Canadian Association
of Physicists

Association canadienne
des physiciens et physiciennes

Contribution ID: **2573** Type: **Invited Speaker / Conférencier(ère) invité(e)**

Analysis of Plasmonic and Plasma Assisted Photoacoustic Response from Metallic Nanostructures Irradiated by Fast and Ultrafast Laser

Monday 3 June 2019 13:45 (30 minutes)

Nanotechnology is rapidly developing as an enabling technology for introducing new highly performant theragnostic tools for biomedical applications. Recently, plasmonic nanostructures (PNs) have shown a great potential for providing an effective method in this field of research and applications. PNs present very peculiar optical properties related to the presence of a large optical absorption cross-section due to the collective oscillation of the conduction electrons by incident laser field known as localized surface plasmon resonance (LSPR). The PNs are also capable of enhancing the incident laser field in the form of scattered near field for even an off-resonance irradiation where the incident laser wavelength is far away from LSPR. If the intensity of the incident laser is large enough, this field enhancement capability can be employed to generate a highly localized free electron (plasma) in the vicinity of the particles. The energy deposition in generated plasma can be considered as an energy source for photothermal ablation therapy, photoacoustic tomography, and light-controlled drug release. In this presentation we will present a model that will serve as a design tool for simulating ultrashort pulsed laser interaction with PNs in water for such applications. This tool is built based on the following physical phenomena that couples: 1) optical properties of the PN obtained from simulation of electromagnetic wave interaction with PN and coupled through resistive heating due to laser pulse to; 2) two temperature model to analyze transient heat transfer in ultrafast regime and temperature increase calculation, where temperature is used as a coupling parameter to; 3) plasma dynamics and 4) structural mechanics analysis for linear thermal expansion, stress and strain calculation for the input as a boundary condition in acoustic-structure interaction for; 5) acoustic pressure wave propagation modeling.

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Session Classification: M2-4 Emerging investigators in bioimaging and medical applications of optics (DPMB/DAMOPC) | Chercheurs émergeants en bioimagerie et applications médicales de l'optique (DPMB/DPAMPC)

Track Classification: Physics in Medicine and Biology / Physique en médecine et en biologie (DPMB-DPMB)