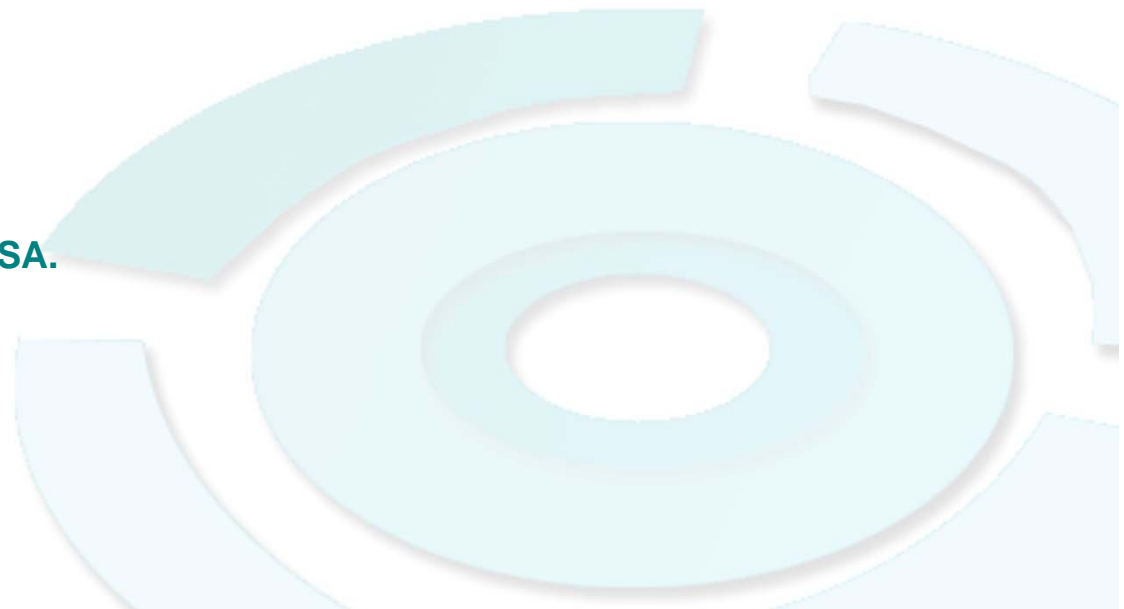


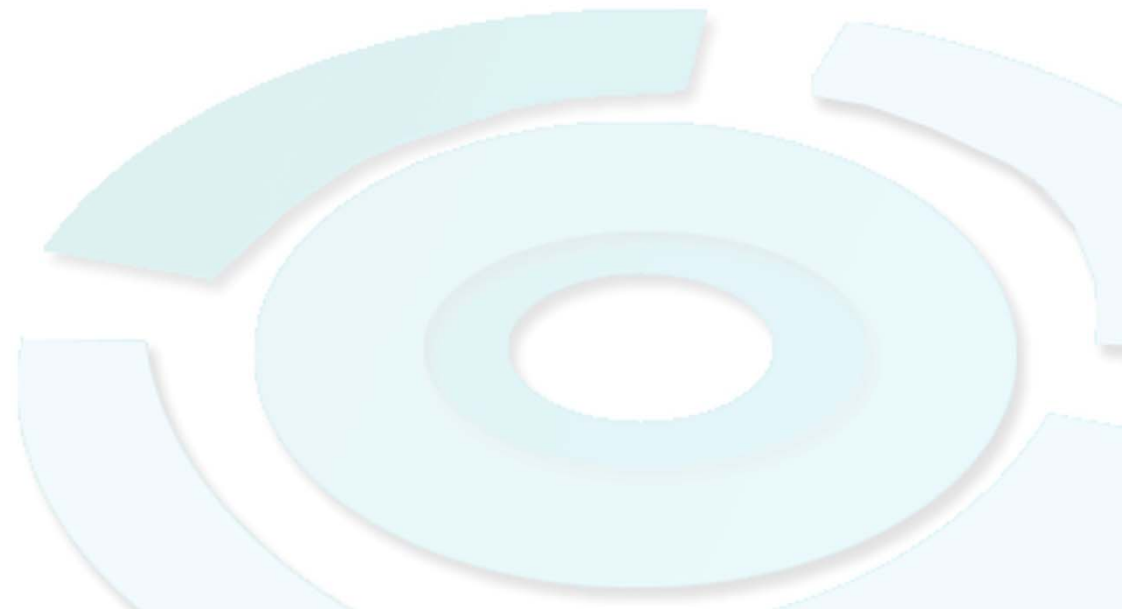
# Surface Plasmon Resonance Biosensors

**Sandro Bordeira and Nuno Reis, BioSurfIT SA.**  
Zaragoza, 29 November 2007

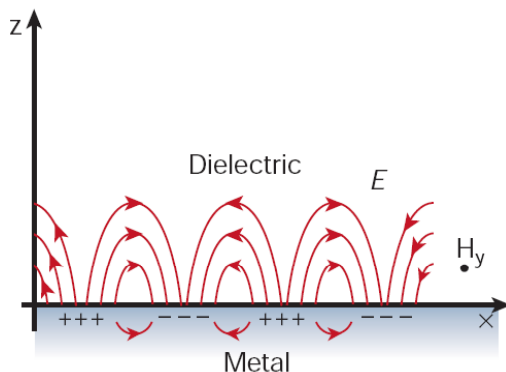
[www.biosurfit.com](http://www.biosurfit.com)



1. **Surface Plasmon Resonance (SPR)**
2. **SPR Biosensors**
3. **Biosurfit Platform**



## MOTIVATION



Surface plasmons result from a coupling between electromagnetic wave and electrons at a surface

Plasmons are only originated at the interface between a metal and a dielectric material.

