Nano-acoustics for Intravascular Ultrasound Imaging and Therapy

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Acoustics associated nanomaterials, nanostructures, nanofabrication and devices (nanoacoustics) has been actively investigated over the past two decades for a broad range of biomedical imaging and therapy applications because of its unique performance enabled by nanotechnology. On the other hand, cardiovascular disease (CVD) remains a major health concern and the search for more effective diagnosis and treatment techniques has been of a great interest. In this talk, micro/nanotechnology enabled small aperture transducers were designed, fabricated and tested for advanced intravascular ultrasound imaging (IVUS) and intravenous sonothrombolysis. In specific, we investigated high frequency (40-60 MHz) micromachined piezoelectric composite transducers and arrays with broad bandwidth (-6 dB fraction bandwidth ~ 80%) for intravascular ultrasound (IVUS) imaging. Dual frequency transducers and arrays (6.5 MHz/30 MHz, 3 MHz/30 MHz) were also successfully demonstrated for microbubble enhanced intravascular superharmonic imaging (or acoustic angiography) toward detection of plaque vulnerability. For the case of intravascular thrombolysis, small aperture (diameter <2 mm) sub-MHz forward-looking and vortex transducers were successfully developed with sufficient peak-negative-pressure for sonothrombolysis. Significantly enhanced thrombolysis rate was observed by using microbubbles and nanodroplets in in-vitro tests. These new findings suggest that nanoacoustics associated small aperture ultrasound transducers and micro/nano-contrast agents are increasingly important in advancing intravascular ultrasound imaging, intravenous therapy, minimal invasive diagnosis and therapy, and image guided drug delivery and surgery.