Multi-Parametric Surface Plasmon Resonance

A unique technique to characterize nanoscale surfaces and interfaces

Excellence in Surface Plasmon Resonance

BioNavis

Surface plasmon resonance (SPR) is a well established technology that has been mainly reserved for the study of biomolecular interactions in life-sciences and pharmaceutical drug discovery. While it has provided a valuable insight into the dynamic nature of binding events at the sensor surface, such as the kinetics and affinity of binding, the technology, as it stands, has only found limited utility in the emerging fields of nano-bio, surface materials and hard-soft interfaces, areas that demand a different set of measurements and capabilities in order to be able to fully understand the mechanisms and behaviour of these systems. Yet, it is possible to derive a whole new insight into dynamic surface analysis and layer-by-layer deposition via SPR, using the appropriate optical configuration and instrument design.

Multi-Parametric Surface Plasmon Resonance (MP-SPR) redefines the capabilities associated with traditional SPR, broadening the scope of what can be achieved with this technology and delivering new opportunities to study the physical events involved both in the formation and properties of hard and soft layers and the interfacial behaviour of these layers with each other in solid, liquid and gaseous environments. This technology has been specifically tailored, via its SPR-scanning mode and multi-wavelength optical configuration, to present a whole new level of understanding in biophysical and biomaterial studies through its ability to analyse biophysical events, such as layer thickness and density (Refractive Index) associated with layer-by-layer surface deposition, ranging from ultra-thin nano- (0.5 – 100 nm) and thick-layer (300 nm – microns) systems.

Here, we present some of the novel features and applications associated with this versatile yet powerful system to characterise surfaces and interfaces and how it can transform your understanding of the nature of materials in the emerging fields of nano-bio and material sciences.

Why MP-SPR?

FLEXIBILITY

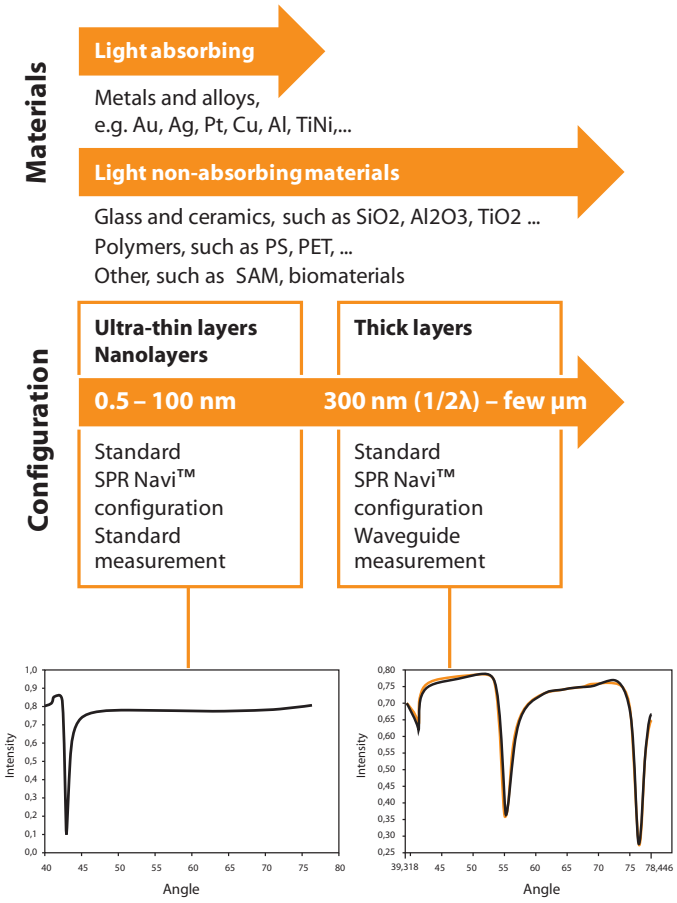
- Measures **physical, optical, chemical and electrochemical** properties
- Measurements of **solids, gas, liquids, complex fluids**
- Measurements at **different wavelengths** with same set-up
- **Open architecture** for connection of other instruments

