

Thirty Years of Unconventional Techniques, Instrumentation and Measurements in Photothermal Thermophysics

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The introduction of photothermal phenomena in the 1970's has generated a wealth of diagnostic techniques which are fundamentally thermophysical in nature and have grown into diverse fields spanning disciplines from fundamental physics, spectroscopy and analytical chemistry to food science, semiconductor properties, materials science and non-destructive evaluation, agricultural and environmental sciences and sensors. Conventional instrumentation and measurement techniques have been dominated by pulsed laser and frequency-domain modulation principles. As is well-known to practitioners and users of thermophysical techniques, there are physical limitations associated with diffusive field transport and interactions with gaseous, liquid and solid matter. In this talk, I will briefly discuss the mathematical fundamentals of the peculiar nature of parabolic diffusion-wave fields ("Diffusion Waves and their Uses," Physics Today Vol. 53, Part I, August 2000, pp. 29-34.) and will present a review of non-conventional ultrasensitive photothermal techniques, instrumentation methodologies and technologies introduced at the Center for Advanced Diffusion-Wave Technologies, University of Toronto, throughout the past 30 years, precisely aimed at enhancing and optimizing the unique and considerable diagnostic capabilities of photothermal thermophysics. Highlights will include: the thermal-wave resonant cavity sensor for environmental gas, fluid pollution monitoring and infrared emissivity measurements; photopyroelectric gas sensors; the Common Mode Rejection Demodulation (CMRD) contrast amplification technique as a platform signal generation and processing methodology of optimal contrast dynamic range; thermal-wave tomography and the depth profilometric inverse problem with applications to industrial case-hardened steels; the thermal-wave radar; Deep-Level Photo-Thermal Spectroscopy (DLPTS) of defects and impurities in semiconductors; and dental thermophotonics of sensitivity and specificity higher than dental x-rays, with applications to kinetics of early enamel demineralization caries induced by, e.g., orange juice, followed by fluoride-mediated remineralization processes.