Proceedings of the 6th International Conference on Multiphase Flow and Heat Transfer (ICMFHT'21)
London, England – March, 2020
DOI:

Indirect Radiation Pressure Drives Micro Heat Engine for Optofluidics

Dr. Jinliang Xu
School of Energy Power and Mechanical Engineering
North China Electric Power
University, Beijing, 102206, P.R. China

Radiation pressure (RP) refers to the momentum transfer of photons during light "particles" impacting a surface. RP is too small to driven micro actuators. For light irradiation on liquid-liquid or gas-liquid systems, the interface deformation is usually ultra-small. Different from classical RP, indirect radiation pressure is introduced for the first time. The idea is that when light irradiates a bubble in nanofluid, self-organization of nanoparticles on bubble interface promotes plasmonic heating to forma a superheating boundary layer there. Because the bubble can be divided into a sunny side and a night side, a net force is generated during the momentum change of the bubble expansion, which is caused by the asymmetric evaporation between sunny side and night side. Because the two-phase fluid is responsible for the momentum change instead of photons, the associated force is called indirect radiation pressure (*IRP*). We show that *IRP* is scaled as $IRP \sim (I \cdot r_b)^2$, behaving faster growth of *IRP* versus light intensity *I* and bubble radius.

Light driven boiling experiment demonstrates an *IRP*-based micro-bubble piston engine. Using 527 nm pulse laser, we show that *IRP* can exceed all the other forces exerted on the bubble. Bubbles always stay underneath the water surface, breaking through the common phenomenon that *vapor shall escape out of air-water interface and enter the environment for open boiling system*. Micro-bubble piston engine works according to the following principle. During pulse on, *IRP* exceeding other forces yields a net force to propel a bubble traveling downward. During pulse off, the bubble changes flow direction from downward to upward, due to non-presence of *IRP*. The piston engine sustains the oscillating ranges of 38□347 □m for bubble diameter and 2.7□457.9 □m for traveling distance of piston. These deformation parameters are at least two to three magnitudes larger than the results attained by classical radiation pressure. Our work can find various applications in optofluidics.