Vision paper on the role and impact of functional electronics on the transition towards a circular economy

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1. Introduction

1.1 Identification of the issue

In its Communication on the **European Green Deal** [1], the European Commission committed to the adoption of **a new circular economy action plan** to accelerate and continue the transition towards a circular economy. While having the potential to create new activities and jobs [2], concluding there is a need to decouple economic activity and well-being from resource uses and its environmental impacts; and a need to do this more quickly.

The majority of products placed on the EU market today rely mainly on unsustainable and sub-optimal use of resources, leading to excessive use of energy and production of waste, and increasing the material use of our economy (doubling by 2060), despite a slight decrease in material intensity (-1.3% material use per unit of output) [3]. While the circular economy action plan will guide the transition of all sectors, actions will focus in particular on **resource-intensive and high impact sectors such as electronics**.

Today the electronics industry is clearly present in different market segments (healthcare, consumer goods, energy, buildings, mobility, safety & security, agri & food, retail…) with a manufacturing sector accounting for 15% GDP and providing around 33 million jobs in Europe. **Europe has a great opportunity to take a leadership role transforming the digital landscape** by developing its capability in digital innovation and technologies. However, much of this is underpinned by electronics and there is a clear **need for the European electronics industry to strengthen its positions at a global level**, by continuously looking to penetrate new market opportunities and niches.

At the convergence of unconventional nano-electronics, flexible & printed electronics and electronic smart systems [4], the term '**functional electronics**' encompasses this ever-increasing capability to integrate key digital technologies with cognitive functions, **shifting from purely physical integration to functional integration**. Smarter (hybrid) electronic components and systems will become viable notably at high structural density on and in novel substrates (including, but not limited to, flexible, organic, printed) and structural systems (e.g. textiles, plastics, laminates, glass, steel).

The digital transformation presents an enormous potential of wealth creation for EU business and society [5].The deployment and utilization of electronic devices is expected to continue and grow in the future : global electrical and **electronic waste production is expected to increase** from 47 to 72 Millions tons from 2017 to 2022 with 6.5 CAGR% [6]. In addition to current challenges faced by the sector, **it is essential and urgent to understand the role and mitigate associated environmental & societal risks of functional electronics in a transition towards a circular economy and a low-carbon society**.

1.2 Statement of the position

We welcome the commitment of the European Commission to adopt a new circular economy action plan and create a **New Industrial Strategy for Europe** [7] which acknowledges and addresses the **interlinked challenges of green and digital transformation**. We also fully support the development of an ambitious sustainable product policy, including a ***Circular Electronics Initiative***.

The EU aims to promote and invest in the necessary digital transformation and tools: as new technologies, sustainable solutions and disruptive innovation are critical to achieve the objectives of the European Green Deal. It is thus **essential to intensify research and**

unlocking the potential for functional electronics to catalyze this shift towards a digitally-enabled circular economy that must contribute to reach the Paris Agreement objectives on climate change mitigation.

While those new solutions are a critical enabler for attaining the sustainability goals of the Green Deal in many different sectors, any adverse effects encouraging a linear "take-make-dispose" economy must be avoided [8]. Research & innovation actions need to guide the emergence of those functional electronics by **ensuring sustainability is put at the heart of those functional electronics solutions**. In addition, it is necessary that this transition is **accompanied by a proper and meaningful regulatory and legislative framework**.

2. Positioning

2.1 Unlock the potential of functional electronics

Functional electronics are transversal enablers and differentiators of European digital transformation, as foreseen in the recent Communication from the European Commission on **Shaping Europe's digital future** [9]. They support a multitude of key enabling technology breakthroughs from 5G and Digitalisation to the Internet of Things and Artificial Intelligence (to name a few). According to the Communication on the European Green Deal, Europe must leverage the potential of the digital transformation for reaching the Green Deal objectives. Functional electronics can contribute in bringing the digital transformation and objectives under the Green Deal together as they address the current hurdle of collecting product relevant data and sharing them along the value chain. As such, functional electronics provide **key contributions to the planned Circular Data Space** under the new Circular Economy Action Plan.

It has been emphasized that digital technologies can contribute to the transition from a linear to a circular economy. However, their net environmental balance sheet still has to be carefully and independently assessed in particular with regard to the Paris Agreement objectives on climate change mitigation. This will enable to identify and demonstrate the potential applications and industrial cases where the role and impact of functional electronics can be beneficial from the triple environmental, economic and societal perspectives. Those technologies have for instance the potential to **improve traceability and transparency** during product lifetime, allow manufacturers to **monitor, control, analyse and optimise materials quality and products performance** [10]. This is of importance under the planned sustainable product framework and the possibility of implementing and managing **digital product passports** for products along their life-cycle [11]. They could also **enhance end of life management practices, predictive and condition-based maintenance** extending product lifetime or **enable new business models** such as product-service systems [12]. These few examples simultaneously illustrate the potential of functional electronics for **maintaining the value of materials and products for as long as possible**, minimising resource use and waste by increasing resource efficiency, mitigate waste generation at production and use stage, enhance repair (incl. self-healing), remanufacturing, recovery, reuse and recycling of materials and products.