FREE SELECTION OF MATERIALS

- Layers in gold, but also other **metals, semiconductors, ceramics and polymers**, e.g. Al2O3, TiO2, Cu, Al, Au, SiO2, graphene, cellulose, lipids,…
- Measurements of **nanolayers** (0.5-100 nm) as well as **thicklayers** (350 nm -microns)
- Freedom to prepare your own surfaces and coatings in-and ex-situ

NOT ONLY STRUCTURE, BUT ALSO FUNCTION

- Measure effectiveness of **biocoatings, while optimizing their thickness, optical properties, anti-fouling, ...**

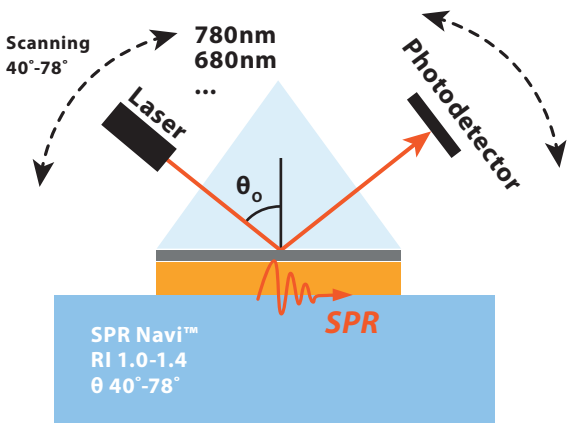


Core principles

Multi-Parametric Surface Plasmon Resonance is based on a optics arrangement, where the light intensity reflected from a surface is recorded as a function of angle of incident light. At lower angle, the intensity of light reaches its maximum at the Total Internal Reflection point. At a certain angle, there is a clear dip of intensity, which is due to the plasmons on the interface between the plasmonic material and adjacent layers.

With other techniques, in order to determine the layer thickness, you have to assume its refractive index. With MP-SPR, you can determine both thanks to measurements in multiple media (such as in air and in liquid) or at multiple wavelengths.

The system can be equipped with up to 3 different wavelenghts.

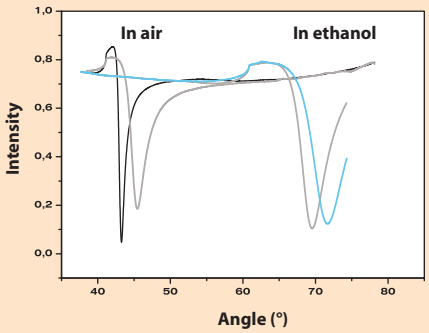


SPR Navi™ instrumentsare used to characterize **Solid / Liquid / Gas / Complex Phase** surfaces and interfaces in terms of their:

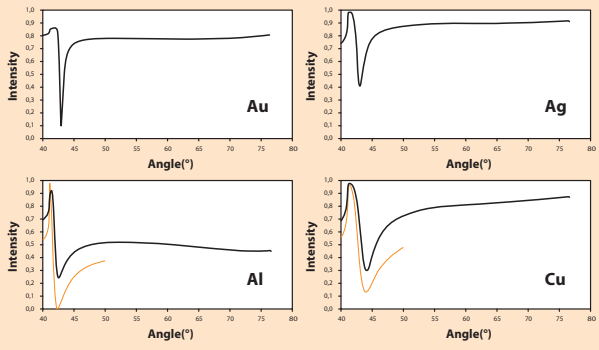
Physical properties: Thickness, swelling, mass
Optical properties: (Complex) refractive index
Biochemical properties: Kinetics, on-/off-rates, adsorption, desorption, affinity, concentration, adhesion
Electrochemical behavior

Key Questions that MP-SPR can answer:

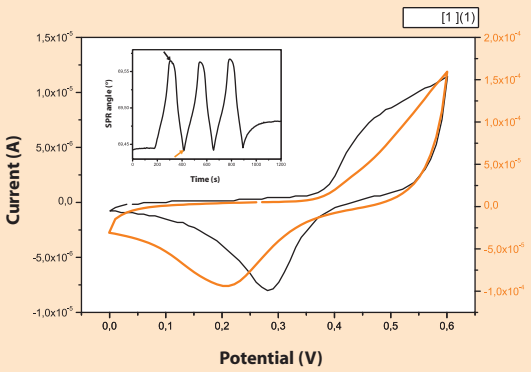
- **What conditions affect polyelectrolyte multilayer growth?**
- **How thick is the deposited layer, what are the optical properties?**
- **Do nanoparticles bind to specific proteins, are they stable?**
- **How does the surface coating react in air to varied moisture levels?**
- **How fast does a protein bind to cellulose, PP, PET, PS?**
- **Which material is the most resistant to fouling?**
- **Is this a monolayer or a bilayer?**



