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

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Sustainable Electronics: what kind of sustainability?

Some examples in the field of microwave devices.

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Need Sustainable Technology

- XX century technology is e-Waste
- Foundry promises net-zero emissions in 2050
- What is a sustainable technology?
  - ❑ Uses sustainable materials and manufacturing
  - ❑ Has lower energy demand and carbon emissions
- What has changed?
  - ❑ Green electronics labels exists since 2005
  - ❑ Government introduce new regulations in terms of sustainability
  - ❑ Consumers look for reparable and energy efficient devices

https://doi.org/10.1016/j.cej.2020.124596

What kind of sustainability?

Paradigm for a Sustainable Tech

1. To reduce required resources of our planet, fabrication materials must change
2. To achieve low carbon emissions, energy efficiency is mandatory (ultra-low power devices)

What could we do to achieve that ?

a. Design low performance for low power electronics
b. Design for maintainability and sustainability

Sustainable Microwave Electronics at CROMA

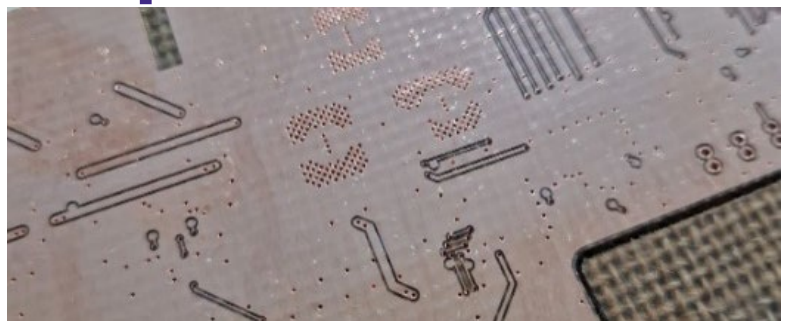
1. Reduction of environmental footprint of electronic devices

2. Design low energy solutions and autonomous systems

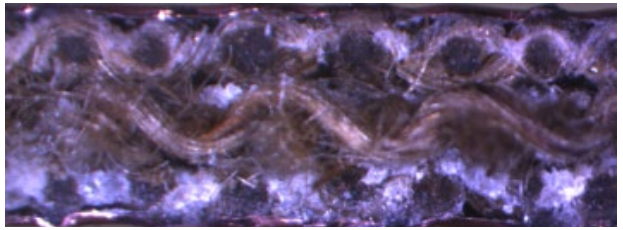
3. Think maintenance and sustainability

Devices on bio-sourced PCB

- DESIRE4EU aims at revolutionize the life-cycle of electronic boards by introducing **bio-based processes and materials** both in their **design, fabrication and end-of-life phases**, to get **fully circular and sovereign European electronics**

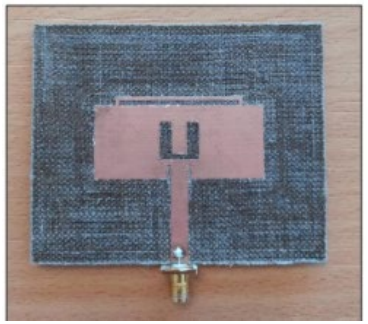


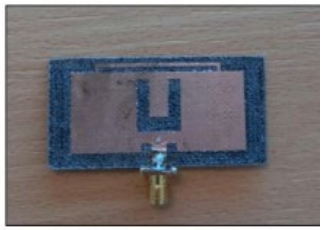
- Jiva Materials (UK) with Infineon
  - Soluboard soluble in hot water
  - recover some components
  - what about the reliability?
- Meshlin (Hungary) with Arduino
  - PLA/flax fibers, bio-sourced Flame Retardant (FR),
  - no PFAS and bioleaching of PCBs



