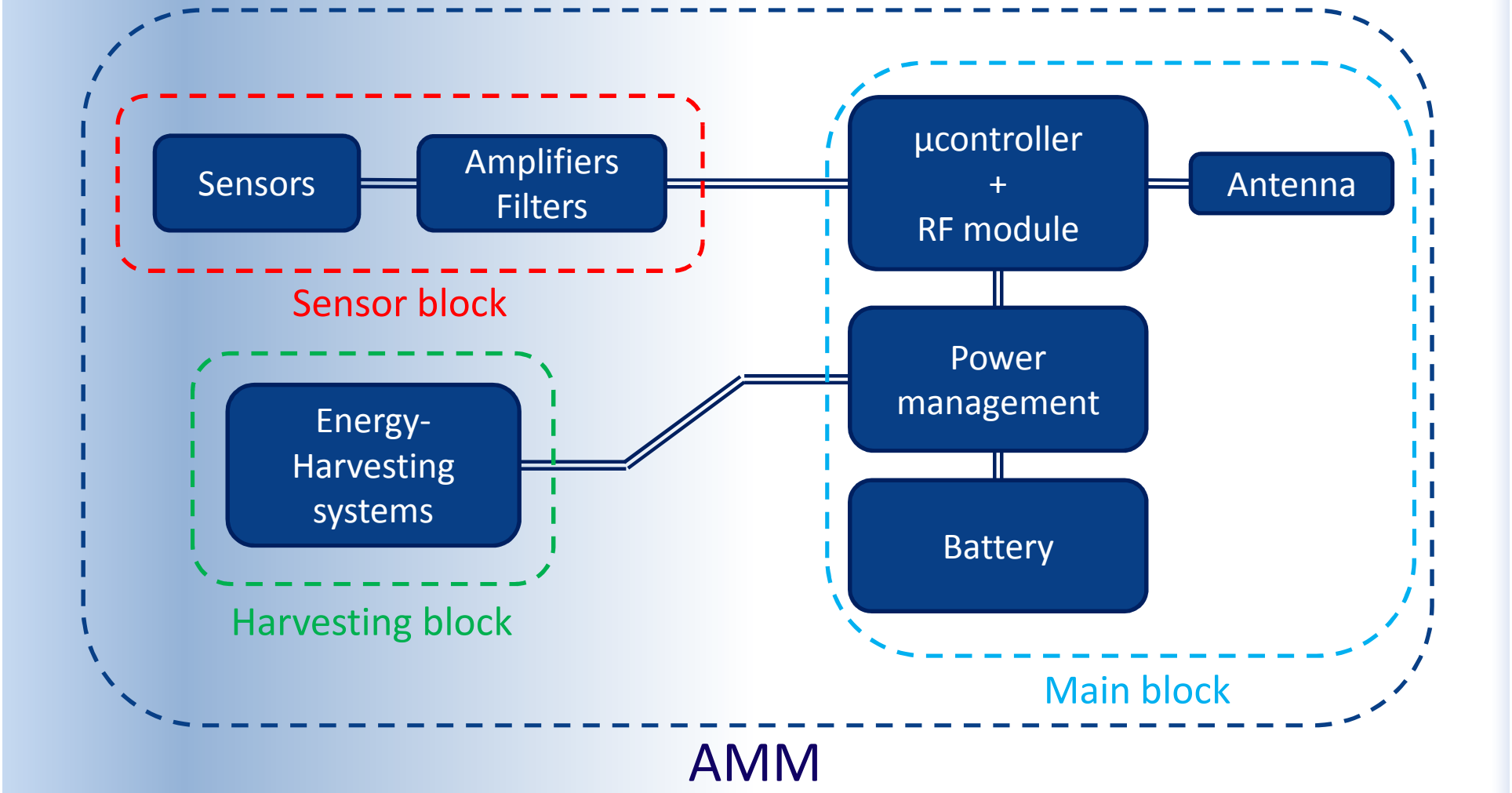
  - Autonomous: energy harvesting system
  - Micro: 1 cm^3 is the target volume
  - Multi-sensors: temperature, vibration, pressure, humidity, light and noise level



Specifications

- *Unlimited* autonomy due to Energy Harvesting
- Wireless: bi-directional (Tx/Rx)
- Suitable for standard environment
- Volume: 1 cm^3
- Measurement rate: 1/min
- Antenna range: 2 m (indoor)

