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Characterization and Application of Bubbles during Thermal Blooming in a Thermal Medium

Characterization and Application of Bubbles during Thermal Blooming

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Abstract

In this work, thermally generated micro-bubbles are characterized using in-line digital holography. A stable bubble can be formed by focusing a 514 Ar laser to a thermal medium. A collimated 633 nm He-Ne laser is used to perform in-line holography. The thermal medium comprises a mixture of a red dye and isopropyl alcohol. To minimize the optical effects arising from convection, the focused pump is introduced vertically into the liquid sample. The recorded in-line holograms are numerically reconstructed to determine the size and 3D shape of the bubbles. Nanoparticle agglomeration around the thermally generated bubbles is tested using a focused probe beam at 405 nm corresponding to the absorption peak of the Ag nanoparticles due to plasmonic resonance. This technique should prove useful in drug delivery systems using nanoparticles agglomerated around microbubbles.

Introduction

When a material reacts nonlinearly to an optical field, it can change the refractive index (RI) of the material due to the Kerr effect. Alternatively, a focused laser beam can heat up a material due to absorption, thereby causing a temperature change and associated change in the RI. In both cases, this induced change in RI, which is proportional to the intensity, causes self-phase modulation (SPM) of the optical beam. Thermal blooming (TB) is a phenomenon that occurs when a thermal medium is heated by a focused laser beam beyond SPM. In this case, a bubble forms inside the thermal lens and is trapped by the focused beam. Pharmaceutical sciences are increasingly using nanoparticles to reduce toxicity and side effects of drugs during drug administration. Our work nanoparticle agglomeration around bubbles and steering should find applications in future drug delivery systems.

Objective

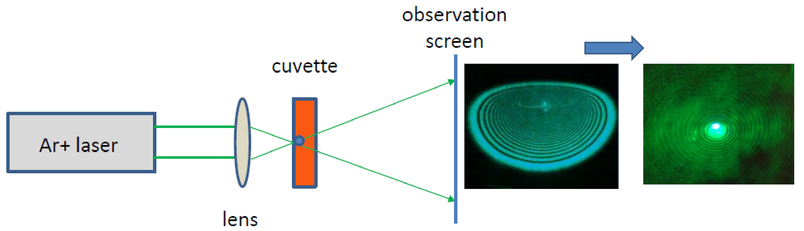
Characterize thermally generated bubbles using DH and introduce a novel way to clustering nanoparticles around thermally generated bubbles.

Methodology

➢ Experiment

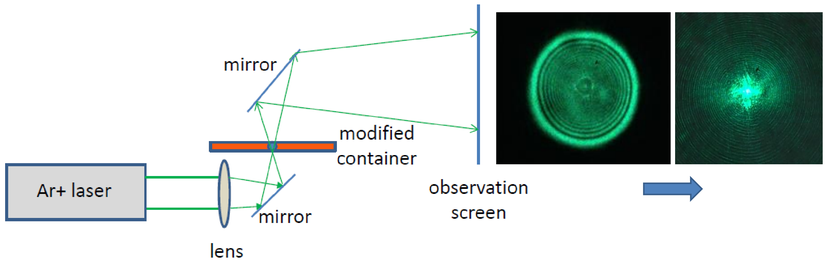
Generation of bubbles is done by focusing (200 mm concave lens) a 514 nm Ar-Ion laser on to the sample.

