

Tuning Photoacoustic Generation in Water with Nanotransducers via Laser Pulse Duration

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Abstract— The photoacoustic effect in liquids, generated by nanotransducers excited with short laser pulses, offers high contrast imaging and promising medical treatment techniques. Understanding the role of the thermal boundary resistance (TBR) and the laser pulse duration in the generation mechanism of acoustic waves is essential to implement efficient photoacoustic nanotransducers [1–3]. This work theoretically investigates, for the paradigmatic case of water-immersed gold nanoplates, gold-nanocylinders [2] and carbon nanotubes [3], the role of the TBR [4] and laser pulse duration in the competition between the launching mechanisms: the thermophone and the mechanophone. In the thermophone, the nanoparticle acts as a nanoheater and the wave is launched by water thermal expansion. In the mechanophone, the nanoparticle directly acts as a nanopiston. Specifically, for a laser pulse duration far exceeding the heat transfer time from the nanostructure to the surrounding water, the thermophone prevails. For the opposite case the mechanophone dominates. Activation of the mechanophone effect is sought to trigger few nanometers wavelength sound waves in water, matching the nanotransducer acoustic frequencies. This is at variance with respect to the commonly addressed case of water-immersed nanotransducer excited with ns laser pulses, where only the thermophone effect significantly contributes. The present findings might be of impact in fields ranging from nanoscale non-destructive testing to water dynamics at the meso to nanoscale. Furthermore, the results point to high-TBR, liquid-immersed nanoparticles as potentially efficient photoacoustic nanogenerators [5], with the advantage of keeping the liquid environment temperature unaltered.

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