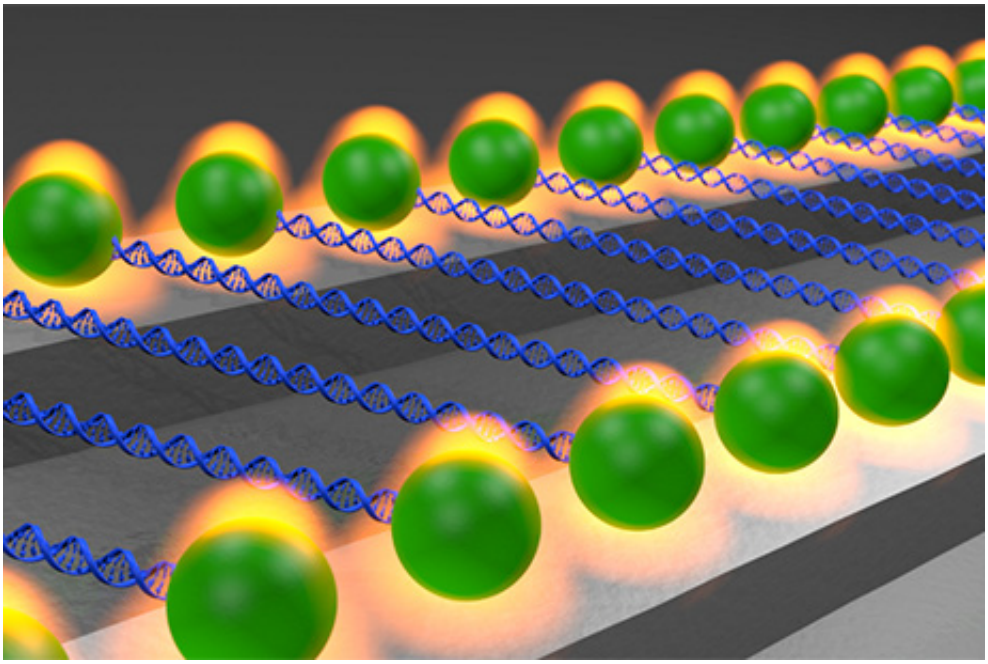
Optical traps on chip manipulate many molecules at once

April 30 2014, by Anne Ju



An illustration of a nanophotonic standing wave array trap (nSWAT) for parallel manipulation and measurements of single molecules. Here, an array of DNA molecules with a bead attached at each end is precisely manipulated between two nSWATs. The position of each nSWAT is independently controlled to relocate and transport the array of trapped beads. Credit: Robert Forties

(Phys.org) —Optical trapping, a technique for studying single molecules, is traditionally delicate, requiring special equipment and a soundproof room, with data collected one molecule at a time.

Cornell physicists have shrunk the technology of an optical trap, which uses light to suspend and manipulate molecules like DNA and proteins, onto a single chip. And instead of just one molecule at a time, the new device can potentially trap hundreds of molecules at once, reducing month-long experiments to days.

"We love single-molecule experiments because the data are beautiful and clear, and we learn so much by manipulating and perturbing molecules and watching how things change," said Michelle Wang, professor of physics, who led the study published online in *Nature Nanotechnology* April 28. But the experimental technique itself could use some improvement, which motivated Wang, who studies DNA and its associated motor proteins, to contemplate solutions.

Wang and colleagues developed a new type of optical trap, drawing on nanophotonics – in this case, using light as nanoscale controllers – as well as on-chip electronics and microfluidics to make a low-power, stable device that can be fitted to conventional microscopes.

Their key innovation is the generation of controllable optical standing waves in nanophotonic waveguides, formed by two counter-propagating light waves, which function as optical trap arrays. This design recycles the same light to produce multiple traps, each of which can hold one molecule, for example, a single molecule of DNA.

"What we have here is a stable and controllable three-dimensional trap array," Wang said. "That's never been done before." They call their device a nanophotonic standing wave array trap, or nSWAT.

To test the device's stability – a key breakthrough – lab members physically tapped on the microscope where they'd mounted their chip. Due to the compact nature of the device, which fits on a penny, they detected little, if any disturbance.

In their paper, they also described transporting molecules over a relatively long distance using the waveguides. This ability lets the new optical trap integrate with existing fluorescence labeling techniques for tagging molecules of interest.

Fabrication of the nSWAT was done exclusively at the Cornell NanoScale Science and Technology Facility (CNF).

Experiments described in the paper, "Nanophotonic trapping for precise manipulation of biomolecular arrays," were completed primarily by co-first authors Mohammad Soltani and Jun Lin, both postdoctoral associates in the Wang lab, with substantial help from several students and postdocs in the lab. Early stages of the project involved helpful discussions with, and loaned equipment from, co-author Michal Lipson, professor of electrical and computer engineering, a nanophotonics expert.

More information: "Nanophotonic trapping for precise manipulation of biomolecular arrays." Mohammad Soltani, et al. *Nature Nanotechnology* (2014) DOI: 10.1038/nnano.2014.79. Received 18 August 2013 Accepted 18 March 2014 Published online 28 April 2014

Provided by Cornell University