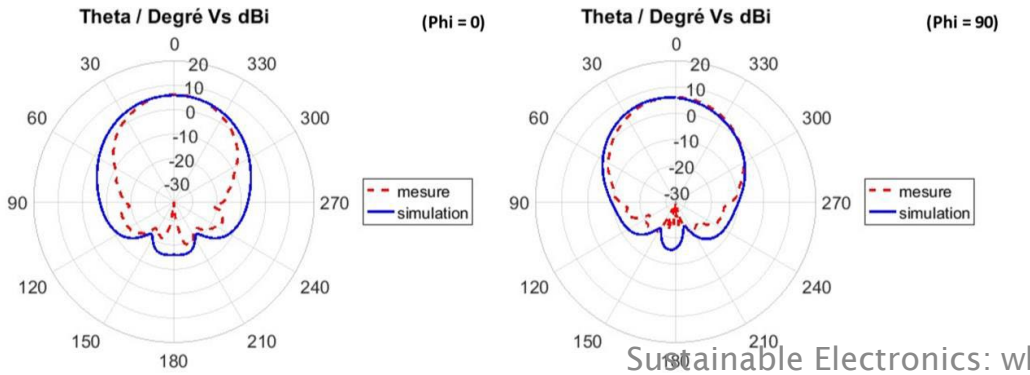
Signal Integrity and Radiation Pattern

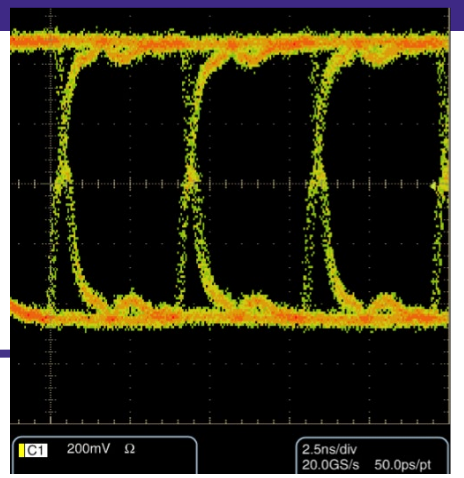
- Antennas on PLA/Flax
  - 5 GHz, size < 10 cm
  - Gains: 4-6 dBi



