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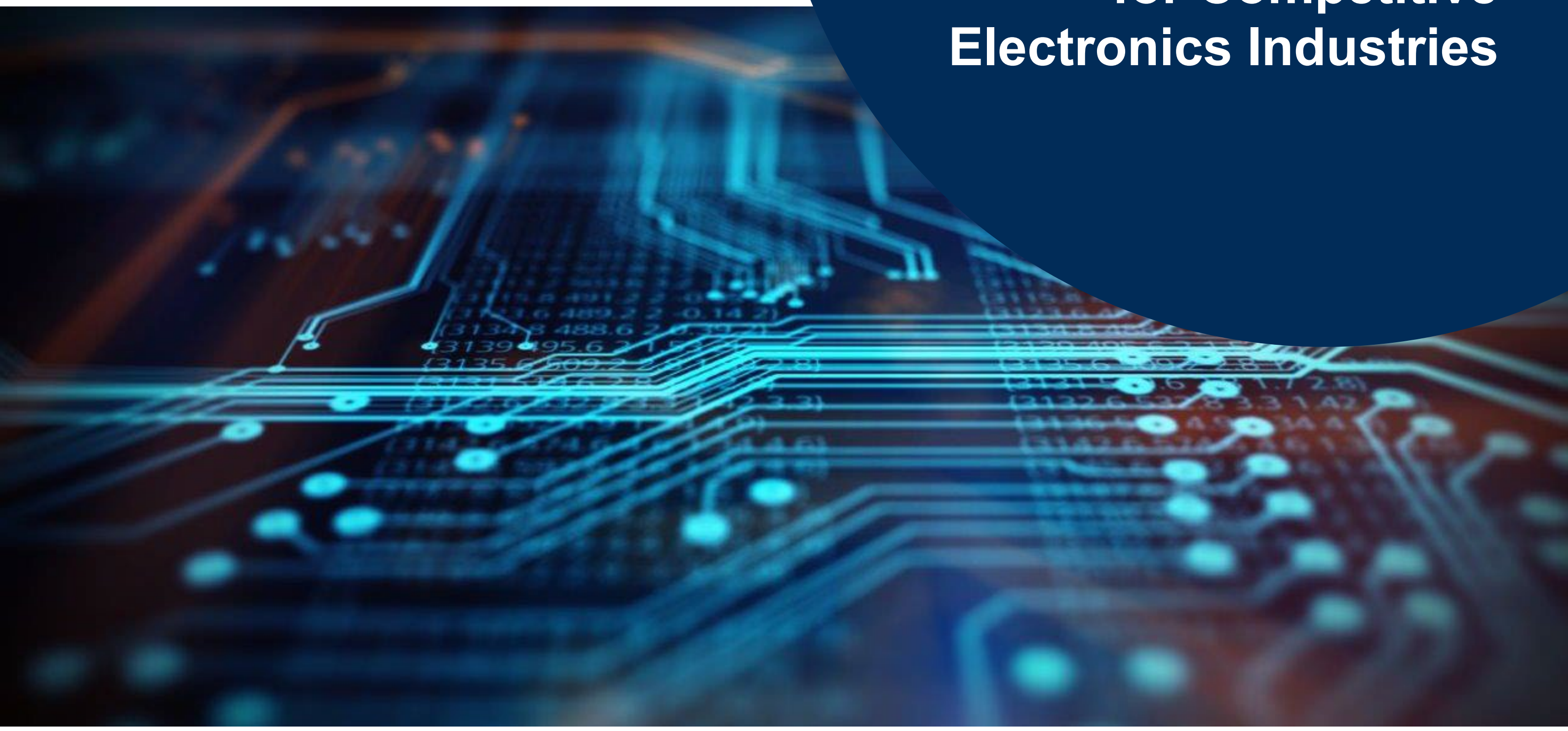
5E

Federating European Electronics Ecosystems for Competitive Electronics Industries



Catalogue of TOP 10 OPPORTUNITIES at the interfaces of the 3 electronics areas

Nanoelectronics – Flexible and Wearable Electronics – Electronic Smart Systems

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GREY SPOTS PER AREA OF APPLICATION

1.1 BUILDING / CONSTRUCTION

B3: Low-power and energy autonomous sensing systems and IoT networks to monitor buildings with respect to their current status (structural health, user behaviour, occupancy, abrasion etc.)