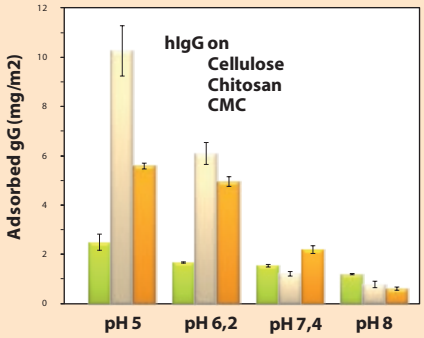
Example 1. Metal-Organic Framework growth measured in air and in liquid. The angular shift corresponds to 10.4 nm in ethanol. (AN#112)



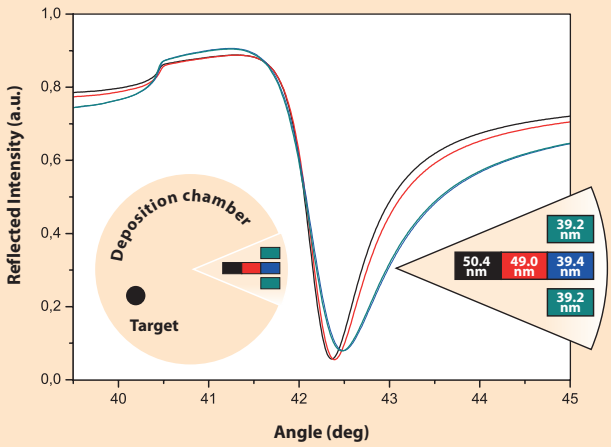
Example 2. Each metallic coating has its own SPR peak characteristics that can be used to study the material deposition process as well as the material interface.



Example 3. Cyclic voltametry scans for slow scanning (black) and fast scanning (orange) of electrodeposited copper. Inset: Angular scan peak minimum sensogram of the electrochemical measurement. (AN#120)



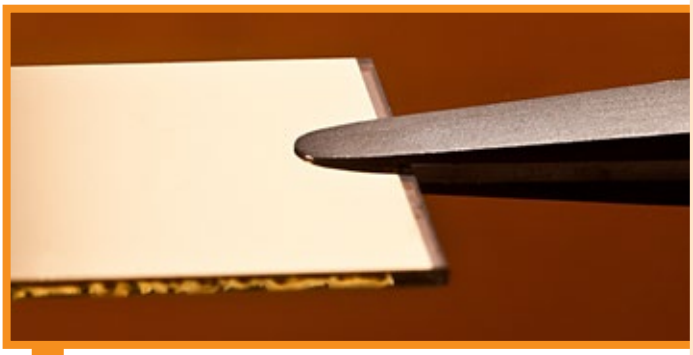
Example 4. Cellulose model surfaces for studying protein interactions using MP-SPR. (AN#126)



Example 5. Off-line optimization of a CVD process. MP-SPR provides information on uniformity of the deposition process. (AN#127)

See our application highlights *with MP-SPR used with different materials, such as graphene and graphene oxide films (#116), polyelectrolyte multilayers (#111), metal-organic framework assembly (#112), PP, PS, PET, cellulose (#115, #126), Lanbmuir-Blodgett film in air (#109),... The key principles to determining thickness and refractive index are explained in #127 (using two wavelengths and two media approach) and in #128 for ultrathin metal films. All of the newest application notes and publications including examples with nanoparticles, deposition process optimization, sensing of hydrogen and more can be found at* ***www.bionavis.com****.*