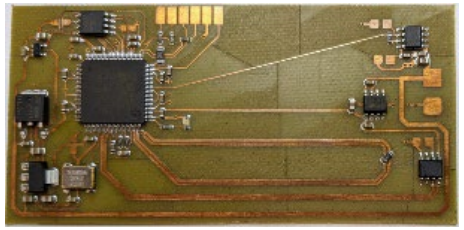


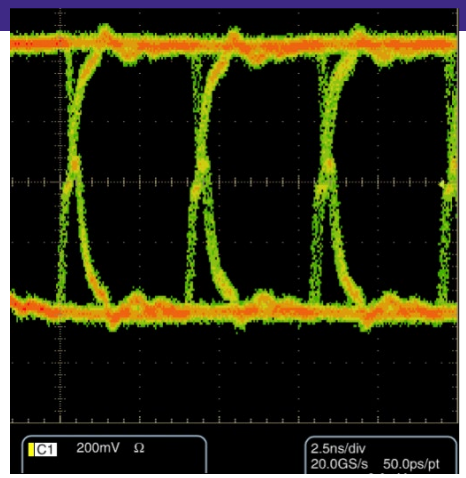
PLA 1,25 mm



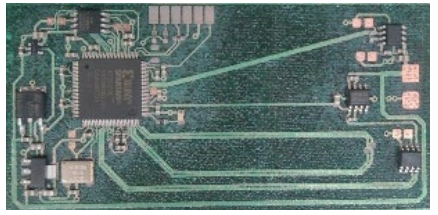


FR4 LVDS2 line





PLA/Flax LVDS2 line



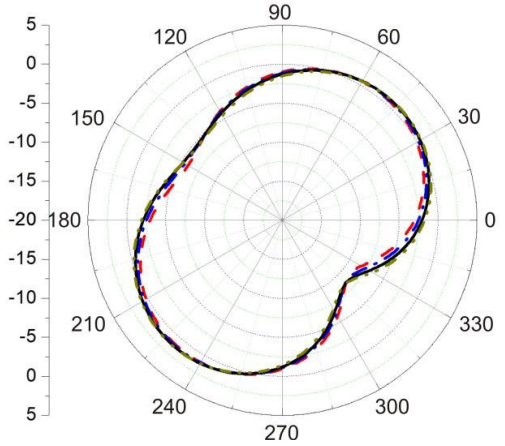
10.1109/EPTC56328.2022.10013255

- Eye diagram with a pseudo-random sequence
  - TTL compliant, low Jitter
  - Crossing at mid-height

Devices on paper substrate

ANR STICK IT

- E4D paper substrate, a low-cost, thin, and flexible material
- Wideband Performance
  - wide frequency range (2.15 GHz to over 10 GHz)
  - exceptional return loss (>20 dB at 2.45 GHz and >30 dB at 5.5 GHz)
- Fabrication via Screen Printing Technology
  - Ink-Efficient Design
  - Flexible antenna
  - omnidirectional radiation patterns



