Lasers and Photonics In Medicine

Light has been used in treating illness for thousands of years. Beginning with the Ancient Greeks and Egyptians using sunlight as a therapy, to treatment of cutaneous tuberculosis in the early 1900s, to the first laser surgery applications in the early 1960s, researchers continue to push boundaries to make diagnoses and treatments faster, safer, less invasive, more precise, and more effective. Today, lasers and light diagnostics and therapy have revolutionized medicine and have penetrated most disciplines including dermatology, ophthalmology, dentistry, otolaryngology, gastroenterology, urology, gynecology, cardiology, neurosurgery and orthopedics.

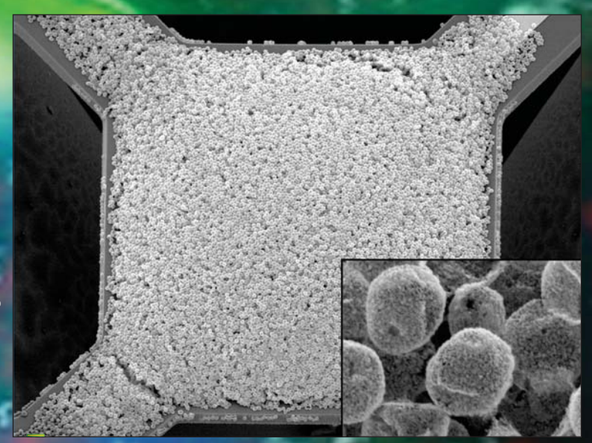


Image credit: TPurdue, NIST

New materials in sensors allow detection of biomarkers by "microhotplates," tiny heating devices on electronic chips.

Breath analysis could rapidly detect illness, including cancer

A new type of sensor has been developed for an advanced breath-analysis technology that rapidly diagnoses patients by detecting biomarkers in a person's respiration in real time. Researchers used a template made of micron-size polymer particles and coated them with much smaller metal oxide nanoparticles. Using nanoparticle-coated microparticles instead of a flat surface allows researchers to increase the porosity of the sensor films, increasing the "active sensing surface area" to improve sensitivity. Detection abilities are in the parts-per-billion range—100 times better than previous technologies.

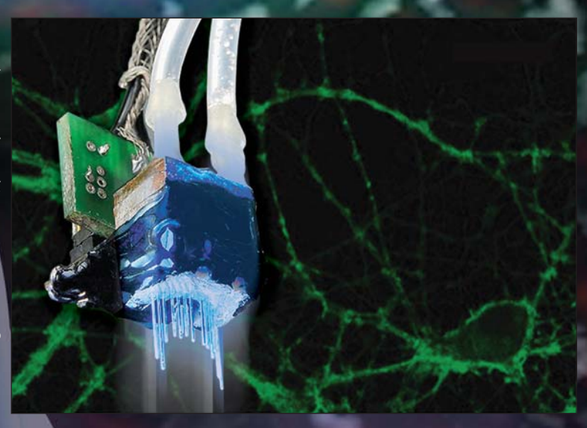


Image credit: Justin Keena, (Keenaphoto.com)

An optical fiber array for targeting neurons in a distributed pattern throughout the brain.

Controlling brain function with targeted diagnosis and treatments

In the new field of optogenetics, neuroscientists at MIT use light to turn genetically modified neurons on and off. Observing how this activity is associated with specific stimuli and behaviors, as well as with brain disorders such as epilepsy and Parkinson's, enables researchers to understand how neurons work together. The ultimate goal is to find ways to repair misfiring brains in a very precise way, unlike current treatments that affect the entire brain. These techniques can also assist in developing drugs to identify which brain circuits are being affected and the behavioral consequences.

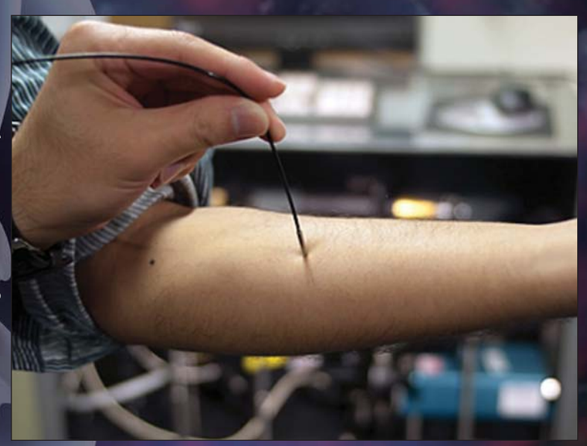


Image credit: JPatrick Gilooly

Light probe, scanning a patient's skin, can detect blood glucose levels without needles.