Experimental Design



Choose a sensor slide

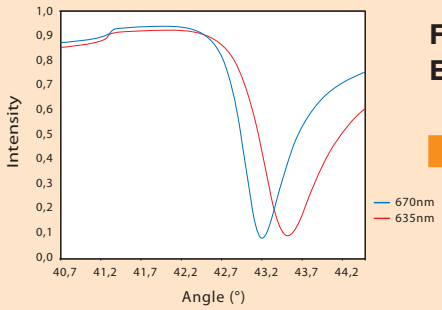
- **Metals: Au, Ag, Al, Cu...**
- **Inorganic: SiO_2, Al_2O_3, ITO, LiF, MgF_2, TiO_2, ZnS, Ti_3NO...**
- **Functionalizations: Carboxymethyldextran (CMD) hydrogel, Planar CMD, other functionalizations available on demand: amine, protein A, biotin,...**

Our users like the flexibility of preparing their own surfaces and routinely work, for instance, with **cellulose, PET, PS, PP** and other biocompatible and biomimetic surfaces.

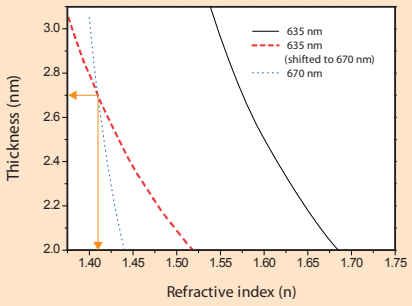
Techniques that can be used for coating of our sensors include vapor deposition, sputtering, sol-gel deposition, Langmuir-Blodgett monolayer depositions, spin coating, dip coating, self assembly, electrochemistry, atomic layer deposition and others.

COATING/DEPOSITION
(*In-Situ, Ex-Situ*)

Substrate verification



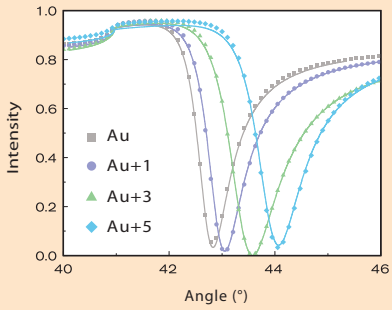
FRESNEL EQUATIONS



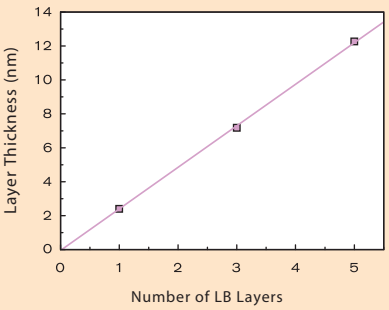
Angular scan at multiple wavelengths or in two media

Resolve thickness and refractive indexof the layer(s).

Functional layer analysis



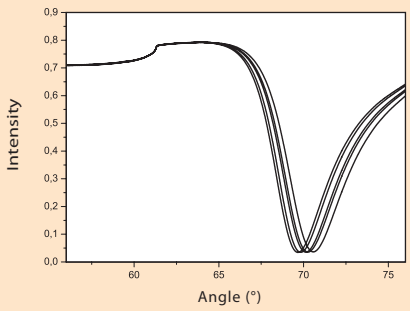
FRESNEL EQUATIONS



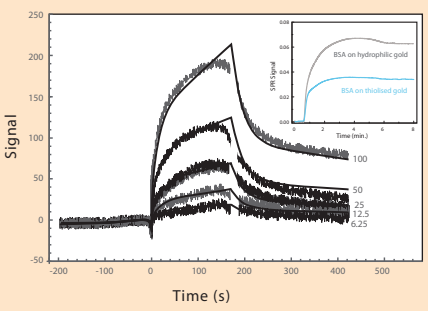
Angular scan at single wavelength

Determine thicknessof each of the layers.

Interaction analysis



BINDING MODELS



Angular scan at single wavelength or fixed angle scan

Molecular interactions. Amount of bound protein on surfaces with different treatments.

