Symposium pour l'électronique & le numérique durables

Le 12 décembre 2024, Grenoble

AVEC tech & fest

NANOELEC.

Univ. Grenoble Alpes – Labex µElec

FRANCE 2030 – PROGRAMME DE RECHERCHE – ÉLECTRONIQUE

UGA Université Grenoble Alpes · NSE/AG · UGA · Grenoble INP UGA · Sciences Po Grenoble UGA

cea · CHU Grenoble Alpes · cnrs · INRAE · Inria · Inserm La science pour la santé From science to health · IRD Institut de Recherche pour le Développement France · Linksium technology transfer & startup building Grenoble Alpes

IoT platforms for research and teaching on frugal and efficient electronics

Sylvain Blayac[1,2], Roger Delattre[1], Marc Ramuz[1], Francçois Bernier, Elias Kharbouche[2], Acacio Marques[2]

Flexible Electronics Department(1) , ID-fab (2)

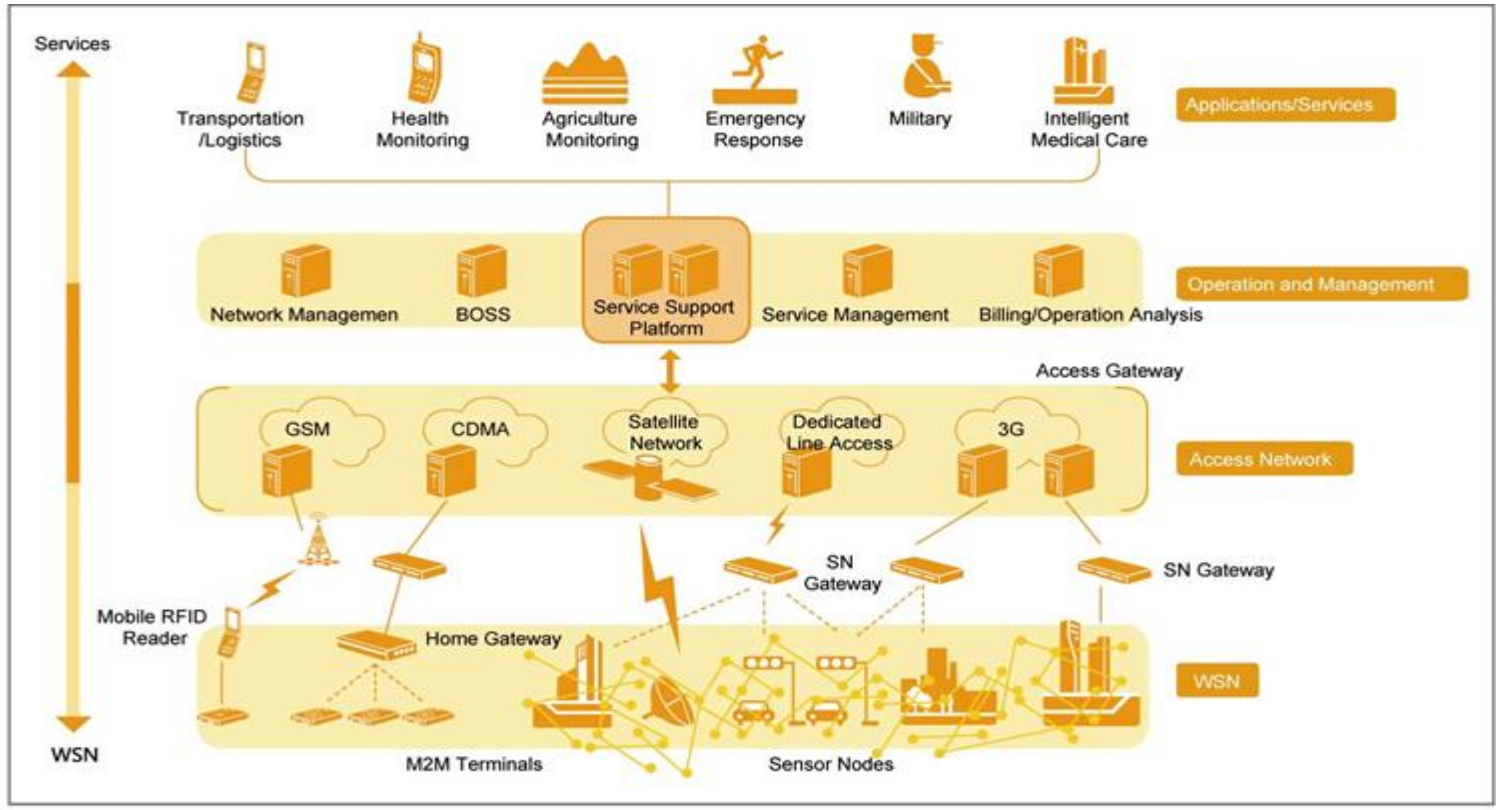
Mines Saint Etienne - Campus Aix Marseille Provence – Gardanne

