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Oder Researches Schottky Contacts

Dr. Tom N. Oder, assistant professor of physics and astronomy, has been researching wide band gap semiconductors. Oder says, "These are different from traditional semiconductors, such as silicon, which have been used in most electronic devices such as computer chips or laser diodes that operate CD players." These traditional semiconductors unfortunately fail to operate under harsh conditions of high temperature or high electrical power. This shortcoming has led to a search for alternatives.

Wide band gap semiconductors have characteristics that allow them to withstand high temperatures and high power yet work quickly with high frequency. This could eliminate the need for cooling. Oder elaborates, "If you have to use a device in a hot environment, usually you have to cool it down so it doesn't fail. If the semiconductor material that you're using can work without cooling, that can save lots of money. It also can withstand a lot of high power, such as in switching controls."

For his doctoral degree, Oder researched a semiconductor called silicon carbide, which has been studied for about fifteen years. For his post-doctoral research, he studied III-nitrides. These both belong to the family of wide band gap semiconductors. He explains, "The purpose of my research is to try to enhance the knowledge base for high power and high temperature applications. Specifically, what I am doing now is developing metal contacts."

Every semiconductor device has to have a metal contact of various types of metal that must be deposited on the semiconductor. Oder says, "When you're controlling communication in and out, you have to apply electrical current into the semiconductor device, usually through the means of the metal that you've deposited on the semiconductor."

Dr. Tom Oder and student Pam Martin work at the YSU Sputter Deposition System, which under high heat will improve the physical and electrical qualities of metal films deposited on semiconductors.

If a device is going to work at high temperatures, then the metal must also be able to withstand that temperature. Oder says, "What I'm doing is research on metal contacts that have very good properties—both electrical properties and thermal properties."

These metal contacts can be one of two types—ohmic or Schottky. Oder says, "An ohmic contact is one in which when you apply voltage, you get high current, always proportionate to the voltage.

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Dr. Thomas N. Oder, assistant professor of physics and astronomy

So the idea is that you want to apply as little voltage as possible to get the necessary current, so you can drive the current with very little energy."

Oder has been focusing on the Schottky contacts. He explains, "The Schottky contact is for use in devices for controlling the current to not flow in one direction but to flow in another. It's a rectifying contact. Usually currents want to flow both ways, and this contact controls it and makes it flow in only one way."

Oder received YSU Research Professorships for 2004–2005 and 2005–2006 to study Schottky contacts on III-nitride semiconductors. "There is a need to develop thermally stable and electrically efficient contacts on the III-nitride semiconductors using quick and inexpensive methods to enhance performance, reliability, and technology transfer for applications above six hundred degrees Celsius," he says.

An example of a harsh environment that could benefit from such a metal contact is a car engine. Oder says, "Inside today's cars, there are electronics that control the engine. The temperature in some engines can go as high as six hundred degrees Celsius, so you have to cool the semiconductor. If you can make one that doesn't need to be cooled, you could eliminate the cooling system, which would make the car lighter. It could also increase the car's lifespan and save costs."

Another possible application is jet aircraft. Oder states, "In jet engines, silicon-based avionics are cooled with jet fuel pumped through heat exchangers. The cooling system introduces serious drawbacks, including addition of a substantial amount of weight, which lowers the efficiency and reliability of the devices."

Another critical area is electrical power generation. Oder states, "At the switching stations, a lot of power is being sent during switching. We saw the results in the major blackout that took place a couple of summers back. I don't know the exact cause of that, but I would guess it related to the failure of an electronic device due to the great amount of high power coming into the device." Metal contacts with superior electrical properties that could withstand such high power could solve this problem.

While doing his post-doctoral research at Kansas State University, Oder developed a micro lens. Optical devices that emit light are being scaled down like other devices. Oder explains, "One of the ways in which you can shape the light that you produce is by using a lens. If your device is in micrometer units, then you want your lens to be micrometer size. However, lenses have to be transparent so they can transmit light of whatever wave length. The III-nitride semiconductor that I'm working on . . . is not only going to be useful for visible light, but it can go to blue and UV light, too. So it has a wide range of applications." Oder has a patent pending on this lens.

When asked if he's had any notable surprises or disappointments in his research, Oder replied, "There are always surprises and disappointments because you always want whatever you do to succeed immediately. That's not what happens in reality. It takes time and persistence. I'm getting some promising results." He presented some of those results in June at the 2005 Electronic Materials Conference in California.

Oder does most of his research at YSU in the wide band gap semiconductor laboratory. He buys needed materials with allocated funds or else collaborates with other researchers. At Kansas State, there are facilities that can produce the semiconductor device materials, and he requests some from there.

When asked if there would be an end-point to this research, Oder answered, "There will always be something. With time, there are other things you have to look at that you don't have time for in the beginning. So there has to be a focus for the moment, and with time, you may redirect your focus to something altogether new or to something that came out of what you've been doing."

Oder believes it is very important to integrate research into education so that students are being trained in how to conduct research. He tries to involve his students as much as possible and has had four students involved in his research. He trains them how to use the equipment safely and properly and conduct tests. He wants his students to be able to

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