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Faculty awarded nearly $128,000 in WiSys grants

PLATTEVILLE, Wis. – University of Wisconsin-Platteville faculty have been awarded three separate applied research grants from the WiSys Technology Foundation – a quarter of all of the applied research grants distributed across UW System's campuses this year. Combined, UW-Platteville's grants total nearly $128,000. This year's UW-Platteville recipients include Dr. Hal Evensen, professor of engineering physics; Dr. Muthu Venkateshwaran, assistant professor of soils and crop science; and Dr. Wei Li, professor of engineering physics.

Evensen and Charles Nelson, a senior electrical engineering major, are researching technology that could ultimately impact the development of smaller and more powerful laptops, tablets, smartphones and similar handheld electronics. The duo is investigating an alternate design for the transistor, a semiconductor device that is fundamentally the building block for all electronics. Evensen and Nelson are exploring the use of carbon nanotube transistors as an alternative to the commonly-used silicon transistors, which pose some limitations.

A backdrop for Evensen and Nelson's project is a theory that originated in 1965 by Gordon Moore, co-founder of Intel. Moore's Law posits that the number of transistors that can fit on a chip is doubling every year and will continue to do so. This has proven true over time and is the reason electronics continue to get smaller and faster. However, according to Evensen, eventually we will run into physical limitations in the number of silicon transistors that can fit on a chip, which is why molecular electronics – such as carbon nanotubes – need to be explored as an alternative.

Evensen and Nelson's project is based on work that Evensen completed two years ago with a research team at UW-Madison while on sabbatical. The team worked on isolating purely carbon nanotubes, and for the first time recently, those carbon nanotube transistors outperformed silicon transistors.

With the help of the WiSys grant, Evensen and Nelson are building on this success and investigating a nanoscale vacuum-channel field effect transistor from aligned carbon nanotubes. Their project idea is actually based on an antiquated concept: earliest computers used vacuum tubes that contained electrodes for controlling electron flow, allowing them to be used as a switch or amplifier. These were eventually replaced by transistors. In the nanoscale vacuum channel transistor, a typical vacuum tube operation is mimicked, using carbon nanotubes as the electrodes. Electrons are traveling across a space as small as 100 nanometers, reducing the possibility of colliding with air molecules. Also, in an old-fashioned vacuum tube, electrons were generated with a hot wire; in this nanoscale model, heat is not required – instead, a low voltage will emit electrons – helping devices rely on less power and solving issues of overheating.

"Right now, all of our transistors are on a big plane, and conceptually we could stack them up, but we can't because they generate too much heat," said Evensen. "However, if they generate less heat we can, and this would allow us to go three dimensional, and something like our computer or phone could contain a lot more processing power."

Evensen said the opportunity for students to be involved in projects such as this one is invaluable. "When they are interviewing with an employer and they can tell them that they used an atomic microscope at only 20 years old, that implies a level of responsibility and maturity for the student," said Evensen. "Also, students appreciate when we use the ideas we teach them in class, and it's important for them to see that things don't always work the first time. When we give them labs in class, they work because we tell them what to do. But, when they work on a project like this, they learn that iterative process and venture into the unknown."

Venkateshwaran's project explores alternative methods to plant disease management using naturally occurring volatile organic compounds isolated from plant growth-promoting rhizobacteria. These compounds have proven to successfully defend plants against disease-causing pathogens, but their use is limited because they quickly evaporate when applied directly in the field. In collaboration with Dr. Raja Annamalai, assistant professor of chemistry, Venkateshwaran is investigating the use of inexpensive and biodegradable polymers as a method of encapsulating the volatile organic compounds, causing them to release in a controlled manner at concentrations sufficient to induce a plant's defense mechanisms against invading pathogens.

Conventional crop production heavily relies on the use of pesticides, which include synthetic herbicides, insecticides and fungicides. These products, according to Venkateshwaran, add significant cost to producers and can pose environmental threats. Furthermore, despite the large investments in disease management made by producers, crop loss due to plant diseases is still a problem – in part because of the emergence of resistant strains of pathogens caused by extensive fungicide use. This technology has the potential to augment or decrease the need for synthetic fungicides and insecticides currently used to control crop pathogens, without the negative impacts associated with their use.

Students from both the soil and crop science and chemistry programs are helping with the research. "This type of research really engages students in active learning," said Venkateshwaran. "When students work on a project like this, it promotes critical thinking and problem-solving skills, team work and project management – a variety of skills that are not feasible to learn in the short time period of a regular lab session."

Venkateshwaran added that the cross-collaboration with chemistry students adds an extra opportunity to the project. "I'm working with really enthusiastic students from the chemistry department right now, and without this opportunity I would not have met them," he said. "The chemistry students learn the plant biology and plant pathology aspects of the project and our soil and crop science students get to learn about the chemistry aspects of the project.”

Li’s project builds on his past successful research, supported by the WiSys Technology Foundation, involving quantum dots – man-made nanoparticles. Quantum dots have a variety of applications from lasers to LED light sources, optoelectronics and medical science. Fabrication of quantum dots, however, is both expensive and time consuming, requiring a trial-and-error fabrication approach.

With the help of this grant, Li hopes to create a semiconductor quantum dot computer-aided engineering simulator, capable of calculating the quantum dot electronic and optical properties accurately and efficiently. This could lead to the first-ever commercial quantum dot design simulation software in the market.

“Think about the electronics or photonics industry and what people do before fabricating,” said Li. “They use computer-aided software to design the devices or systems and then they fabricate them. The engineers can improve the designs and do whatever they can think of without adding any cost. Quantum dot technology is new and a software is needed to simulate and design the quantum dots before the fabrication, too.”

Two engineering physics students – Samuel Belling and Heather Cihak – are currently assisting Li with this project. Belling has been working on the project since last summer. “Students benefit greatly from this research,” said Li. “It helps give them a clear career plan for what they want to do in the future, and it makes them competitive.”

WiSys collaborates with UW System to offer the faculty grant programs each year. The applied research grants aim to encourage faculty and staff to utilize their expertise and apply their scholarship to support economic development in Wisconsin.

WySis is holding its annual conference at UW-Platteville on July 24-25. For more information, visit http://www.wisys.org/events/.

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