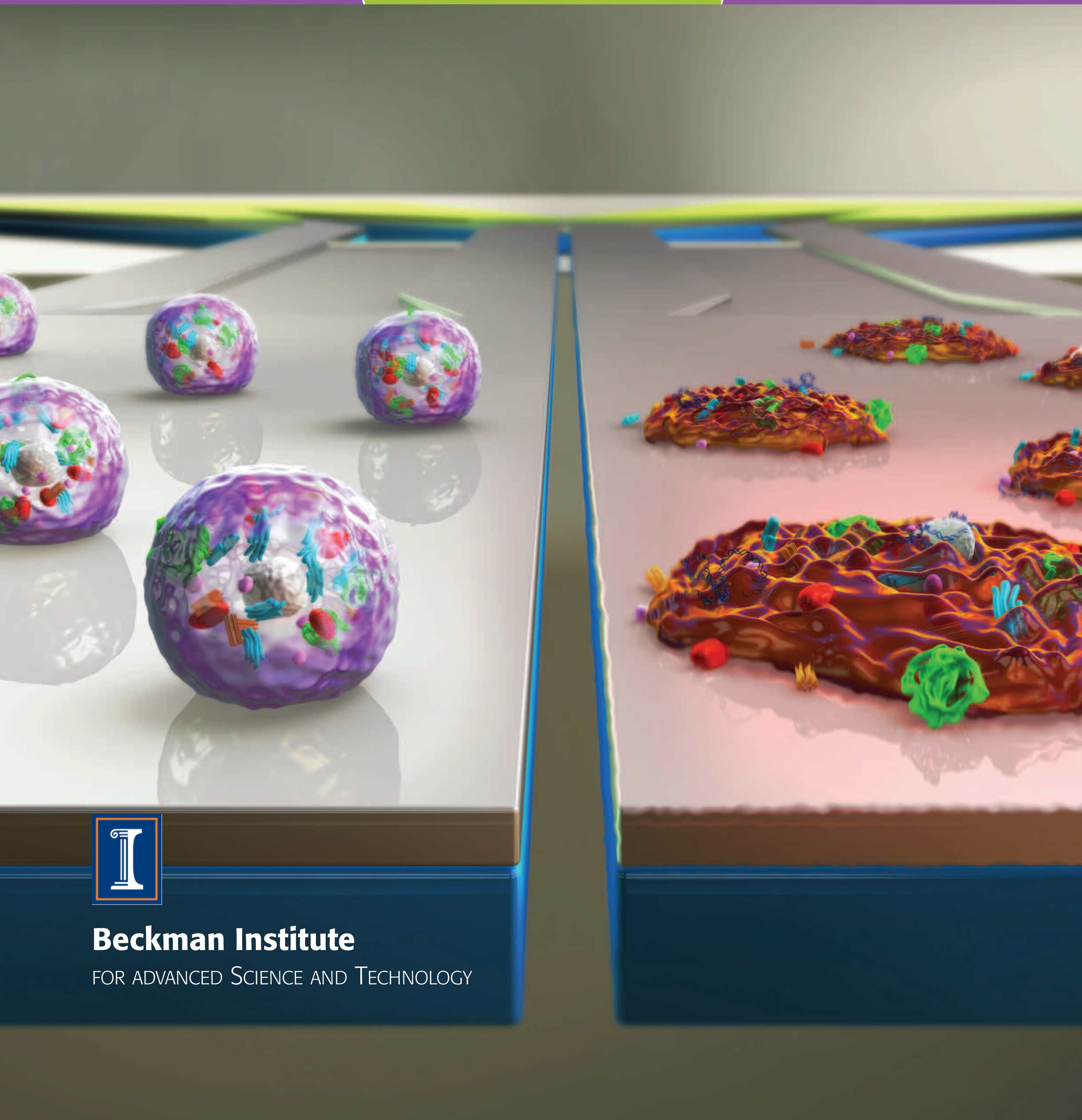
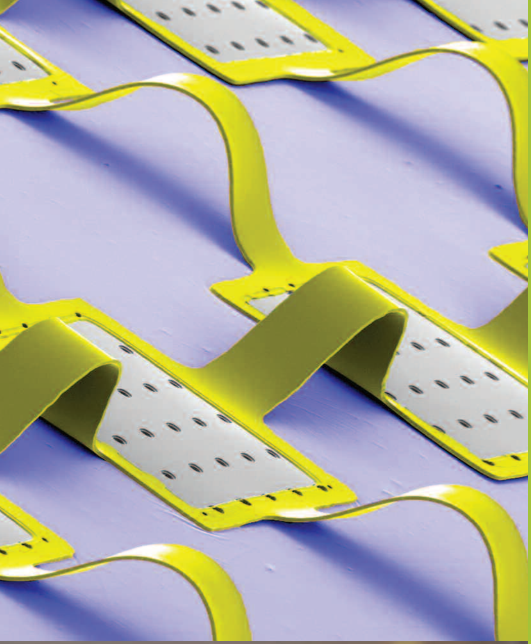
