University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Doctor of Philosophy

of

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"Metallic Nanoparticles: Analytical Properties of the Acoustic Vibrations and Applications"

Department of Electrical and Computer Engineering

Thursday, August 3, 2017
9:30 A.M.
Engineering and Computer Science Building
Room 468

Supervisory Committee:
Dr. Reuven Gordon, Department of Electrical and Computer Engineering, University of Victoria (Supervisor)
Dr. Tao Lu, Department of Electrical and Computer Engineering, UVic (Member)
Dr. Fraser Hof, Department of Electrical and Computer Engineering, UVic (Outside Member)

External Examiner:
Dr. Li-Lin Tay, Measurement Science and Standards, National Research Council Canada

Chair of Oral Examination:
Dr. Neil Burford, Department of Chemistry, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

This thesis focuses on the analytical properties of the acoustic vibrations and applications of metallic nanoparticles. With regard to the analytical properties of the acoustic vibrations, we focus on nanoparticle acoustic resonance enhanced four-wave mixing (FWM) as an in situ characterization technique for characterizing nanoparticles' shape, size, and size distribution. The nonlinear optical response of metallic nanoparticles is resonantly driven by the electrostriction force which couples to the acoustic vibrations of nanoparticles. Information about nanoparticles' shape, size, and size distribution can be obtained by analyzing the resonant peak position and linewidth in the FWM signal which carries the information about the vibrational modes. We characterize different nanoparticle solutions of different materials, shapes, and sizes using this FWM technique. Information obtained from the FWM characterization agrees well with the scanning electron microscopic examination, indicating the FWM technique can serve as an in situ nanoparticle characterization tool. We also demonstrate the FWM technique can be used for monitoring nanoparticle growth in situ.

With regard to the applications of metallic nanoparticles, we focus on quantification of an exogenous cancer biomarker Acetyl Amantadine using surface-enhanced Raman scattering (SERS). Raman spectroscopy can provide unique fingerprint information of molecules, which can be used as a chemical detection and identification technique. The intrinsically weak Raman signal caused by the small scattering cross section presents a barrier for trace chemical detection. Localized surface plasmon resonance of metallic nanoparticles can provide large local field enhancement, which can be utilized to enhance the intrinsically weak Raman signal. In order to achieve higher local field enhancement, we focus on using the gap structures formed between nanoparticles instead of using discrete nanoparticles. Molecules should locate within the hot spots of the gap structures to experience the largest enhancement. This requires that molecules should be extracted from volume onto the metallic surface. Based on these guidelines, two SERS platforms are designed using gold nanoparticles (nanorods and nanospheres) combined with different surface functionalization techniques. The performance of these two platforms are characterized by investigating the sensitivity and limit of detection (LOD). 16 ng/mL and 0.4 ng/mL LODs are achieved for nanorod and nanosphere platforms, respectively.