Explore the Power of
Evanescent Fields

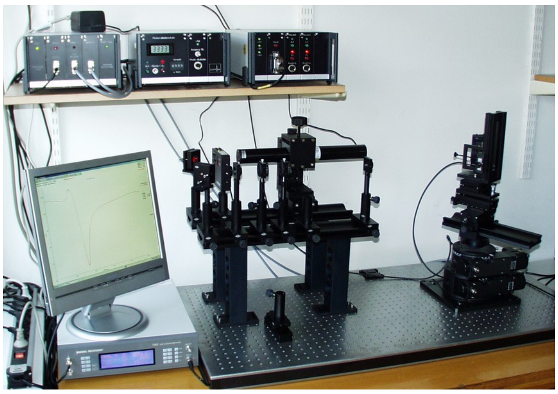
RT 2005-Spectrometers

Introduction

Surface Plasmon Spectroscopy (SPS) plays a dominant role in labelfree interaction analysis on surfaces in real-time. It utilises changes in surface sensitive propagation of evanescent waves due to adsorption of molecules.

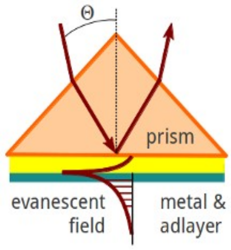
The RT 2005 Surface Plasmon Spectrometer is the result of decade long development of optical evanescent wave spectroscopy set-ups within the group of Prof. Wolfgang Knoll (Material Science) at the Max-Planck-Institute for Polymer Research in Mainz, Germany.

Designed originally for basic research the RT 2005 Spectrometer combines easy handling and robustness with a maximum in flexibility. The use of high quality components guarantees highest reliability. A novel arrangement of the optical components makes the alignment of the spectrometer fast and simple. The open and modular system allows easy implementation of extensions for microscopy, electrochemistry, fluorescence detection or QCM-D.



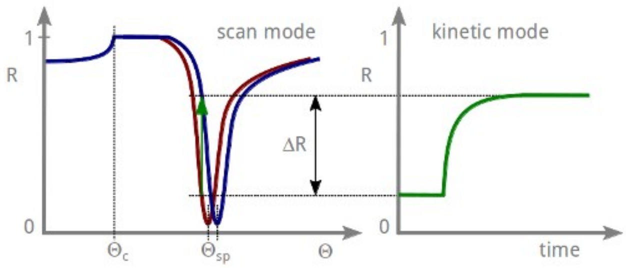
SPR Technology

Surface Plasmons are surface electromagnetic waves that propagate parallel along a metal/dielectric interface. They are very sensitive to small changes at this interface for example induced by the adsorption of molecules to the surface. Plasmon excitation requires p-polarized light (polarization occurs parallel to the surface), most setups operate with a low power visible laser and polarisers. Most practical applications utilise the Kretsch-mann configuration. A thin metal film is evaporated on the base of a prism and the evanescent wave propagates through the metal film.



The major components, light source, sample holder and detector are mounted on a precise goniometer stage for precise control of incoming and reflected light beam.

In case of plasmon resonance, a dip in the reflected spectrum is observed. If an additional adlayer of a dielectric compound is attached to the metal layer, the resonance frequency, i.e. the angle at which the surface plamon is detected, shifts to larger angles. In the so-called "scan mode", angular scans are performed to obtain surface plasmon spectra, from which the optical thickness of the dielectric adlayer can be obtained by model-fit calculations.



Besides the scan-mode which yields static information about the generated adlayer at the metal surface, the SPR technique can be used also to obtain kinetic information of the dielectric adlayer formation in-situ. In this case, the reflectivity is measured as a function of time at a distinct angle of incidence. Typically the angle chosen is at the low slope of the decreasing reflectivity within the surface plasmon resonance peak. Binding of a dielectric compound to the interface causes the resonance angle of the surface plasmons to shift to higher angles due to the formation of the dielectric adlayer.

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This shift causes the reflectivity at the low slope of the resonance peak to increase over time until a constant value of the reflectivity is reached, i.e. formation of the adlayer is completed.

RT 2005 Spectrometer

The RT-2005 spectrometer is a flexible yet powerful breadboard based system. Plasmon excitation is achieved with a standard 633 nm HeNe laser, a sensitive silicon detector senses the reflected light. Polarisers allow easy selection of p- or s-polarised light, the measurement cell is optimised for small sample volumes, a peristaltic pump can be offered as an option. A preconfigured Windows based computer system controls the spectrometer. The WASPLAS software was improved for SPR applications constantly since 1997. Careful component selection and optimisation of the setup guarantees low sensitivity measurements down to 10 pg/mm^2 for label-free protein adsorption. The optional PMT fluorescence detection enhances the sensitivity down to the atto-molar level [1], corresponding to a molecular surface concentration of only 10 fluorescence labelled proteins [mm^2 min]. The system is delivered in a light tight box with a small footprint of only 120 x 60 cm^2. System options like PMT Fluorescence and Temperature Control can easily be upgraded in the field.

