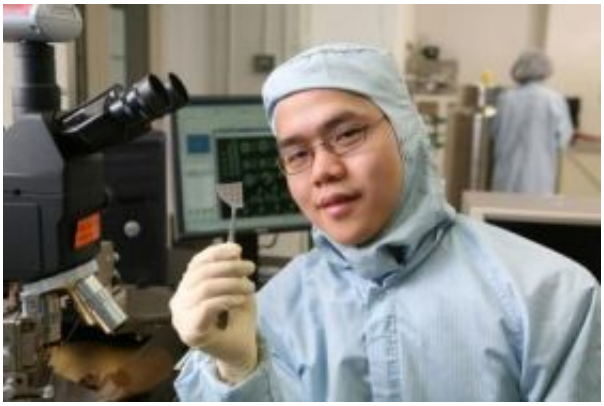
Rensselaer student invents alternative to silicon chip

May 13 2008



Weixiao Haung and new GAN transistor. Credit: Rensselaer Polytechnic Institute

Even before Weixiao Huang received his doctorate from Rensselaer Polytechnic Institute, his new transistor captured the attention of some of the biggest American and Japanese automobile companies. The 2008 graduate's invention could replace one of the most common pieces of technology in the world—the silicon transistor for high-power and high-temperature electronics.

Huang, who comes from humble roots as the son of farmers in rural China, has invented a new transistor that uses a compound material known as gallium nitride (GaN), which has remarkable material properties. The new GaN transistor could reduce the power consumption

and improve the efficiency of power electronics systems in everything from motor drives and hybrid vehicles to house appliances and defense equipment.

“Silicon has been the workhorse in the semiconductor industry for last two decades,” Huang said. “But as power electronics get more sophisticated and require higher performing transistors, engineers have been seeking an alternative like gallium nitride-based transistors that can perform better than silicon and in extreme conditions.”

Each household likely contains dozens of silicon-based electronics. An important component of each of those electronics is usually a silicon-based transistor know as a silicon metal/oxide semiconductor field-effect transistor (silicon MOSFET). To convert the electric energy to other forms as required, the transistor acts as a switch, allowing or disallowing the flow of current through the device.

Huang first developed a new process that demonstrates an excellent GaN MOS (metal/oxide/GaN) interface. Engineers have known that GaN and other gallium-based materials have some extremely good electrical properties, much better than silicon. However, no useful GaN MOS transistor has been developed. Huang’s innovation, the first GaN MOSFET of its kind in the world, has already shown world-record performance according to Huang.

In addition, Huang has shown that his innovation can integrate several important electronic functions onto one chip like never before. “This will significantly simplify entire electronic systems,” Huang said. Huang has also designed and experimentally demonstrated several new novel high-voltage MOS-gated FETs which have shown superior performance compared to silicon MOSFET in terms of lower power consumption, smaller chip size, and higher power density.

The new transistors can greatly reduce energy loss, making energy conversion more efficient. “If these new GaN transistors replaced many existing silicon MOSFETs in power electronics systems, there would be global reduction in fossil fuel consumption and pollution,” Huang said.

The new GaN transistors can also allow the electronics system to operate in extremely hot, harsh, and high-power environments and even those that produce radiation. “Because it is so resilient, the device could open up the field of electronic engineering in ways that were not previously possible due to the limitations imposed by less tolerant silicon transistors,” he said.

Huang has published more than 15 papers during his time as doctoral student in the Department of Electrical, Computer, and Systems Engineering at Rensselaer. Despite obvious difficulties, his parents worked tirelessly to give Huang the best possible educational opportunities according to Huang. And when school wasn’t enough, Huang’s father woke him up early every morning to practice mathematical calculations without a calculator, instilling in Huang a lifelong appreciation for basic, theoretical mathematics and sciences.

He received a bachelor’s in electronics from Peking University in Beijing in 2001 and a master’s in physics from Rensselaer in 2003. He will receive his doctorate from Rensselaer on May 17, 2008 and plans to work as a device engineer in the semiconductor industry.

Source: Rensselaer Polytechnic Institute