Block diagram



Applications

- Industrial (predictive maintenance, …)
- Building (home automation, HVAC, …)
- Environment (weather station, …)
- Healthcare (patients or elderly people, …)
- Logistics (monitoring of freight, …)
- …

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Energy Harvester

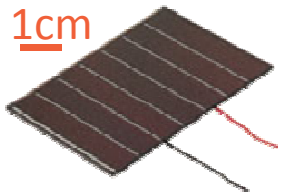
- Criteria:
  - Adaptative to various environments
  - High specific power
  - Low cost and mature
- Baseline: solar panel
  - Light is often present in most applications
  - High power density (typ. 1000 W/m²) and high efficiency of solar panels (typ. 15%)
  - Fair cost and mature technology

AMM 4 versions

- Coin cell:
  - Limited autonomy: up to 3 years (normal mode)
  - Zero risk of occasional power failure
  - Volume = 2.5 cm³

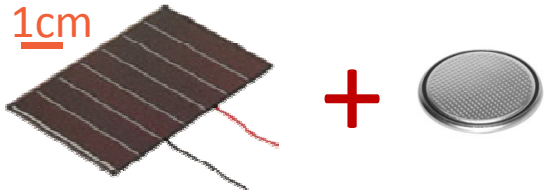
Commercial coin cell

- Solar panel:
  - *Unlimited* autonomy
  - Low risk of occasional power failure
  - Volume = 6.8 cm³



Commercial solar panel

- Hybrid: coin cell + solar panel
  - *Unlimited* autonomy
  - Zero risk of occasional power failure
  - Volume = 6.8 cm³



- Conventional DC power supply

RF Antenna

- Frequency: 868 MHz results from a trade-off between antenna size and antenna range
- Customized RF antenna : compact, flexible and very efficient

	Ideal antenna	Commercial antenna	Antenna A	Antenna B
Standing Wave Ratio (SWR)	1	2.2	1.7	**1.3**

- Antenna range (1dBm): >10 m indoor, >100 m outdoor

Power consumption

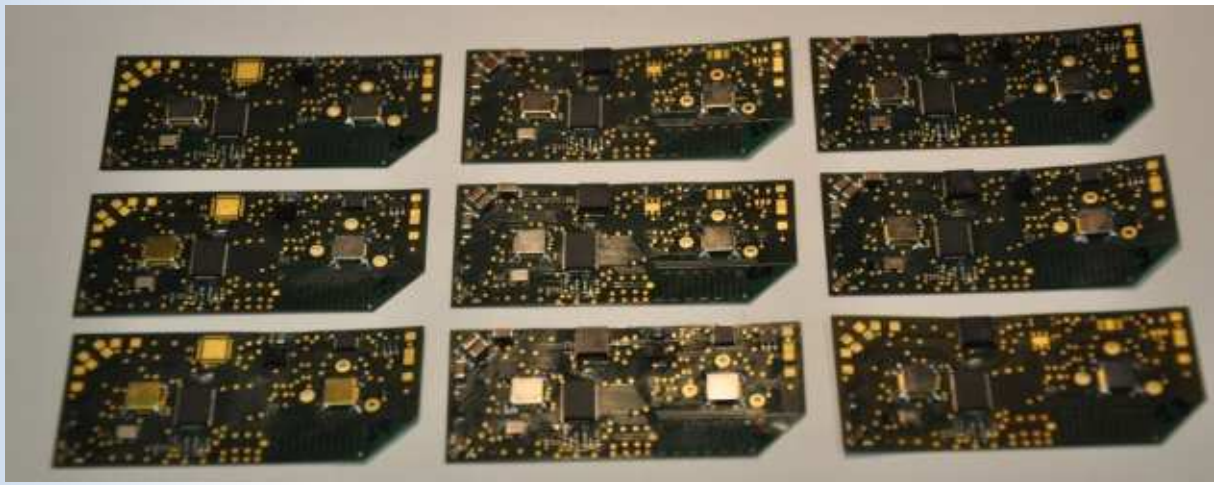
- In home automation for example:
  - Needed antenna range: 10 m → 1 dBm
  - ID number + temperature + humidity + light → 4 bytes
  - Parameters slowly vary → 60 s

RF power (dBm)	Data (bytes)	Sampling period (s)	Power (µW)
1	4	60	**9.2**
11	4	60	13.9
1	4	30	14.6
1	4	5	68.5
1	9	60	24.8