IOT paradigm

CMP lab departments

Data management

Hadrware security
Flexible Electronics
Bio electronics



Sustainability concerns

Use-cases and impact

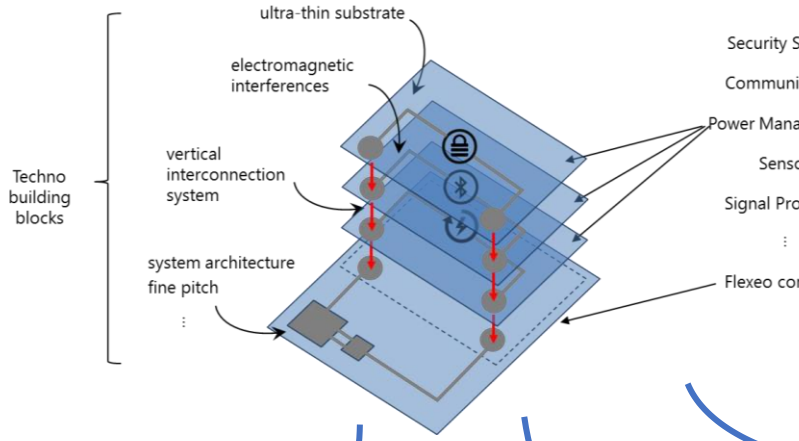
Data storage energy and material consumption

Environmental dissemination, material and energy consumption

Try to develop a sustainability-aware approach for IOT-related research and education

Flexeo project initial goals

- Flexeo: Flexible and conformable electronic objects ecosystem
  - Flexible and conformable
  - « Fully wireless »
  - Autonomous
  - Reconfigurable
  - Lightweight

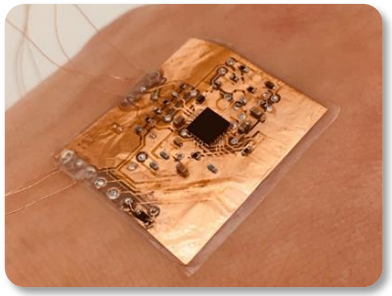


4.0 Industry

Energy harvesting

Biorobotics

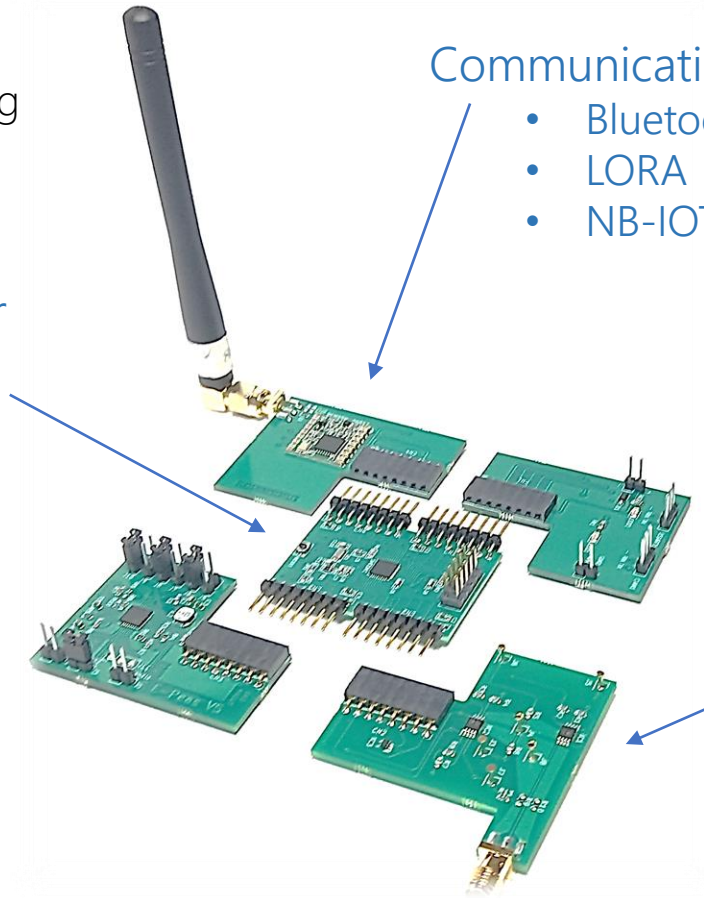
« Wearable devices »



- Technology development goals
  - A1: Electronic architecteure
  - A2: Integration building blocks
  - A3: Embedded energy
  - A4: Sensors and communications

OCASS platform

- Co-developped for research and teaching
- Reduced components set
- Specially designed to low power operation/ energy harvesting