The minimum feature size is defined by the diffraction limit, and is of the order of wavelength .

## Maxwell's equations

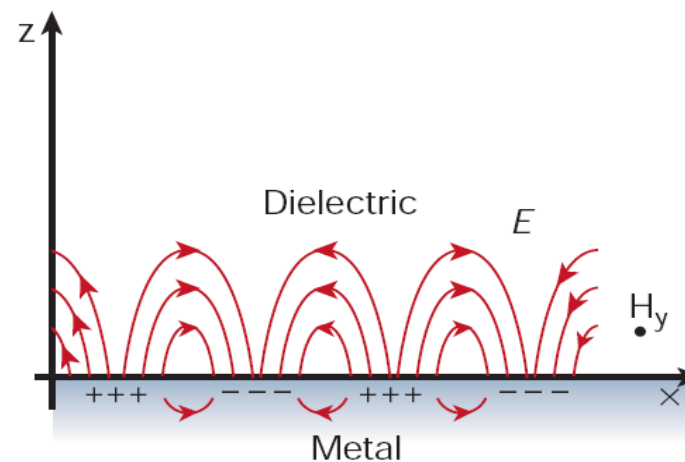
$$\begin{aligned} \nabla \cdot \mathbf{E} &= \frac{\rho}{\epsilon} \\ \nabla \cdot \mathbf{H} &= 0 \\ \nabla \times \mathbf{E} &= -\mu \frac{\partial \mathbf{H}}{\partial t} \\ \nabla \times \mathbf{H} &= \mathbf{j} + \epsilon \frac{\partial \mathbf{E}}{\partial t} \end{aligned}$$

Charge neutrality,  $\rho = 0$   
 No direct current,  $\mathbf{j} = 0$   
 Nonmagnetic materials,  $\mu_r = 1$  ( $\mu = \mu_0$ )

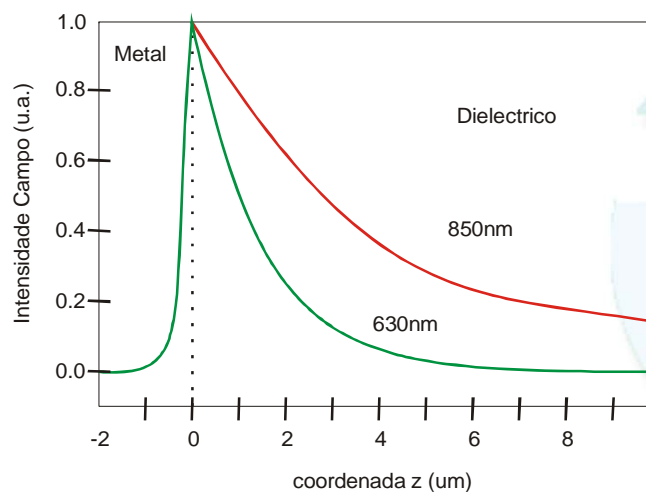


$$\begin{aligned} \nabla \cdot \mathbf{E} &= 0 \\ \nabla \cdot \mathbf{H} &= 0 \\ \nabla \times \mathbf{E} &= -\mu_0 \frac{\partial \mathbf{H}}{\partial t} \\ \nabla \times \mathbf{H} &= \epsilon \frac{\partial \mathbf{E}}{\partial t} \end{aligned}$$

