SEMINAR ANNOUNCEMENT

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
COLLEGE OF DESIGN AND ENGINEERING
Website: https://cde.nus.edu.sg/ece

Area: Microelectronic Technologies & Devices (MTD)

Host: Asst Prof Fong Xuanyao Kelvin

TOPIC	:	**From Atomistic, Non-Equilibrium Quantum Statistical Mechanics Theory to Today's Transistor Design and Global Impact – A 30-Year Journey**
SPEAKER	:	**Prof Gerhard Klimeck** **Elmore Professor of Electrical and Computer Engineering, Purdue University**
DATE	:	**Tuesday, 1 July 2025**
TIME	:	**10:30AM-11:30AM**
VENUE	:	**E5-03-20**

ABSTRACT

30 years ago, the appropriate quantum transport theories, basis sets, algorithms, user interfaces, and dissemination methods for quantum device modeling were subjects of intense debate and uncertainty. The development of the Nanoelectronic MOdeling (NEMO) toolset commenced in 1994 at Texas Instruments, continued in 1998 and NASA/JPL, and has been ongoing at Purdue since 2004. Modern nanoscale transistor design extensively employs advanced quantum transport modeling tools, representing physical devices in three dimensions with atomistic basis sets. The NEMO implementations of the Non-Equilibrium Green Function (NEGF) formalism with atomistic tight-binding basis have become the benchmark for quantitative and predictive device simulation. This methodology has now been widely adopted by most device modeling research teams. In 2015, Intel integrated NEMO5 into their in-house design suite, utilizing a top-100 ranked supercomputer for design explorations [1]. Silvaco initiated commercialization efforts [2] in 2018, with industry leaders such as Samsung and TSMC developing their in-house solutions based on NEMO. NEMO's capability to accurately model crystal orientations and strain in complex systems facilitated the development of Texas Instruments' rotated substrate technology in 2004 [3], significantly impacting chips used in billions of cell phones. Contemporary 3D FinFETs [4] and nanosheet transistors share the 5 nm central length characteristics with 1D resonant tunneling diodes (RTDs). The quantitative and predictive modeling of 1D RTDs (1994-1997) established the standards necessary for today's 3D nano-transistors.

NEMO's applications extend beyond usage by experts equipped with specialized computational hardware. Over 49,900 users on nanoHUB.org, the pioneering comprehensive scientific computing cloud platform, have investigated various nanoscale devices such as nanowires, ultra-thin-body transistors, and quantum dots utilizing the intuitive NEMO/OMEN tools. These tools are supplemented by straightforward applications, rendering them accessible to a broad spectrum of users. Notably, more than fifty percent of nanoHUB's simulation users participate in formal educational settings across 1,000 institutions globally, immersing themselves in device exploration and modeling principles. nanoHUB hosts 850+ apps and tools, along with over 2300 courses.

This presentation will provide an overview of the critical physical phenomena needed to be captured for realistic device design, how high-performance-computing can deliver results to engineers & students, and how NEMO has been deployed on nanoHUB.org.

This work would not have been possible without my hundreds of collaborators who helped to build, test drive, break, and rebuild NEMO/OMEN [5-9,12-14] and nanoHUB [10,11]. I have the deepest appreciation for their hard work, dedication and in most cases their personal friendship. The citations here just cover some of the fundamental developments. Citations to these papers lead to hundreds of publications enabled by my collaborators and friends.

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BIOGRAPHY

Gerhard Klimeck is the Elmore Chaired Professor of Electrical and Computer Engineering at Purdue University and leads two research centers in Purdue's Discovery Park. He is also Vice President for Academic Information Technology and Deputy CIO. Previously he worked at the central research Laboratory of Texas Instruments and NASA/JPL/Caltech. His research interest is in computational nanoelectronics, high performance computing, and data analytics. He helped to create nanoHUB.org, the largest virtual nanotechnology user facility serving that served over 15 million users. He led the teams who developed the NEMO software tools. Dr. Klimeck is a fellow of the Institute of Physics (IOP), the American Physical Society (APS), the Institute of Electrical and Electronics Engineers (IEEE), the American Association for the Advancement of Science (AAAS), and the German Humboldt Foundation. He has published over 525 printed scientific articles; he has been recognized for his co-invention of a single-atom transistor, quantum mechanical modeling theory, and simulation tools. His NEMO5 software has been used since 2015 at Intel to design nano-scaled design transistors. The nanoHUB team was recently recognized by a top 100 by R&D award - Making simulation and data pervasive.