Options

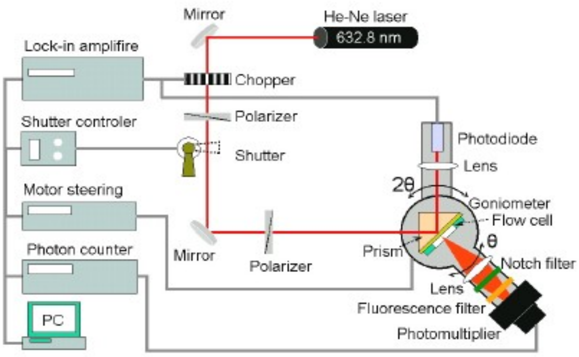
Temperature Control

While the vast majority of SPR measurements is done at room temperature some applications might require working at different temperatures or controlling the temperature precisely at a set value. Our RT-Temp thermostated cell allows convenient operation at temperatures ranging from 15-50 °C. High precision is guaranteed by a computer controlled Peltier element.

PMT Fluorescence Detection

Surface plasmon (field enhanced) fluorescence spectroscopy (SFPS) uses the greatly enhanced electromagnetic field of a surface plasmon mode to excite surface confined fluorophores. The general setup of a SFPS is schematically shown below. The ability to simultaneously monitor the interfacial refractive index changes and the fluorescence signals in real time offers a huge potential for applications of SPFS in surface immunoreaction detection. The RT-PMT

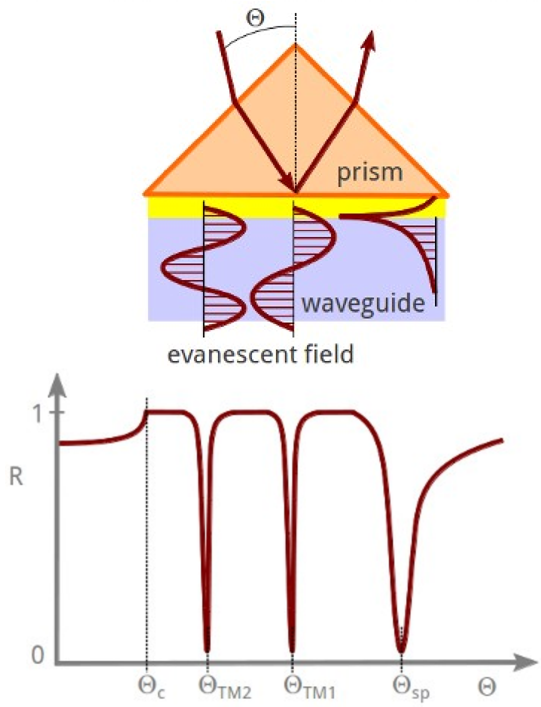
fluorescence option comes with a photomultiplier tube for maximum sensitivity.



It can be ordered together with the basic system or later upgraded in the field. The RT2005 comes with all necessary connectors which makes the upgrade very simple.
Alternatively to the single element PMT we can offer CCD spectrometers for wavelength resolved measurement or scientific grade CCD cameras for fluorescence imaging on request.

Optical Waveguide Spectroscopy OWS

Optical waveguide spectroscopy (OWS) is a technique similar to SPR. If the thickness of a dielectric layer on a metal- (e.g., gold or silver) coated substrate is sufficiently large, optical waveguide modes are observed in addition to the surface plasmon resonance.
By use of the different waveguide modes measured in reflectivity for p- (TM-) and s- (TE-) polarization, respectively, one can calculate/simulate various properties of the waveguide structure like anisotropic refractive index and geometrical thickness independently [2,3].



Software

The control of the spectrometer is achieved via the WASPLAS software. The origin of WASPLAS dates back to 1997. Since then it was continuously developed by incorporating the feedback and requirements from the 50+ spectrometers installed worldwide. Today WASPLAS is one of the key factors ensuring reliable and robust operation of the spectrometer.

Three different modes of operation are includes with WASPLAS:

Scan Mode
Takes the complete angular scan. The scan acquisition time is typically in the range of a few minutes.

Kinetic Mode
Monitors the reflectivity as a function of time at a fixed angle of incidence with a time resolution <0,1 s.

Tracking Mode
Monitors the shift of the plasmon resonance dip in real time with a time resolution <4 s.

Operation at arbitrary angles of incidence and control of s- and p-polarization of the incident light enables anisotropy measurements and separation of optical constants n and d.

WINSPALL software computes the reflectivity of optical multilayer systems. It is based on the Fresnel equations and the matrix formalism. The typical result is usually the optical thickness [nm] and/or surface coverage
[ng/cm2]

Literature

[1] F. Yu, B. Persson, S. Lofas and W. Knoll Attomolar sensitivity in bioassays based on surface plasmon fluorescence spectroscopy
Journal of the American Chemical Society, 126, 2004, p. 8902-8903

[2] P. W. Beines, B. Menges, W. Knoll et al Responsive Thin Hydrogel Layers from Photo-Cross-Linkable Poly(N-isopropylacrylamide) Terpolymers, *Langmuir*, 23(4), 2007, p.2231-2238

[3] Y. Zong, B. Menges, W. Knoll et al. Azobenzene-containing polyamic acid with excellent Langmuir-Blodgett-Kuhn film formation behavior suitable for all-optical switching, Langmuir, 21, 2005, p. 7036-7043

[4] W. Knoll
Interfaces and thin films as seen by bound electromagnetic waves Annual Review of Physical Chemistry, (1998), 49, p. 569-638