Defined as the normal mode: < 10 µW

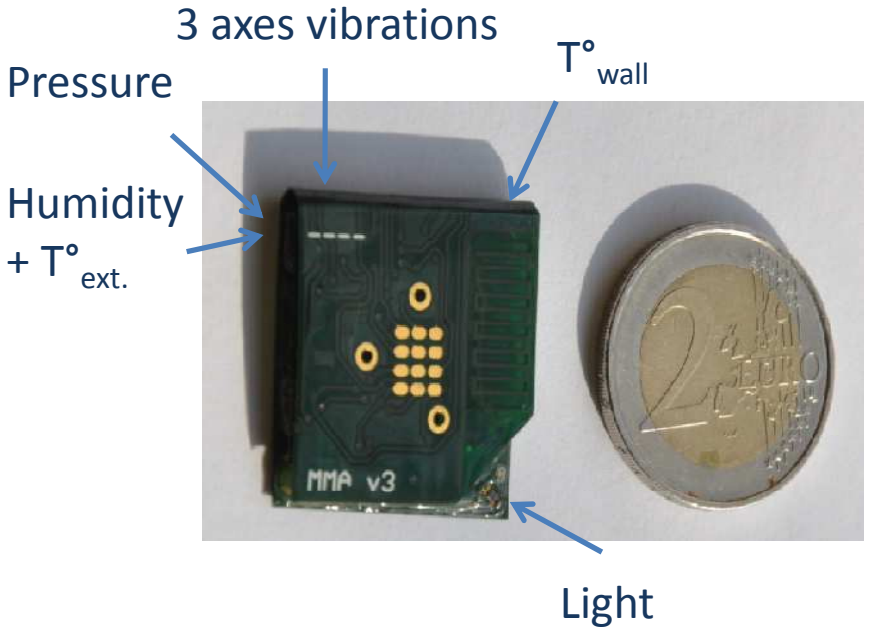
Realization

- Flexible PCB to (i) reduce the overall size and to (ii) allow flexibility
- 0201 SMT components are mounted automatically
- Bare dies are wirebonded with 25 µm wires



AMM – coin cell

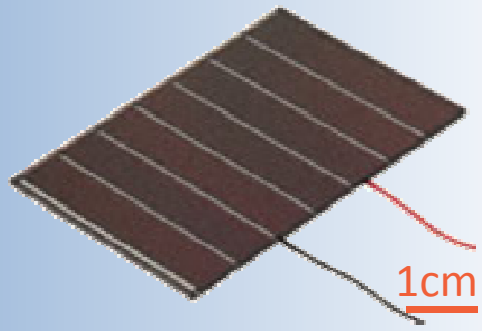
- The version powered by a coin cell is compact and comprises:
  - Up to 5 integrated sensors
  - Up to 3 external sensors
  - USB port
  - Connection for auxiliary power supply



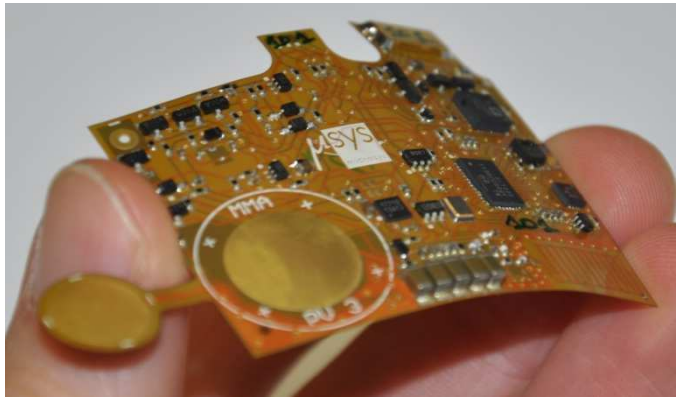
AMM – hybrid

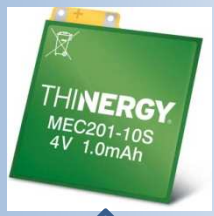
- The hybrid version requires an advanced power management: several power flows

