Title: **Challenges and opportunities of steep-slope electron devices**

Author: **Marco Pala**, DPIA, University of Udine, Italy

Abstract: Nowadays, the most relevant challenge in micro/nanoelectronics is to find an optimal trade-off between electrical performance and power consumption [1]. The most straightforward strategy to reduce the dynamic power in integrated circuits, namely the scaling of the supply voltage V_{DD}, is no longer a viable path for circuits based on Si-MOSFETs, which must obey the Boltzmann limit of the sub-threshold swing S.

Alternative device architectures promising to break the Boltzmann limit and to achieve sub-threshold swings smaller than 60 mV/dec typically suffer from low drive currents [2] and high sensitivity to traps [3].

This talk will discuss recent advances in the development of efficient steep-slope devices by discussing experimental results on broken-gap Ga/Sb vertical nanowire tunnel-FETs providing high on-state current I_{on} and steep S at a low V_{DD} = 0.3 V [4]. The physics of these devices will be analyzed thanks to 3-D full quantum self-consistent simulations adopting the non-equilibrium Green's functions methodology [5].

Finally, the presentation will focus on recent device designs proposing innovative cold-source FETs based on the density-of-states engineering of their source regions, enabled by the unique electronic properties of 2D lamellar materials [6-7].

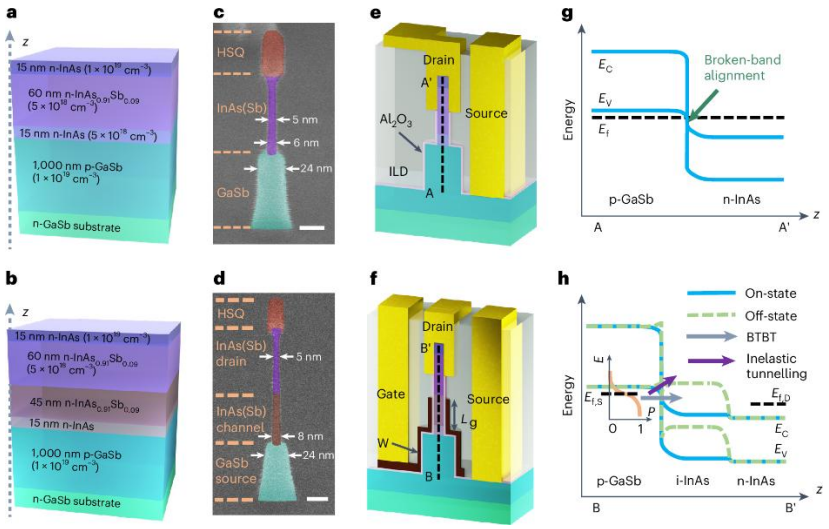

Image from Y. Shao, M. Pala, H. Tang, B. Wang, J. Li, D. Esseni, J.A. Del Alamo, Nature Electronics 8 (2), 157-167 (2025).

References:

[1] S. Datta, et al., Attojoule switching energy in logic transistors, Science 378, 733–740 (2022).

[2] H. Lu, A. Seabaugh, Tunnel field-effect transistors: state-of-the-art. IEEE J. Electron Devices Soc. 2, 44–49 (2014).

[3] M. Pala, D. Esseni, IEEE Trans. Electron Devices 60, 2795–2801 (2013).

[4] Y. Shao, M. Pala, H. Tang, B. Wang, J. Li, D. Esseni, J.A. Del Alamo, Nature Electronics 8 (2), 157-167 (2025).

[5] M. G. Pala, P. Giannozzi, and D. Esseni, Phys. Rev. B, Condens. Matter 102, 045410 (2020).

[6] D. Logoteta, J. Cao, M. Pala, P. Dollfus, Y. Lee, G. Iannaccone, Physical Review Research 2 (4), 043286 (2020).

[7] D. K. Nguyen, A. Pilotto, D. Lizzit, M. Pala, P. Dollfus, D. Esseni, IEEE Transactions on Electron Devices 72 (12), 7114-7121 (2025).