PhD in Chemical Sciences

Advanced Course

Optical Biosensing

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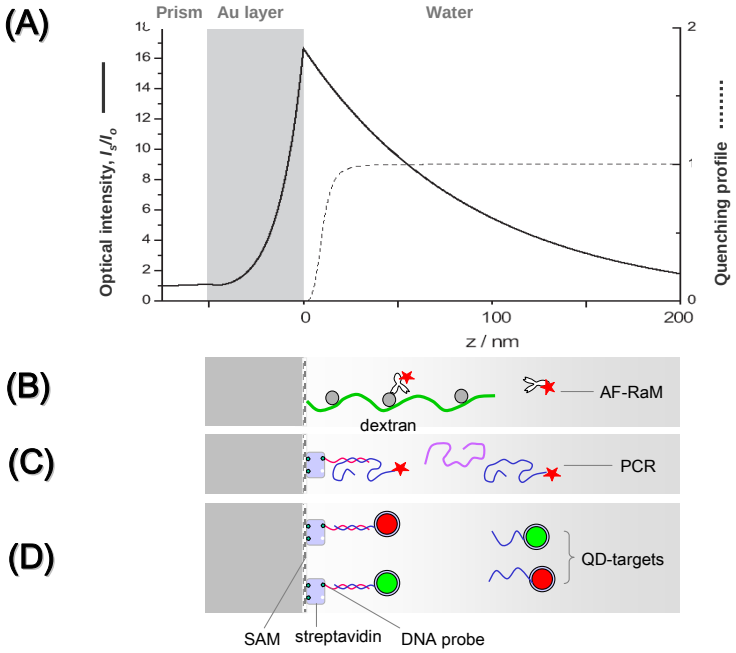
Monday, July 2, to Friday, July 6,
9:30 am – 12:30 noon



In this lecture series, we will address fundamental and applied aspects of the use of optical techniques for bio- and chemical sensing. A focus will be on the application of evanescent optical techniques, in particular, surface plasmon and waveguide optics. The examples presented and discussed include DNA analytics (short oligonucleotide, including PNAs, PCR amplicons, aptamers), protein binding studies, and lipid bilayer membrane systems.
A particular emphasis will be put on the quantitative evaluation of the kinetic and thermodynamic parameters governing this type of biosensing, and on the importance of the interfacial architecture of the functional coating of the optical transducer surfaces for optimizing sensitivity while minimizing non-specific binding.
And finally, we will present a few cases for hyphenated sensing approaches, e.g., the combination of optical techniques with the quartz crystal microbalance, electrochemical methods, and with fluorescence spectroscopy.

Literature:

Knoll, W., Interfaces and Thin Films as Seen by Bound Electromagnetic Waves, *Ann. Rev. Phys. Chem.* **49**, 569-638 (1998)

Knoll, W., Guided Wave Optics for the Characterization of Polymeric Thin Films and Interfaces, *Handbook of Optical Properties Vol. II - Optics of Small Particles, Interfaces, and Surfaces. R. E. Hummel, P. Wißmann (Eds.)*
373-400 (1997)

Rothenhäusler, B.; Knoll, W., Surface-Plasmon Microscopy, *Nature* **332**, 615-617 (1988)

Zizlsperger, M.; Knoll, W., Multispot Parallel On-line Monitoring of Interfacial Binding Reactions by Surface Plasmon Microscopy, *Progress in Colloid & Polymer Science* **109**, 244-253 (1998)

Liebermann, T.; Knoll, W., Surface-Plasmon Field-Enhanced Fluorescence Spectroscopy, *Colloids and Surfaces A***171**, 115-130 (2000)

Yu, F.; Yao, D.; Knoll, W., Surface Plasmon-Field-Enhanced Fluorescence Spectroscopy Studies of Interactions between Antibody and Surface Coupled Antigen, *Anal. Chem.* **75**, 2610-2617 (2003)

Knoll, W.; Kasry, A.; Liu, J.; Neumann, T.; Niu, L.; Park, H.; Robelek, R.; Yu, F., Surface Plasmon Fluorescence Techniques for Bio-Affinity Studies, *Handbook of Surface Plasmon Resonance, Eds. R.B.M. Schasfoort and Anna J. Tudos* **Chpt. 9**, 275-312 (2008)

Knoll, W.; Yu, F.; Neumann, T.; Niu, L.; Schmid, E., Principles and Applications of Surface-Plasmon Field-Enhanced Fluorescence Techniques, *Topics in Fluorescence Spectroscopy, Vol 8: Radiative Decay Engineering (Eds. J. R. Lakowicz, C. D. Geddes)* **Chpt. 10**, 305-332 (2005)

Kasry, A.; Knoll, W., Long Range Surface Plasmon Fluorescence Spectroscopy for Bio-Affinity Studies, *Appl.Phys.Letters* **89**, 101106 (2006)

Wang, Y.; Dostalek, J.; Knoll, W., Long Range Surface Plasmon-enhanced Fluorescence Spectroscopy for the Detection of Aflatoxin M-1 in milk, *Biosens. Bioelectron.* **24**, 2264-2267 (2009)

Yu, F.; Persson, B.; Lofas, S.; Knoll, W., Atto-Molar Sensitivity of Surface Plasmon Fluorescence Spectroscopy, *J. Am. Chem. Soc.* **126**, 8902-8903 (2004)

Feng, CL.; Zhong, XH.; Steinhart, M.; Caminade, AM.;Majoral, JP.; Knoll, W., Functional quantum-dot/dendrimer nanotubes for sensitive detection of DNA hybridization, *Small* **4**, 566-571 (2008)

Yu, F.; Knoll, W., Surface Plasmon Diffraction Biosensor, *J. Opt. Phys. Mater.* **14**, 149-160 (2005)

Zong, Y.; Xu, F.; Su, XD.; Knoll, W., Quartz crystal microbalance with integrated surface plasmon grating coupler, *Analytical Chemistry* **80**, 5246-5250 (2008)

Monday, July 2, 9:30 am- 12:30 (aula D Chemistry Building)

Introduction to evanescent wave optics: from Maxwell's theory to guided optical waves
Surface plasmon modes at the (noble) metal/dielectric interface (Kretschmann configuration, grating-coupled surface plasmons)
Surface plasmon diffraction, surface plasmon microscopy
Guided optical waves (planar, slab waveguides, integrated Mach-Zehnder Interferometer)

Affinity reactions between surface-immobilized receptor molecules and ligands binding from solution
Langmuir adsorption behavior; kinetics, titration, global analysis

Tuesday, July 3, 9:30 am- 12:30 (aula D Chemistry Building)

Surface plasmon fluorescence spectroscopy
DNA analytics (Oligonucleotides, amplicons, arrays, surface PCR, aptamers)
Quantum dots as chromophores
Coupling with microfluidics

Wednesday, July 4, 9:30 am- 12:30 (aula D Chemistry Building)

Anodized alumina waveguide platform for ultra-sensitive biosensing
Protein binding studies
ELISA-type studies
Binding to brushes
Hydrogels as sensor binding matrix

Thursday, July 5, 9:30 am- 12:30 (aula D Chemistry Building)
Tethered lipid bilayer membranes (tBLMs)
Binding studies with/at tBLMs

Friday, July 6, 9:30 am- 12:30 (aula Magna Chemistry Building)

Combination with electrochemical studies
Coupling SPR with QCM-D

This series will be continued in the fall with a course on "Bioelectronic Sensing"