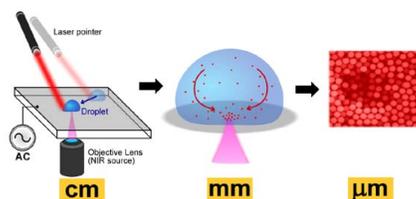


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Laser, electric fields combined for new 'lab-on-chip' technologies

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This graphic illustrates a new technology that combines a laser and electric fields to manipulate fluids and tiny particles such as bacteria, viruses and DNA for a range of potential applications from drug manufacturing to food safety. The technologies could bring innovative sensors and analytical devices for "lab-on-a-chip" applications. (Stuart J. Williams, University of Louisville)

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WEST LAFAYETTE, Ind. - Researchers are developing new technologies that combine a laser and electric fields to manipulate fluids and tiny particles such as bacteria, viruses and DNA for a range of potential applications, from drug manufacturing to food safety.

The technologies could bring innovative sensors and analytical devices for "lab-on-a-chip" applications, or miniature instruments that perform measurements normally requiring large laboratory equipment, said [Steven T. Wereley](#), a Purdue University professor of mechanical engineering.

The method, called "hybrid optoelectric manipulation in microfluidics," is a potential new tool for applications including medical diagnostics, testing food and water, crime-scene forensics, and pharmaceutical manufacturing.

"This is a cutting-edge technology that has developed over the last decade from research at a handful of

universities," said Alope Kumar, a Wigner Fellow and staff member at Oak Ridge National Laboratory.

He is lead author of an article about the technology featured on the cover of the July 7 issue of [Lab on a Chip magazine](#), published by the Royal Society of Chemistry. The article also has been flagged by the publication as a "HOT Article" and has been made free to access at <http://blogs.rsc.org/lc/2011/06/15/issue-13-now-online/>

The article is written by Wereley; Kumar; Stuart J. Williams, an assistant professor of mechanical engineering at the University of Louisville; Han-Sheng Chuang, an assistant professor in the Department of Biomedical Engineering at National Cheng Kung University; and Nicolas G. Green, a researcher at the University of Southampton.

"A very important aspect is that we have achieved an integration of technologies that enables manipulation across a very wide length scale spectrum," Kumar said. "This enables us to manipulate not only big-sized objects like droplets but also tiny DNA molecules inside droplets by using one combined technique. This can greatly enhance efficiency of lab-on-a-chip sensors."

Kumar, Williams and Chuang are past Purdue doctoral students who worked with Wereley. Much of the research has been based at the Birck Nanotechnology Center at Purdue's Discovery Park.

The technologies are ready for some applications, including medical diagnostics and environmental samples, Williams said.

"There are two main thrusts in applications," he said. "The first is micro- and nanomanufacturing and the second is lab-on-a-chip sensors. The latter has demonstrated biologically relevant applications in the past couple of years, and its expansion in this field is immediate and ongoing."

The technology works by first using a red laser to position a droplet on a platform specially fabricated at Purdue. Next, a highly focused infrared laser is used to heat the droplets, and then electric fields cause the heated liquid to circulate in a "microfluidic vortex." This vortex is used to isolate specific types of particles in the circulating liquid, like a micro centrifuge. Particle concentrations replicate the size, location and shape of the infrared laser pattern.

"This works very fast," Wereley said. "It takes less than a second for particles to respond and get pulled out of solution."

Systems using the hybrid optoelectric approach can be designed to precisely detect, manipulate and screen certain types of bacteria, including particular strains that render heavy metals less toxic.

"We are shooting for biological applications, such as groundwater remediation," Wereley said. "Even within the same strain of bacteria some are good at the task and some are not, and this technology makes it possible to efficiently cull those bacteria from others. The bacteria could be injected into the contaminated ground. You seed the ground with the bacteria, but first you need to find an economical way to separate it."

Purdue researchers also are pursuing the technology for pharmaceutical manufacturing, he said.

"These types of technology are good at being very dynamic, which means you can decide in real time to grab all particles of one size or one type and put them somewhere," Wereley said. "This is important for the field of pharmacy because a number of drugs are manufactured from solid particles suspended in liquid. The particles have to be collected and separated from the liquid."

This process is now done using filters and centrifuges.

"A centrifuge does the same sort of thing but it's global, it creates a force on every particle, whereas this new technology can specifically isolate only certain particles," Wereley said. "We can, say, collect all the particles that are one micron in diameter or get rid of anything bigger than two microns, so you can dynamically select which particles you want to keep."

The technology also may be used as a tool for nanomanufacturing because it shows promise for the assembly of suspended particles, called colloids. The ability to construct objects with colloids makes it possible to create structures with particular mechanical and thermal characteristics to manufacture electronic devices and tiny mechanical parts. The nanomanufacturing applications are at least five years away, he said.

The technology also can be used to learn fundamental electrokinetic forces of molecules and biological structures, which is difficult to do with existing technologies.

"Thus there are very fundamental science applications of these technologies as well," Kumar said.

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Note to Journalists: An electronic copy of the research paper is available from the journal or by contacting Emi Venere, Purdue News Service, at 765-494-4709, venere@purdue.edu

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ABSTRACT

Hybrid opto-electric manipulation in microfluidics—opportunities and Challenges

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Hybrid opto-electric manipulation in microfluidics/nanofluidics refers to a set of methodologies employing optical modulation of electrokinetic schemes to achieve particle or fluid manipulation at the micro- and nano-scale. Over the last decade, a set

of methodologies, which differ in their modulation strategy and/or the length scale of operation, have emerged. These techniques offer new opportunities with their dynamic nature, and their ability for parallel operation has created novel applications and devices. Hybrid opto-electric techniques have been utilized to manipulate objects ranging in diversity from millimetre-sized droplets to nano-particles. This review article discusses the underlying principles, applications and future perspectives of various hybrid opto-electric techniques that have emerged over the last decade under a unified umbrella.

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