Ultra-Deep Thermophysical Diagnostics in Animal Bones with Fat-Skin Overlayers Using a New Pulsed Photothermal Radar

K. Sreekumar and A. Mandelis [C, S]
University of Toronto, Center for Advanced Diffusion-Wave Technologies, Department of Mechanical and Industrial Engineering, Toronto, ON, Canada
mandelis@mie.utoronto.ca

Characterization of bone for the early diagnosis of osteoporosis is a challenging task and is of high scientific merit and social impact [1]. As an effort to exploit the promising features of non-ionizing bio-optical techniques, we have initiated the development of a *highly depth-resolved photothermal radar* for the early diagnosis of bone-osteoporosis [2]. Relatively low optical absorption in the therapeutic optical window (700-1300 nm) and strong absorption of infrared photons by water molecules in tissues make the available depth information carried by the conventional photothermal signal at the skin surface too limited for biologically reliable diagnosis. A novel pulsed photothermal radar, operating at 808 nm, makes simultaneous use of the reduced static thermal field (baseline) and of photothermal signal non-linearity, thereby extending the resolvable depth to an otherwise unattainable level consistent with practical interest [3]. Experiments conducted on the variation of the pulsed radar peak delay time with sample thickness for a goat bone with a fat-skin overlayer, with and without a back-surface absorber will be described. The bone was of wedge shape with thickness varying from 0.5-2.5 mm and the thickness of fat-skin overlayer was about 1 mm. The back absorber was a graphite coating. This sample, to a good extent, mimics a natural bone with marrow (optical absorber) inside. The presence of a back absorber was detectable up to a depth of about 2.7 mm below the surface, which was the plane of detection. Neither the conventional frequency scan technique nor the harmonic modulation radar was capable of this type of ultra-deep absorber sensing. In addition to the delay time, both radar output amplitude and half-width of the cross-correlation peak have been found to be sensitive to the subsurface features.

[1] Osteoporosis Prevention, Diagnosis and Therapy, National Institutes of Health Consensus Development Conference Statement, 2000.
[2] K. Sreekumar and A. Mandelis, Rev. Sci. Instrum. **82**, 074906 (2011).
[3] B. D. Fornage and J-L. Deshayes, J. Clin. Ultrasound **14**, 619 (1986).