This seminar is co-organized with the Institut Denis Poisson

GREMAN seminar

THURSDAY

5

DECEMBER

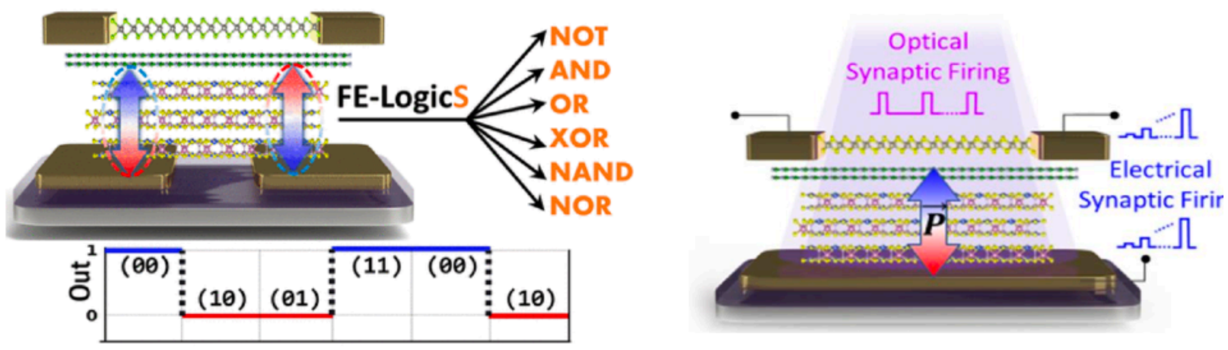

Figure 1: Schematics of van der Waals ferroelectric devices. Left: Reconfigurable ferroelectric logics. Right: Photoferroelectric Artificial Synapse.

Jean-Francois DAYEN

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Van der Waals ferroelectric heterostructures for in-memory computing and emergent electronics

2:15pm - 3:15pm (Amphi 21 - Batiment F - Faculté des Sciences - Grandmont)

2D ferroelectric materials are attracting fast growing interest for the implementation of complex more-then-Moore and beyon-Moore architectures that are challenging to design with standard thin film technology.[1] Here, I will present recent developments on the coupling of a 2D vdW electon gas with various ferroelectric gate controls. We will discuss how these systems allow for rethinking circuit topology and memory-logic interaction, opening up new research directions in the area of frugal computational enhancement and neuromorphic computing for AI. I will first detail how by making use of the switchable polarization state of two splitted ferroelectric gates, the electrical potential landscape within a semiconductor channel can be permanently and reconfigurably modified.[2] While using the non-volatile ferroelectric states encoded in each gate, the ferroelectric logic circuits can function as six alternative logic gates, while CMOS circuit are limited to a single function. Such Re-FeFET circuits demonstrate high compactness, with an up to 80% reduction in transistor count compared to standard CMOS design. Moreover, the device can operate as a photodiode and generate photovoltaic energy. Finally, I will present how light-structure interactions in vdW systems allow for implementing the non-volatile electrical and optical control of the ferroelectric polarization in ferroelectric/semiconductor heterostructures.[3] The wavelength-dependent study unveils ferroelectric polarization control and decouples the mechanisms driven by photogenerated carriers for each material and at the interfaces. Following, long-term potentiation/depression, and spike rate-dependent plasticity are shown using electrical AND optical controls, enabling optically stimulated and optically assisted synaptic devices.

References

[1] Jin, T. et al. *ACS Nano* 2022, 16, 9, 13595–13611. [2] *A. Ram. et al. ACS Nano* 2023, 17, 21, 21865–21877. [3] M. Soliman, et al., ACS Appl. Mater. Interfaces 2023, 15, 12, 15732.2 (2018).