University Research News

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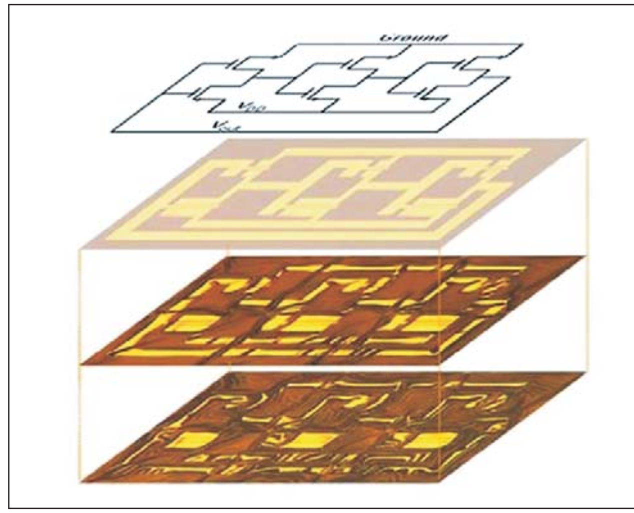
University of Illinois—Flexible Circuits

Scientists have developed a new form of stretchable silicon integrated circuit that can wrap around complex shapes, such as spheres, body parts, and aircraft wings, and can operate during stretching, compressing, folding, and other types of extreme mechanical deformations, without a reduction in electrical performance.

In December 2005, a U of I research group 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, collaborators at Illinois, Northwestern University and the Institute of High Performance Computing in Singapore report an extension of this basic wavy concept to two dimensions, and at a much more sophisticated level to yield fully functional integrated circuit systems.

Achieving high degrees of mechanical flexibility, or foldability, is important to sustaining the wavy shapes. According to Materials Science Professor John Rogers, “The more robust the circuits are under bending, the more easily they will adopt the wavy shapes which, in turn, allow overall system stretchability. For this purpose, we use ultrathin circuit sheets designed to locate the most fragile materials in a neutral plane that minimizes their exposure to mechanical strains during bending.”



Circuit diagram (top image) and optical images of a stretchable silicon ring oscillator circuit on a rubber substrate: the “as fabricated” flat state (top micrograph) and in moderate and high states of biaxial compression (middle and bottom micrographs). Photo courtesy John Rogers.

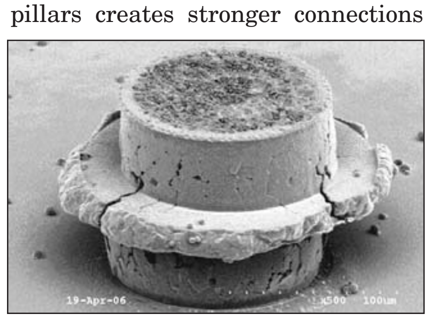
The new design and construction strategies represent general and scalable routes to high-performance, foldable and stretchable electronic devices that can incorporate established, inorganic electronic materials whose fragile, brittle mechanical properties would otherwise preclude their use.

The work was funded by the National Science Foundation and the U.S. Department of Energy.

Georgia Tech—Copper Interconnections

Graduate student Tyler Osborn and Regents’ professor Paul Kohl at the Georgia Institute of technology have developed a novel fabrication method to create all-copper connections between computer chips and external circuitry. Improving these two types of connections will increase the amount and speed of information that can be sent throughout a computer or other high-speed system.

The vertical connections between chips and boards are currently formed by melting tin solder between the two pieces and adding glue to hold everything together. Kohl’s research shows that replacing the solder ball connections with copper pillars creates stronger connections and the ability to create more connections. Solder and copper can both tolerate misalignment between two pieces being connected, according to Kohl, but copper is more conductive and creates a stronger bond.



Scanning electron microscope image of two copper pillars bonded together. Image courtesy of Georgia Tech and Tyler Osborn.

Key to the development is the fabrication process, which involves a sequence of electroplating a copper “bump,” electroless plating for the connection, and an annealing process to create stronger bonds and make the copper more pliant.

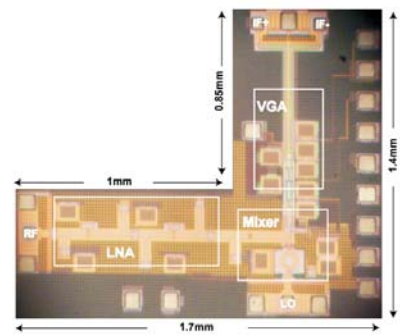
Funding for the research was provided by Semiconductor Research Corporation (SRC). Several industry partners are also involved.

UC Berkeley—Low Power 60 GHz CMOS Receiver

Researchers at the University of California, Berkeley have developed a receiver IC for 60 GHz applications, using 90 nm standard CMOS and consuming just 24 milliwatts. In a paper delivered at ISSCC 2008, Bagher Afshar, Yanjie Wang and Ali M. Niknejad reported on this work. The design relied on extensive electromagnetic simulation and carefully modeled building blocks, such as coplanar waveguide transmission lines, metal-oxide-metal capacitors and custom BSIM3 large signal transistor models.

The receiver incorporates a shared junction cascode LNA, an active single-balanced commutating mixer and a variable gain baseband amplifier with 2.2 GHz bandwidth. An on-chip bifilar balun creates the differential LO signal required to drive the mixer. Matching is accomplished with transmission lines rather than inductors, for more reliable process results and also for DC continuity.

Funding sources include the National Science Foundation, FGSR grant of the University of Alberta, and a DARPA award. STMicroelectronics donated the wafer fabrication.



Photomicrograph courtesy UC Berkeley

University of Maryland—WiMAX Forum Endorsement

The WiMAX Forum® has announced it has named the MAXWell Lab at the University of Maryland as home to the first WiMAX Forum endorsed applications lab in North America. Companies located in the United States and across the globe will benefit from and be able to more quickly take advantage of new applications for the mobile broadband Internet as a result of the WiMAX applications testing and development work conducted at the MAXWell Lab.

Designed to be an environment where future innovators from the university and wireless industries can develop and test new WiMAX applications, the MAXWell Lab will support application testing in a “live” operating environment at a technologically neutral site. The initial focus of the MAXWell Lab, which is part of the University of Maryland Institute for Advanced Computer Studies, will be location-aware applications.