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Flexible electronics could help put Arrhythmic hearts back on rhythm

Mar 24, 2010 - Arrhythmic hearts soon may beat in time again, with minimal surgical invasion, thanks to flexible electronics technology developed by a team of University of Illinois researchers, in collaboration with the University of Pennsylvania School of Medicine and Northwestern University. These biocompatible silicon devices could mark the beginning of a new wave of surgical ele

Engineers Edge - Arrhythmic hearts soon may beat in time again, with minimal surgical invasion, thanks to flexible electronics technology developed by a team of University of Illinois researchers, in collaboration with the University of Pennsylvania School of Medicine and Northwestern University. These biocompatible silicon devices could mark the beginning of a new wave of surgical electronics.

Co-senior author John Rogers, the Lee J. Flory-Founder Chair in Engineering Innovation and a professor of materials science and engineering at Illinois, and his team will publish their breakthrough in the cover story of the March 24 issue of Science Translational Medicine.

Several treatments are available for hearts that dance to their own tempo, ranging from pacemaker implants to cardiac ablation therapy, a process that selectively targets and destroys clusters of arrhythmic cells. Current techniques require multiple electrodes placed on the tissue in a time-consuming, point-by-point process to construct a patchwork cardiac map. In addition, the difficulty of connecting rigid, flat sensors to soft, curved tissue impedes the electrodes' ability to monitor and stimulate the heart.

Rogers and his team have built a flexible sensor array that can wrap around the heart to map large areas of tissue at once. The array contains 2,016 silicon nanomembrane transistors, each monitoring electricity coursing through a beating heart.

The Pennsylvania team demonstrated the transistor array on the beating hearts of live pigs, a common model for human hearts. They witnessed a high-resolution, real-time display of the pigs' pulsing cardiac tissues â€“ something never before possible.

"We believe that this technology may herald a new generation of devices for localizing and treating abnormal heart rhythms," said co-sernior author Brian Litt, of the University of Pennsylvania.

"This allows us to apply the full power of silicon electronics directly to the tissue," said Rogers, a renowned researcher in the area of flexible, stretchable electronics. As the first class of flexible electronics that can directly integrate with bodily tissues, "these approaches might have the potential to redefine design strategies for advanced surgical devices, implants, prosthetics and more," he said.

The biocompatible circuits â€“ the first ones unperturbed by immersion in the body's salty fluids â€“ represent a culmination of seven years of flexible electronics study by Rogers' group. The researchers build circuits from ultrathin, single-crystal silicon on a flexible or stretchy substrate, like

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a sheet of plastic or rubber. The nanometer thinness of the silicon layer makes it possible to bend and fold the normally rigid semiconductor.

"If you can create a circuit that's compliant and bendable, you can integrate it very effectively with soft surfaces in the body," such as the irregular, constantly moving curves of the heart, Rogers said.

Collaborations with a theoretical mechanics group at Northwestern University, led by Younggang Huang, yielded important insights into the designs.

The patchwork grid of cardiac sensors adheres to the moist surfaces of the heart on its own, with no need for probes or adhesives, and lifts off easily. The array of hundreds of sensors gives cardiac surgeons a more complete picture of the heart's electrical activity so they can quickly find and fix any short circuits. In fact, the cardiac device boasts the highest transistor resolution of any class of flexible electronics for non-display applications.

The team's next step is to adapt the technology for use with non-invasive catheter procedures, Rogers said. The U. of I. and Pennsylvania teams also are exploring applications for the arrays in neuroscience, applying grids to brain surfaces to study conditions of unusual electrical activity, such as epilepsy.

"It sets out a new design paradigm for interfacing electronics to the human body, with a multitude of possible applications in human health," Rogers said.

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