groups had similar neuronal counts. The Aarhus neurobiologist believes his results show that cell loss does not accompany aging—even when there's obvious memory impairments—in rats. However, he's still concerned about the discrepancies between his human data, which do show some loss of hippocampal neurons, although not in the CA regions, and his results in rats, where there was no loss at all.

Still, other neurobiologists are enthused about the new neuronal counting method. "West's work is the definitive work in counting cells in the brain as a function of age or disease," says Paul Coleman, a neurobiologist at the University of Rochester Medical School in New York. But some experts aren't convinced that the older methods were flawed enough to produce consistently erroneous results. "I can't explain why there are discrepancies—Mark does excellent work—but I'm very confident in our data," says Landfield, now at the University of Kentucky College of Medicine in Lexington. The large gaps between cells and very obvious decreases in packing density in hippocampal tissue from older brains his team found cannot, he maintains, be explained by changes in the volume of the hippocampus. He adds that his team has recently completed a study using techniques similar to West's and still finds a decrease in neuron number with age.

Others, such as Stony Brook's Rapp, point out that West's behavioral tests failed to rule out reasons for a rat's poor performance in the water maze—such as age-related blindness or decreased motor skills—that have nothing to do with memory loss. If other factors were responsible, then a failure to find cell loss in the hippocampus would be less surprising. West agrees he couldn't test for everything, but insists his methods were good enough to pinpoint rats that had at least some types of cognitive impairment.

Everyone agrees that the only way to resolve the issue of what happens in the hippocampus during aging is with more data, and some of that may not be long in coming. Rapp and psychologist Michela Gallagher at the University of North Carolina, Chapel Hill, say they have new rat data corroborating West's results. "I think we're going to shortly arrive at a fairly convincing demonstration that hippocampal lesions don't exist [in normal aging]," predicts Gallagher.

If so, something else—perhaps a loss of connections between neurons or functional changes such as a disruption of cells' ability to communicate chemically with each other—could underlie a fading memory. In that case, the search would be on for treatments that could spell clearer skies for people under the forgetful cloud of old age.

**–Ingrid Wickelgren**

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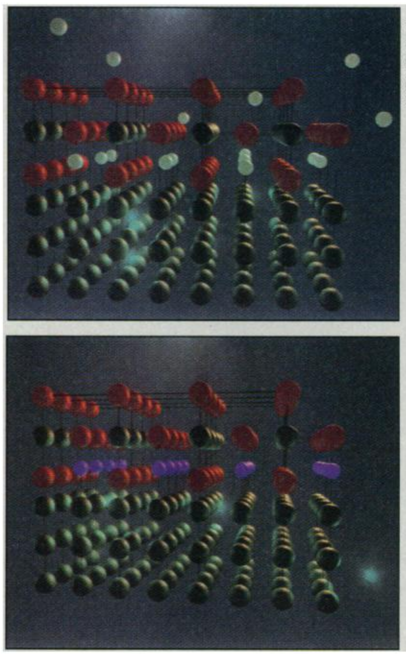
MICROELECTRONICS

# Isotope Switch Toughens Transistors

A favorite bugaboo of English teachers is the dangling modifier, a description unattached to any subject. When it comes to integrated circuits (ICs), though, the most dreaded hang-up of all is the dangling bond. Instead of hampering the flow of narrative, dangling bonds—unoccupied chemical binding sites in, say, silicon atoms—clutch at free electrons and resist the flow of current, slowing transistors and damaging them with the heat that's generated. Chipmakers try to delay the damage by diffusing hydrogen into nearly finished wafers to cap off the bonds. But as circuits get smaller and the electric fields that drive them get larger, that remedy falls short, as energetic "hot" electrons strip away the protective hydrogen.

That's why some semiconductor researchers are reaching for superlatives to describe the discovery that a simple isotope switch—deuterium for hydrogen—can improve transistor lifetimes by factors of 10 to 50, according to a paper just accepted at *Applied Physics Letters*. Twice as heavy as hydrogen but virtually identical chemically, deuterium is much harder to separate from bonds on a wafer's silicon substrate, say the authors, Joseph Lyding and Karl Hess of the Beckman Institute at the University of Illinois, Urbana-Champaign, and Isik Kizilyalli at AT&T Bell Laboratories in Orlando, Florida.



LYDING ET AL.

**Holding the line.** In simulations, deuterium atoms *(purple)* cluster at a silicon-oxide boundary, while hydrogens *(white)* stray.

The finding "has huge implications worldwide," says Dan DiMaria of IBM's Thomas J. Watson Research Center in Yorktown Heights, New York. It could be "extremely important," he says, for understanding chip failure. And while some researchers, including DiMaria, doubt that the technique will quickly penetrate chip manufacturing because of the large investment in existing protective strategies, others suggest that it could soon yield more durable circuits that could be driven harder.

The bonds in question lie at the interface between a wafer's silicon base, or substrate, and the insulating layer of silicon dioxide grown over it. Current flows along this interface when the circuit—a transistor, for example—is open. The problem, says Hess, is that the oxide "does not fit perfectly on top of the silicon," having a slightly larger spacing between the atoms in its lattice. This mismatch leaves dangling silicon bonds that can snap up electrons and impede current flow.

For decades, says Hess, chipmakers have battled this problem by bathing chips in hydrogen gas during a final, high-temperature "annealing" step. The hydrogen atoms slip through the IC's layers and terminate the dangling bonds—at least until hot electrons strip away the hydrogen. Other measures, such as incorporating nitrogen into the oxide lattice, which may help confine the hydrogen, or designing a transistor's current drain to reduce the maximum electric fields, can help. But they can be expensive and cut into performance.

That's where matters stood until last October, says Lyding, when he was "shooting the breeze" in Hess's office about some basic experiments he had done showing that deuterium is much harder to knock loose from a bare silicon surface than hydrogen is. When Hess saw the work's implications for ICs—his own specialty—he "jumped out of his chair," says Lyding. They gave the deuterium treatment to some chips obtained from AT&T, then began collaborating with Kizilyalli, who showed the large improvement in lifetime in "accelerated" tests that drive the chips harder than spec. At least part of the explanation is simple, says Hess: "If you played pool and had a smaller [cue] ball, it would not transfer as much energy to the bigger balls"—the larger deuterium atoms.

"I didn't realize [the effect] would be so major," says Kizilyalli. Because deuterium is inexpensive and the treatment is simple, "it will be readily adopted by industry," says Jeffrey Bude of AT&T Bell Laboratories in Murray Hill, New Jersey.

Others aren't so sure. "This kind of data really needs to be verified" by other groups, says Leo Yau of Intel Corp. in Beaverton, Oregon, and industry will want to know whether the technique is compatible with existing processes. Still, the dread of the dangling bond is so great that even Yau admits, "If it works, people will use it."

**–James Glanz**