The EU is currently in the midst of two transformations (green & digital), which until now have rarely been aligned. To promote and invest in necessary "aligning" solutions, **mobilising research and fostering innovation is a first key prerequisite for gaining a holistic understanding and demonstrating the full potential** of functional electronics for accelerating the transition towards a circular economy, in particular, regarding their **net balance environmental impacts**. It is essential to **adequately steer the integration** of

functional electronics in the relevant market segments and take advantage of their potential at the right steps of products lifecycle.

2.2 Design safe, sustainable and circular solutions

Unlocking the potential of functional electronics is key for accelerating a transition towards a circular economy. However **this transition will not happen, and could cause significant adverse effects, if it is not governed and guided well**, and if sustainability is not at the heart of those emerging technological developments. The share of digital technologies in global greenhouse gas emissions has increased by half since 2013, from 2.5% to 3.7% of global emissions. The demand for raw materials such as rare and critical metals, essential for both digital and low-carbon energy technologies, is also growing [13].

It is critical for functional electronics-based products and processes to **develop efficient eco-design approaches**. EU Ecodesign directive [14] targets to reduce energy and resource consumption by promoting the better environmental performance of products and that way design choices have an impact on various steps of the material and product lifecycle. They are key drivers in enabling more circular products: they could allow a sustainable sourcing of primary or secondary raw materials (such as substitutes to critical or scarce raw materials, produced from more energy-efficient manufacturing processes, generating less waste like net-shape processing); an optimised resource use (such as low and smart energy consumption); an environmentally sound and safe product use (such as alternative to Volatile Organic Compounds); a prolonged product use (such as increasing reparability and self-healing properties); and more efficient recycling (such as a facilitated sorting and/or disassembly).

Smart eco-design from the perspective of **clean material cycles** is a key prerequisite for circular functional electronics-based products: to reuse, refurbish or recycle products, stakeholders must be able to rely on the intrinsic safety of the materials from a health and environmental point of view. Minimizing the use of hazardous and/or persistent substances in products can increase the potential for their recyclability or reuse. Meanwhile it must be noted that miniaturization may limit the viability of recycling as the amounts of material used, compared to the effort needed to retrieve it does not create a business case for recycling.

Due to the ongoing penetration in ever-increasing diversity of market segments, when these new electronic devices come to the end of their lifetime, there is **need to understand and demonstrate how they can be recycled or dealt with in a responsible, sustainable, carbon-neutral and resource efficient manner**. Therefore they should be included when the EU Commission is developing possible Union-wide end-of-waste criteria and how standardisation may contribute. This demonstration needs to be guided by the sense of purpose and take account of the ecological benefits of the new technologies when conducting an overall life cycle assessment.

Research, development & innovations actions are key for developing those systemic and methodological needs and associated skills, fostering standardisation and providing guidance on an adequate regulatory and legislative framework. Examples here are the current requirement for printed batteries made out of non-hazardous materials to be dismantled and disposed of separately, or the equal treatment of OPV and PV under WEEE guidelines, which leads to disadvantageous disposal due to the large differences in materials between the two technologies. In both examples, the current regulatory framework results in a loss of ecological benefit of those functional electronics technologies.

3. Conclusion (& policy recommendations)

To build European leadership at global level, the EU needs to increase significantly the demonstration & large-scale deployment of new technologies across sectors and across the single market, building new innovative value chains.

Being in the midst of two crucial transformations (green & digital), the EU should mobilize research and foster innovation for maximising the synergies. **Being transversal enablers and differentiators of Europe's digital transformation, it is essential to understand the role and impacts of functional electronics for simultaneously accelerating the transition towards a circular economy while proving a global net beneficial effect on climate change mitigation**. Coordinated R&D actions are needed to develop functional electronics technologies based on the eco-design principles and also to investigate the potential for functional electronics to accelerate this transition and be sustained by innovation and infrastructure actions in a subsequent phase of industrialisation to fully unlock their potential. It is clear that those **actions can not translate into economic value or have a profound societal impact without incoporating sustainability parameters & practices at the heart of their approaches** (*E.g.* utilizing materials originating from renewable resources, compostable or bio-degradable materials, self healing materials, effectively reusing/recycling materials, components and products (circular economy), designing products tailored for circular economy (eco-design) and/or using energy- and material-efficient manufacturing processes).

For **maximizing those synergies**, it is crucial to have an **appropriate governance framework**. With ambitions to support design for circularity, to provide tools to industry for managing their supply chain, to set minimum requirements preventing environmentally harmful products/ substances to reach the EU market and to identify options to prioritise reuse and repair before recycling, it is **essential that the sustainable products policy included in the new circular economy action plan provides those enabling regulatory conditions for functional electronics**.

