

Electronics from the Bottom Up: A New Approach to Nanoelectronic Devices and Materials

Vision

The [Network for Computational Nanotechnology](#) seeks to bring a new perspective to engineering education to meet the challenges and opportunities of modern nanotechnology. Fifty years ago our field faced a similar challenge brought on by the advent of the transistor and it was met effectively by the Semiconductor Electronics Education Committee (SEEC), a group of 30 leaders in the field from both industry and academia who produced [seven undergraduate textbooks and four films](#) that reshaped the [teaching of electronics](#) and trained a generation of engineers ready to lead the modern electronics industry.

Today we face the need for a comparable revolution in education. Ever since the birth of solid state physics, materials have been described in terms of average material parameters like the mobility or the optical absorption coefficient which are then used as inputs to macroscopic device models. This two-step approach is being widely used even for modern nanostructured materials, but we believe that it is no longer adequate to meet the challenges and opportunities of our day. An integrated approach is needed that embeds new ways of thinking, emerging from current research on nanoscience, directly into the models used for non-equilibrium problems like nanoscale transistors, energy conversion devices and bio-sensors. The objective of this initiative is to establish and disseminate the fundamentals of this novel viewpoint through a carefully coordinated collection of seminars, short courses and full-semester courses.

“Electronics from the Bottom-up” is designed to be a resource for educators and self-learners and a model for a new way of teaching electronic devices that we hope will inspire students and prepare them to contribute to the development of nanoelectronic technology in the 21st Century. This project, launched in the fall of 2006, is producing a set of educational resources that are being disseminated at summer schools, lectures, and on nanoHUB.org.

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2012 Summer School

July 16-20, Purdue University, West Lafayette, IN, USA

[2012 Summer School](#)

2011 Summer School

July 18-22, Purdue University, West Lafayette, IN, USA

The 2011 Summer School featured a set of ten lectures on the topic “Near-Equilibrium Transport: Fundamentals and Applications” and a set of five lectures on “Solar Cell

Fundamentals.” Five tutorials on selected topics in nanoscience and nanotechnology were also presented.

Summer Schools

- [2011 NCN@Purdue Summer School: Electronics from the Bottom Up](#)
 - [Near-Equilibrium Transport: Fundamentals and Applications](#) M. Lundstrom.
 - [Solar Cell Fundamentals](#) M. Lundstrom, J. Gray, and M. A. Alam.
 - [Thermal Transport Across Interfaces](#) T. Fisher.
 - [Atomistic Material Science](#) A. Strachan.
 - Additional Sessions:
 - Lessons from Nanoelectronics [Presentation](#), [Q&A](#), S. Datta.
 - Spin Transport and Topological Insulators [Part 1](#), [Part 2](#), S. Datta.
 - [Atomistic Modeling and Simulation Tools for Nanoelectronics and their Deployment on nanoHUB.org - Part 1](#) G. Klimeck.
- [2010 NCN@Purdue Summer School: Electronics from the Bottom Up](#)
 - [Nanoelectronic Devices. With an Introduction to Spintronics](#) S. Datta and M. Lundstrom.
 - [Additional Tutorials on Selected Topics in Nanotechnology](#) G. Klimeck, U. V. Waghmare, T. Fisher, N. S. Vidhyadhiraja.
 - [Tutorial 3: Materials Simulation by First-Principles Density Functional Theory](#) U.V. Waghmare.
 - [Tutorial 4: Far-From-Equilibrium Quantum Transport](#) G. Klimeck.
- [2009 NCN@Purdue Summer School: Electronics from the Bottom Up](#)
 - [Nanostructured Electronic Devices: Percolation and Reliability](#) M. A. Alam.
 - [Colloquium on Graphene Physics and Devices](#) S. Datta, M. Lundstrom and J. Appenzeller.
- [2008 NCN@Purdue Summer School](#)
 - [Nanoelectronics and the Meaning of Resistance](#) S. Datta.
 - [Physics of Nanoscale MOSFETs](#) M. Lundstrom.
 - [Percolation Theory](#) M. A. Alam.

Short Courses

- [Atomistic Material Science](#) Ale Strachan, Summer 2011.
- [Colloquium on Graphene Physics and Devices](#) Supriyo Datta, Mark Lundstrom and Joerg Appenzeller, Summer 2009.
- [Far-From-Equilibrium Quantum Transport](#) Gerhard Klimeck, Summer 2010.
- [Materials Simulation by First-Principles Density Functional Theory](#) U.V. Waghmare, Summer 2010.
- [Near-Equilibrium Transport: Fundamentals and Applications](#) Mark Lundstrom, Summer 2011.
- [Nanoelectronic Modeling: From Quantum Mechanics and Atoms to Realistic Devices](#),

Gerhard Klimeck, Fall 2009

- [Nanoelectronics and the Meaning of Resistance](#), Supriyo Datta, Summer 2008
- [Nanostructured Electronic Devices: Percolation and Reliability](#), M. Ashraf Alam, Summer 2009
- [Physics of Nanoscale MOSFETs](#), Mark Lundstrom, Summer 2008
- [Percolation Theory](#), M. Ashraf Alam, Summer 2008
- [Solar Cell Fundamentals](#) Mark Lundstrom, Jeff Gray, and M. Ashraf Alam, Summer 2011.
- [Thermal Transport Across Interfaces](#) T. Fisher, Summer 2011.
- [Concepts of Quantum Transport](#), Supriyo Datta, 2006

Full Semester Courses

- [Electronic Transport in Semiconductors](#), Mark Lundstrom, [Fall 2011](#), [Fall 2009](#)
- [Fundamentals of Nanoelectronics](#), Supriyo Datta, [Fall 2008](#), [Fall 2004](#)
- [Atom to Transistor](#), Supriyo Datta, [Spring 2009](#), [Spring 2004](#)

Seminars

- [Lessons from Nanoelectronics](#), Supriyo Datta
- [Spin Transport and Topological Insulators I](#), Supriyo Datta
- [Spin Transport and Topological Insulators II](#), Supriyo Datta
- [A Beginning Introduction](#), Supriyo Datta
- [McCoy Lecture: Nanodevices and Maxwell's Demon](#), Supriyo Datta
- [PASI Lecture: Nanodevices and Maxwell's Demon, Part 1](#), Supriyo Datta
- [PASI Lecture: Nanodevices and Maxwell's Demon, Part 2](#), Supriyo Datta
- [HCIS-15 Lecture: Nanodevices and Maxwell's Demon](#), Supriyo Datta
- [Physics of Nanoscale Transistors: An Introduction to Electronics from the Bottom Up](#), Mark Lundstrom
- [The Long and Short of Pick-up Stick Transistors: A Promising Technology for Nano- and Macro-Electronics](#), Ashraf Alam
- [Geometry of Diffusion and the Performance Limits of Nanobiosensors](#), Ashraf Alam, Pradeep Nair

Related Resources

- [Nanoscale Transistors](#), Mark Lundstrom, [Fall 2008](#), [Fall 2006](#)
- [Principles of Semiconductor Devices](#), Ashraf Alam

Those with comments or questions or who are interested in participating in this initiative should contact [Mark Lundstrom](#).

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