Radiation pattern (E-plane) for a bending radius between 1 and 10 mm

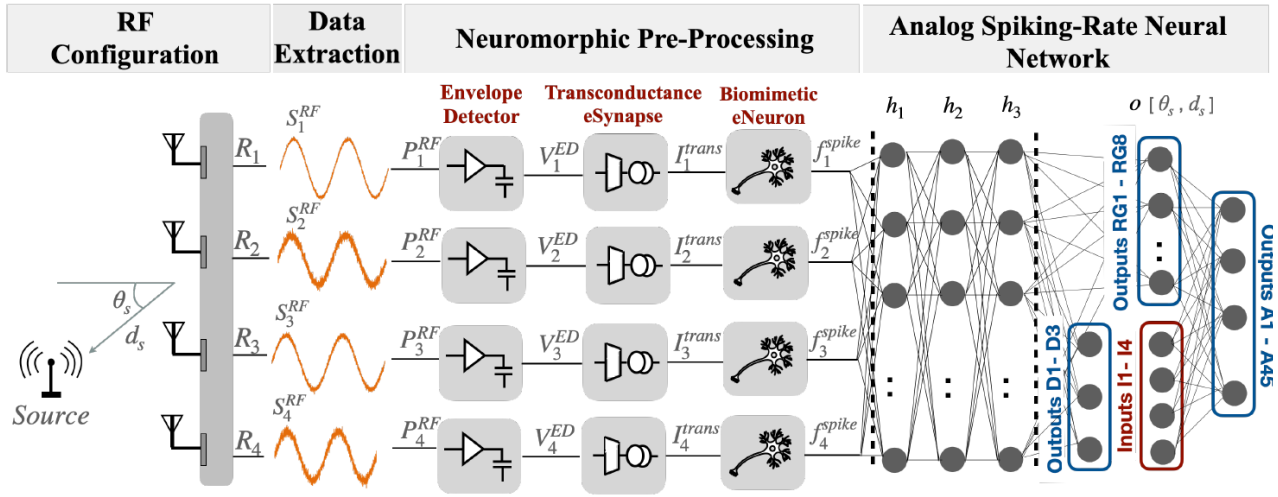
Broadband antenna

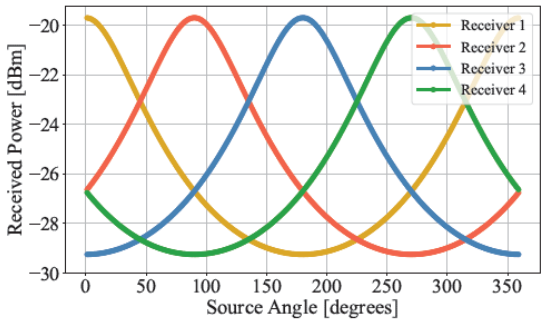
Bended broadband antenna

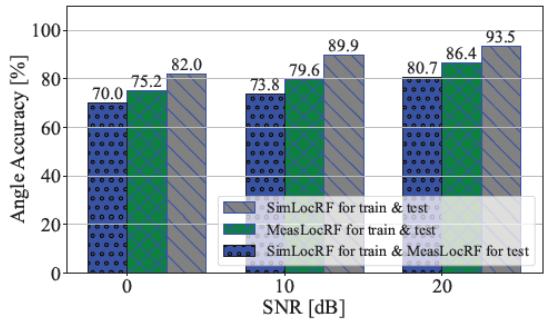
10.23919/EuCAP.2017.7928575
10.23919/EuMC54642.2022.9924459

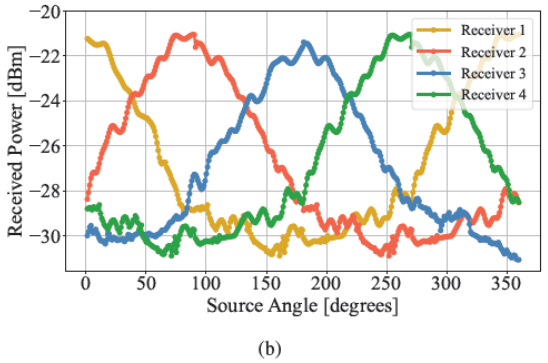
Spiking-Rate Neuromorphic System for Efficient RF Source Localization

