Liquid lens creates tiny flexible laser on a chip

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(PhysOrg.com) -- Like tiny Jedi knights, tunable fluidic micro lenses can focus and direct light at will to count cells, evaluate molecules or create on-chip optical tweezers, according to a team of Penn State engineers. They may also provide imaging in medical devices, eliminating the necessity and discomfort of moving the tip of a probe.

Conventional, fixed focal length lenses can focus light at only one distance. The entire lens must move to focus on an object or to change the direction of the light. Attempts at conventional tunable lenses have not been successful for lenses on the chip. Fluidic lenses, however, can change their focal length or direction in less than a second while remaining in the same place and can be fabricated on the chip during manufacture.

"We use water and a calcium chloride solution because they are readily available and safe and their optical properties have been well characterized," said Tony Jun Huang, James Henderson assistant professor of engineering science and mechanics. "There are lots of possibilities about what fluids we can use. Most solutions change their refractive indices if the concentration changes."

He notes that they could use a variety of solutions with water. There are also a number of commercially available "refractive index fluids" which could potentially provide better optical properties and make these Liquid-Gradient Refractive Index (L-GRIN) lenses work even better.

Huang, working with engineering science and mechanics graduate students Sz-Chin Steven Lin, Michael I. Lapsley, Jinjie Shi and Bala Krishna Juluri and bioengineering graduate student Xiaole Mao, who is the first author on the paper, reported their work in a recent issue of Lab on a Chip.

To create their lens, the researchers have constant, tiny streams of calcium chloride surrounded by two adjustable streams of water. By increasing or decreasing the flow rate of the water, they can shorten or lengthen the focusing distance of the lens. The focal length changes because the amount of diffusion of calcium chloride into the water changes and alters the refractivity of the fluid. The researchers can swing the focal point side to side by changing the flow rate of the water on only one side, skewing the point of focus left or right.

"With these two combined, we will have the capability of directing the light to any given point within the device," said Huang.

One application, according to Huang, would be as optical tweezers positioned directly on a chip the size of a quarter. This would eliminate the complex systems now necessary for optical tweezers. Optical tweezers made up of focused laser beams can capture tiny particles like cells, stabilize them, move them and even rotate them at will.

"Our L-GRIN lens is probably the only microlens that can focus and steer the light simultaneously and yet is still small enough to fit on such a biochip," said Huang.

Huang notes that there are applications for this fluidic lens in other places as well. Currently, for an endoscope operator to focus light on a specific internal location, the probe itself must be manipulated into place, sometimes causing discomfort. With these fluidic lenses, aiming the light can be done simply by changing the lens while the instrument remains in one place.

Provided by Pennsylvania State University (news : web)