develop organic diodes have resulted in devices with maximum frequency response of no more than 10 kHz and with output current densities of less than 1 A/cm^2 under an applied ac voltage. Since response speed is governed by the capacitance of a device, the researchers predict that reduced device areas will yield a 10-fold or more improvement in response time when scaling the device to micron-scale dimensions.

The scientists attribute the enhanced performance to the heat treatment, prior to which the performance was poor. They believe that the heat treatment causes the Cu to diffuse into the C_{60} layer, forming a stable metallic interface to the C_{60} layer. The device's strong electron acceptor properties lead to a conducting charge-transfer complex similar to the heavily doped interface in silicon technology to form a good ohmic contact. This situation allows for efficient electron injection from the Cu cathode into C_{60}, increasing by about three orders of magnitude after heat treatment. Atomic force microscopy revealed that the C_{60} recrystallized, enhancing carrier mobility. Al, on the other hand, forms covalent bonds to C_{60}, resulting in the observed work-function increase from 4.2 eV to 5.2 eV, which is consistent with the observed *I–V* curve reversal.

Organic diodes, with their response speed in ac mode below 10 kHz, are not stable in air. The C_{60}-based organic diode, however, did not show any noticeable performance decay, even after a 40 h stress test in air without encapsulation at 2.4 ac voltage and 1 MHz frequency, whereas normal organic diodes were found to have a reported lifetime of no more than 17 h even under current conditions that are three orders of magnitude less severe.

ALFRED A. ZINN

Protein Hydrogels Engineered to Promote Cell Growth

A research team at The Johns Hopkins University (JHU) has created a class of artificial proteins that self-assemble into a gel that can be tailored to send different biological signals stimulating the growth of selected types of cells. Tissue engineers use hydrogels to provide a framework or scaffold upon which to grow cells. The researchers hope to advance their technique to the point that it can be used to treat medical ailments by growing replacement cartilage, bones, organs, and other tissue in the laboratory or within a human body.

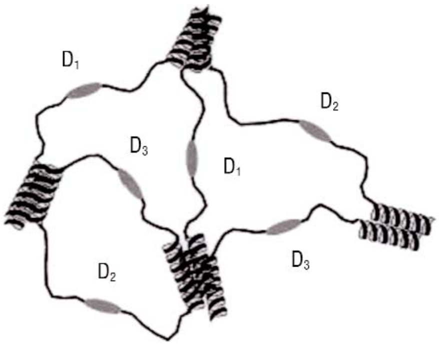

Figure 1. Schematic illustration depicting a hydrogel network with three distinct bioactive domains (D) formed by the self-assembly of modular proteins. Illustration by Will Kirk.

"We're trying to give an important new tool to tissue engineers to help them do their work more quickly and efficiently," said James L. Harden, whose laboratory team, L. Mi and S. Fischer, developed the biomaterial. Harden, an assistant professor in the Department of Chemical and Biomolecular Engineering at JHU, reported on his work at the 227th national meeting of the American Chemical Society in Anaheim, Calif., on March 28.

Harden's hydrogel is made by mixing specifically designed modular proteins in a buffered water solution. Each protein consists of a flexible central coil containing a bioactive peptide sequence and flanked by helical-associating end modules. The helical ends are based on the leucine zipper, a well-known motif in nature.

"We utilized three different types of these leucine zippers," said Harden, "an acidic helix A with glutamic acid residues in both the e and g positions, a basic helix B with lysine residues in both the e and g positions, and a mixed helix C with glutamic acid residues in the e positions and lysine residues in the g positions. The charge patterning of these helices supports the formation of very stable heterotrimer bundles of A+B+C due to favorable electrostatic interactions between the acidic and basic e and g residues on neighboring helices."

These end modules are designed to attract each other and form three-member bundles. This bundling leads to the formation of a regular network structure of proteins with three-member junctions linked together by the flexible coil modules (see Figure 1). In this way, the biomaterial assembles itself spontaneously when the protein elements are added to the solution.

"The helices have a hydrophobic strip of leucines along one face," said Harden. "When these proteins are put in water, they associate by overlapping these hydrophobic strips in order to keep water from coming into contact with the hydrophobic portions."

The assembly process involves three different "sticky" ends. But between any two ends, one or more bioactive sequences can be inserted, drawing from a large collection of known sequences. Once the gel has formed, each central bioactive module is capable of presenting a specific biological signal to the target cells. Certain signals are needed to stimulate the adhesion, proliferation, and differentiation of cells in order to form particular types of tissue.

Harden's goal is to provide a large combinatorial library of these genetically engineered proteins. A tissue engineer could then draw from this collection to create a hydrogel for a particular purpose.

"We want to let the end user mix and match the modules to produce different types of hydrogels for selected cell and tissue engineering projects," Harden said.

News of MRS Members/Materials Researchers

Diran Apelian of Worcester Polytechnic Institute has been named a fellow of the Metal Powder Industries Federation in recognition for his innovative work in metal processing and in building bridges between the industrial and academic communities.

Shefford P. Baker, of the Department of Materials Science and Engineering at Cornell University, was promoted to associate professor with tenure in November 2003.

Alexandre Blais, a postdoctoral fellow at Yale University, has received the 2004 **Howard Alper Postdoctoral Prize** from the Natural Sciences and Engineering Research Council of Canada in recognition of his research findings to improve the practical aspects of quantum-bit (qubit) construction and to offer a new way to maintain quantum coherence, the key to a successful quantum processor. The prize is one of Canada's premier awards for recent doctoral graduates. Blais received his PhD degree from Université de Sherbrooke in Canada.

Damon Canfield, president and CEO of New Product Innovations (NPI), has been named an **Ernst & Young Entrepreneur of the Year** for 2004. The award recognizes Canfield's leadership in transforming NPI from a technical services organization providing product engineering and materials