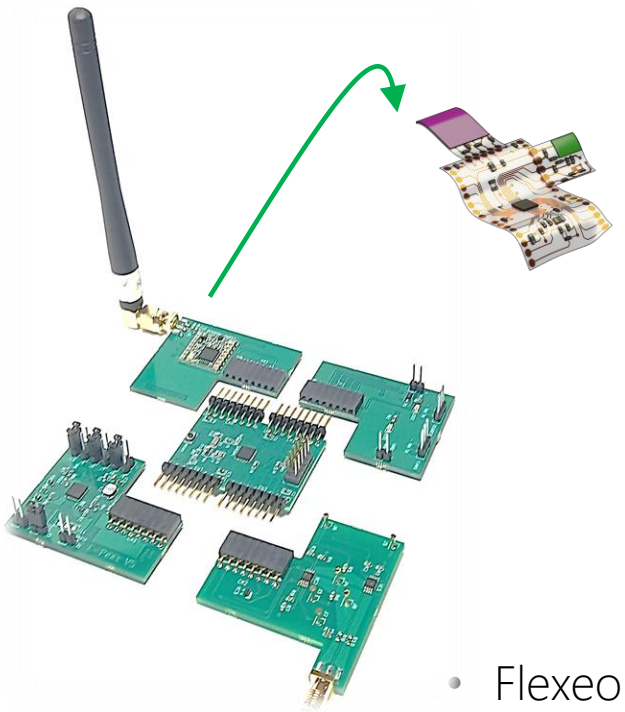
Communication low power multiprotocoles
- Bluetooth Low Energy
- LORA
- NB-IOT (à venir)

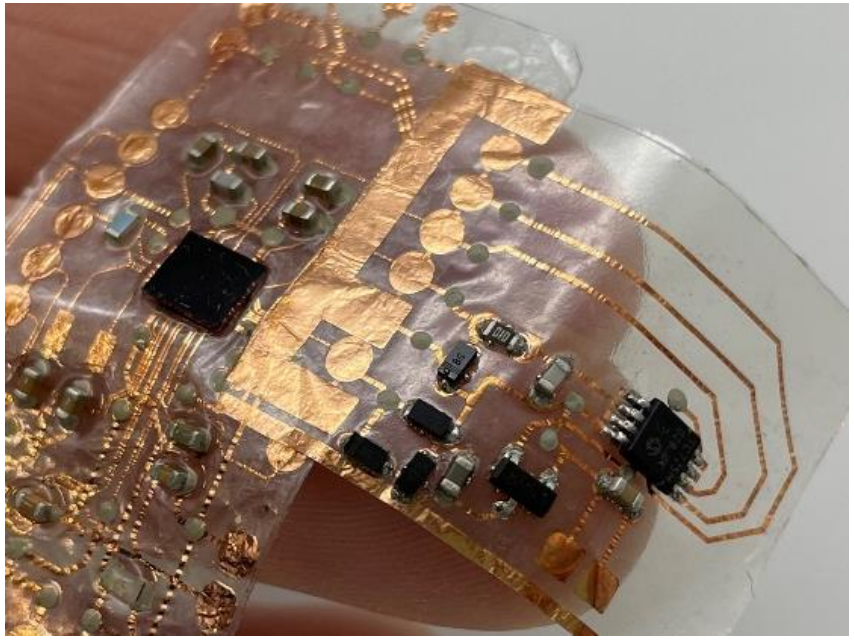
« Core layer » STM 32 low power
+ IA embarquée

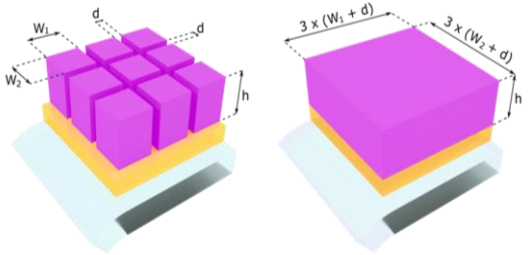
Energie embarquée compatible
« harvesting »:
- Solaire
- Thermique
- Mécanique
- Eolien

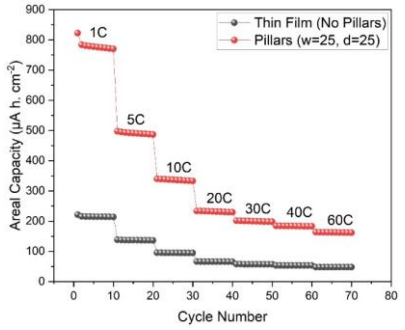
Layer multicapteurs

Flexeo platform



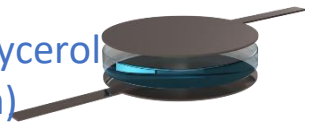


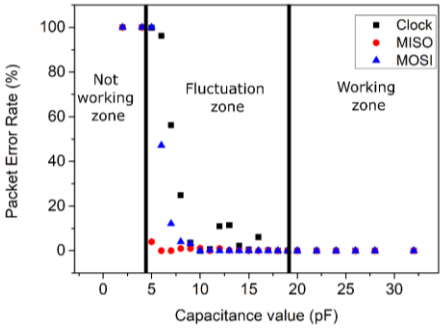




Reconfiguration layer

PDMS:glycerol
(t=16,2 µm)