Plasmon electron density waves excited by light photons



Occurs at the metal-dielectric interface

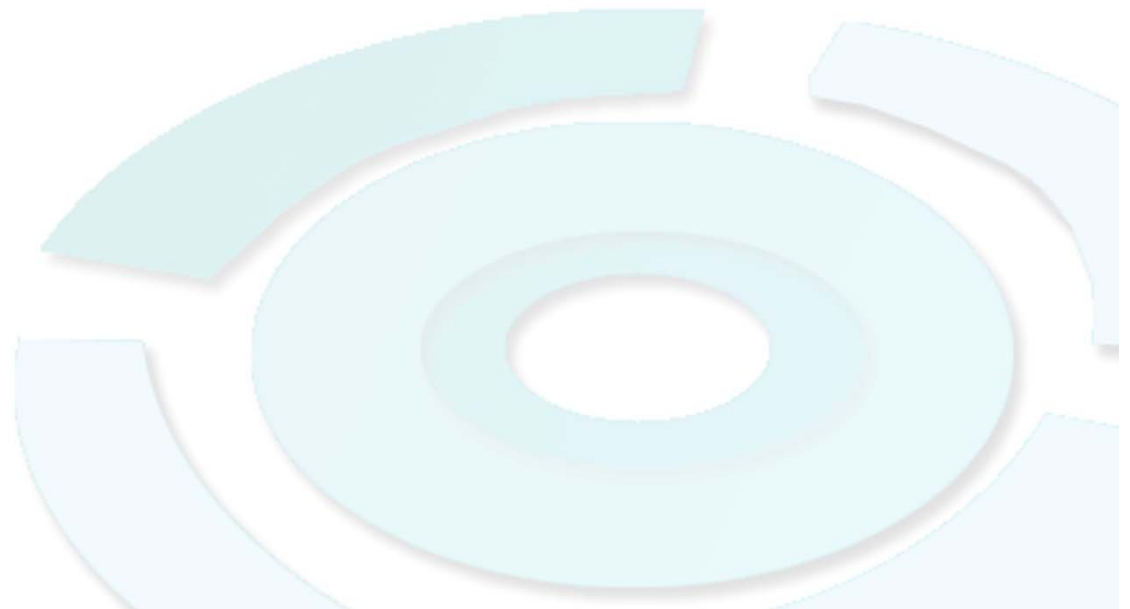


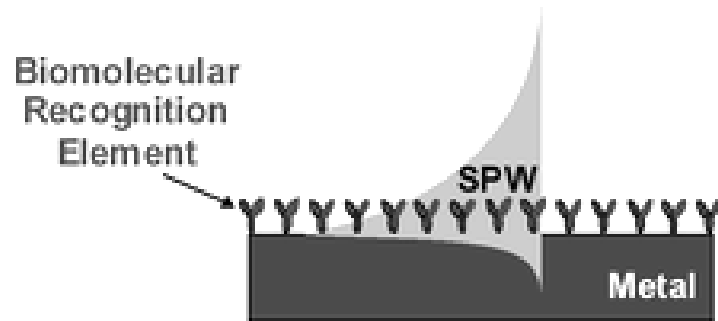
Wave vectors must satisfy:

$$k_{sp} = k \sqrt{\frac{\epsilon_d \epsilon_m}{\epsilon_m + \epsilon_d}}$$

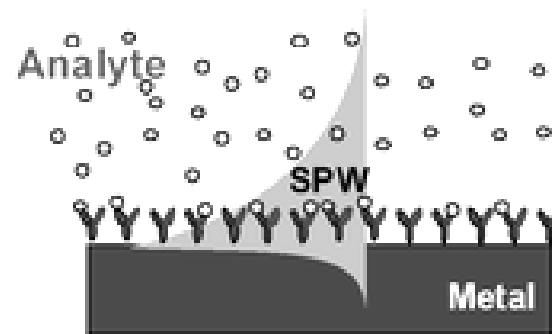
# SPR Biosensors

**The big challenge!**



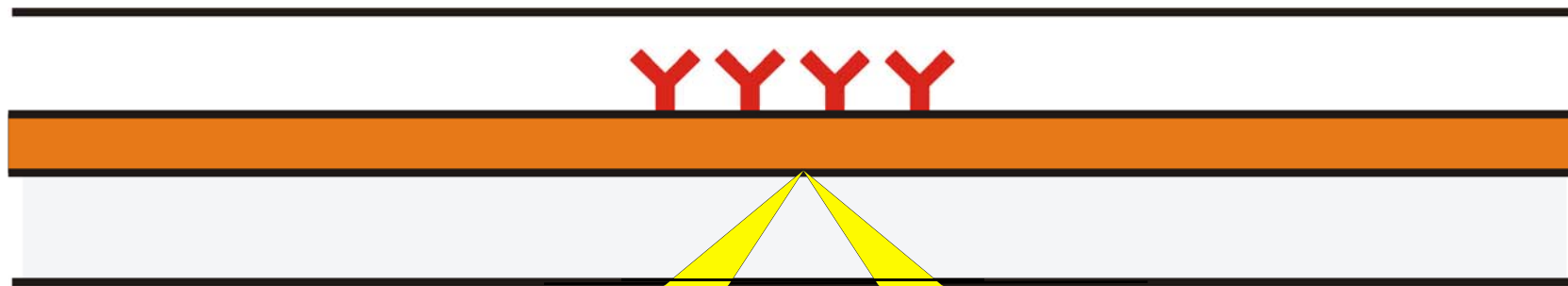


**PRIOR BINDING:**  
 Biolayer refractive index,  $n$   
 SPW propagation constant,  $\beta$

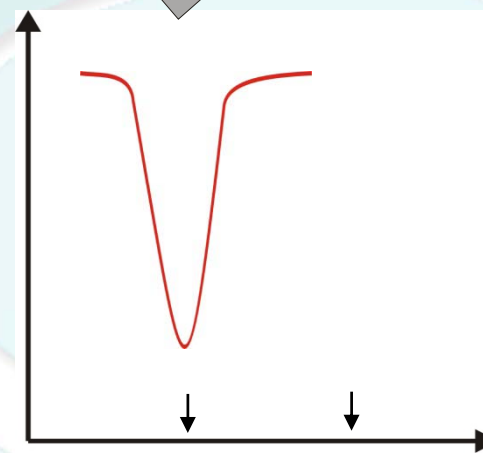


**ANALYTE BINDING:**  
 Analyte concentration,  $c$   
 $n \rightarrow n + \Delta n$   
 $\beta \rightarrow \beta + \Delta\beta$

