Gem of an idea: A flexible diamond-studded electrode implanted for life

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(PhysOrg.com) -- Diamonds adorning tiaras to anklets are treasures but these gemstones inside the body may prove priceless.

Two Case Western Reserve University researchers are building implants made of diamond and flexible polymer that are designed to identify chemical and electrical changes in the brain of patients suffering from neural disease, or to stimulate nerves and restore movement in the paralyzed.

The work of Heidi Martin, a professor of chemical engineering, and Christian Zorman, a professor of electrical engineering and computer science, is years from human trials but their early success has drawn interest worldwide.

"Right now, we're trying to develop diamond-coated electrodes for implantable devices which last a lifetime," Martin said. "A patient would have one surgery and that's it."

For most materials, it's hell inside the body. But even inside us, a diamond is forever. Unlike standard electrodes, diamonds won't corrode, Martin said.

Diamond is so hard and rigid, however, that an entire implant made of the stuff would quickly damage surrounding tissue and the body would seal off the implant as if it were a splinter, Zorman said.

The key is to use just enough diamond. " We only need diamond at the biological interface – where the device connects with a nerve," Zorman said.

To marry one of the world's hardest materials and a flexible plastic, Martin and Zorman use much the same process used to manufacture computer chips.

Martin's lab grows diamond film – real diamond - under high temperature, in a vacuum. By adding impurities they change the diamond's properties. For electrodes, the team adds boron, turning the diamond blue. Blue diamonds, including the famous Hope Diamond at the Smithsonian, conduct electricity.

Because diamond is made at 800 to 900 degrees Celsius, a temperature that would melt the polymer base, Martin first selectively grows a series of tiny squares of diamond film on silicon dioxide, the stuff of sand and quartz.

Zorman's group then lays down a thin flexible polymer that fills in the gaps between diamonds, followed by a layer of metal that connects to the back of the diamonds and will conduct electricity. Lastly, he adds a thick layer of flexible polymer base. They then dip the device in hydrofluoric acid, which eats away the silicon dioxide and frees the probe.

Small, cortical probes that measure chemical changes at a location in the brain or along a nerve have two diamond contacts affixed. These probes are designed to assist health researchers who are trying to understand the role of chemicals in stimulating nerves or communicating within the brain.

Recent research has found, for example, a link between a deficiency in the neurotransmitter dopamine and Parkinson's disease.

Currently, medical researchers are using carbon-based needle electrodes to monitor neurotransmitters. But, the electrode is fragile – a glass tube supports the carbon, Martin said. The polymer and diamond probe can remain in the body much longer and the diamond has proved exceptional at chemical sensing, Martin said.

Martin and Zorman also build electrodes with arrays of eight or more electrically-connected diamond segments. These are designed for neruoprostheses, to stimulate nerves, enabling a paralyzed patient to stand or a blind patient to see.

With space inside the body at a premium, the diamond has another advantage. Lab tests show one diamond-coated electrode can monitor chemical and electrical signals as well as stimulate nerves.

Martin has also found another way to make a flexible probe coated with diamond, by growing diamond film on a wire of rhenium alloy. Metals typically become brittle in the high-heat of diamond processing.

But she's able to bend a diamond-coated tungsten-rhenium wire 75 degrees before fracturing and a molybdenum-rhenium alloy more than 90 degrees.

Martin, Zorman and their lab staff have been invited to several leading international conferences this year to talk about the work, including the Electrochemical Society meeting in Vancouver in April and the European Materials Research Society meeting, Strasbourg, France in June. They also presented this work at the 2010 Solid State Sensor, Actuator and Microsystems Workshop in Hilton Head SC in June.

Martin spoke at Budapest, Diamond 2010: 21st European Conference on Diamond, Diamond-Like Materials, Carbon Nanotubes, and Nitrides, last month and will talk at a Veterans' Affairs seminar in Cleveland in

December.

"The potential to help make a device that can help clinically and advance research would be so thrilling," Martin said. "The time scale is long, but I think we have a good chance at it."

Provided by Case Western Reserve University

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