From the Director

I am pleased to present the current issue of *Advances*, a quarterly e-brief update of the Frederick Seitz Materials Research Laboratory (FSMRL) at the University of Illinois. In this issue, we feature new advances in flexible electronics and photonic crystals as well as our recent outreach efforts in materials characterization.

The primary mission of the FSMRL is to foster interdisciplinary research at the forefront of materials science. Our laboratory brings together world-class faculty, graduate students, and post-doctoral researchers with expertise in condensed matter physics, chemistry, and materials science. We house several multi-investigator programs in the broadly defined areas of quantum, nanoscale, computational, and soft materials. These programs derive great benefit from our central facilities for materials fabrication and characterization, which are widely recognized as amongst the finest.

(Cont. on pg 2)

Foldable and stretchable, silicon circuits conform to many shapes

A team of scientists led by FSMRL researcher John Rogers (MatSE) have developed a new form of stretchable silicon integrated circuit that can wrap around complex shapes and can operate during stretching, compressing, folding and other types of extreme mechanical deformations, without a reduction in electrical performance. Their work appeared in the April 25th issue of the journal *Science*.

By carefully optimizing the mechanical layouts and structural configurations, silicon can be used in integrated circuits that are fully foldable and stretchable. A few years ago, Rogers reported the development of a one-dimensional, stretchable form of single-crystal silicon with micron-sized, wave-like geometries. That configuration allows reversible stretching in one direction without significantly altering the electrical properties, but only at the level of individual material elements and devices. Now, Rogers and his collaborators at the University of Illinois, Northwestern University, and the Institute of High Performance Computing in Singapore have extended this basic wavy concept to two dimensions, and at a much more sophisticated level to yield fully functional integrated circuit systems.

Rogers and his team have constructed integrated circuits consisting of transistors, oscillators, logic gates and amplifiers. The circuits exhibit extreme levels of bendability and stretchability, with electronic properties comparable to those of similar circuits built on conventional silicon wafers. Achieving high degrees of mechanical flexibility, or foldability, is important to sustaining the wavy shapes. For this purpose, they use ultrathin circuit sheets designed to locate the most fragile materials in a neutral plane that minimizes their exposure to mechanical strains during bending. Their new design and construction strategies represent general and scalable routes to high-performance, foldable and stretchable electronic devices that can incorporate established, inorganic electronic materials whose fragile, brittle mechanical properties would otherwise preclude their use.

This research is partially supported by DOE/BES Materials Sciences and Engineering Division through the FSMRL Materials Research Cluster (MRC) on *Programming Function via Soft Materials*.

Suslick Awarded 2007 Sir George Stokes Medal

FSMRL researcher Ken Suslick (Chemistry) was recently awarded the 2007 Sir George Stokes Medal from the Royal Society of Chemistry.

The Sir George Stokes Medal was established in 1999 to recognize the multidisciplinary dimension of analytical science. The award recognizes outstanding and sustained contributions to analytical science by work in a complementary field, leading to developments of seminal importance to chemical analysis.

His research is partially supported by DOE/BES Materials Sciences and Engineering Division through the FSMRL Materials Research Cluster (MRC) on *Nano-Oxide Photocatalysis for Solar Energy Conversion*.
*From the Director (continued from page 1)*

est mid-scale facilities in the nation.

Each quarter, *Advances* introduces the researchers involved in the FSMRL and highlights their recent accomplishments. Together, we are transforming fundamental scientific discoveries into technological advances in the areas of photonics, flexible electronics, superconductor devices, and energy materials (e.g., catalysts, fuel cells, and photovoltaics).

I hope that you enjoy learning more about the Frederick Seitz Materials Research Laboratory and our impact on the scientific community and society as a whole.

Jennifer A. Lewis  
FSMRL Director

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**Silicon photonic crystals designed for optical cloaking**

Through computer simulations, FSMRL researchers **Harley Johnson** (MechSE) and Dong Xiao, have demonstrated an approximate cloaking effect induced by the behavior of concentric rings of silicon photonic crystals. Their research was published in the April 15th issue of the journal *Optics Letters*, and builds on earlier work in which an invisibility cloak operating in the microwave region of the electromagnetic spectrum was reported by researchers at Duke University, Imperial College in London, and Sensor Metrix in San Diego (October, 2006). In this prior experimental demonstration, microwave cloaking was achieved through a thin coating containing an array of tiny metallic structures called ring resonators. To achieve this effect at visible wavelengths, ring resonators that are much smaller than can be made with current technology are required.

To overcome this problem, Xiao and **Johnson** designed a simple axisymmetric structure composed of thin concentric layers of silicon and air that surround a container composed of air. The width and spacing of the rings can be tailored for specific wavelengths of light. When light of the correct wavelength strikes the coating, it bends around the container and continues on its way, such that an observer sees what is behind the container, as though it isn’t there. However, the wave fronts are slightly perturbed as they pass around the container, hence the researchers refer to their approach as ‘approximate’ cloaking. Although their current simulations are in two dimensions, this cloaking concept can be readily extended to three dimensions by replacing the concentric rings with spherical shells of silicon, separated by air or another dielectric material.

This research is supported by DOE/BES Materials Sciences and Engineering Division through the FSMRL Materials Research Cluster (MRC) on *Programming Function via Soft Materials*.

UI News Bureau Physical Sciences Editor James E. Kloeppep contributed to the articles in this issue.

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**2nd Annual Workshop on Advanced Materials Characterization**

The 2008 Advanced Materials Characterization Workshop was held June 11-12 at the Frederick Seitz Materials Research Laboratory. The event featured lectures and instrument demonstrations given by the FSMRL central facilities staff on several analytical techniques, including AFM, XRD, optical microscopy and spectroscopy, AES, XPS, SIMS, RBS, SEM and TEM. The two-day event drew over 160 participants from our campus as well as 40 scientists from other research, industrial and academic institutions. Notably, the workshop was co-sponsored by 19 major analytical equipment vendors.