

Memristive self-organizing dendrite networks for brain-inspired computing

Description of the proposed research

Artificial Intelligence needs a hardware revolution to sustain the ever-growing demand of computing power in our society, where the huge energy consumption and environmental impact of computation with current technologies is unsustainable. In the race toward future computing, bioinspired technologies have been shown as promising hardware solutions for computing beyond the Turing model and the classical von Neumann architectures. Going beyond transistor-centred hardware solutions, the research community is exploring new device concepts and architectures that leverage physical phenomena for computing “*in materia*” with physical laws to emulate the effectiveness of information processing capabilities of our brain [1,2]. In the framework of the ERC Starting Grant MEMBRAIN [3], the PhD project is devoted to the realization of memristive networks of dendritic structures able to process information and to store knowledge on the same physical substrate. During the PhD, that lies at the crossroad of nanotechnology, physics, materials science and machine learning, the PhD will develop memristive circuits by coupling lithographic techniques and electrochemical processes, with the aim of controlling the dendrite network topology through the applied electric field. These networks will be electrically characterized by means of multiterminal measurements, and resulting dendritic structures will be analysed through the development of appropriate data analysis techniques, with the aim of correlating network topology, emergent functionalities and computing capabilities of the system.

[1] Milano, Gianluca, et al. “In materia reservoir computing with a fully memristive architecture based on self-organizing nanowire networks” *Nature materials* 21.2 (2022): 195-202.

[2] Milano, Gianluca, et al. “Tomography of memory engrams in self-organizing nanowire connectomes.”; *Nature Communications* 14.1 (2023): 5723.

[3] ERC Starting Grant “Memristive self-organizing dendrite networks for brain-inspired computing” – MEMBRAIN – PI: Gianluca Milano