

Photoacoustic Microscopy Experiment with Gold Nanostructures: Sound Generation by Precious Metal

Research Advisor: Dr. Park, Summer URP – 2026

Photoacoustic microscopy is an emerging technique for *in vivo* imaging which provides high-resolution images due to the weak acoustic scattering. It is based on photoacoustic effect. Monochromatic beam of light excites the electrons, and due to the thermal expansion the ultrasound waves are emitted. Precise detection and collection of ultrasound waves can provide a lot of information about the absorption contrast at any location in the sample. Gold nanoparticles will be used to study the feasibility of photoacoustic (PA) microscopy with nanostructures, a biomedical technology used for laser-controlled drug release. By focusing incident electromagnetic radiation in an array of points and recording the PA response, a sample can be rasterized in two dimensions producing a complete microscopic image. The effect of the optical lens on the spatial resolution of the image will be studied. Gold nanoparticles have been widely used for applications both in biology and chemistry due to their unique optical properties. These properties are conferred by the interaction of light with electrons on the gold nanoparticle surface. At a specific wavelength of light, collective oscillation of electrons on the gold nanoparticle surface cause a phenomenon called surface plasmon resonance resulting in strong extinction of light. The particular wavelength of light where this occurs is strongly dependent on the gold nanoparticle size and shape.

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 (~ 1 W) sized about 1 mm in diameter is used to deposit optical energy and produce the PA effect from gold nano structures. This approach is potentially transformative concept to understand PA imaging in undergraduate research labs and will be used in science and engineering teaching labs.

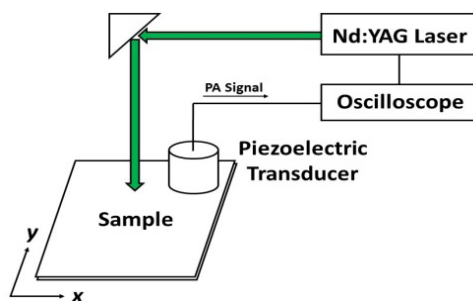


Diagram of photoacoustic imaging setup

The student will learn how to build up experimental setup with optics, operate lasers and analyze data. The student will also be required to present the work at the Southeastern Regional Meeting of the American Chemical Society (SERMACS) held in Memphis, TN in 2026.