SPR Navi™ 210A

MP-SPR with automated handling of 6 samples

See also

SPR Navi™ 200

Semi-automated

W 32 x H 40 x D 34 cm
(15" x 12.5" x 12.4")
12 kg (22 lbs)

SPR Navi™ 220A

Well-plate automation

W 62 x H 41 x D 47 cm
(24.5" x 16" x 18.5")
30 kg (66 lbs)

- **Automatic dual channel injector**
- **Low running costs**
- **Virtually maintenance-free**
- **Easy operation**

Measuring principle	Multi-Parametric SPR based on a true goniometric SPR arrangement with a rotating laser (true angular resolution 0.001˚)
Wavelength of light	670 nm (others by request) in each channel
Additional wavelengths (feature exclusive to SPR Navi™)	780 nm (others by request) enables measurements of refractive index and thickness and measurements on light-absorbing samples) The system can be equipped with up to 4 different wavelengths (2 per channel).
SPR Navi™ scanning angular range (feature exclusive to SPR Navi™)	40˚ - 78˚
Mode of operation	Fixed angle mode – measuring at a single angle (intensity vs time sensogram, "traditional SPR") Angular scan mode – scanning across a range of angles (many parameters available, e.g. intensity vs angle, "MP-SPR")
Refractive index (RI) range	1.00-1.40 (bulk) Can be extended with additional wavelengths; Note: Layers that MP-SPR can measure can have much higher RI. MP-SPR determines complex refractive index also.
Dynamic range	38 000 mdeg
Noise level	Short-term noise 0.3 µRIU, Baseline drift (long term) < 1µRIU/min; in Selectively Amplified SPR 100-fold improvement (practically non-detectable). Note: 1 x 10-6 of Refractive Index Unit corresponds to 1 pg/mm² surface coverage of a typical protein.
Measurement range	Kinetics k_a 10^3-10^8 $M^{-1}.Sec^{-1}$, k_d 10^{-7}- 0.1 Sec^{-1} (Note that ka and kd values are highly dependent of each other, as well as the Bmax (binding maximum) values of the assay.) Layer thickness and RI from 5 Å to 100 nm (all materials), 300 nm to microns (transparent materials). Multiple layers also possible.
Sampling rate	from 4 ms
Flow cells	Standard: Easily exchangeable, 2 channels, PDMS material, 100µm cell height Optional flow cell modules: PEEK, gas, electrochemical (open and flow-through cuvettes), custom
Sample loading and injection	Automated parallel or serial injections (automatic switch)
Liquid handling	Fully automated handling of up to 6 samples, built-in degasser, syringe pump
Flow cell volume	1 µl as a standard
Sample volume	Min. 20 µl (or less through partial loop fill), Max. 1 ml
Programs	Freely configurable sequence for unattended operation
Injections	Full loop, partial loop
Instrument dimensions	W 44 x H 41 x D 51 cm (17" x 16" x 20"), 22 kg (48,5 lbs)
Smallest detected molecules	Hydrogen (2 D_a), dopamine (153.18 D_a), cocaine (303.13 D_a), naproxen (230.26 D_a), quinidine (360.5 D_a) for instance.
Volumes	Injection volume recommended 50 µL (less using partial loop fill function), max. 250 µL (standard) to 2 mL Standard flow-cell volume 1 µL Measured spot volume 80 nL
Flow-rates	1 µl/min to 1 mL/min with installed tubing set, up to 6 mL/min with larger tubing diameter
Measurement temperature	15-45°C (7°C below to 20°C above room temperature)
Instrument dimensions	W 44 x H 41 x D 51 cm (17" x 16" x 20"), 22 kg (48,5 lbs)

Specifications are subject to change without prior notice.

About Us

BioNavis Ltd is an innovative company established in 2006. We manufacture SPR Navi™ measurement instruments that are based on Multi-Parametric Surface Plasmon Resonance (MP-SPR) technology. This technology enables determination of layer thickness, optical properties and real-time measurements of molecular interactions on a wide range of materials.

About MP-SPR

This new and unique MP-SPR technology has been developed over 20 years at VTT Technical Research Centre of Finland by Dr. Janusz Sadowski. MP-SPR is based on traditional Surface Plasmon Resonance technology that is now well established in pharma and life sciences. Thanks to our unique optical arrangement, we are able to bring MP-SPR to serve also material science and other multidisciplinary fields.

Contact information

BioNavis
BioNavis Ltd
Elopellontie 3 C
33470 Ylöjärvi (Tampere-region)
FINLAND
Tel: +358 10 271 5030
e-mail : info@bionavis.com

Excellence in Surface Plasmon Resonance
BioNavis

www.bionavis.com