Technologies / Value:

- Smart sensor systems for ubiquitous application
- (Wireless) communication techniques
- Networks of IoT integrated inside building environments
- Sensor systems harvesting the needed energy from the environment

Applications:

This includes sensors and sensor systems for

- Indoor monitoring (gas, temperature, humidity, energy consumption etc.)
- Control of structural integrity (stress/strain, vibration, inclination, material quality)
- Sensors to support the construction process of buildings (e.g. integrated in construction machines or construction materials)

Challenges:

Long-term stability of sensor elements (including long-term power supply), wireless communication, structural health monitoring including predictive assessment (detection of almost unnoticeable changes, recognition of failure patterns for early detection of emerging hazards). Find appropriate ab initio and retrofit solutions.

Coupling sensing with other functionalities:

Integration of e.g. humidity sensors into concrete or screed to allow monitoring of the maturation process, integration of sensors in constructive elements and combine them with actuator elements (adaptive construction)

Opportunities:

1. **Transfer sensor, harvesting and communication solutions developed and tested for the building sector to other application domains**
2. **Transfer monitoring and assessment techniques (algorithms, AI tools etc.) to other application domains**

1.2 CONSUMER ELECTRONICS

C3: Low-cost, reliable and recyclable energy harvesting & storage solutions for high-volume consumer electronics markets

The major factors driving the growth of the energy harvesting systems market include the growing demand for safe, power-efficient, environmentally friendly and durable systems that require minimum or no maintenance.

Technologies / Value:

- Power electronics;
- RF energy harvesting, wireless power transfer;
- Piezo-electric, electrostatic, electromagnetic transduction;
- Thermal and photovoltaic harvesting;
- Energy harvesting modules based on OPV;
- Thin-film batteries.

Applications:

- Outdoor and Indoor applications, well-being applications, home automation, mobile & wearables applications.

Challenges:

Major challenges related to communication in consumer electronics applications are:

- Replacing disposable batteries with wireless charging;
- Turning wired devices into wire-free versions;
- Reliability, cost and recyclability.

Coupling with other functionalities: Actuating, sensing and processing.

Opportunities: see Energy opportunities

1. **New approaches for energy harvesting & storage integration at component and system levels (two-in-one solutions)**
2. **Recyclable low-cost energy storage for mobile & wearable applications**

C4: Solutions for reliable and sensitive multi-sensing and data fusion/exploitation algorithms for signals dynamic management

Integrated sensors in consumer electronics are often closely related to well-being and wearable applications. Due to their compact size, reliability, low-power, performance and cost-efficiency, sensors have been widely adopted in consumers electronics applications.

Technologies / Value:

- MEMS sensing: accelerometer, gyroscope, pressure, temperature, humidity, acoustic, gas;
- Microcontrollers;
- Pressure sensors;
- ECG sensing;
- Electrochemical sensing;
- Bio-impedance sensors;
- Pulse-oximeter;
- Galvanic skin response.

Applications:

- Wearables, smart watches, intelligent clothing, sport gears, Human Machine Interface (HMI)
- Monitoring and analysing developing safety hazards

Challenges: Majors challenges related to sensing in consumer electronics applications are:

- Shrinking size and power of sensors;
- Multi-sensing systems;
- Sensing data fusion and data exploitation.

Coupling with other functionalities: Actuating and processing.

Opportunities:

1. **Build on the technologies spill-over effects of the adoption of sensors in automotive safety and wearable medical devices**
2. **Multi-sensing for security, safety prediction**

1.3 DIGITAL MANUFACTURING

D2: Next generation sensor systems for safe, efficient, optimised and self-enabled manufacturing

Technologies / Value:

- MEMS, MOEMS, optical, chemical, electrochemical, magnetic, acoustic, inertial sensors for combinational sensing;
- Position, pressure, temperature, humidity, gas, acceleration sensors for multi-parameter sensing.

Applications:

- Monitoring of all relevant parameters at the level of equipment, machines, tools, parts, materials, workers, manufacturing environment and monitoring of processes;
- Delivering data for decision support in safe, efficient, optimised and smart manufacturing;
- Sensor systems for Industry 4.0.

Challenges:

- Combinational sensing, multi-parameter sensing and smart sensing;
- Interface with data processing and analytics, AI, software;
- Real-time.