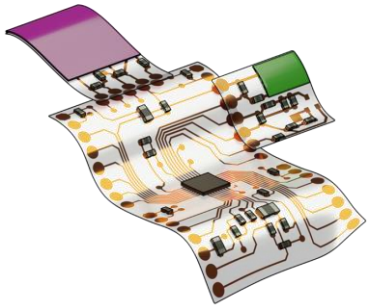


- Flexeo platform technology
  - Ultrathin parylene-C substrate
  - Two metal levels STM32 core layer with copper leaf techology
  - Reconfigurable layers with solderless capacitive bus
  - >90% weight and material consumption reduction
  - Micropillar flexible Li-ion battery technology or flash charging technology

Flexeo ecosystem use cases

MINES Saint-Étienne | Institut Mines-Télécom

Flexeo / OCASS



4.0 Industry & edge computing

cea

TRAXENS connecting the dots

EDITAG

ibs Innovative Ion Implant

Airlab: Environmental Monitoring

Cerema

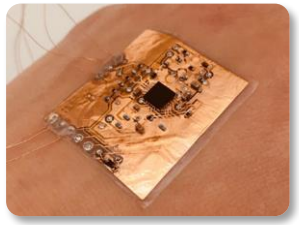
Augmented perception

ONERA
THE FRENCH AEROSPACE LAB

Biorobotics

INSTITUT DES SCIENCES DU MOUVEMENT ETIENNE JULES MAREY

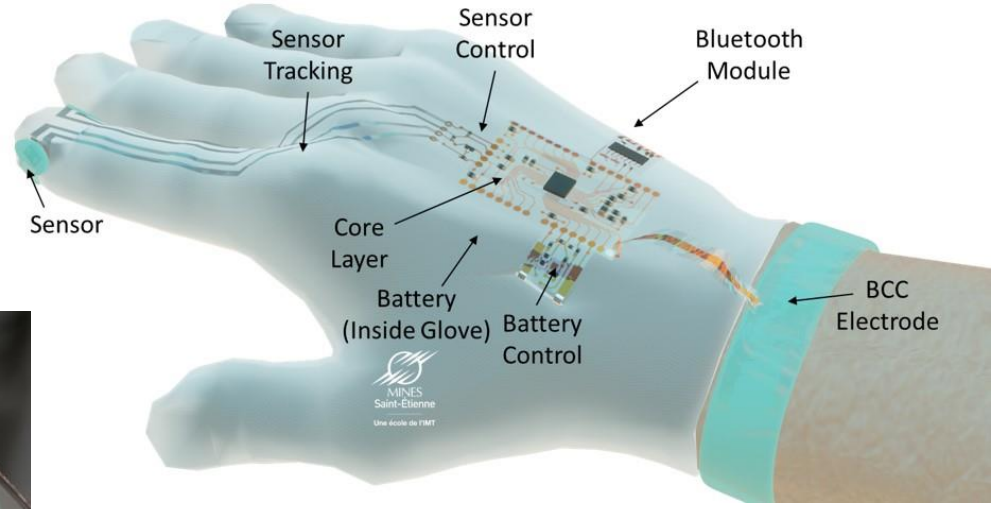
Implantables

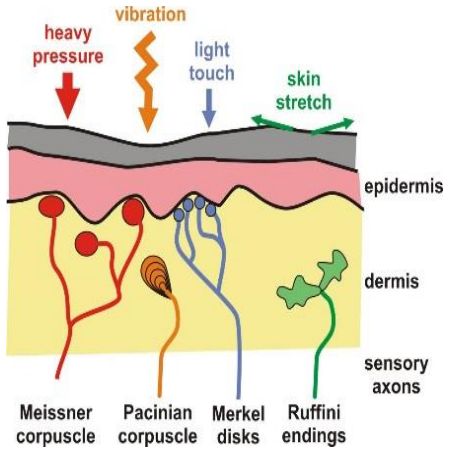


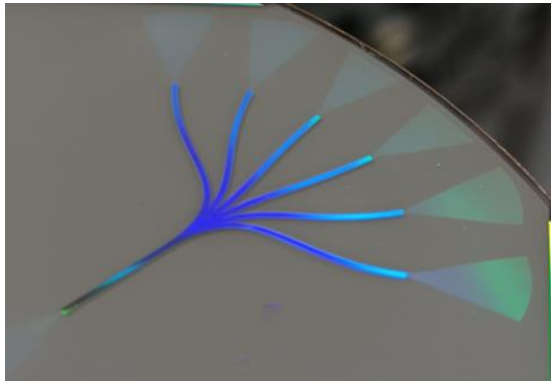
Wearable technology use case

Augmented perception

- « Leantronics »
  - PDMS optical waveguide e-skin sensor
  - Ultralight core layer substrate
  - Low consumption body channel coupling
  - « Silicon light » haptic pixels