**TRANSDUCTION:**  $q_{\min} = f(n, \Delta n, \beta, \Delta\beta)$

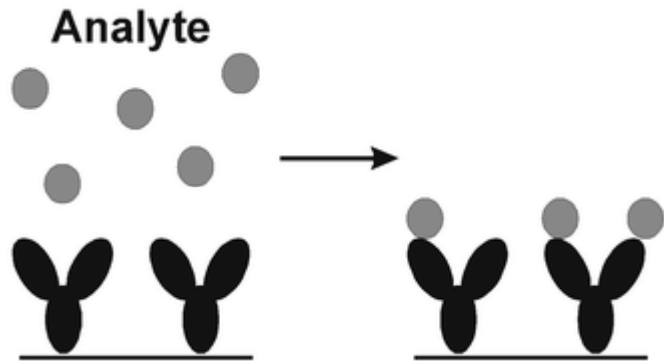


Intensity

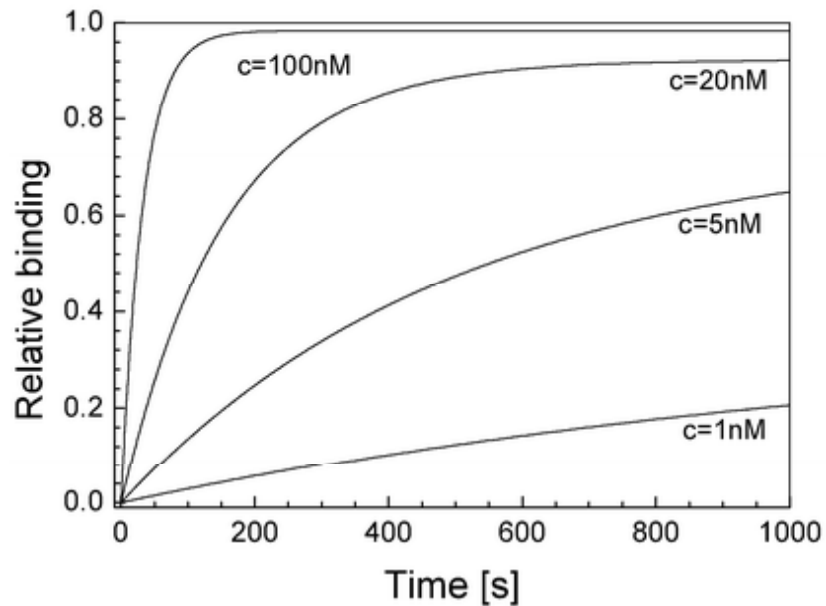


angle

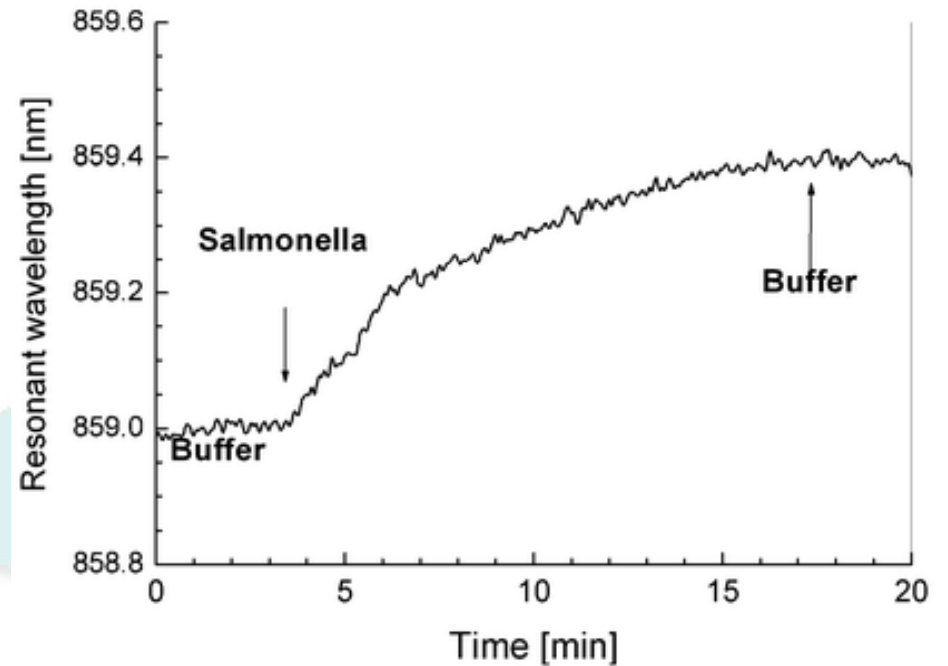
# Direct detection



Sensor surface coated with antibodies

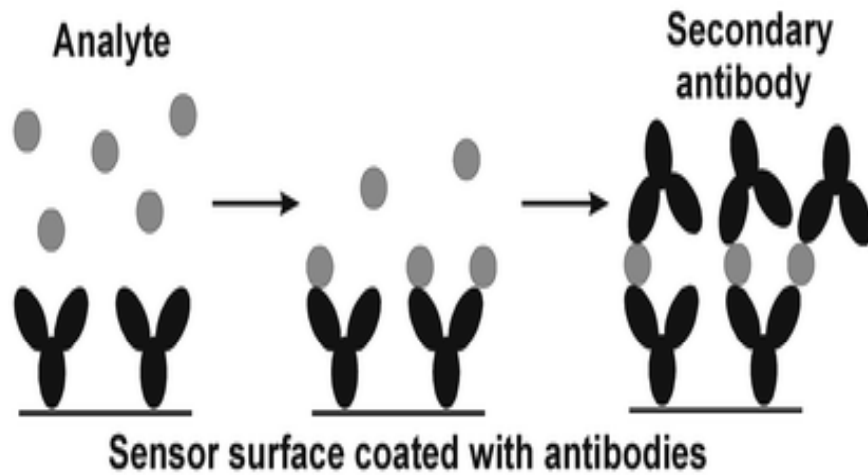


