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UB Engineers Tackle Nanoelectronics Roadblocks

Published: Saturday, February 25 2006 @ 7:55 PM CST
Contributed by: ByteEnable

BUFFALO, N.Y. – University at Buffalo engineers are working to solve two significant roadblocks impeding the creation of smaller, faster and more powerful electronic devices.



Working atom by atom, Cemal Basaran, Ph.D., and David Kofke, Ph.D., are taking on the problems of electromigration and thermomigration — the tendency for atoms to behave erratically when charged by the very high density electrical currents required to power super-small and super-powerful electronic devices.

Basaran is director of the [Electronics Packaging Lab](#) in the UB School of Engineering and Applied Sciences and is professor in its Department of Civil, Structural and Environmental Engineering. A UB Distinguished Professor, Kofke is chair of the Department of Chemical and Biological Engineering in the School of Engineering and Applied Sciences.

High electrical current densities and high temperature gradients create voids within metal conductors, the researchers explain. This leads to breakdowns in circuitry and results in device failure. Moreover, as electronic devices and their circuits get smaller — down to the nanoscale — the damaging effects of electromigration and thermomigration increase.

With the support of a \$250,000 grant from the National Science Foundation, Basaran and Kofke are using computer simulations and laboratory experiments to devise ways to lessen or stop electromigration and thermomigration. Engineers from the Intel Corp. are collaborating with the UB researchers on the project.

"Once we learn to stop this self-destructive process in metals, any component in a computer chip can be made at the nanoscale," says Basaran. "But unless you solve this problem, you cannot have fast-performing nanoelectronic devices, and further miniaturization in electronics may not be possible."

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The science of nanoelectronics is focused on creation of nanoscale circuits, wires and packaging of semiconductors. The goal of industry is to use these components to manufacture a new class of very small and very powerful electronic devices, such as wristwatch-sized supercomputers. One nanometer is about 1/100,000 of a human-hair diameter.

Working at the nanoscale level, the researchers intend to build semiconductor devices one atom at a time. According to Basaran, controlling placement of atoms in a material will give the researchers precise control of their properties, thus reigning in the erratic behavior that causes system breakdowns.

"When you design materials at the atomic scale you get properties you wouldn't get otherwise," Basaran says. "You get exact properties that you want instead of what nature dishes out for you. This means you can do things with a material that you couldn't imagine doing before with the same material."

The goal of the UB researchers is to design nanoscale chips, circuits and solder joints that can withstand very high current densities and very high temperature gradients.

"High current density changes everything," Basaran says. "It makes everything faster and more powerful. If you want a faster computer you need higher current density."

Today's computers operate at a maximum 1,000 amps per square centimeter. The UB researchers' work may one day enable computers to operate with a current density 1,000 times greater.

The University at Buffalo is a premier research-intensive public university, the largest and most comprehensive campus in the State University of New York.

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