

The Department of Mechanical Engineering presents:

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Photomechanical, Photothermal and Photothermomechanical Mechanisms of Interaction of Nanosecond-Long Laser Pulses With Artificial Tissue Models and Pigmented Melanoma Cells in Medical Applications

Nanosecond-long laser pulses are used in both branches of biomedical optics: where photons affect tissue (therapy) and where tissue affects photons (diagnostics). A current problem in vascular laser surgery is that small blood vessels, with short thermal relaxation time, remain after the treatment with laser pulses longer than such relaxation time. This problem is approached irradiating artificial skin models with nanosecond laser pulses. The objective is to take advantage of its high intensity to induce plasma that produces cavitation bubbles, which may serve as blood vessel photodisruption mechanism. Permanent and transient bubbles were identified as a function of the laser dose, number of pulses and repetition rate. Additionally, scattering effects were added to the skin models, which increased the threshold fluence for plasma formation.

Energy from nanosecond laser pulses couples to a material through the combination of linear and nonlinear absorption according to both, laser light intensity and material properties. The first results in heat generation and thermoelastic expansion; while the second results in an expanding plasma formation that launches a shock wave and a cavitation/boiling bubble. Such mechanical effects were studied using three different experimental techniques: piezoelectric sensors, time-resolved imaging (TRI) and time-resolved interferometry (TRIF). The relative roll of linear and nonlinear absorption upon bubble formation is discussed.

A melanoma detector takes advantage of pressure waves originated upon absorption of energy from nanosecond laser pulses within melanoma cells. Excessive energy creates boiling bubbles around melanosomes that damage the plasma membrane. It is important to elucidate the optimum laser parameters for this application. Melanoma cells were irradiated with nanosecond laser pulses at $\lambda = 355$ and 532 nm to: determine cell survival rate, compare the photoacoustic signal, determine the critical laser fluence for melanin leakage from melanoma cells and study the intracellular interactions and their effect on the plasma membrane integrity. Cell survival decreased with increasing laser fluence for both wavelengths, although the decrease is more pronounced for $\lambda=355$ nm. Melanin leaks from cells equally for both wavelengths. No significant difference in photoacoustic signal was found between wavelengths. TRI showed damage to plasma membrane due to bubble formation.