Solar panel or other energy harvesters



Microsystem



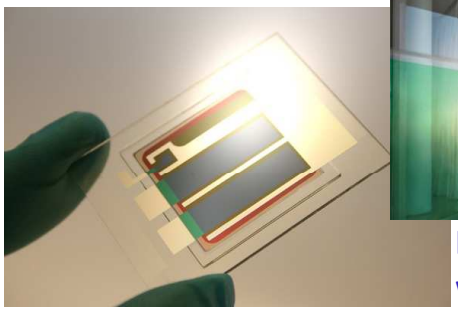


Rechargeable battery

Coin cell

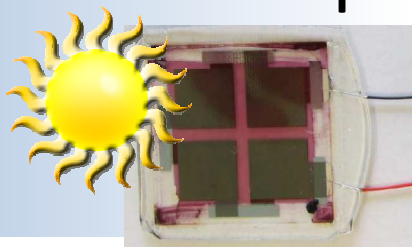
Potential of OPV

- The ongoing activity is to replace the solar panel by Organic PhotoVoltaic cells (OPV). In fact, despite a lower efficiency, they are:
  - Flexible and thin
  - Shock resistant
  - Transparent



Heliatek world record cells with 12.0% efficiency.
© Heliatek GmbH

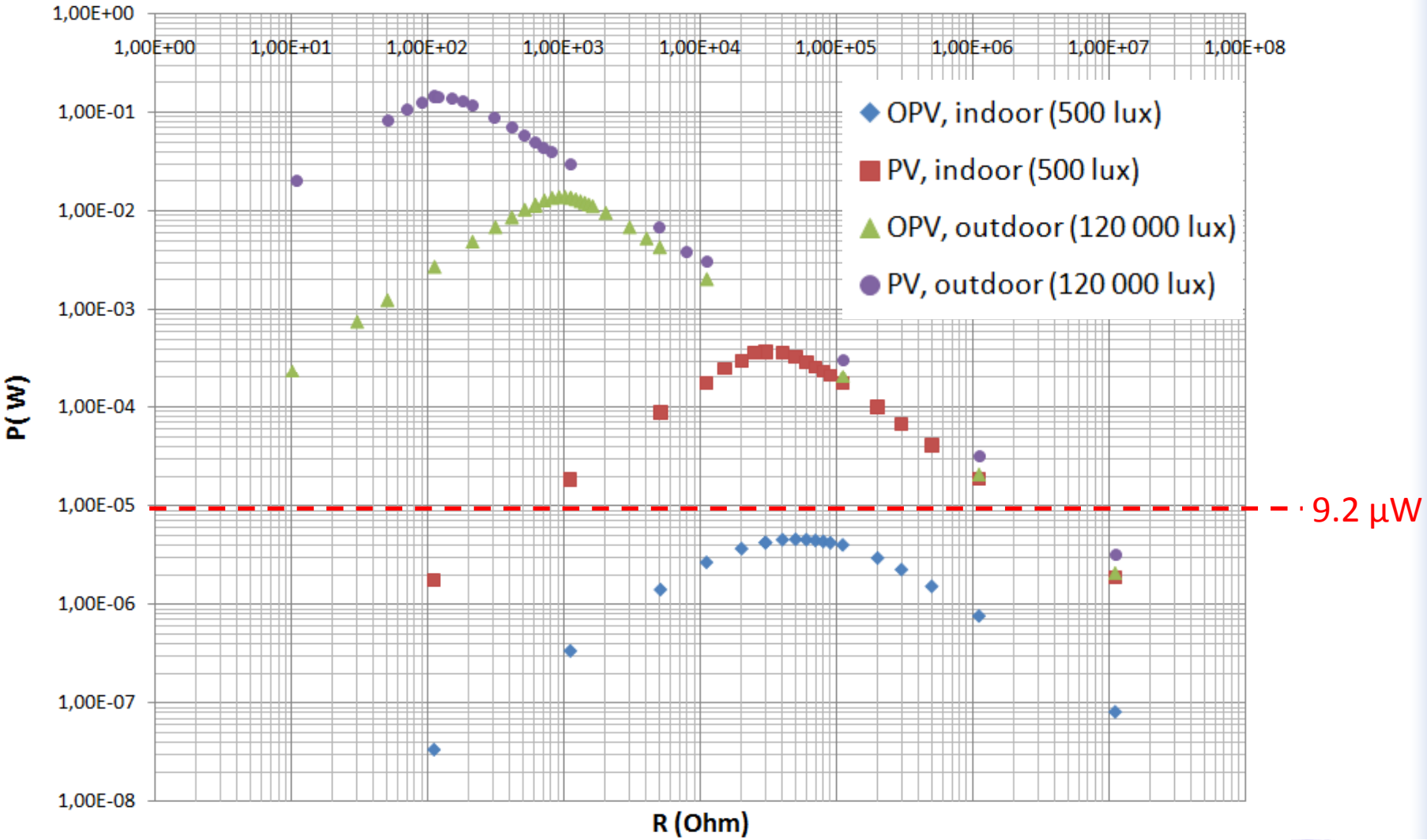
- OPVs manufactured and encapsulated by Materia Nova, partner on the project, have been tested :