## DETECTION OF LARGE ANALYTES



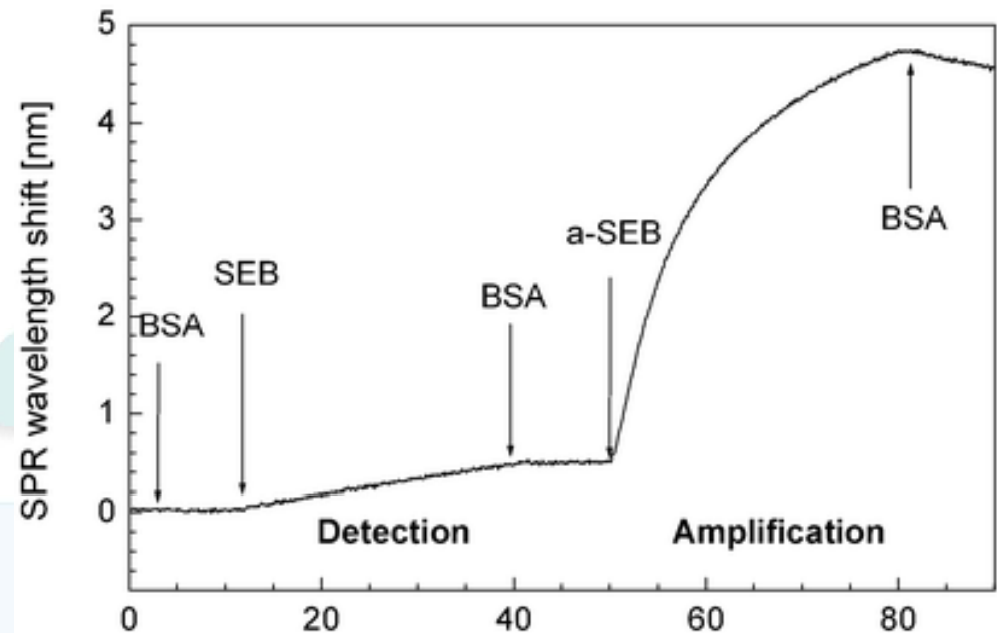
Direct detection of *Salmonella enteritidis* at a concentration of  $10^6$  cfu / mL

## Sandwich assay

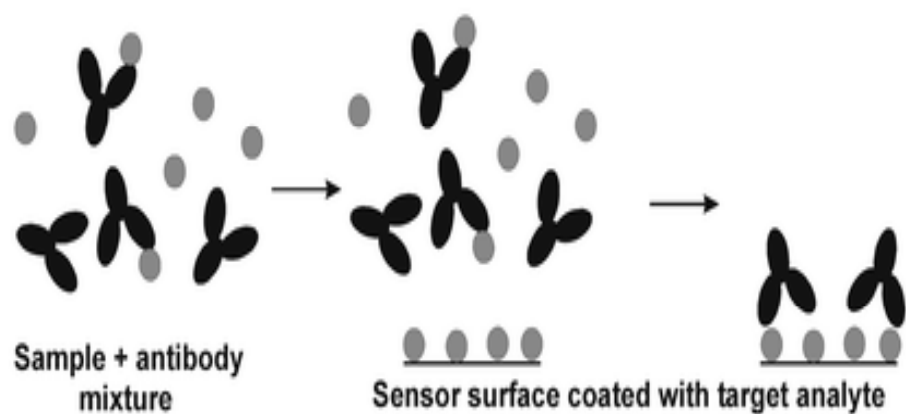


The secondary antibodies bind to the previously captured analytes further increasing the number of bound biomolecules and thus also the sensor response.

