Optical imaging has been gaining tremendous emphasis over the years, due to its considerable contribution in the area of molecular medicine. Optical imaging methods bear the potential to perform efficient, inexpensive, and non-invasive molecular interrogations in deep tissues in humans with high spatial resolution. By deciphering precise functional and molecular information of biological processes in deep tissues, optical imaging methods hold promise to provide better understanding and early detection of diseases. Researchers are harnessing the power of near infrared (NIR) light (>700 nm; typically between 700 and 900 nm) to optically image deep tissues as imaging in that wavelength window increases penetration depth in tissues and reduces background noise, while interrogating tissues beyond the superficial layer.

In this talk, we will first discuss our recently published work on deep-tissue imaging using our developed all-NIR multi-photon microscopy (MPM) method. All-NIR MPM employs 1550 nm multi-photon excitation, and images signal from NIR fluorophores. We have demonstrated that all-NIR MPM method can achieve greater than five-fold imaging depth compared to other existing NIR excitation microscopy methods while imaging deep tissues. In this study, we also compared the attributes of the all-NIR MPM method and two other NIR excitation microscopy methods, namely, NIR single-photon confocal microscopy method (NIR SPCM) and NIR multi-photon excitation with visible detection method (NIR/VIS MPM), for deep tissue imaging. Homologous cyanine dyes provided the fluorescence for imaging. Intact kidneys were harvested after administration of kidney clearing cyanine dyes in mice. NIR SPCM and NIR/VIS MPM methods achieved similar maximum imaging depth of ~100 µm. The all-NIR MPM method enabled imaging >500 µm deep in the harvested kidneys. Although, the all-NIR MPM method used 1550 nm excitation where water absorption is relatively high, cell viability and histology studies demonstrated that the laser did not induce photo thermal damage at the low laser powers used for the kidney imaging. This study provides guidance on the imaging depth capabilities of NIR excitation-based microscopic methods and reveals the potential to multiplex information using these platforms.

Next we will briefly present our study on NIR fluorescence lifetime (FLT) imaging microscopy (NFLIM), in which cancer cell populations were sorted based on distinct FLTs of NIR dyes in such cells. We will then briefly discuss two of our recent works on segmentation of FLIM images of cells using a multi-resolution community detection method and on noninvasive deep tissue imaging of live mice using NIR FLT molecular tomography (NFMT) method.

Finally, we will present an overview of our developed analytical framework for optimal statistical design of microfluidic microsphere array devices. The talk will conclude by discussing how we can integrate NFLIM, NFMT, statistical image segmentation and deconvolution, and optimal statistical design with the all-NIR MPM method to improve deep-tissue imaging performance as well as obtain maximal functional and molecular information from the associated images which has enormous clinical implications.

**Bio:** Pinaki Sarder obtained his B.Tech. degree in Electrical Engineering from the Indian Institute of Technology, Kanpur, in 2003, and the M.Sc. and Ph.D. in Electrical Engineering from Washington University in St. Louis (WUSTL) in 2010. His Ph.D. work involved Designing and Imaging of Position-Encoded Microsphere Arrays and Genomic Signal Processing using tools from Statistical Signal Processing. He is currently a Postdoctoral Research Associate in the Department of Radiology at Washington University School of Medicine, St. Louis. His current research work includes Molecular Imaging, involving Multi-Photon and Fluorescence Lifetime (FLT) Imaging Microscopy of cells and tissues and FLT Molecular Tomography of small animals, as well as Statistical Signal Processing. Dr. Sarder received the NIH funded Imaging Sciences Pathway fellowship in 2007. His publications include 11 refereed first-authored journal articles and one refereed first-authored book chapter. These original works contributed in diverse disciplines, including Signal Processing, Optimization, Microscopy, Biomedical Optics, and Instrumentation.