Biological Microcavity Laser

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Recent advances in the manufacture of semiconductor microstructures, made at Sandia National Laboratories, have made possible the creation of a vertical cavity surface-emitting laser on a chip, which has shown remarkable success in analyzing biological cells and microparticles.

The laser is created of a nanometer thick layer of gallium aluminum arsenide sandwiched between two layers of gallium arsenide. Stimulating the center layer with electrical pulses creates electron-hole pairs which release photons when they recombine. The reflective gallium arsenide layers act as mirrors, reflecting the photons until they exit the upper mirror as a coherent beam. By etching a micro-channel in the substrate, it is possible to pump fluid containing cells into the reflecting chamber, where they affect the frequency of the resulting laser light. A high resolution spectrometer is used to analyze the resulting light, giving information about the fluid or cell within the chamber.

So far the system has been able to differentiate between normal and sickle shaped red blood cells, and astrocytes and glioblastomas (healthy and malignant brain cells, respectively), as well as perform assays of the protein content of fluids.

The biocavity laser system has the potential to provide real time information of as many as 100,000 cells per second (5 times the current best rate). System costs are projected to be as low as $10,000 to $50,000 and the devices could be used in surgery to give immediate information about the malignancy of biopsies. This is in comparison to the current method of cytometry, which requires a separate room, a highly trained technician, and several hours to separate and stain cells to be evaluated.

Biocavity lasers have also demonstrated the ability to micro-manipulate individual cells using the laser-tweezer effect perform microsurgery on cells, destroy selected cells, and measure refractive index values of cell constituents.

Researchers have also begun using the ability of the biocavity laser to determine the type and concentration of protein within a cell in order to investigate the process of stem cell differentiation. This avenue of inquiry also has potential in the treatment of cancer, since cancer cells operate almost as stem cells in reverse, stopping cooperation with neighboring cells and trying to reproduce rapidly and spread to other areas of the body. For example, cancerous cells in adult livers produce alpha fetoprotein, a substance normally only produced by in fetal livers.

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