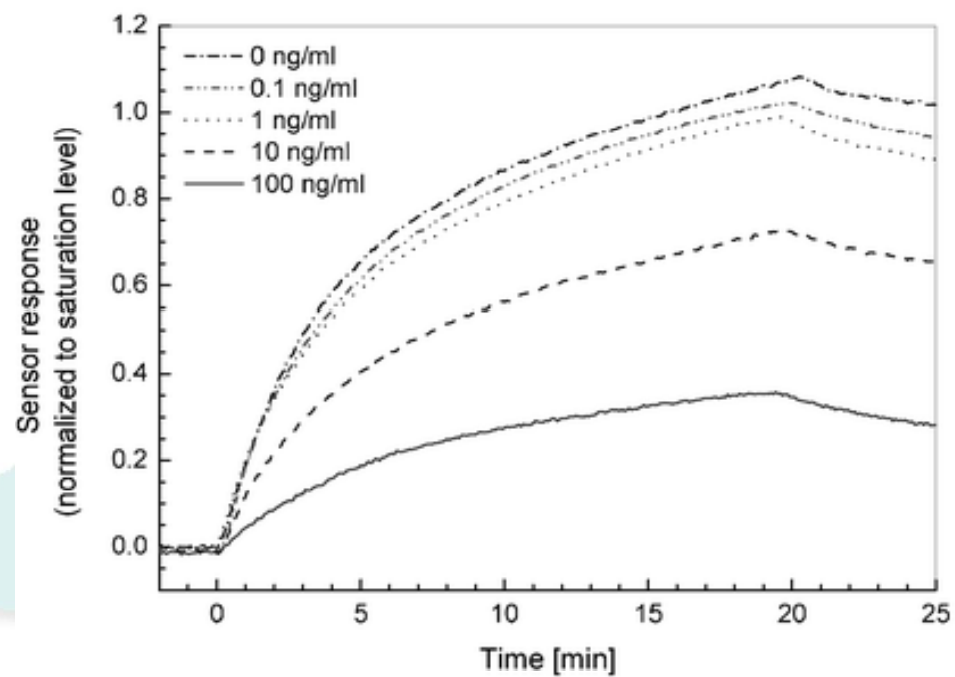
### DETECTION OF MEDIUM SIZE ANALYTES



# Inhibition assay



## DETECTION OF SMALL ANALYTES



Detection of atrazine using inhibition assay

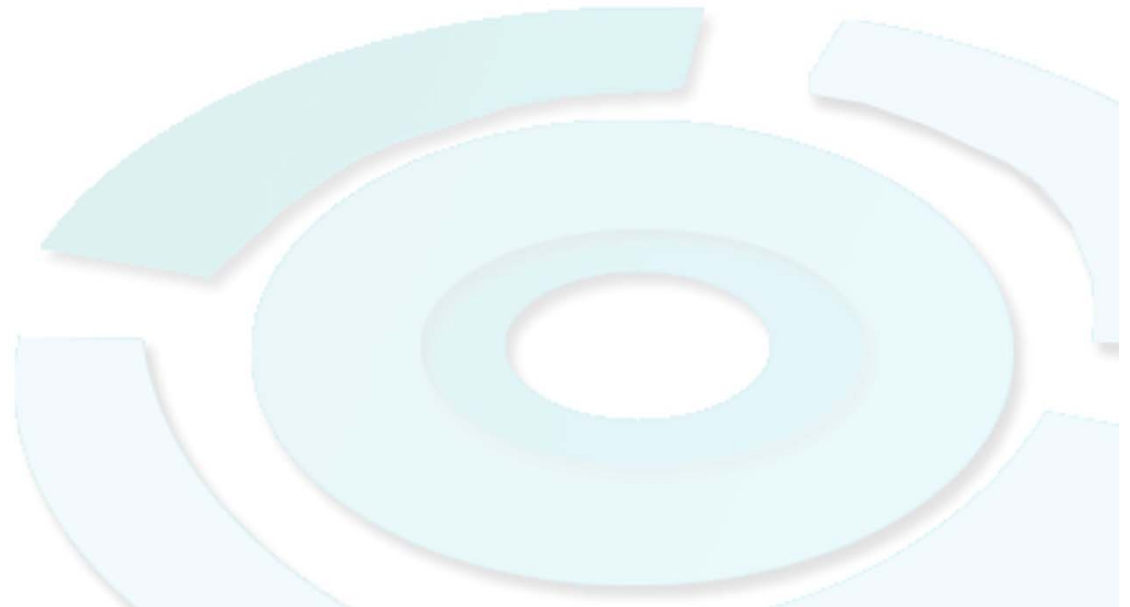
## Examples of Chemical and Biological Analytes Targeted by SPR Technology

Analyte	Detection limit
<b>Small molecules:</b> <b>Atrazine</b>	<b>0.1 ng/ml</b>
<b>Hormones:</b> <b>Human choriogonadotropin</b>	<b>50 ng/ml</b>
<b>Protein toxins:</b> <b>Staphylococcal enterotoxin B</b>	<b>0.5 ng/ml</b>
<b>Bacterial pathogens:</b> <i>Escherichia coli</i> <i>Salmonella enteritidis</i> <i>Listeria monocytogenes</i>	<b>5x10<sup>4</sup> cfu/ml</b> <b>5x10<sup>4</sup> cfu/ml</b> <b>5x10<sup>4</sup> cfu/ml</b>