Coupling with other functionalities: Smart sensor systems for monitoring and control integrate sensing, processing, communicating and actuating

Opportunities:

1. **Next generation sensor systems will allow self-calibrating machines and tools as well as self-organised, self-learning and self-maintained manufacturing**
2. **Multi-level efficiency, safe production and overall process optimisation will be achieved thanks to the exploitation of combinational and multi-parametric sensing**

1.4 ENERGY

N1: High-yield energy harvesting approaches for replacing or reducing primary energy uses

Technologies / Value:

- Several energy vectors: electric, piezo-electric, electrostatic, heat, light, chemical, magnetic, acoustic, mechanic;
- Large energy window: from mW (RF, piezo, electrostatic) to kW (e.g. PV module);
- Variety of transducer technologies for direct conversion of harvested energy (from any vectors) into electrical energy.

Applications:

- Generic by nature;
- Any applications in any sectors where energy is critical for the effective operation of a product and where fossil energy can be advantageously replaced or complemented.

Challenges:

- Selecting the best energy harvesting technology for a given application (e.g. harsh environment, remote sites) with high system/product integration level (energy vector, energy scale, reliability, lifetime & cost).

Coupling *energy harvesting* with other functionalities: energy storage, sensing, communicating for wireless sensors node (abandoned / remote sensors)

Opportunities:

1. **Energy harvesting as a (sole) primary energy source: roadmapping of technologies for self-powered products or product functionalities (e.g. PV for IoT)**
2. **Energy harvesting as a (significant) secondary energy source :** roadmapping of technologies for products with high harvested/primary energy substitution ratios and high CO2 footprint reduction level (e.g. PV for street lighting, PV tiles)
3. **New approaches for energy harvesting and storage integration at system/component levels (two-in-one solution):** roadmapping of technologies for products with large energy autonomy and/or remote or low-accessibility needs

1.5 ENVIRONMENT

E1: Gas, pollutant, particle and waste monitoring solutions for healthy and safe working & living environments

Technologies / Value:

- Wide sensing capability: physic-chemical sensors (T°, humidity, gas, particle) and optical sensors (gas);
- Sensors (physical) scale from nano to cm and from ppm sensitivity to qualitative (rain sensing);
- Smart sensor systems for indoor & outdoor air-quality monitoring.

Applications:

- Air-quality monitoring indoor (home, office, building…) & outdoor (city, countryside, factory, transport);
- Waste collection: waste track-and-trace.

Challenges:

- Evaluate influence of the indoor / outdoor air-quality on people health;
- Long-term stability, robustness, sensitivity of sensors;
- Sensors integration into autonomous stationary or wearable systems: flexibility, stretchability, size;
- Wireless communication, secure data handling and management.

Coupling with other functionalities: communicating, energy harvesting

Opportunities:

1. **Autonomous sensing: implementing energy harvesting/storage solutions in sensors networks**
2. **Wireless/cloud communication hardware & protocols for environmental data transmission and management**
3. **Environmental monitoring and physiological sensing to correlate air-quality / health : diagnostic, prevention and prediction**
4. **Environmental/physiological sensors integration into wearables: new sensors with better flexibility, stretchability, conformability**

1.6 FOOD & AGRICULTURE

F1: Sensing for quality, safety and security tracing & monitoring along food value chains

Technologies / Value:

- Wide sensing capability: time, physico-chemical (temperature, humidity, gas, integrity, freshness), optical (colour indicator), acoustic;
- Large portfolio of sensors with various sizes, form factors, sensitivity, sensibility, integrability level and cost.

Applications:

- Quality & security monitoring;
- Logistics track-and-trace.

Challenges:

- Establish a set of protocols and regulations on the food security of IP implications;
- Passive sensing of eating behaviours in effective health intervention services as a mean of validating self-report measures;
- Providing personalised food based on a better understanding of ourselves/health and medical domain, implementation of coordinated traceability systems along the food supply chain;
- Combination of advanced models and AI-tools applied on collected data to support decision making;
- Ensuring high-security level in the management of data.

Opportunities:

1. **Development of a new generation of electronic devices to build future nanoprocessors, nanomemory, nanobattery and nanosensors**
2. **Printed electronics used to improve crops production**
3. **Passive sensing to self-report the caloric intake and eating behaviour**
4. **Smart systems for food quality and safety (e.g. smart sensor with diagnostic capabilities)**
5. **Given the vast economic scale of agricultural industry and current deployment of IoT devices for precision farming, the potential of deploying billions of systems for environmental monitoring is at the horizon**

1.7 IoT/SMART CONNECTED OBJECTS

I2: Sustainable energy harvesting and energy storage solutions for low-power and autonomous IoT devices

Technologies / Value:

- Several natural energy vectors: electric, piezo-electric, electrostatic, heat, light, chemical, magnetic, acoustic, mechanic;
- Large energy window: from mW (RF, piezo, electrostatic) to kW (e.g. PV module);
- Variety of transducer technologies for direct conversion of harvested energy (from any vectors) into electrical energy;
- Low-power, low-consumption systems.

