2D Nanomaterials for Advancing Neuromorphic Computing

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(invited talk)

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Current classical computers are playing a critical role in advanced research such as in biology, climate analysis, economics, genomics, finance, etc. In many aspects, computing fuels the advances of our modern society. Yet, recent developments in artificial intelligence (AI) and machine learning will require even more powerful computing systems such as exascale computations per second due to an ever-increasing amount of data. But classical computing systems are hindered by the von-Neumann communication bottleneck, the physical separation between processor and memory. This offers the opportunity to explore a novel computing paradigm where the brain can serve as a computational model of how to deal with large amounts of (often fuzzy) information while being extremely dense, error-resilient and power efficient.

In this talk, a novel and alternative neuromorphic computing paradigm based on oscillating neural networks (ONN) will be presented. Energy efficient relaxation oscillators based on phase-change VO_2 material for oscillating neurons and tunable 2D TMD MoS_2 memristors for synapses are the building blocks of ONN architecture [1-3]. Inspired by neural oscillations or brain waves, in ONN, the information is encoded in the phase of coupled oscillators. The talk will cover aspects from materials, devices, circuits to ONN architecture design and hardware implementation and demonstration on AI tasks. This work is conducted in the framework of the EU H2020 NEURONN project, www.neuronn.eu.

[1] A. Todri-Sanial, S. Carapezzi, C. Delacour, M. Abernot, T. Gil, E. Corti, et al., “How Frequency Injection Locking Can Train Oscillatory Neural Networks to Compute in Phase,” *preprint*, hal-lirmm.ccsd.cnrs.fr/lirmm-03164135, 2021.

[2] S. Carapezzi, C. Delacour, G. Boschetto, E. Corti, M. Abernot, A. Nejim, et al., “Multi-Scale Modeling and Simulation Flow for Oscillatory Neural Networks for Edge Computing,” *19th IEEE Interregional NEWCAS Conference*, 2021.

[3] C. Delacour, S. Carapezzi, M. Abernot, G. Boschetto, N. Azemard, et al., Oscillatory Neural Networks for Edge AI Computing. *IEEE Computer Society Annual Symposium on VLSI (ISVLSI 2021)*, Jul 2021, Tampa, United States.