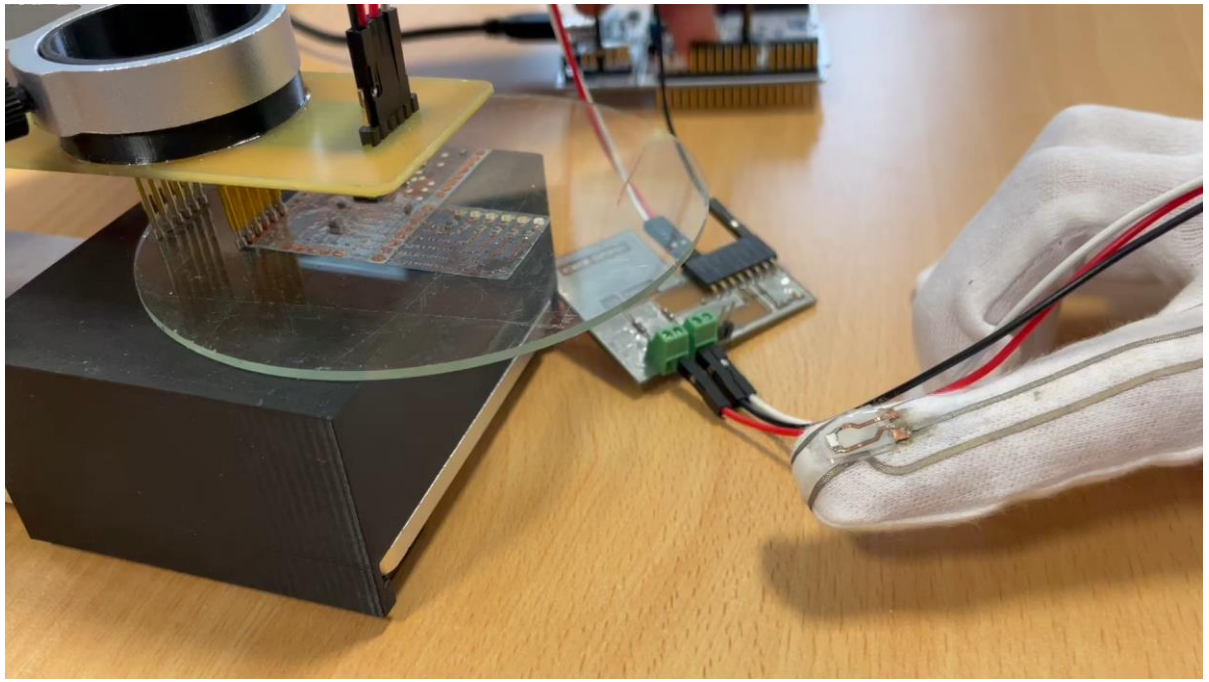






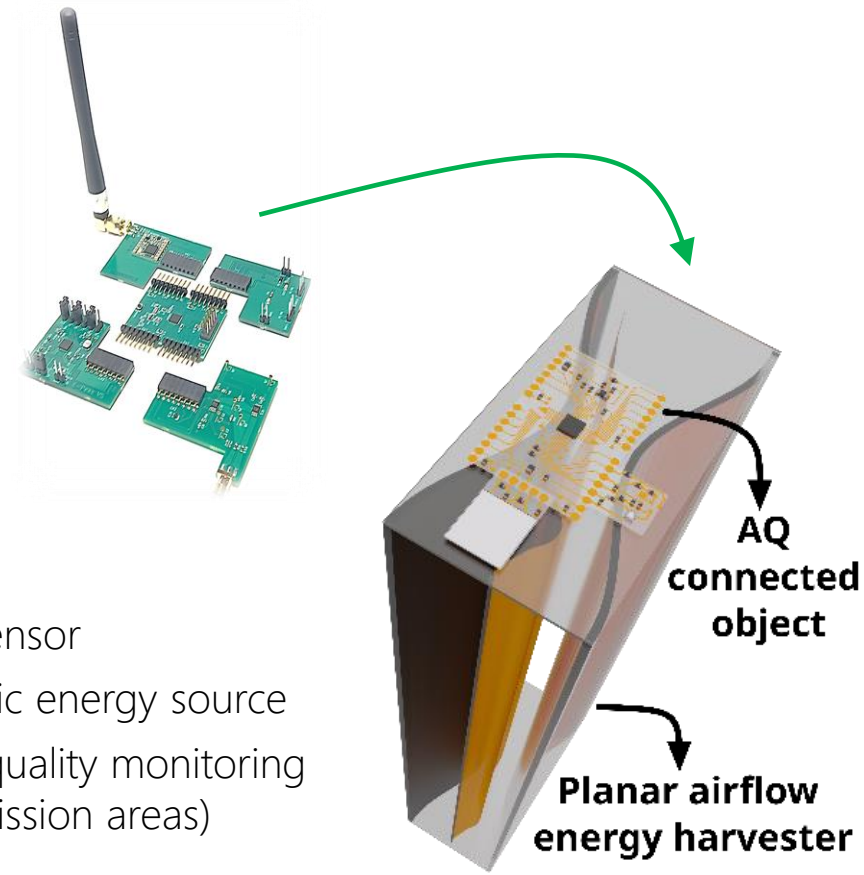
Design, Fabrication and Characterisation of Multi-Parameter Optical Sensors Dedicated to E-Skin Applications
L Fliegans, J Troughton, V Divay, S Blayac, M Ramuz - Sensors, 2022

