Centre de Nanosciences et de Nanotechnologies

Soutenance de thèse

Lundi 27 mai

15h00
Université de Sherbrooke
Faculté de Génie 2500, boul. de l'Université Sherbrooke
(Québec) J1K 2R1 - C1-3114

Frédéric BANVILLE

"Surface nanostructuring for high-resolution surface plasmon resonance imaging"

Jury members :

Michael CANVA	DR1	Institut d'optique Graduate School	Directeur de thèse
Marie FRéNEA-ROBIN	Maître de Conférences	Université Claude Bernand Lyon 1	Rapporteur
Jean-François MASSON	Professeur	Université de Montréal	Rapporteur
Paul CHARETTE	Professeur	Université de Sherbrooke	Directeur de thèse
Michel GRANDBOIS	Professeur	Université de Sherbrooke	CoDirecteur de thèse
Stéphane COLLIN	Chargé de Recherche	Centre de Nanosciences et de Nanotechnologies	CoDirecteur de thèse
Philippe GOGOL	Enseignant-Chercheur	Centre de Nanosciences et de Nanotechnologies	Examinateur
Serge CHARLEBOIS	Professeur	Université de Sherbrooke	Examinateur

Abstract : In pharmacological research, living cells are widely used as the sensing medium for biological studies, such as cell apoptosis and cellular reorganization. Different characterization systems are developed to analyze and quantify biological information. Surface plasmon resonance (SPR) imaging is sensitive to minute refractive index variations occurring in a medium at the proximity of a metal layer. It has found many applications in pharmacological research since it allows the real-time image acquisition and does not require biological labeling like for fluorescence. However, the propagative nature of surface plasmons (PSPs) limits the spatial resolution by spreading the information in the direction of propagation of the PSPs. This means that it is difficult to spatially resolve details smaller than the attenuation length of the PSPs, generally of the order of tens of micrometers. Several research groups have worked on this limitation in order to improve the spatial resolution in SPR imaging. However, although spatial resolutions lower than that of the propagation have been obtained, those techniques require compromises, such as loss in temporal resolution or in refractive index. In this thesis project, plasmonic devices were designed and characterized in order to improve spatial resolution in SPR imaging, while minimizing compromises with other imaging parameters. These SPR chips are composed of nanostructured metal surfaces where the guided mode combines the properties of propagative plasmons and localized plasmons. An in-house numerical modeling software has demonstrated how the geometry of nanostructured surfaces can be optimized to reduce the attenuation length of the plasmonic mode, while maintaining a high imaging contrast. An optimum geometry was identified, and micron-sized structures have been observed using the optimized nanostructured SPR chips. Experimental results showed a reduction in propagation by a factor of 6.3 compared to uniform metal surfaces. The imaging performances of nanostructured SPR chips were assessed by studying cellular responses following pharmacological stimulation. The chips were used in real-time monitoring of integrity changes in confluent endothelial cell layer following stimulation. Quantification of intercellular gaps in the monolayers showed a significant increase in the number of small holes detected (~ 1µm2) when using nanostructured SPR chips. This increase in sensitivity to cellular activity is the result of improved spatial resolution. Finally, the study of morphology in highly linear cytoskeleton cell enabled the observation of subcellular structures and the monitoring of cytoskeleton reorganization in individual cells. The nanostructured SPR chips designed and realized during this thesis show a strong potential label-free live cell imaging.

Mots clés en anglais : Biophotonics,Label-free biodetection applications,Live cell imaging,Surface plasmon resonance,Surface nanostructuring,Spatial resolution

UMR9001 CNRS-UPSUD
10 boulevard Thomas Gobert
91120 Palaiseau