Experimental setups - bubble generation

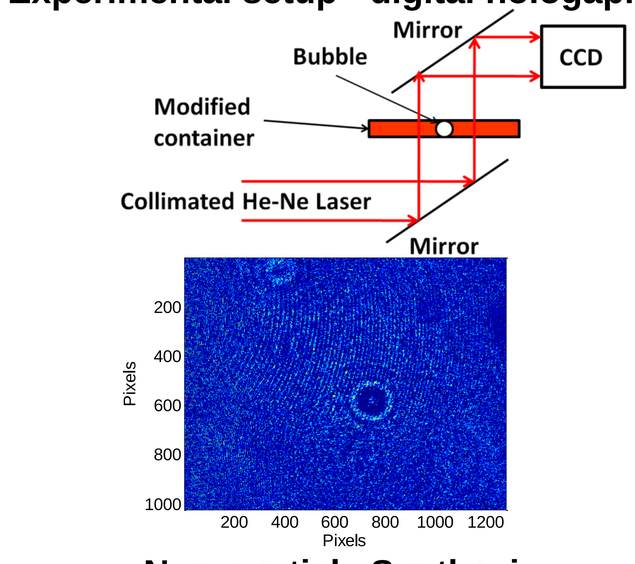


Experimental setup for generating the bubbles. Diffraction patterns for SPM and TB are shown.

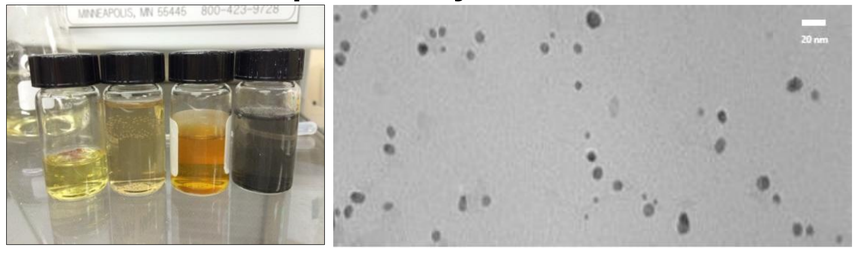
A new set up is introduced to minimize the effect of gravity and symmetric ring patterns can be observed. New container is made from regular microscopic slides.

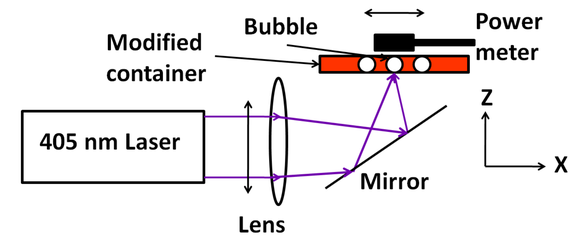


Experimental setup - digital holography

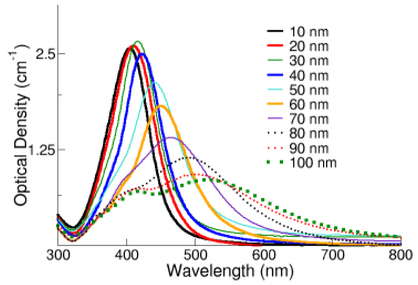


Nanoparticle Synthesis

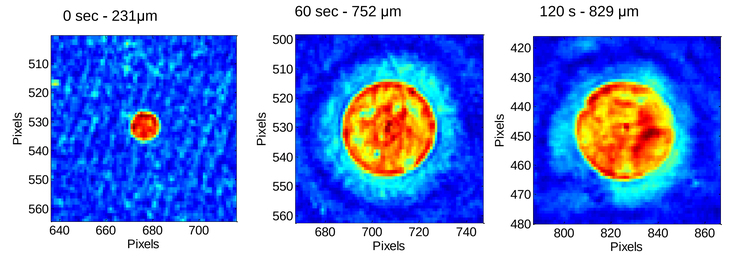




405 nm laser is focused on to the sample and output power is measured in the presence and the absence of bubble



Results



	Bubble x, Nanoparticles x	Bubble x Nanoparticles √	Bubble √ Nanoparticles x	Bubble √ Nanoparticles √
Average (mW)	18.04	14.84	5.88	3.46

Future Work

➢Applications in future drug delivery systems.
➢Obtain exact relation between bubbles size and time.
➢Develop a method to observe the agglomeration of nanoparticles around bubbles without using expensive techniques such as TEM.

References

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