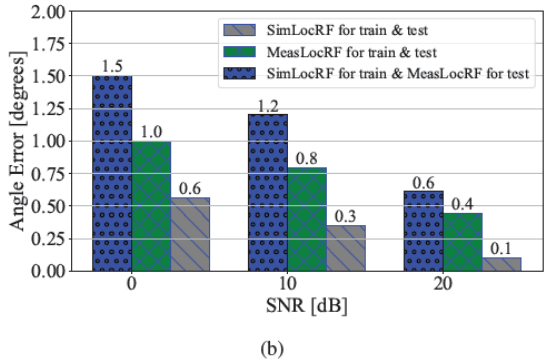
10.29292/jics.v19i3.889





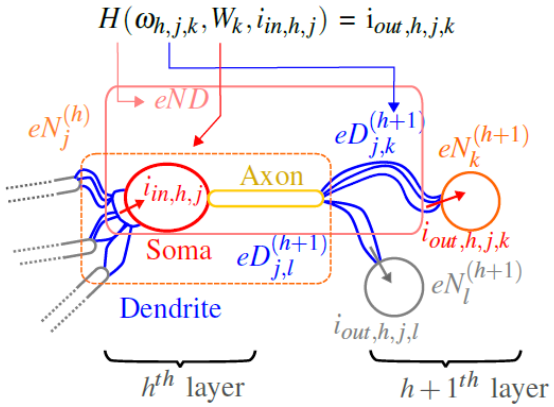


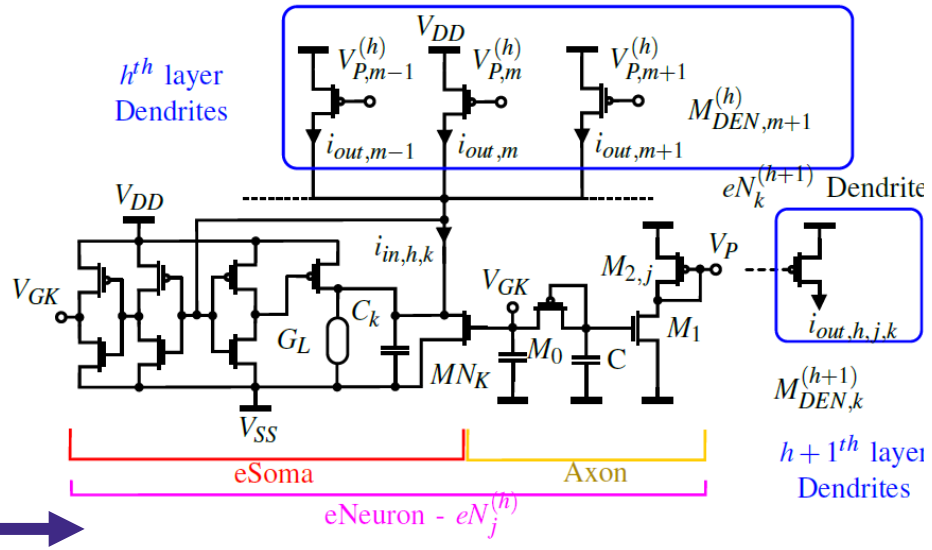


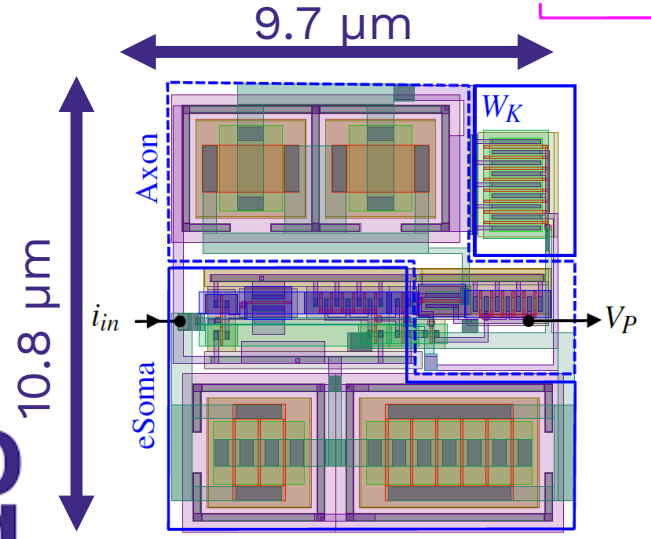


- RSS detection
- 1-degree angular resolution
- Power consumption of 403 nW
- 20 dB SNR
- High accuracies: 93.5% (simulated) and 86.4% (experimental)

