UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

"Energy, Thermal, and Thermoelectric Effects in Nanoscale Devices"

Prof. Eric Pop

Stanford University, USA
Dept. of Electrical Engineering and Materials Science & Engineering
SystemX Alliance and Precourt Institute for Energy

Short Abstract: In this short course, we will examine energy-related topics in modern nanoelectronics, from fundamentals to systems. Fundamental topics include energy storage and transfer via electrons and phonons, ballistic limits of current and heat, meso- to macroscale mobility and thermal conductivity. Applied topics include power in nanoscale devices (1D nanotubes and nanowires, 2D materials, 3D silicon CMOS, resistive memory and interconnects), circuit leakage, temperature measurements, thermoelectric energy conversion, and thermal challenges in densely integrated systems. The course is intended to bridge knowledge gaps between students with Electrical Engineering, Mechanical Engineering, Materials Science, and Physics backgrounds. Basic knowledge of semiconductors, transistors, and Matlab (or similar) are recommended.

Course Contents in brief:

1) Electrons and Phonons: Microscopic Origin of Macroscopic Laws
2) Quasi-Ballistic Current and Heat Flow
3) Boundary Scattering and Thermal Boundary Resistance
4) Self-Heating in Nanomaterials and Nanoscale Devices
5) Thermal Effects in Nanoscale Devices (CMOS, 1D, 2D, and memory)
6) Thermal Resistance – Device and System Estimates
7) Nanoscale Temperature Measurements
8) Thermoelectric Energy Conversion

Total # of hours: 16

References:

[1] E. Pop, "Energy Dissipation and Transport in Nanoscale Devices," *Nano Research* 3, 147 (2010)

[2] E. Pop et al., "Thermal Properties of Graphene: Fundamentals and Applications," *MRS Bull.* 37, 1273 (2012)

[3] E. Pop, "Monte Carlo Transport and Heat Generation in Semiconductors," *Annu. Rev. Heat Transfer* 17, 385 (2014)

[4] D. Cahill et al., "Nanoscale Thermal Transport II: 2003-2012", *Appl. Phys. Rev.* 1, 011305 (2014)

CV of the Teacher

Eric Pop (epop@stanford.edu) is an Associate Professor of Electrical Engineering (EE) and Materials Science & Engineering (MSE) at Stanford University. He was previously on the faculty of the University of Illinois Urbana-Champaign (2007-13) and also worked at Intel (2005-07). His research interests are at the intersection of electronics, nanomaterials, and energy. He received his PhD in EE from Stanford (2005) and three degrees from MIT (MEng and BS in EE, BS in Physics). His honors include the 2010 PECASE from the White House, and Young Investigator Awards from the ONR, NSF CAREER, AFOSR, and DARPA. He is an IEEE Senior member, he served as the General Chair of the Device Research Conference (DRC), and on program committees of the VLSI, IRPS, MRS, IEDM, and APS conferences. In a past life, he was a DJ at KZSU 90.1 from 2001-04. Additional info about the Pop Lab is available online at poplab.stanford.edu.

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Dates:

June 12, 14.00-17.00

June 13, 09.00-12.00

June 14, 09.00-12.00, 12.00-13.00 TBC

June 15, 09.00-12.00

June 16, 09.00-12.00