Assessment of environmental footprint of semiconductor manufacturing industry to promote more sustainable processes

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The European green deal aims to ensure net-zero emissions by 2050, making Europe the first climate-neutral continent in the world, as well as a target of 55% less emissions by 2030, in comparison to 1990 [1]. Global digital market is growing by 6% a year and semiconductor industry growth is forecast at 45% in 2030. The IC industry commits to a decarbonisation plan to reduce its greenhouse gases emissions, preserve energy, water and other resources. The Life Cycle Assessment (LCA) in this context plays a crucial role in helping to identify the main environmental impacts and known as “hotspots”, allowing giving recommendations to mitigate the environmental footprint of chips manufacturing in clean rooms [2].

Building upon international ISO standards (e.g. ISO 14040/44), the Product Environmental Footprint (PEF) method, recommended by the European Commission [2], based on LCA provides the principles, framework and guidelines to quantify environmental impacts throughout the entire life cycle of products (Fig.1). For LCA studies, we use SimaPro® software, an ISO-compliant LCAs tool, coupled with the Ecoinvent v3.10 database.

We will present different LCA studies conducted at CEA-Leti on the chips manufacturing on Silicon wafers. The environmental impacts assessment includes both the infrastructure to maintain ultra-clean environments [3] (Fig.2), and the process steps required for manufacturing [4-6] of different technologies [7]. The major contributors in clean rooms are energy use (electricity, natural gas), resource consumption (e.g., water, chemicals, acids, metals…), emissions in air (e.g., CO_2, PFCs), and waste treatments of effluents.

Finally, we will illustrate eco-design solutions for both facilities and processes in clean rooms such as: Improving energy efficiency, reducing water consumption (reuse/recycling), replacing PFCs gas with lower global Warming Potential (GWP) gas, substituting materials containing harmful compounds (PFAS, CMR, etc.), promoting the circularity of critical materials and developing efficient waste treatment.

References

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Fig. 1 Life cycle and 4 main phases of a PEF study

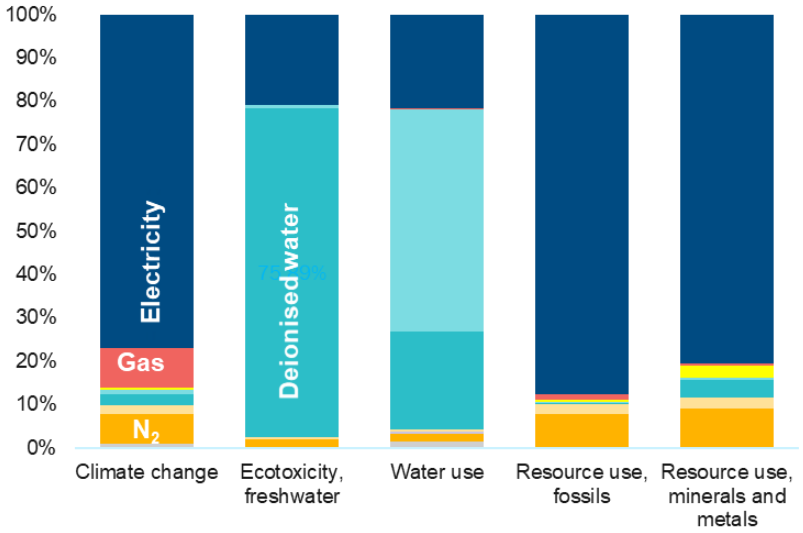

Fig. 2 LCA of infrastructure within CEA-Leti cleans rooms [3]