Muhammad A. Alam / Purdue University

"The Emerging Challenge of and Biomimetic Solutions to Self-heating in FINFET, ETSOI, Nanosheet, & Surround-gate Transistors: A Material, Device and System Perspective"

By early 2000s, many researchers would begin their talks with an iconic cartoon that compared the power dissipation of an IC, with that of a rocket nozzle and the Sun. The message was clear: the voltage must be scaled to keep power-dissipation at bay. Fast forward to 2017 – the tyranny of short channel effects at the sub 32 nm nodes has led to the development of FINFET and ETSOI technologies, with Si Nanosheet-FET and gate-all-around III-V transistors on the horizon. The short channel effects are controlled, but at the expense of additional self-heating of the system. Stacks of materials (many poor thermal conductors) now surround the very hot channel to make the bad situation worse. In this tutorial, I will explain how self-heating redefines and conflates the traditional notions of performance and reliability of transistors and frontend and backend reliability of modern ICs. I will also explain how high-frequency operation and novel biomimetic heat-dissipation strategies (e.g. inverse opal, 3D printing, etc.) may help manage this emerging performance and reliability challenge for sub-20nm technologies.

Muhammad A. Alam holds the Jai N. Gupta professorship at Purdue University, where his research focuses on the physics and technology of semiconductor devices. From 1995 to 2003, he was with Bell Laboratories, Murray Hill, NJ. Since joining Purdue in 2004, Dr. Alam has published over 300 papers and he is among the top-20 contributors on diverse topics involving transistors, reliability, biosensors, and solar cells. He is a fellow of IEEE, APS, and AAAS. His awards include the 2006 IEEE Kiyo Tomiyasu Medal for "Contributions to device technology", 2015 SRC Technical Excellence Award for "Fundamental contributions to reliability physics", and 2018 IEEE EDS Award for "For educating, inspiring, and mentoring students and electron device professionals around the world". More than 350,000 students worldwide have learned some aspect of semiconductor devices from his web-enabled courses.