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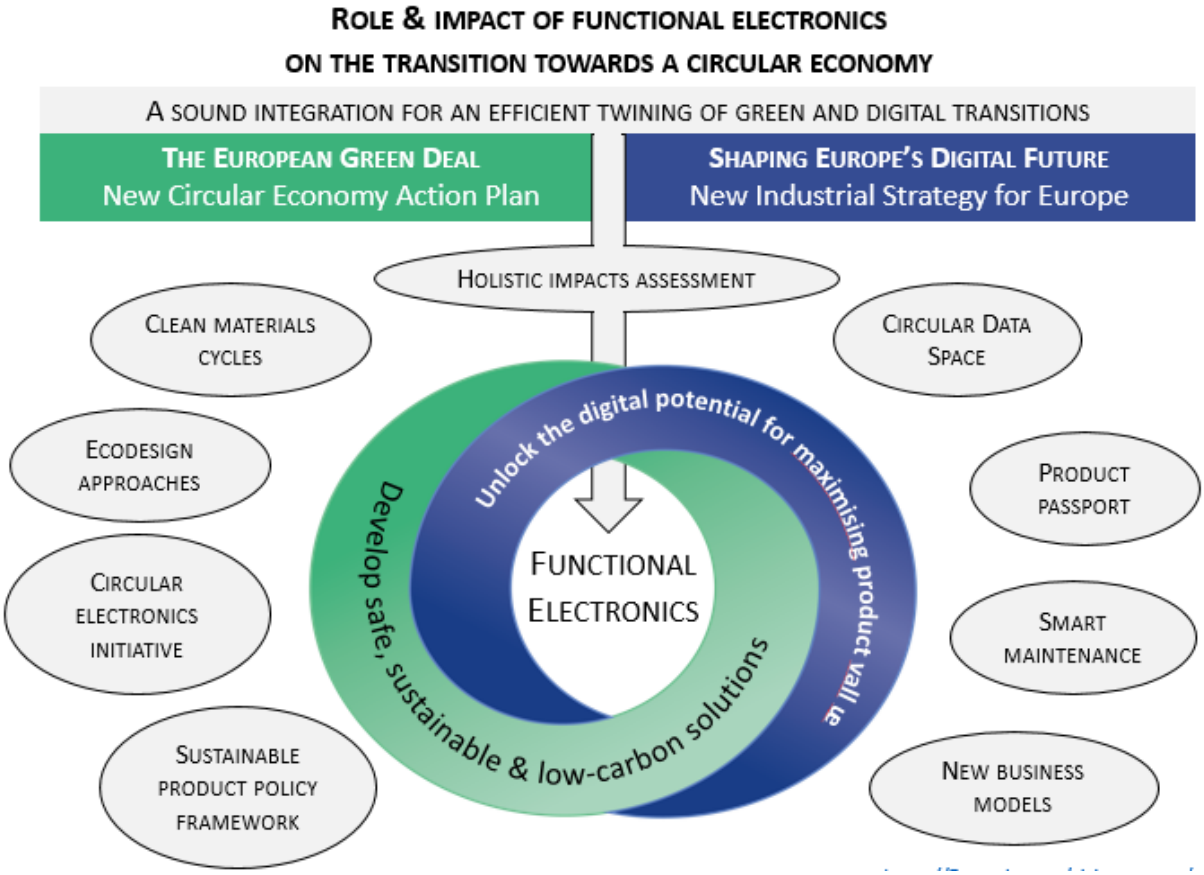

This Vision Paper is a result of the 5E project that reinforces collaboration and outreach of the electronics industry across Europe and supports its stakeholders in seizing opportunities.

[1] European Commission, The European Green Deal, COM (2019) 640 final
[2] In 2016, sectors relevant to circular economy employed >4Million workers in EU, and activities such as repair, reuse and recycling generated almost €147 billion in value added while standing for around €17,7 billion worth of investment, according to European Commission, SWD(2019) 90 final
[3] OECD (2019), Global Material Resources Outlook to 2060.
[4] https://5e-project.eu/
[5] The World Economic Forum estimates that the combined global value of digital transformation to society and industry will exceed US$100 trillion by 2025, the European Parliamentary Research Service identified that an efficiently functioning digital single market could contribute €415 billion per year to EU economy for the period 2014-2019 and create hundreds of thousands of new jobs.
[6] Sullivan, M. Printed Electronics: Global Markets to 2022, BCC Research LLC. 2018
[7] https://ec.europa.eu/info/sites/info/files/communication-eu-industrial-strategy-march-2020_en.pdf
[8] European Policy Center (2019), Creating a digital roadmap for a circular economy.
[9] final https://ec.europa.eu/info/sites/info/files/communication-shaping-europes-digital-future-feb2020_en_4.pdf
[10] www.circularise.com
[11] www.bamb2020.eu
[12] www.signify.com
[13] The Shift Project, (2019), Lean ICT- towards digital sobriety, www.theshiftproject.org
[14] https://ec.europa.eu/growth/industry/sustainability/ecodesign_en