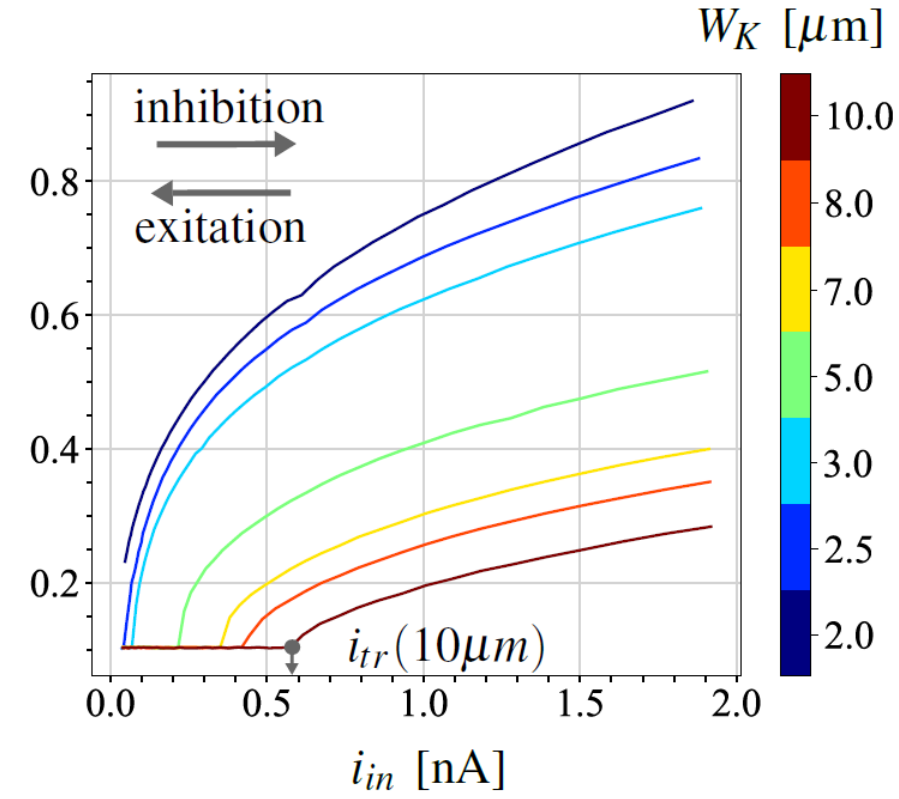
Neuromorphic Circuits







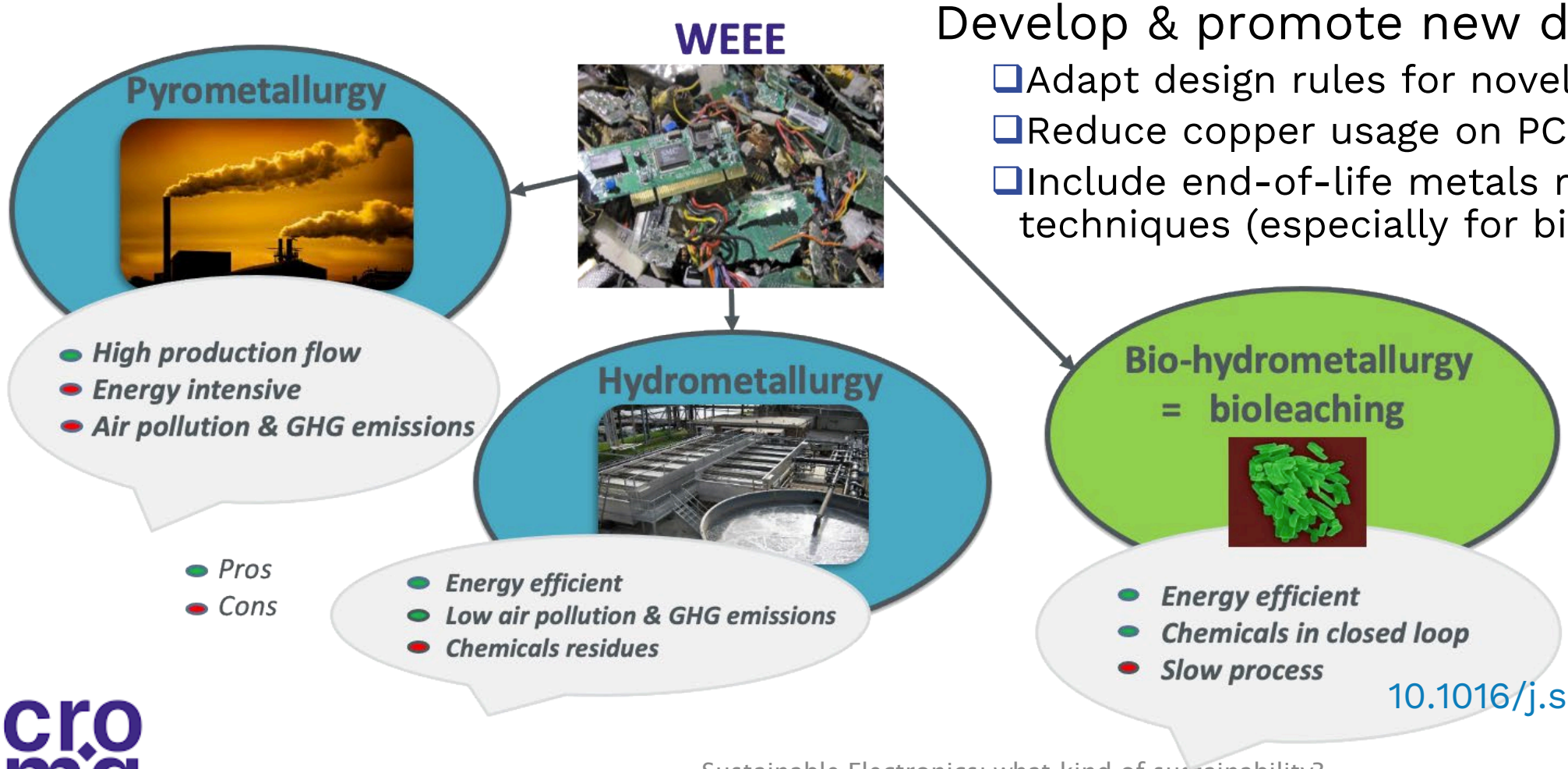
$$E_{eff} = 10\ fJ/spike$$
$$\sigma = 1.8\ \%$$
$$Mismatch \leq 4\ pA$$