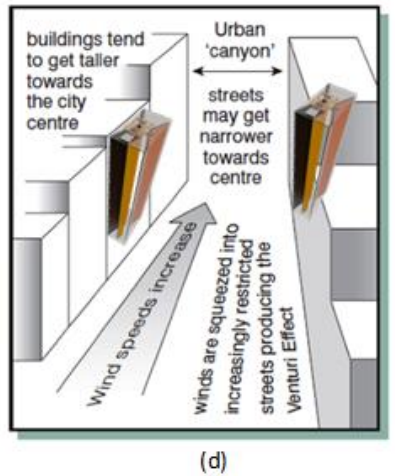
Tactile glove demonstration



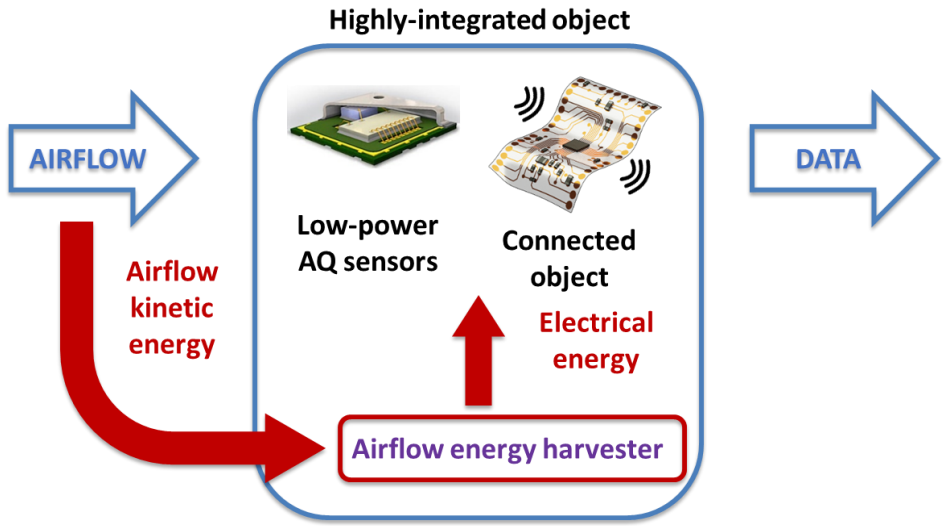
Environmental Monitoring Use Cases

Airlab project concept

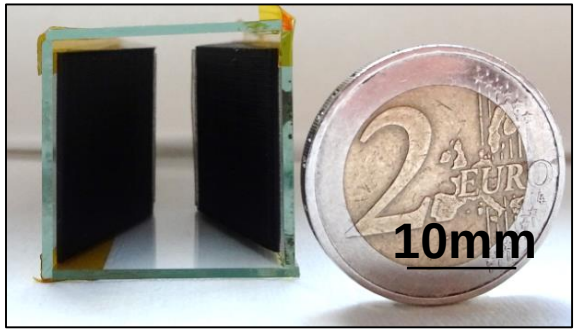




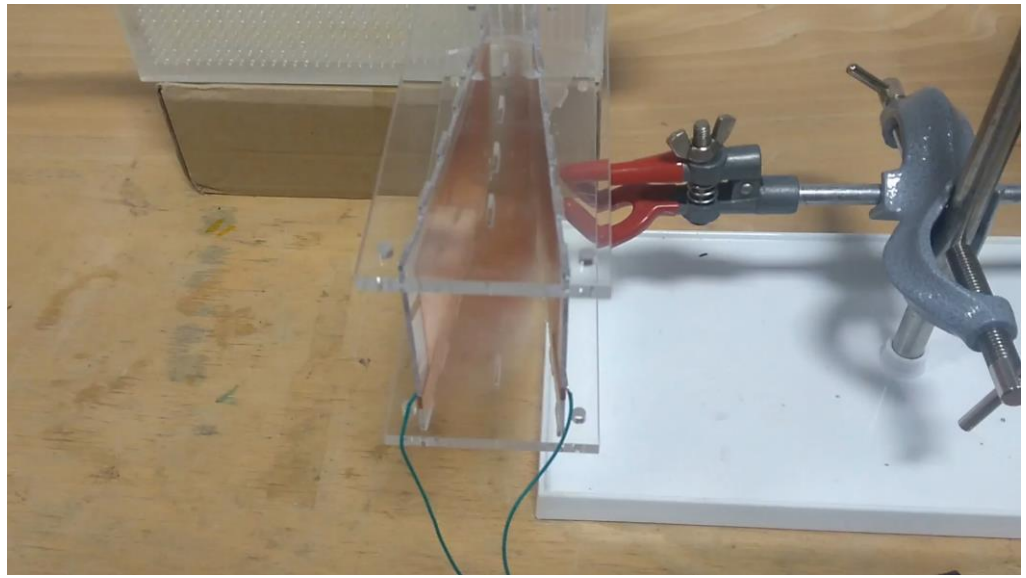
- Airlab concept
  - Autonomous air quality sensor
  - Wind Actuated triboelectric energy source
  - Agile deployment for air quality monitoring in urban canyons (low emission areas)

