Ultrasonic Imaging with Sub-Optical Wavelength Elastic Waves

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Ultrasound is widely used for imaging, measurement and diagnostics in the MHz region and is very familiar as a powerful medical diagnostic tool but also finds widespread application in engineering as a non-destructive testing tool. Typically ultrasonic wavelengths are in the mm-micron range, many times longer than the wavelength of visible light which limits the resolution that these systems can achieve. By using acoustic waves in the GHz region, it is possible to perform ultrasonic imaging and measurement using ultrasound with wavelengths less than that of visible light and, potentially, to achieve higher resolution than optical microscopy. However, as the frequency of the ultrasound goes up the attenuation rises steeply and it becomes a considerable technical challenge to generate and detect the acoustic wave with sufficiently signal-to-noise ratio to permit measurement and imaging. Despite this nanoscale ultrasonics has much to offer as a powerful diagnostic tool. In this paper we discuss some of the practical problems standing in the way of nano-ultrasonics and some of the solutions, especially the use of pico-second laser ultrasonics and development of nano-ultrasonic transducers[1] using layered and nanoparticle structures. We present experimental results showing the measurement of protein adhesion and imaging on cell phantoms and 3T3 fibroblast cells.

References

[1] R. Smith, F. Perez Cota, L. Marques, X. Chen, A. Arca, K. Webb, J. Aylott, M. Somekh, and M. Clark, ”Optically excited nanoscale ultrasonic transducers”, JASA, accepted for publication (2015).