MateriaNova
MATERIALS R&D CENTRE

EMRA

OPV vs. PV: out power (1)



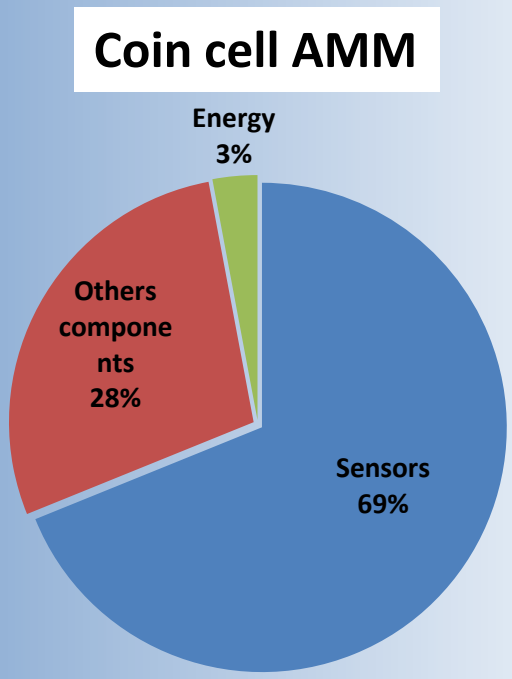
OPV vs. PV: out power (2)

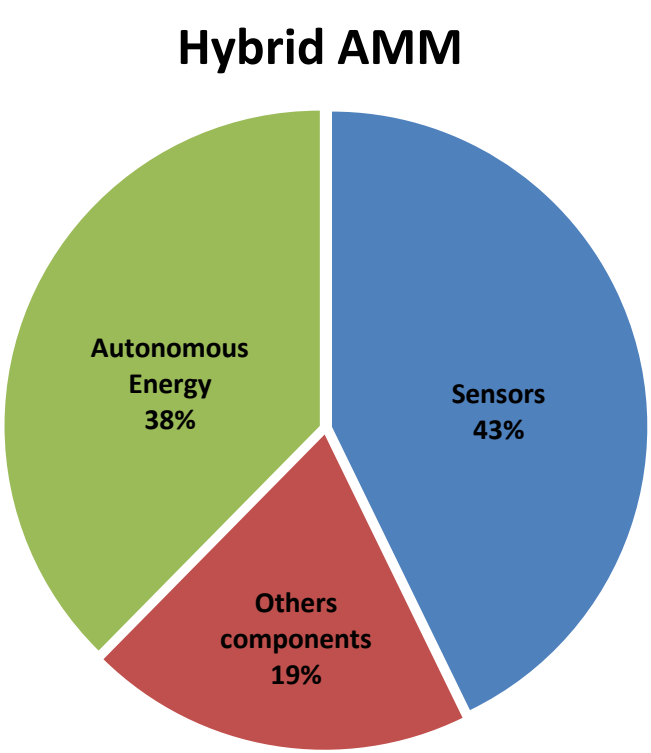
- The curves have been normalized regarding the surface:
  - The OPV can be used in outdoor (120 000 lux)
  - The PV generates up to 149 mW, thus an overload circuit has been implemented
- Max output power of PV and OPV respectively:

P_{max}	Indoor (500 lux)	Outdoor (120 000 lux)
PV	374.0 µW	149 000 µW
OPV	4.6 µW	13 800 µW

Cost comparison

- Cost distribution: the full autonomy involves an extra cost, to be compensated by no maintenance costs





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Conclusions

- The AMM platform can be implemented in various versions, to answer to need:
- The coin cell AMM:
  - ☺ Compact (2.5 cm^3), zero risk of occasional power failure
  - ☹ Battery replacement is needed (3 years in the normal mode)
- The hybrid AMM:
  - ☺ *Unlimited* autonomy and zero risk of occasional power failure
  - ☹ Larger volume (6.8 cm^3), extra cost

Outlook

- Improve the performance of the AMM (increase sampling rate for vibration and noise level…)
- Create a Wireless Sensors Network with tens of AMM using bi-directional communication
- Implement new energy harvesters, as OPV for example

Thank you for your attention