## SPR Biosensors Advantage

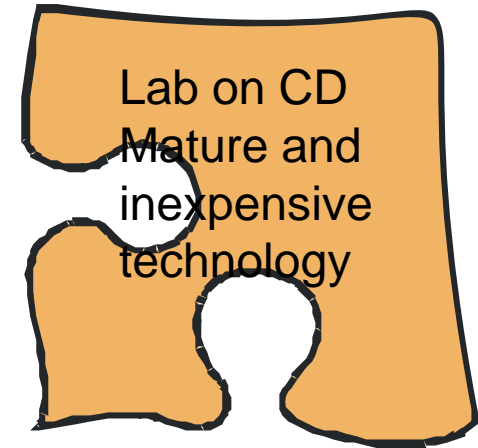
1. **Optical biosensors based on spectroscopy of surface plasmons provide a label-free, fast, specific and sensitive alternative to traditional laboratory analytical techniques.**
2. **SPR offers a platform for real time study of macromolecules and their interactions allowing determination of specificity, interaction models, kinetic rates, equilibrium constants, thermodynamic constants, and epitope mapping.**
3. **SPR sensors can detect small, medium and large analytes at relevant concentrations (0.1-1 ng/ml).**
4. **SPR biosensor technology can be extended to many important areas such as medicine, environmental protection, food and drug screening and security.**

