Professor: Andreas Mandelis

Topic: Development of a Catheter for Photoacoustic Endoscopy Imaging of Coronary Artery Lipids

The ongoing research projects at Center for Advanced Diffusion-Wave and Photoacoustic Technologies (CADIPT) include developing a novel Wavelength-Modulated Differential Photoacoustic Imaging (WM-DPAI)-based endoscopy system for early detection of atherosclerotic plaques. A conventional single-ended photoacoustic (PA), being a hybrid imaging modality that combines superior optical contrast of optical imaging and high depth resolution of ultrasound imaging, has been showing promising imaging capabilities in various fields of biomedical diagnostics. However, its sensitivity and specificity further need to be improved to enable early detection of plaques and to prevent the possible life-threatening cardiovascular complications such as heart attack and stroke before they start to proliferate. We want to achieve this by employing the second laser with different wavelength, therefore making the system differential. The two wavelengths are chosen to be 1210nm and 980nm based on the absorption spectrum of various biological components found in human atherosclerotic vessel. Cholesterols, a major component of the plaques, have negligible absorption in the 980-nm spectral region, but exhibit distinctively high absorption in the 1210-nm region due to the second overtones of the C-H bond vibrations within the lipid molecules. Other important components found in human blood vessels such as collagen, blood and water, however, show much smaller difference in their absorption properties at those two wavelengths. When these two waveforms are modulated out-of-phase (~180-degree phase difference) and tuned to have the same PA amplitude ratio from the non-plaque regions of the vessel, most or all the undesired background absorptions and system noise will be effectively suppressed towards a zero baseline by means of complete destructive interference (CDI). Once tuned, the differential system then becomes extremely sensitive to small PA signals that specifically emerge from the lipid contents of the plaques.

The student is expected to be actively involved in different stages of imaging experiments. This will include, but not limited to, (1) developing a concise Labview software for catheter automation and integrating it into the existing CADIPT software (2) *ex-vivo* human sample imaging data acquisition (3) testing and optimizing signal/data processing. The student will learn how the signal/data flows and how they are processed in PA imaging or in general biomedical imaging modalities. The student will also learn how to utilize his programming knowledge into a real-world application through this project.