Photoacoustic Spectroscopy: Light in and Sound out

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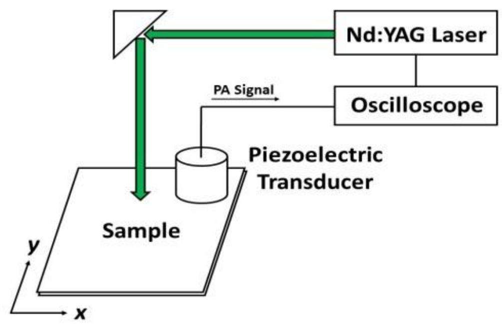
Summer URP – 2018

Photoacoustics is the generation of acoustic waves by modulated optical radiation. Alexander Graham Bell accidently found the photoacoustic effect in 1880. Photoacoustic spectroscopy records the heat release via pressure changes, following the conversion of absorbed energy into heat. photoacoustic spectroscopy does not measure transmitted light intensities, sample opacity and scattering difficulties do not limit this analytical method. Photoacoustics can be used to determine different thermophysical and acoustic properties of a system, such as density, sound velocity, thermal diffusivity, and viscosity.



Photoacoustic microscopy is an emerging technique that utilizes the photoacoustic effect When a monochromatic beam of light excites the material, it causes thermal excitation or expansion, which is responsible for the creation of acoustic waves. Wave production leads to the increase of pressure inside the sample, and resulted fluctuations can be recorded using ultrasonic transducer. A precise collection of ultrasound acoustic waves can provide a lot of information about the absorption contrast at any location in the sample. Photoacoustic imaging is mainly used in order to provide functional or physiological parameters of the living or dead tissue. In this research, the fundamentals of photoacoustic imaging will be studied, using the high power pulsed Nd:YAG laser and phantoms made from carbon black and nano structures.

In this research, invisible gold nanoparticles inside the 2-dimensional hydrogel phantom will be detected by the PA effect. The concept in the PA microscopy is quite simple: the incident electromagnetic radiation is focused to a very small spot size. The sample then can be rastered under the light beam in two dimensions. By recording the PA signal amplitude at each spot a complete microscopic image of the sample can be obtained. The hydrogel-based phantom is placed on a glass slide and imaged before, during and after laser irradiation using a piezoelectric ultrasound transducer positioned on the top of the glass. The pulsed laser for the PA imaging of gold nanoparticles is provided by Nd:YAG laser system. The repetition rate of the output laser beam is 10 Hz and the pulse width is 10 ns. The laser is capable of providing nanosecond pulse at 532 nm as well as 1064 nm pulse. 532 nm pulsed light is used in high intensity treatment of spherical gold nanoparticles and further PA imaging, while 1064 nm pulsed light is used high intensity treatment of gold nanorods and further PA imaging. High intensity laser spot (~1W) sized about 1 mm in diameter is used to deposit optical energy and produce the PA effect from gold nano structures (spherical gold nanoparticles and gold nanorods).

The students will learn how to build up experimental setup with optics, operate lasers and analyze data. The students will also be encouraged to present their work at the 70th Southeastern Regional Meeting of the American Chemical Society (SERMACS) held in Augusta, GA in 2018.