<Professor Mincheol Shin's Lab.>

Computational Nanoelectronics Laboratory
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■ Contact information

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■ Current state of the Lab. (in 2025 Spring Semester)

PhD Students: 2 Master's Student: 5

■ Research Areas

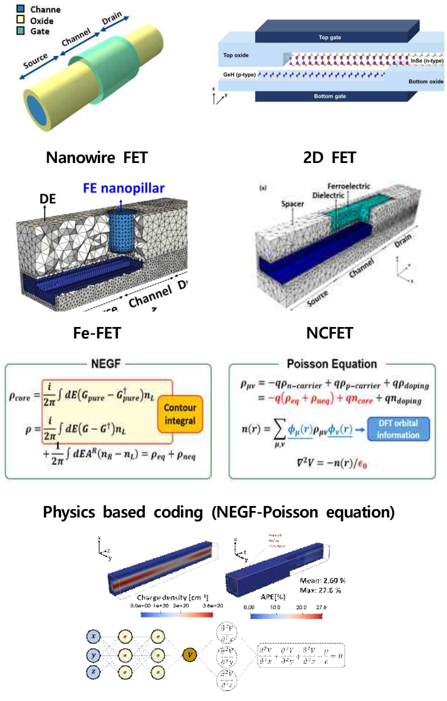
As the feature size of conventional planar metal-oxide-semiconductor field-effect transistors (FETs) shrinks into the nanometer regime, novel devices such as nanowire and tunnel FET have emerged as the next generation devices. The classical or semi-classical approach is no longer valid for the nano-sized devices so quantum-mechanical, atom-level treatment is required.

In our laboratory, we have been developing **simulators for advanced nano scaled logic devices** based on the quantum mechanical principles. Si-based as well as non-Si devices such as 2D materials and III-V compounds are being considered. To treat the devices in the atomistic level, density functional theory and the non-equilibrium Green's function method are employed to calculate the quantum charge transport.

We have also studied **the next generation memory devices**, such as ferroelectric FET (FeFET) and magnetic random access memory (MRAM). For **FeFET**, we use in-house Phase-field-based simulator.

For an optimization of nanoscale devices, we have developed **machine learning(ML)-based device optimization framework** where TCAD simulator and Bayesian optimization algorithm are combined.

We are currently developing advanced transport models through **physics-informed neural networks** and more. Through this approach, we aim to construct advanced transport models and explore solutions to complex real-world problems by enhancing predictions and modeling.



ML-based device simulation/optimization

■ Recommended courses & Career after graduation

Prospective students should have good background knowledge on semiconductor physics and devices. Basic/advanced courses on the quantum mechanics, solid-state physics, and C language are also recommended to take. After graduation, they may continue their research career in universities or research institutes or work in semiconductor companies in Korea and overseas.

■ Introduction to other activities besides research

It is strongly encouraged that students set aside time for regular physical exercises. Besides research, it is emphasized that students acquire ability to develop and express their idea, thinking, opinions through reading, writing and presentation (scientific or non-scientific).

■ Introduction to the Lab.

Computational science/engineering is a new, a third way of doing research, besides the traditional way of doing research which is theory or experiment. Remarkable progress in the computer power and increasing needs for computation has led to the era of computational science/engineering. To meet the needs of the times, CNL provides its members with environments and experiences, which help them become the experts in semiconductor device physics and computational electronics. At the time of graduation, they are expected to be capable of handling all the semiconductor-device related issues that become more and more complex and ready to work both in industry and academia.

■ Recent research achievements (2022-2025)

[1] "Transport Properties of Crystalline IGZO Channel Devices: Effects of Cation Disorders, Composition and Dimensions", Deokhwa Seo, Seung Hyo Han, Jun-Hwe Cha, Seiyon Kim and Mincheol Shin, 70th IEEE International Electron Devices Meeting (IEDM), SF, USA, 2024

[2] "Three-dimensional phase-field based quantum transport simulations of polar topological states," Hyeongu Lee and Mincheol Shin, 69th IEEE International Electron Devices Meeting (IEDM), SF, USA, 2023

[3] "A Novel Neural-Network Device Modeling based on Physics-informed Machine Learning", Bokyeom Kim and Mincheol Shin, IEEE Transactions on Electron Devices, vol. 70, no.11, 6021 - 6025, Nov. 2023.

[4] "Efficient device simulations using density functional theory Hamiltonian and non-equilibrium Green's function: heterostructure mode space method and core charge approximation," Seonghyeok Jeon and Mincheol Shin, Journal of Computational Electronics, May 2023.