Prospects of High Frequency Biomedical Ultrasound

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High frequency ultrasonic imaging (> 30 MHz) is considered by many to be a frontier in ultrasonic imaging because higher frequencies yield much improved spatial resolution. The consequence is a reduced depth of penetration. It has many biomedical applications ranging from visualizing internal and surface structures of the blood vessel wall and mapping anterior segments of the eye, to characterizing skin tumors. An added significance is the recent intense interest in small animal imaging for the purpose of evaluating the efficacy of drugs and gene therapy. A few novel applications are being investigated at USC. These include the development of a 60 MHz 64 element linear array mounted on a biopsy needle for identifying microcalcifications during breast biopsy. The main challenge lies not only in the design and fabrication of the array but also in the development of interconnect. In another project, a forward looking intravascular catheter with 32 element phased array mounted at the tip is being developed. It will facilitate catheter guidance and avoid perforation during catheterization.

Biomedical applications of high frequency ultrasound especially in the ultrahigh frequency (UHF) range > 100 MHz other than imaging (acoustic microscopy) have been mostly overlooked. At UHF frequencies, the width of an ultrasound beam is of only a few microns, approaching the dimensions of many cells, hence it may be called “ultrasound microbeam”. Sensitive UHF single element transducers have been developed to allow these applications to be advanced. In particular, the developments of acoustic tweezer for manipulating cells and acoustic transfection for transporting drug and genes across cell membrane are just two prominent examples. Efforts in utilizing acoustic tweezer to measure intercellular forces and cellular deformability and in utilizing UHF ultrasound to examine cellular mechanotransduction have also been pursued.