Tailored Ultrasound for Nanoagent-Assisted Imaging and Therapy: Customized Transducers and Pulse Controls

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Ultrasound is broadly employed in nanomedicine for both imaging and therapy. As diverse biocompatible micro/nanoagents have emerged as a promising therapeutic paradigm for cancer treatments, nanoagent-assisted ultrasound techniques have also attracted increasing attention. However, it is challenging to take full advantage of micro/nanoagent responses (e.g., harmonic oscillations, broadband shocks, and microjets) by using conventional transducers with standardized pulsing schemes, i.e., low-power, short pulse for imaging and high-power, long-pulse for therapy. Lack of suitable ultrasound transducers with a proper pulsing guideline is a crucial technological gap in nanoagent-assisted ultrasound fields. My research has focused on filling this gap by developing customized ultrasound transducers and optimal pulsing schemes. In this talk, I will present three different customized transducer designs for nanoagent-assisted ultrasound applications: 1) dual-frequency stacked-type transducer for interventional acoustic angiography, 2) forward-viewing intravascular sonothrombolysis transducer, 3) laser-generated focused ultrasound transducer. This talk will cover both diagnostic and therapeutic applications in cardiovascular diseases (atherosclerosis, deep vein thrombosis, and pulmonary embolism) and cancers (detection of tumor in prostate or pancreas and remotely-controlled doxorubicin delivery). The developed transducers outperformed conventional standard transducers in 1) microbubble's higher harmonics (>4th harmonics) detection, 2) cavitation-enhanced mechanical effects, and 3) the precise control of treatment volume. Based on the demonstrated feasibility, this talk will present future perspectives and promising transducer designs in various nanomedicine-assisted ultrasound applications.

Jinwook Kim is a Postdoctoral Research Associate in the Joint Department of Biomedical Engineering, The University of North Carolina at Chapel Hill. He received his B.S. and M.S. degrees in Mechanical Engineering from Kyungpook National University, Daegu, South Korea in 2010 and 2012, respectively. His initial graduate research focused on developing broadband underwater transducers for SONAR using piezo-composites. He received his Ph.D. degree in Mechanical Engineering from North Carolina State University, Raleigh in 2017. His dissertation work focused on developing miniaturized custom ultrasound transducers for the controlled acoustic excitation of microbubbles and microgels in medical imaging and therapy. His novel transducer designs have been recognized with Best Paper Award (IEEE International Ultrasonic Symposium 2016) and Science News articles (ScienceDaily and News Atlas). His current research interests include nanodroplet-assisted sonodynamics and acoustic hologram lens designs for biomedical applications.