University of Victoria | Graduate Studies

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

of

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"Label-free Plasmonic Detection using Nanogratings Fabricated by Laser Interference Lithography"

Department of Chemistry

Friday, February 17, 2017
2:30 P.M.
Clearihue Building
Room C113

Supervisory Committee:
Dr. Alexandre Brolo, Department of Chemistry, University of Victoria (Supervisor)
Dr. Fraser Hof, Department of Chemistry, UVic (Member)
Dr. Cornelia Bohne, Department of Chemistry, UVic (Member)
Dr. Peter Wild, Department of Mechanical Engineering, UVic (Outside Member)

External Examiner:
Dr. Bryon Gates, Department of Chemistry, Simon Fraser University

Chair of Oral Examination:
Dr. James Tully, Department of Political Science, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Plasmonics techniques, such as surface plasmon resonance (SPR) and surface-enhanced Raman scattering (SERS), have been widely used for chemical and biochemical sensing applications. One approach to excite surface plasmons is through the coupling of light into metallic grating nanostructures. Those grating nanostructures can be fabricated using state-of-the-art nanofabrication methods. Laser interference lithography (LIL) is one of those methods that allow the rapid fabrication of nanostructures with a high-throughput. In this thesis, LIL was combined with other microfabrication techniques, such as photolithography and template stripping, to fabricate different types of plasmonic sensors. Firstly, template stripping was applied to transfer LIL-fabricated patterns of one-dimensional nanogratings onto planar supports (e.g., glass slides and plane-cut optical fiber tips). A thin adhesive layer of epoxy resin was used to facilitate the transfer. The UV-Vis spectroscopic response of the nanogratings supported on glass slides demonstrated a strong dependency on the polarization of the incident light. The bulk refractive index sensitivities of the glass-supported nanogratings were dependent on the type of metal (Ag or Au) and the thickness of the metal film. The described methodology provided an efficient low-cost fabrication alternative to produce metallic nanostructures for plasmonic chemical sensing applications. Secondly, we demonstrated a versatile procedure (LIL either alone or combined with traditional laser photolithography) to prepare both large area (i.e. one inch2) and microarrays (µarrays) of metallic gratings structures capable of supporting SPR excitation (and SERS). The fabrication procedure was simple, high-throughput, and reproducible, with less than 5 % array-to-array variations in optical properties. The nanostructured gold µarrays were integrated on a chip for SERS detection of ppm-level of 8-quinolinol, an emerging water-borne pharmaceutical contaminant. Lastly, the LIL-fabricated large area nanogratings have been applied for SERS detection of the mixtures of quinolone antibiotics. Enrofloxacin, an approved veterinary antibiotic, and one of its active metabolite, ciprofloxacin. The quantification of these analytes (enrofloxacin and ciprofloxacin) in aqueous mixtures were achieved by employing chemometric analysis. The limit of quantification of the method described in this work is in the ppm-level, with <10 % SERS spatial variation. Isotope-edited internal calibration method was attempted to improve the accuracy and reproducibility of the SERS methodology.