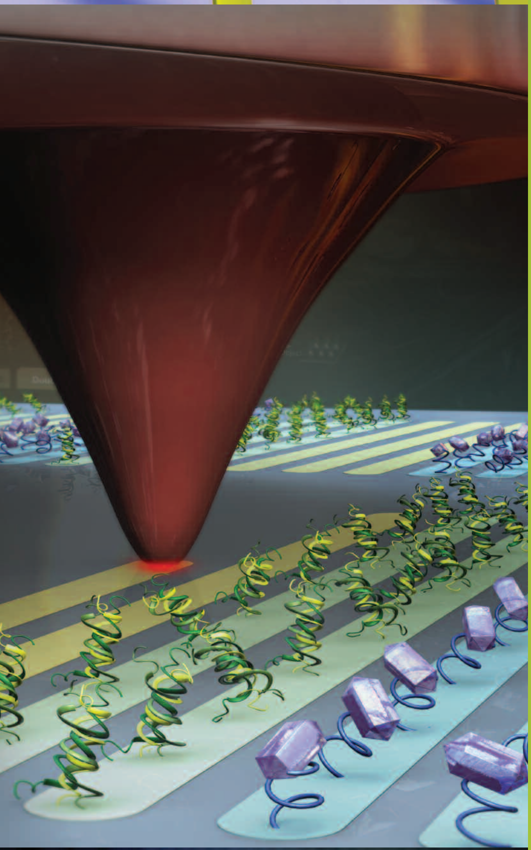
Electronics Research

