



Headlines

Simple technique yields complex structures

Self-assembling materials could aid next-generation electronics

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PRINCETON, N.J. -- In a discovery with potential uses from electronics to biology, Princeton engineers have invented a simple procedure for making microscopically small particles assemble themselves into complex materials.

The technique allows scientists to force mixtures of tiny beads to crystallize into tailored structures that could be ideal for channeling laser light through next-generation telecommunications devices or for mechanically sorting DNA molecules as part of cheaper, faster biological tests.

In a paper published recently in *Physical Review Letters*, chemical engineering graduate student William Ristenpart and Professors Dudley Saville and Ilhan Aksay showed how they could start with a liquid suspension of jumbled silica and polymer particles and subject them to high frequency alternating currents to guide the particles into various structures.

The technique bypasses the expensive and painstaking lithographic techniques that are currently used to make minute structures. Lithography uses a highly energized beam of electrons to carve material one feature at a time. With Ristenpart's approach, the particles all assemble themselves into patterns in a matter of seconds.

A benefit of the discovery is that it lets scientists manipulate two kinds of particles at once -- glass and plastic -- and to control their behavior somewhat independently, even when the different particles are essentially the same size. Previous self-assembly efforts have focused on making structures out of a single kind of particle or out of particles of significantly different sizes. The new technique allows a richer variety of structures, because both the frequency of the electric field and the chemical properties of the particle ingredients can be adjusted.

"In a manner of speaking, you now have two knobs to turn," said Saville, who is Ristenpart's co-adviser and a co-author of the paper.

"It's very fast, practical and economically viable," said Aksay, also a co-adviser and co-author.

The finding exemplifies the high quality of Ristenpart's work, his advisers said. The University



William Ristenpart
(photo: Denise Applewhite)

recently named Ristenpart a winner of the Porter Ogden Jacobus Fellowship, which is the highest honor awarded to graduate students. The fellowship provides full tuition and a stipend for the final year of study for one student from each division: humanities, social sciences, natural sciences and engineering.

Ristenpart said he came upon the technique while attempting a more complicated procedure for making two-component crystals. He thought he could make one set of particles separate from one another and then fit another kind of particle into the spaces, but it was not working. "So one time I got kind of frustrated and threw in another bunch of particles at the same time just to see what would happen, and it turned out really nicely," he said.

Then came the hard part of figuring out what was happening. When Ristenpart applied high frequency alternating current, the particles spread apart; low frequency current pulled them together. After much study, he found that both effects were stronger when the particles were highly polarized -- that is, when they had strong positive and negative charges. Beyond that similarity, there are complex differences, which Ristenpart is continuing to investigate.

The discovery opens new realms for study. "It wasn't just that he stumbled into the Northwest Passage," said Saville. "He worked out how to do it and then figured out the mechanism behind it, which to me is one of the most important aspects."

As the researchers improve both the theory and practice of the technique, they expect that it will begin to find applications in diverse fields.

One of the primary uses could be in optical electronics, an emerging technology in which beams of light replace electric current as a way of transmitting information. Optical computer chips need materials for shunting and processing the light, as wires and semiconductors do in conventional electronics. Engineers already have built microscopically structured crystals for that purpose and introduced tiny impurities to act like bumpers or channels for the light. Ristenpart's technique could allow them to control the placement of those impurities and create better light guides.

In biology, researchers increasingly are interested in using microscopic structures to probe the physical properties of cells and molecules. Princeton biophysicist Robert Austin uses tiny structures to sort biological molecules such as DNA, which are conventionally manipulated with elaborate chemical techniques. Austin said Ristenpart's technique "has clear utility" in his work. "Any technique that bypasses expensive and time-consuming electron beam lithography to create self-organized arrays is extremely useful in biology," he said.

For Ristenpart, however, the appeal of the work comes less from the applications than the excitement of simply making the materials and understanding what is happening. He is continuing his investigation of the mechanism, inspired by the hope of making ever more intricate patterns.

"The fact that you can throw a bunch a particles together, zap them with an electric field and make them line up in really beautiful patterns -- that, to me, is just really amazing," he said.