Needle-free glucose monitoring

Measuring blood analytes requires withdrawal of one or more blood samples and a cumbersome measurement process. Non-invasive, light-based techniques would revolutionize processes by making them painless and with instant results—especially helpful for diabetics. One technique uses near-infrared (NIR) Raman Spectroscopy, a method that identifies chemical compounds based on the frequency of vibrations of the bonds holding the molecule together. The technique can reveal glucose levels by simply scanning a patient's skin.

Image credit: National Cancer Institute

Photosensitizing drugs, coupled with laser light, kill cancer cells.

Photodynamic therapy (PDT)

Photodynamic therapy (PDT) began clinical use in the 1980s, and today is used to treat a variety of cancers. Current common applications include esophageal, skin, lung and prostate cancers. A sensitizing agent—a chemical compound—is administered to the patient, which is taken up and retained in the tumor. This photosensitizer can be excited by light of a specific wavelength, often laser light, producing a form of oxygen that kills nearby cells. PDT continues to be developed to determine optimal combinations of photosensitizers, light sources, and treatment parameters.

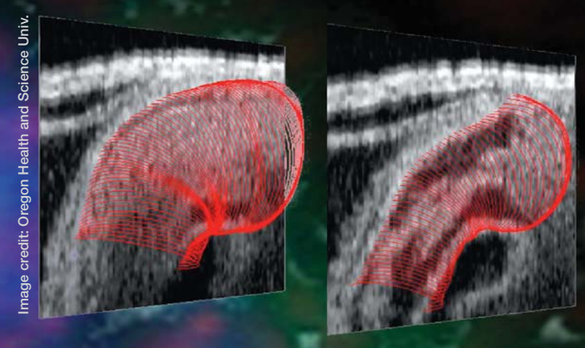
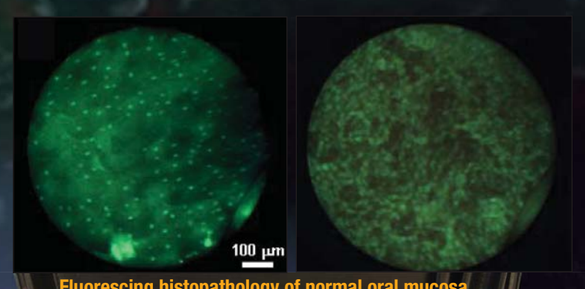


Image credit: Oregon Health and Science Univ.

Segmented geometry of the myocardium of a chick embryonic heart outflow tract during expansion and contraction. See: http://spie.org/documents/newsroom/videos/3365/Rugonyi.wmv for a video of the beating motion of the heart.

Finding the source of congenital heart disease

Optical coherence tomography (OCT) imaging technique can give micron-level, cross-sectional, and 3D images of living biological tissue in real time, using the coherence properties of laser light. OCT, already used in ophthalmology, is now being used in other areas of medicine such as hemodynamics. Studies with chick embryos that include both morphological and Doppler imaging allow researchers to determine how hemodynamic stresses model a healthy heart during development. This understanding could lead to early diagnosis and treatment of congenital heart disease.



Fluorescing histopathology of normal oral mucosa (left) and oral squamous carcinoma (right). Below: portable high-resolution microendoscope.

Photo courtesy of Mark Pierce

Portable, inexpensive and early cancer detection by light-induced fluorescence

Current procedures for cancer screening typically involve visual inspection of the tissue surface under white-light illumination. Researchers have recently developed a portable system to enable high-resolution in situ evaluation of cellular features of tissues—especially useful in the developing world. This system utilizes an epifluorescence microscope coupled with a flexible fiber-optic imaging bundle, which images cells by application of a fluorescent labeling solution. Weighing three pounds and operable with a laptop computer and battery, this device is currently useful in detecting oral cancers, with future applications in esophageal and cervical cancers.

SPIE.org

SPIE