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Plasma technologies for electrification: Where we are, where we're headed

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With the ongoing energy transition, electricity is becoming the main energy carrier and commodity but the rate of deployment of solar, wind and hydraulic energy harvesting capacity far outpaces the capabilities to immediately use, transport, or store the electricity being produced. This technological bottleneck is because few industrial processes use electricity as main energy input, and that electricity cannot easily be stored and transported at scale. These observations are supported by the World Economic Forum that identified as top cleantech research and development priorities for 2026-2030 zero-carbon fuels, industrial chemical conversion processes and inter-seasonal electricity storage. There is clearly an urgent need for on-demand and scalable renewable electricity conversion processes and storage means. Plasma is a promising processing medium to electrify several industry-relevant chemical processes thanks to its reliance on electricity as sole energy input, seemingly unlimited range of chemical reaction conditions, and natural fit to distributed utilization (small to large scale via parallelization, fast light-up/turn-down cycles, control of reaction times from hours down to microseconds). Through careful control of the electrical power and reactive gas delivery, chemical processing conditions not otherwise achievable can be attained with high energy and material efficiencies. Such novel reactive environment is particularly appealing for hard-to-decarbonize processes (e.g. ammonia and ethylene synthesis) and for the conversion and upcycling of stable and abundant greenhouse gases (e.g. carbon dioxide, methane). In comparison with the semiconductor industry where unique plasma technologies enable most breakthroughs and thus, secured dominance, much remains to be developed, understood and adopted in the chemical process industry characterized by conservatism and massive assets. In this talk, I will review the (non-fusion) plasma technologies being developed and present a personal outlook for the energy transition context.

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Keyword-3

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