Department of Physics & Astronomy

PHYSICS NEWS FLASH

Breaking the Right Bonds for Better Chips

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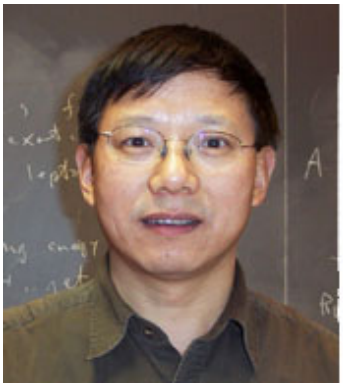

Dr. Zhenyu Zhang

Dr. Zhenyu Zhang is a member of the research team that has successfully used laser light to selectively strip hydrogen from silicon, an accomplishment that could mean more microchips for less money.

When silicon chips debuted in 1961 they became the cornerstone of today's microelectronics industry. Four decades later, they can house millions of transistors on a surface smaller than a penny. These microchips are built by stacking layers of silicon one on top of the other. Each layer is "terminated" by adding hydrogen atoms, which bond to the silicon and protect the layer from contamination, maintaining electrical stability. The hiccup has been that those hydrogen atoms have to be removed to add the next silicon layer. Historically this has involved using high temperatures, which risks damaging the layers and results in fewer chips and lost revenue. In the May 19 issue of *Science*, Dr. Zhang and his colleagues from the University of Minnesota and Vanderbilt University show that laser light can successfully break the bonds between hydrogen and silicon at room temperature.

The hydrogen-silicon bond has well-understood properties. The research team tuned a free-electron laser to frequencies where those bonds typically vibrate. When light photons from the laser and the bonds vibrate in synch, the bonds absorb the light and split apart. The scientists found the process generated very little heat, and could be completed with a high level of selectivity—essentially "cherry-picking" hydrogen atoms from the surface.

"This is one of the dream projects of a scientist, in the sense that a significant step forward in some fundamental research may indeed influence the everyday life of the society," Dr. Zhang said. "If this discovery could eventually lead to a technology for fast and mass production of high purity silicon crystals at low growth temperatures, the whole semiconductor industry will benefit substantially, as well as the solar energy industry."

The team of Dr. Philip I. Cohen of the University of Minnesota, Dr. Leonard C. Feldman, Dr. Norman Tolk, and Dr. Zhiheng Liu of Vanderbilt, and Dr. Zhang developed the laser technique for selective bond breaking. The experimental work reported in the Science article was conducted at Vanderbilt's W.M. Keck free-electron laser center, and was motivated by a theoretical prediction, reported in a 2004 *Applied Physics Letters*, of Dr. Biao Wu of Oak Ridge National Laboratory, Dr. Cohen, Dr. Feldman, and Dr. Zhang.

Dr. Zhang joined the University of Tennessee in 1997, two years after coming to East Tennessee as a research scientist at Oak Ridge National Laboratory. He has been a Professor

of Physics (UT/ORNL Joint Faculty) since 2003. Dr. Zhang earned his Ph.D. in physics at Rutgers University in 1989. He is a fellow of the American Physical Society and is the co-founding director of the International Center for Quantum Structures of the Chinese Academy of Sciences.