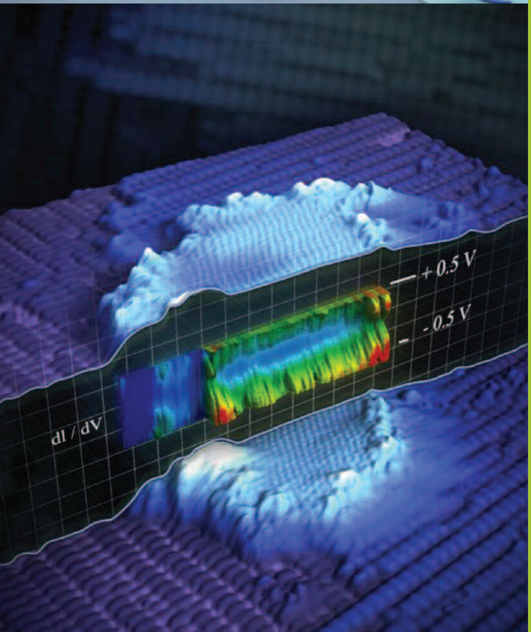


Beckman Institute

FOR ADVANCED SCIENCE AND TECHNOLOGY

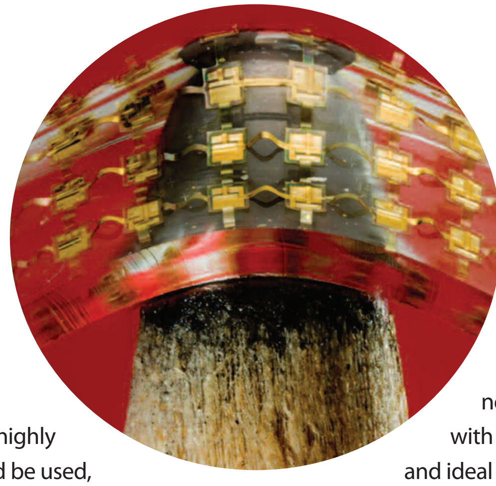






Electronics Research

Exploring the interface between basic science and applications involving electronics has been an integral part of research at the Beckman Institute since it opened in 1989. That work in an area that has become an essential ingredient of modern life continues to be as cutting edge in the 21st Century. From the discovery of a method that uses deuterium for reducing hot electron damage in integrated circuit transistors in the mid-1990s to recent breakthroughs like electronics with stretchable or self-healing properties, research aimed at advancing current electronics technology or finding alternatives to silicon such as carbon nanotubes is a major focus of the Beckman Institute.



John Rogers is pushing the boundaries of electronics with his breakthrough discovery of stretchable silicon and other innovative methods for creating flexible electronics. Among the many potential applications are bio-compatible sensors for health monitoring, and replacing rigid silicon wafers with highly flexible microprocessors that could be used, for example, in sports apparel that incorporates electronics.

Beckman researchers are also developing self-healing capacities for electronics. **Jeff Moore** and **Paul Braun** led a project that used microcapsules containing unfunctionalized single-walled carbon nanotubes that, when ruptured, released the CNTs and formed a bridge between two probe tips, completing the circuit and restoring the current. In the other line led by **Moore**, **Nancy Sottos,** and **Scott White**, microcapsule methods employ healing agents that are released when the capsules are ruptured in response to damage, restoring conductivity within 40 microseconds. The technology is being developed for use in a wide range of energy storage systems, including batteries, and can easily be integrated into existing manufacturing methods.

Carbon materials such as graphene and carbon nanotubes (CNTs) have great potential for future use in electronics, either as a replacement for silicon or for integration with current technologies. **Joseph Lyding** created a Dry Contact Transfer (DCT) system for depositing carbon nanotubes onto a silicon substrate, creating a technology that could lead to 10 times faster processing speeds than those found with current silicon-based circuits. **Eric Pop**'s research uses CNTs, graphene, and phase change materials like the germanium antimony telluride to provide the same or greater computing power than silicon electronics, but with lower dissipation.

Paul Braun and his group have developed a self-assembling three-dimensional nanostructure for battery cathodes that enables extremely quick charging and discharging without sacrificing energy storage capacity. The new technology is compatible with current manufacturing methods and ideal for use in consumer electronics, electric vehicles, and medical devices, among other applications.

William King and his collaborators have developed a thermochemical method that offers unique advantages for nanopatterning, especially in the area of protein and DNA nanolithography. King has been a leader in developing nanoscale tools like an atomic force microscopy probe used as a soldering iron for deposition and other applications, such as in nanoelectronic devices.

Jean-Pierre Leburton has broken new ground in the nexus of applied physics and electrical engineering, especially as applied to semiconductor physics. Leburton has shown that the lack of the thermoelectric effect — a fundamental property of conductors — in metallic carbon nanotubes means they offer less resistance than other metal conductors, making them ideal for electronics applications.

Photonics research at Beckman investigates a wide variety of processes and materials for applications in electronics and optoelectronics. **Jennifer Lewis, Yi Lu,** and **Braun** were part of a collaboration that demonstrated the ability of 3-D photonic bandgap waveguide structures to execute 90-degree turns in the space of a few microns, enabling on-chip integration with optical devices.

Harley Johnson studies the mechanics of electronic materials and microelectromechanical systems in applying mechanics principles toward new technologies.