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Researchers Find Peptides That Bind to Semiconductors

Discovery Opens Way to New Materials Assembly Technique

Santa Barbara, Calif.--A pathbreaking paper published in the June 7 issue of the journal Nature reports the successful binding of a biological material--peptides--to inorganic semiconducting materials. Peptides are short chains of amino acids. Joining biological to semiconducting materials is the first step to a whole new materials assembly technique that will operate on the nanoscale.

Most semiconducting devices such as computer chips are made from the top down, meaning that substance is subtracted from a bulk material to make a chip. Patterns are imposed on the material and etched into it. The new technique aims at building from the bottom up, i.e., atom by atom or molecule by molecule.

The research reported in the paper "Selection of Peptides With Semiconductor Binding Specificity for Directed Nanocrystal Assembly" represents a first crucial step towards employing biological systems that already know how to build things on the nanoscale to building very small inorganic structures for us.

One of the paper's authors is Evelyn Hu, professor of electrical and computer engineering and director of the Center for Quantized Electronic Structures at the University of California at Santa Barbara (UCSB). Another author is Angela Belcher, who received her Ph.D. in chemistry from UCSB in 1997 and who as a postdoctoral fellow at UCSB teamed up with Hu to initiate the research that led to the published results.

Belcher is currently an assistant professor of chemistry and biochemistry at the University of Texas at Austin. Her graduate student there, Sandra Whaley, is the paper's first author. Also contributing from UT Austin are Paul F. Barbara, the Richard J.V. Johnson-Welch Regents Professor, and Douglas S. English, a postdoctoral fellow.

Hu, the research team's expert on inorganic electronic materials, explains, "The techniques we have developed for working with semiconducting materials on the microscale are not adequate for working on the nanoscale, which is orders of magnitude smaller. We face challenges in how to integrate nanoscale components to build complex structures, but nature does just that all the time. So the idea behind this research is to mimic nature and build electronic devices the way nature would."

The approach used by these researchers involves isolating viruses that contain peptides that will bind to materials such as gallium arsenide, indium phosphide or silicon--materials not usually thought to have affinities to peptides.

Furthermore, the Nature paper reports the finding of peptides that not only bind to gallium arsenide, indium phosphide and silicon, but can distinguish between different crystal orientations of gallium phosphide.

In addition, the authors state at the end of the published paper, "We are currently designing bivalent synthetic peptides with two-component recognition; such peptides have the potential to direct nanoparticles to specific locations on a semiconductor structure. These organic-inorganic pairs should provide powerful building blocks for the fabrication of a new generation of complex, sophisticated electronic structures."

In other words, think of those tailor-made peptides as two-sided tapes wherein each side sticks to a different nanoscale semiconducting particle. The tape enables the assembly of the particles into an electronic structure which can consist of layers of different semiconducting materials or different phases of the same material or some combination of both.

The new assembly technique opens the gateway to nanoscale structures. On the one hand, smaller semiconductor structures will mean smaller devices such as desktop computers shrunk to the size of a wristwatch. On the other hand, there is the prospect of mixing together nanocomponents of different materials to make entirely new materials with exciting new properties.

"We do not yet understand," said Hu, "the underlying principle that determines why a given peptide binds to a given semiconductor. Understanding that will give us the control to do many marvelous things which we as yet only dimly imagine."

Note: Evelyn Hu can be reached at 805-893-2368 and Angela Belcher at (512) 471-1154 or (512) 751-3393.

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Media Contact

Tony Rairden
trairden@engineering.ucsb.edu
805.893.4301