Below 50 nm nonlinear core-shell nanomarkers for imaging in turbid media

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Abstract

Barium titanate ($BaTiO_3$) nanoparticles are one of the second harmonic generation (SHG) nanoparticles, which can be applied as exogenous probes for imaging systems. In the first part of this project, for the first time to my best knowledge $BaTiO_3$ nanoparticles whose diameters are below 50 nm have been investigated. The size distribution measurements of $BaTiO_3$ nanoparticles via dynamic light scattering (DLS) and transmission electron microscopy (TEM) images show that the mean size of the $BaTiO_3$ nanoparticles is around 15 nm. The SHG signals from the $BaTiO_3$ nanoparticles with the diameter from 22 to 53 nm are characterized experimentally and theoretically. The SHG power shows the quadratic dependence with respect to the incident power, which proves the obtained signals are indeed SHG. The polarization dependent SHG response is in good agreement with the simulation result while revealing the information on the orientation of the crystal axis of individual particles.

A plasmonic core-shell nanocavity is known to enhance the SHG signal under the resonance conditions. Therefore, in the second part of this project, the plasmonic $BaTiO_3$/Au core-shell nanostructures were investigated theoretically and experimentally. The theoretical modeling gives the quantitative enhancement value at a given wavelength of the incident light and shows the effects of different shell thickness on the enhancement of the incident light. The $BaTiO_3$/Au core-shell nanostructures were fabricated via chemical synthesis. The spectral measurements of the core-shell nanostructures determine the resonance wavelength.

As the last part of the project, Imaging through highly scattering media using $BaTiO_3$ nanoparticles as nanomarkers were studied theoretically and experimentally. The SHG efficiency through a mouse liver tissue with the thickness 10, 20, and 30 μm was calculated using a Multilayer Monte-Carlo approach. Multiphoton imaging of $BaTiO_3$ nanoparticles demonstrated the comparable value with the simulation result.