# BioSurfIT Platform

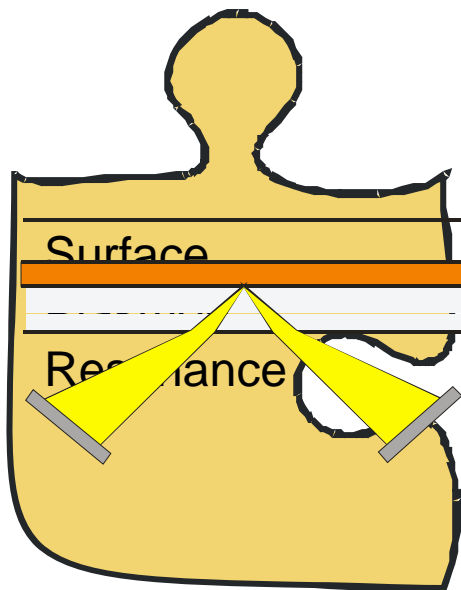




Immobilization of  
Biomarkers

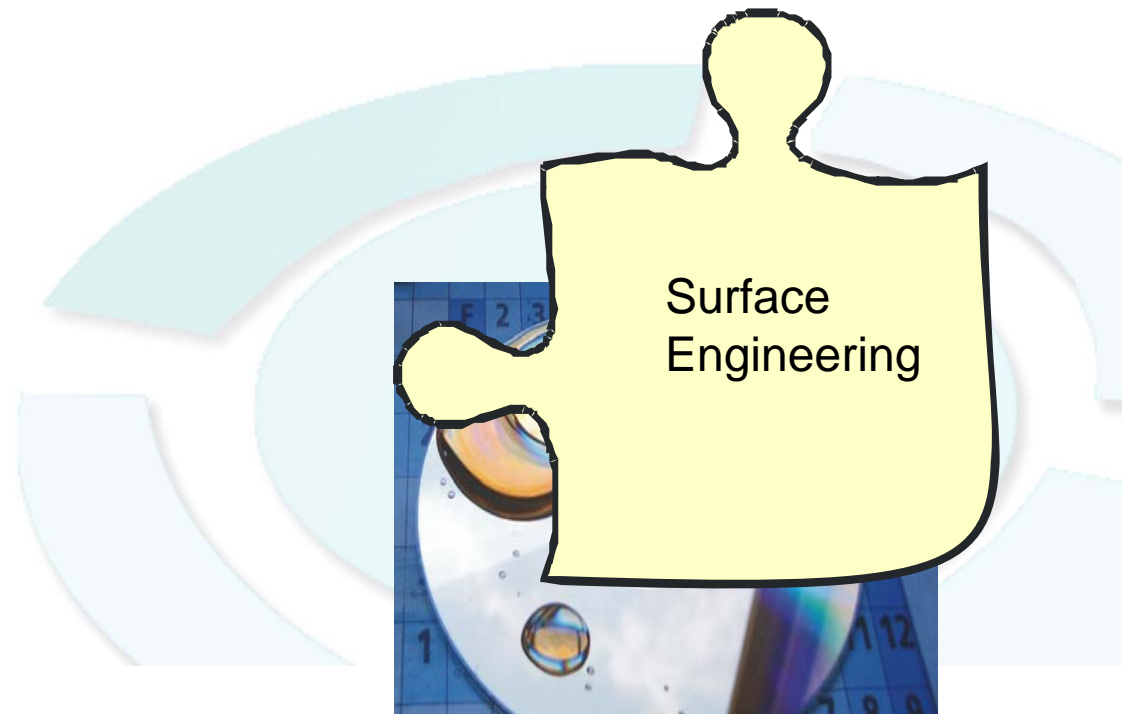


Lab on CD  
Mature and  
inexpensive  
technology



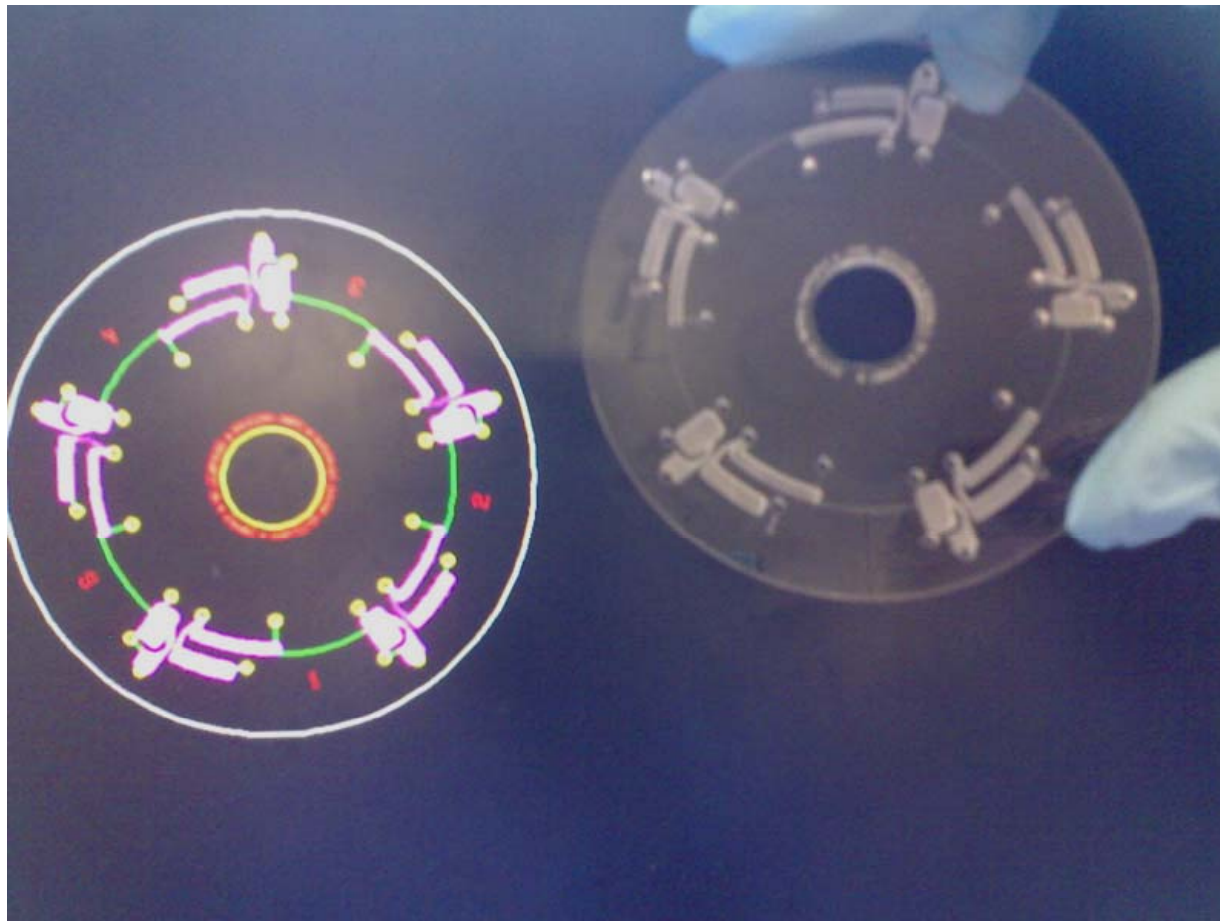
Surface

Resonance



Surface  
Engineering

**Example:  
Blood Plasma Separation**



Analyte group	Primary use
Bacteria (e.g., <i>Helicobacter pylori</i> , <i>Streptococcus A</i> and <i>B</i> , <i>Chlamydia trachomatis</i> , <i>Treponema pallidum</i> )	Diagnosis of bacterial infections
Inflammatory markers (e.g., CRP, PCT)	Detection of inflammation / infection, monitoring of antibiotic therapy
Cardiac markers (e.g., BNP, cTnI/T, CK-MB, myoglobin)	Diagnosis and management of cardiac diseases
Tumor markers (e.g., PSA, nuclear mitotic apparatus protein, fecal occult blood)	Detection of cancer
Viruses (e.g., adenovirus, HIV, Hepatitis B, RSV, rotavirus, Influenza A and B)	Diagnosis of viral infections
Drugs-of-abuse (e.g., barbiturates, opiates, amphetamine, cocaine, marijuana)	Detection of the use of illicit drugs

**Point of care testing (10 minute test duration)**