Applications: autonomous, wearable IoT devices / systems across all applications sectors

Challenges:

- Best match between energy harvester technology and environment energy sources;
- Long term stability and robustness of energy harvesting / storage components;
- Substitute battery;
- Low-power energy management;
- Environment sustainability and recycling of energy harvesting/storage components.

Coupling with other functionalities: communicating, sensing, actuating, computing

Opportunities:

1. **Multi-energy harvesting**
2. **High-yields energy harvesting and high-storage density technologies**
3. **Self-powered sensors and sensor networks**

1.8 MEDICAL / PHARMACEUTICAL / LIFE SCIENCE

M2: High-performance and secure communication building blocks to increase autonomy and efficacy of electronic devices intended for medicine and healthcare

Communicating is key for self-sustainability or autonomy of smart medical / well-being devices to safely handle high volumes of data as part of networked systems, including CPU and data storage. Furthermore, miniaturisation, in-vivo interventions and autonomous modes increasingly require remote control enable through embedded wireless communication modules. Digitising healthcare can only be achieved with high-performance and secure communication building blocks.

Technologies / Value:

- Short-range communications: ZiGBee and Bluetooth Low Energy (BLE) are the most commonly used standards;
- Long-range communications: SigFox, LoRaWAN and NB-IoT are the most commonly used standards for Low-Power Wide-Area Networks (LPWANs). The deployment and integration of 5G technologies is highly expected to generalise digital health;
- Specific electrodes technologies used at the neurointerface to provide new forms of Human-Machine communications.

Applications:

- Body area networks;
- Monitoring and diagnostics applications, control;
- Data exchange with intracorporeal, implanted, wearable devices and robots (assistive, interventional, rehabilitation…).

Challenges:

- Communications in Healthcare must be safe, secure and reliable;
- Nanoelectronics specific challenge: high-volume, low-cost communications with embedded hardware security and safety features;
- Communicating at the neurointerface to advance Human2Machine and Machine2Machine interfaces.

Coupling with other functionalities: sensing, processing and actuating for monitoring or automation applications and remote control of devices.

Opportunities:

1. **Future deployment of 5G offers new opportunities in healthcare, in particular transmitting huge amount of data with high speed (1 Gbps), low power and low latency (1ms or less)**, which is a prerequisite to generalise tele-surgery, -medicine and –rehabilitation
2. **Mastering communication at the neurointerface can change the way Human2Machine interfaces are designed and implemented**

1.9 TRANSPORT / MOBILITY / AUTOMOTIVE

T4: Novel sensors to act on changing situations in surrounding, varying from traffic, weather, … to assist in ADAS (autonomous driving assistance system), safety and power consumption

Self-driving cars: Act on changes in the surroundings, varying from traffic, weather and changing situations. Human-machine interfaces inform the driver of these changes, give feedback on activities (e.g. haptic switches), assist in autonomous driving assistant system (ADAS), environmental control issues.

Technologies / Value:

- MEMS accelerometers, magnetic, chemical and gyroscopes), industrial (image sensors), infrastructures (air quality gas sensors) and defence (LiDAR sensors), electric, magnetic;
- Hydraulic, electro-hydraulic and electro-mechanical sensors and actuators;
- Adaptive systems (aerodynamics, acceleration, breaking);
- Reaction to signalling / speed limits etc. (motor control, steering control, break control);
- LIDAR, radar and cameras for lane control, level 2 automation, environment recognition;
- Accelerometers, GPS-navigators;
- Data fusion.

Applications:

- MEMS devices are extensively used in cars for airbag sensors, electronic stability control, tire pressure monitoring, fuel injector pressure sensors, roll over detection sensors, vehicle dynamic control VDC sensors, throttle position sensors and other safety features.

Challenges:

- Integration, lamination of sensors;
- Sensors capability and sensors interoperability complying to automotive standards;
- Product integration (form factor, encapsulation, size limitation).

Coupling with other functionalities: sensing, computing, communicating, signalling

Opportunities:

1. **Integration of novel sensors in the ADAS in order to notify and act on changing conditions while driving**
2. **Integration of sensors into car interiors by structural electronics to decrease costs and allow form factor freedom**
3. **Sensors to monitor environmental concerns on a very localised level such as a car**

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