SBCCI60457.2023.10261961

Best Trade off is $if \approx 1.0$

Design for circularity of the PCB



Develop & promote new design rules:

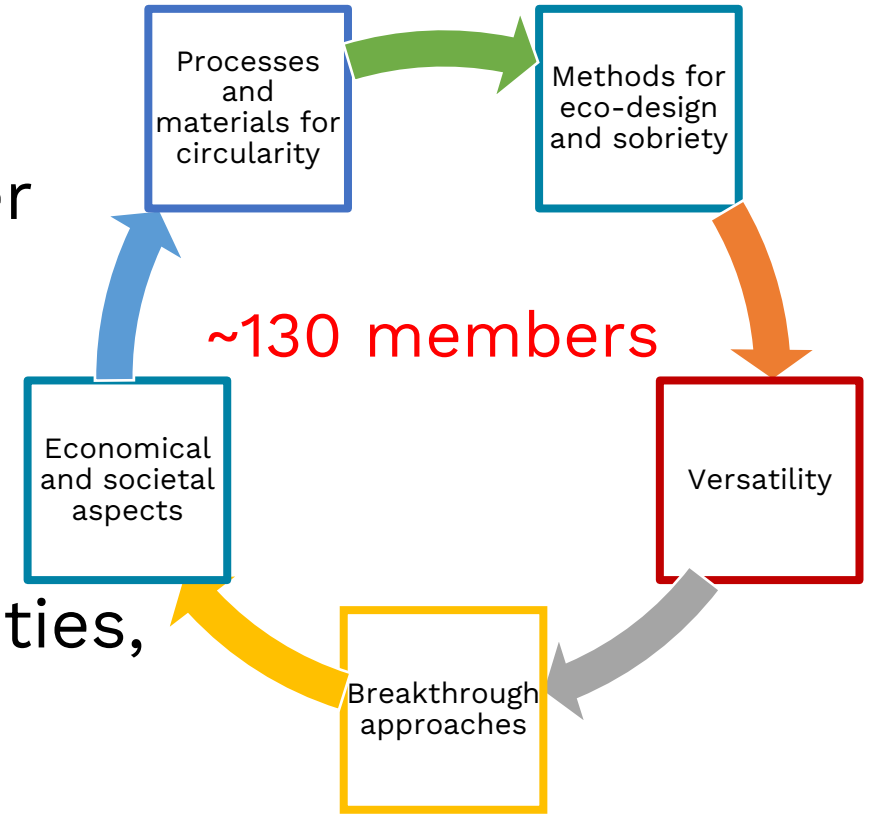
- ❑ Adapt design rules for novel bio-substrates
- ❑ Reduce copper usage on PCB
- ❑ Include end-of-life metals recovery in design techniques (especially for bioleaching process)

10.1016/j.susmat.2024.e00902

Launch of GdR DEFIE

Dispositifs Electroniques à Faibles Impacts Environnementaux

- Federate labs in sustainable electronics
  - ❑ micro & nano-electronics, microwaves, power electronics
  - ❑ optoelectronics, materials, processes, supply chains
- Promote exchanges with companies.
  - ❑ scientific and technological watch activities,
  - ❑ joint responses to calls for projects.



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