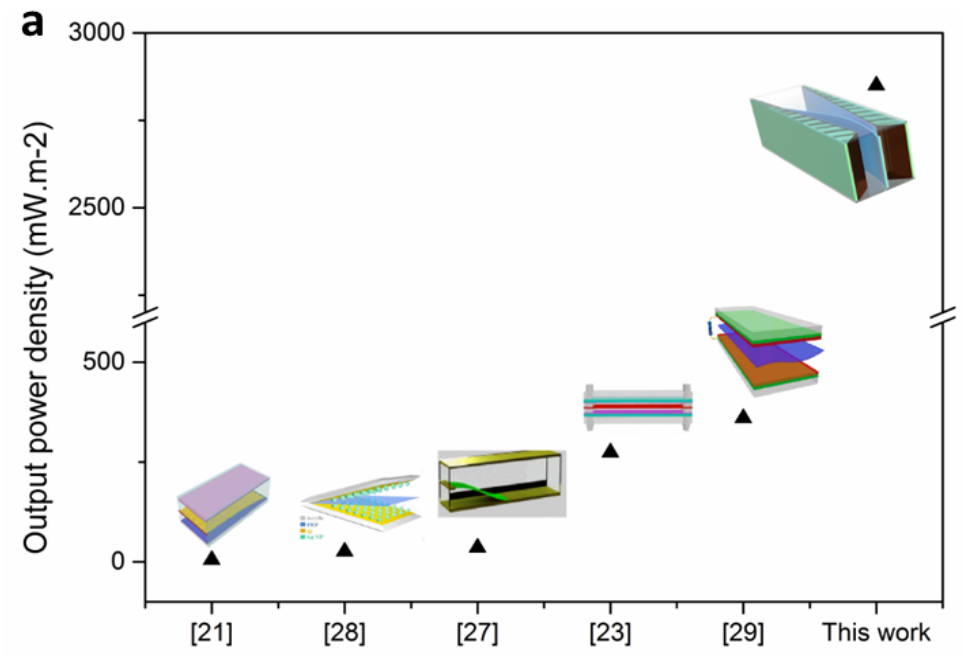


Triboelectric Energy Harvester



Wind Actuated TriboElectric NanoGenerator (WATENG)

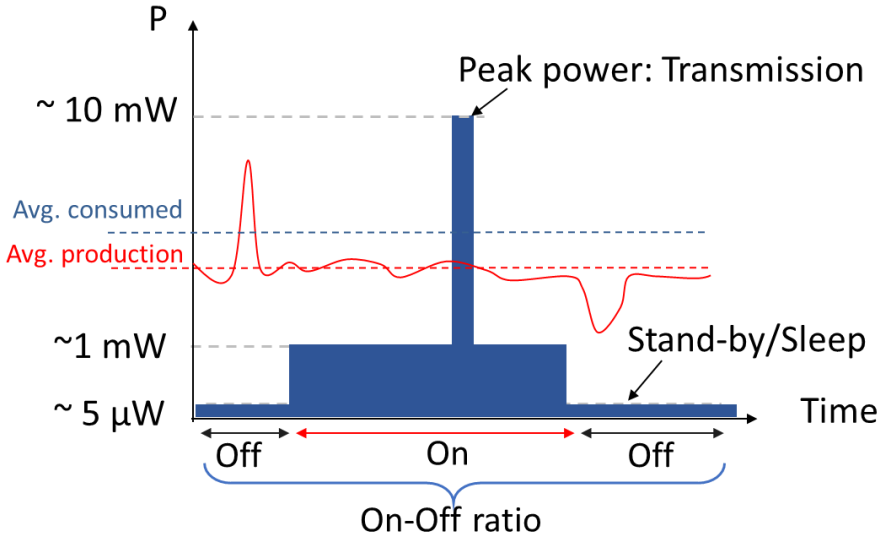




A. N. Ravichandran et al., Nano Energy, vol. 62, Aug. 2019

- Device characteristics
  - Available average power of several mW.cm^{-2}in stabilised wind
  - High (~1000V) voltage and low current (10µA)
  - Ultra simple architecture (2 electrodes – 1 plastic flag)

