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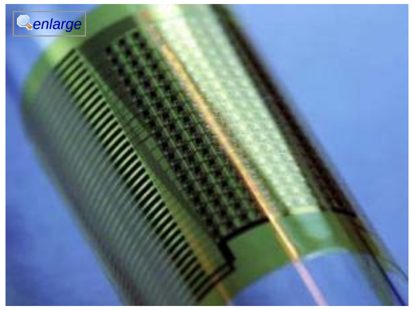
Stretchable Electronics Device Holds Promise for Treating Irregular Heart Rhythms

ScienceDaily (Mar. 24, 2010) — The electronics can bend, stretch and twist. No small feat. Now the flexible and stretchable electronics can map waves of electrical activity in the heart with better resolution and speed than that of conventional cardiac monitoring technology.



A new type of implantable device uses flexible silicon technology. (Credit: Dae-Hyeong Kim, Ph.D., University of Illinois)

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Researchers from Northwestern University, the University of Illinois at Urbana-Champaign and the University of Pennsylvania are the first to demonstrate a flexible silicon electronics device used for a medical application. The thin device produced high-density maps of a beating heart's electrical activity, providing potential means to localize and treat abnormal heart rhythms.

The results are published as the cover story in the March 24 issue of the journal *Science Translational Medicine*.

The emerging technology holds promise for a new generation of flexible, implantable medical devices, for the treatment of abnormal heart rhythms or epilepsy, as well as new flexible sensors, transmitters, and photovoltaic and microfluidic devices.

"The heart is dynamic and not flat, but electronics currently used for monitoring are flat and rigid," said Northwestern's Yonggang Huang, a senior author of the paper. "Our electronics have a wavy mesh design so they can wrap around irregular and curved surfaces, like the beating heart. The device is thin, flexible and stretchable and brings electronic circuits right to the tissue. More contact points mean better data."

Huang is the Joseph Cummings Professor of Civil and Environmental Engineering and Mechanical Engineering at the McCormick School of Engineering and Applied Science.

The device, capable of directly sensing and controlling activity in animal tissue, is based on flexible electronics developed in 2008 by Huang and his collaborator John A. Rogers at the University of Illinois. Brian Litt, M.D., of the University of Pennsylvania, and his colleagues designed the medical experiments and tested the device in a large animal model.

Rogers and Litt are senior authors of the paper. Rogers is the Flory-Founder Chair Professor of Materials Science and Engineering at Illinois; Litt is associate professor of neurology and associate professor of bioengineering at Penn.

In the experiments conducted at Penn, the team demonstrated that the electronics continue to operate when immersed in the body's fluids, and the mechanical design allows the device to conform to and wrap around the body's irregularly shaped tissues. The device uses 288 contact points and more than 2,000 transistors positioned closely together. Standard clinical systems usually have only five to 10 contact points. (The new device is 14.4 millimeters by 12.8 millimeters, roughly the size of a nickel.)

By bringing electronic circuits right to the tissue, rather than having them located remotely, the device can process signals right at the tissue. This close contact allows the device to have a much higher number of electrodes for sensing or stimulation than is currently possible in medical devices.

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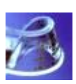

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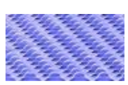

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The device can collect very large amounts of data from the body, at high speed. Researchers will be able to map the body's complicated electrical networks in much more detail, with more effective implantable medical devices and treatments likely to emerge.

The current device is not wireless. The next big step in this new generation of implantable devices, say the researchers, will be to find a way to move the power source onto them. One solution could be to have the heart power the device.

Huang and Rogers' so-called "pop-up" technology allows circuits to bend, stretch and twist. Such electronics can be used in places where flat, unbending electronics would fail, like the heart, brain or other places on the human body.

Any significant bending or stretching to circuits renders an electronic device useless, which is what limits current electronics for use on the body. Huang and Rogers jumped this sizeable hurdle by creating an array of tiny circuit elements connected by metal wire "pop-up bridges." When the array is bent or stretched, the wires -- not the circuits -- pop up. This approach allows circuits to be placed on a curved surface. (In the partnership, Huang focuses on theory and design, and Rogers focuses on the fabrication of the devices.)

The title of the paper is "A Conformal, Bio-Interfaced Class of Silicon Electronics for Mapping Cardiac Electrophysiology." In addition to Huang, Rogers and Litt, other authors of the paper are Jianliang Xiao, of Northwestern; Dae-Hyeong Kim and Yun-Soung Kim, of the University of Illinois; and Jonathan Viventi, Justin A. Blanco, Nicholas Annetta, Andrew Hicks, Joshua D. Moss and David J. Callans, of the University of Pennsylvania.

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Journal Reference:

1. Yonggang Huang, John A. Rogers, Brian Litt et al. **A Conformal, Bio-Interfaced Class of Silicon Electronics for Mapping Cardiac Electrophysiology**. *Science Translational Medicine*, (in press)

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