ACOUSTICS2008/2736 Theory and applications of frequency domain photoacoustic microscopy

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In frequency domain photoacoustic microscopy, the pulsed laser source used for ultrasound excitation in conventional photoacoustic imaging is replaced by a low power, amplitude modulated laser source. The acoustic signals are detected using an interferometer or contact transducer, coupled to a RF lock-in amplifier or vector network analyzer. The detection bandwidth reduction afforded by this technique allows for a significant improvement in signal-to-noise ratio (SNR) over systems using pulsed laser excitation. In this paper, the method of frequency domain photoacoustic microscopy is reviewed and compared to the pulsed-laser based approach. Methods for processing the frequency domain data to extract the information of interest are discussed, along with the effects of measurement bandwidth and frequency resolution. A new technique to optically downshift acoustic signals detected using an optical interferometer to a fixed intermediate frequency is presented, which allows for the detection of high frequency (100's of MHz- GHz) acoustic signals using low frequency, low cost detection electronics. Several applications of frequency domain photoacoustic microscopy are presented including the inspection of thin films and environmental barrier coatings and the photothermal operation of nano-electro-mechanical systems. Finally, potential applications of this technique for the characterization of biological media are discussed.