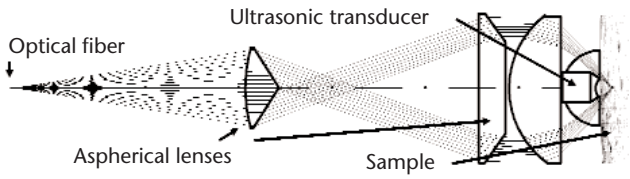
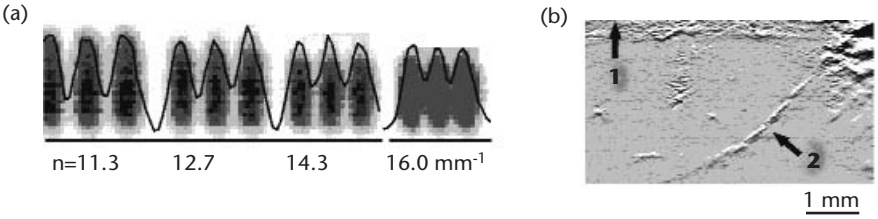
Making Skin Transparent



Design of the photoacoustic sensor of the imaging system used for the tomography experiments.



(a) Image resolution test with a bar chart embedded 4 mm deep in a tissue phantom. (b) Imaging depth test with a black double-stranded cotton thread embedded obliquely in the abdominal area of a rat. Arrows mark the skin surface (1) and the thread (2).

Medical imaging researchers are always trying to increase the resolution and penetration of their instruments, with the ultimate goal of achieving the same microscopic resolution in living tissue that can be obtained by biopsy, thus eliminating the often painful process of taking biopsy samples. In a step toward creating "virtual biopsies," a Texas A&M University team has now developed dark-field photoacoustic tomography—a major improvement over the conventional photoacoustic microscopy that has been a mainstay of materials studies—to obtain 15-μm resolution in living tissues at depths of up to 3 mm (Opt. Lett. **30**, 625).

In photoacoustic tomography, a laser pulse penetrates a translucent sample. More absorbent—and thus darker—portions of the sample are suddenly heated by the absorbed light and expand slightly. This pulse of expansion in turn generates an ultrasonic pulse that an ultrasonic transducer can pick up. In this manner, clear images can be generated from the ultrasonic pulses, even though the photons producing the heat are strongly scattered.

Until recently, photoacoustic imaging had been used exclusively for solid-state materials, in which the objects of interest were close to the surface. But the Texas team decided to modify the technique to probe deeper into living tissues. "Previously, purely optical imaging methods of the skin detected singly backscattered photons to achieve spatial resolution," explained Lihong Wang, the principal investigator of the team. "But scattering is so severe that it's impossible to get a signal from depths of more than 1 mm in most cases."

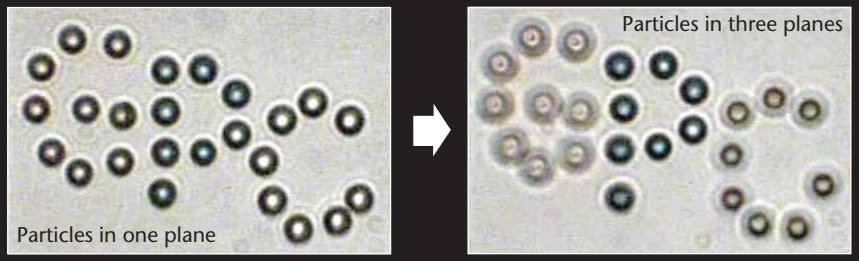
Instead, the team took a laser beam tuned to 532 nm (green) and delivered a 6.5-ns pulse. The radiation was preferentially absorbed by blood, which heats and expands, creating an ultrasound pulse that is detected by a 50-MHz center frequency wideband focused ultrasonic transducer. The ultrasound wave was then focused to produce an image, and depth information was obtained by measuring the time of return of the ultrasound pulse. A 15-μm depth resolution and 45-μm lateral resolution was achieved.

The experiments yielded penetration depths of 3 mm with rat skin, but the team believes that they can obtain much higher penetrations — up to 5 cm — using 800-nm infrared radiation, which absorbs far less.

The technique will enable medical researchers and clinicians to determine the degree of oxygenation in blood vessels, given that blue, unoxygenated blood absorbs far more red radiation than red, oxygenated blood. Such information could help physicians detect skin cancers and other health problems.

DID YOU KNOW?

Scientists at the Risø National Laboratory in Roskilde, Denmark, have developed an optical tweezers system that moves tiny particles in three dimensions at the click of a mouse (Appl. Phys. Lett. 86, 074103). The system converts an 830-nm laser beam into an array of independently controlled optical traps that can move many particles simultaneously. The traps are made by passing the beam through a spatial light modulator and spatial polarization modulator, both controlled by a computer. As the light intensity and polarization change, particles can be moved about. Jesper Glückstad, leader of the research team, says that the device has applications in sorting cells for stem-cell research and in seeding crystal growth, among other fields.



Scientists coordinated the patterns of these 25 commercially dyed polystyrene spheres and formed the letters "GPC" in two (left) and three dimensions. The spheres have a diameter of 3 μm.