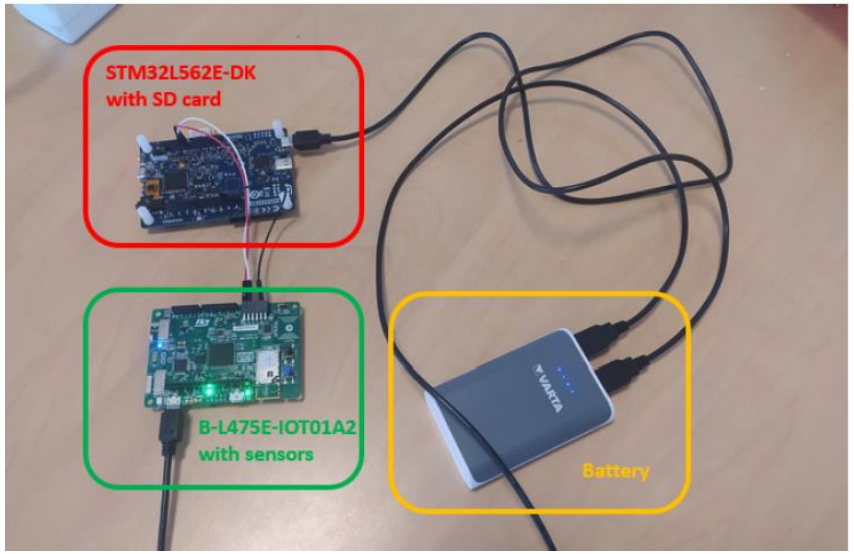
Autonomous air quality sensor case-study

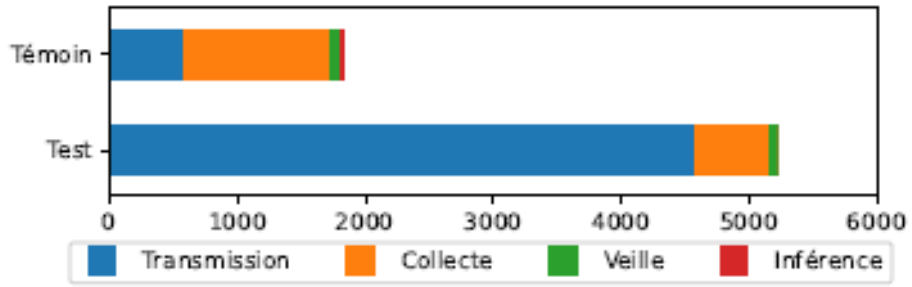


- System features
  - Adaptive power balance through duty cycle management
  - Capability of 37 opérations (Sensing + TX/RX) per day @ 5 m.s-1
  - High compactness and intagrability
  - Battery free
  - Rare earth free

Kharbouche, E., Ferreira, W. L., Garcia, D., Bernier, F., & Blayac, S. (2022, September). Highly Integrated Planar Airflow Energy Harvester for Self-Powered Air Quality Monitoring. In *2022 IEEE International Smart Cities Conference (ISC2)* (pp. 1-5). IEEE.

Edge computing for data and energy reduction





- Embedded AI opportunities:
  - Local pattern recognition for event detection
  - Event-driven transmission decision: reduction of transmission energy budget (/10)
  - Negligible additional consumption for inference
  - Strong reduction in cloud data storage (information vs extensive data)
  - High bit-rate (high consumption) communication protocol not necessary

Machine learning pour l'exploitation de données temporelles : domain adaptation et optimisation d'inférence sur des microcontroleurs low power.
PhD Baptiste Nguyen (CEA-EMSE)

Summary

- Designing frugal and efficient IOT platforms
  - Energy efficient generic platform (OCASS)
  - Flexeo platform reduction of volume and material consumption > 90%
  - Platforms are currently used for teaching: 100 students / year

- Exploring added value for society:
  - Frugal wearables devices for tactile perception restoration
  - Fully autonomous environmental monitoring for smart-city
  - Edge computing for drastic energy and data budget reduction

Efficiency is the key: Impact / Overall consumption

Tech should not be necessary High or Low but Fair

Join us for Fair Tech Day 2025!

« Thinking technology in relationship with sustainable development objectives »

Coming session: june 2025

Acknowledgements

- Flexeo/OCASS team

Briques technologiques	
M. Fayolle (Thèse projet)	Communications intra et extra layers, BCC…
E. Kharbouche (Thèse école)	Sources Harvesting
V. Divay (Thèse Leanpod))	Capteurs de force
A. Albertengo (Thèse projet)	Layer Energie
L. Fliegans (Thèse ANR optiskin)	Capteurs optiques
B. Nguyen (Thèse IPCEI-CEA)	IA embarquée

Support Technologie et conception	
D. Garcia: ingénieur projet W. Lamboglia Ferreira: ingénieur projet	Conception core layer et support conception electronique
F. Bernier: ingénieur support plateforme P. Coddet: ingénieur support plateforem	Prototypage/impression 3D/objets
S. De Mulatier: Post Doc projet	Développement de briques et technologie d'intégration
Joseph Troughton: Post-doc projet	Intégration démonstrateur

- EC EMSE: S. Blayac, R. Delattre, T. Djenizian, M. Saadaoui, M. Ramuz