IMPROVED SENSITIVITY OF LOCALIZED SURFACE PLASMON RESONANCE TRANSDUCERS USING REFLECTION MEASUREMENTS

Ofer Kedem, Alexander Vaskevich and Israel Rubinstein

Department of Materials and Interfaces, Weizmann Institute of Science, Rehovoth 76100, Israel

Background

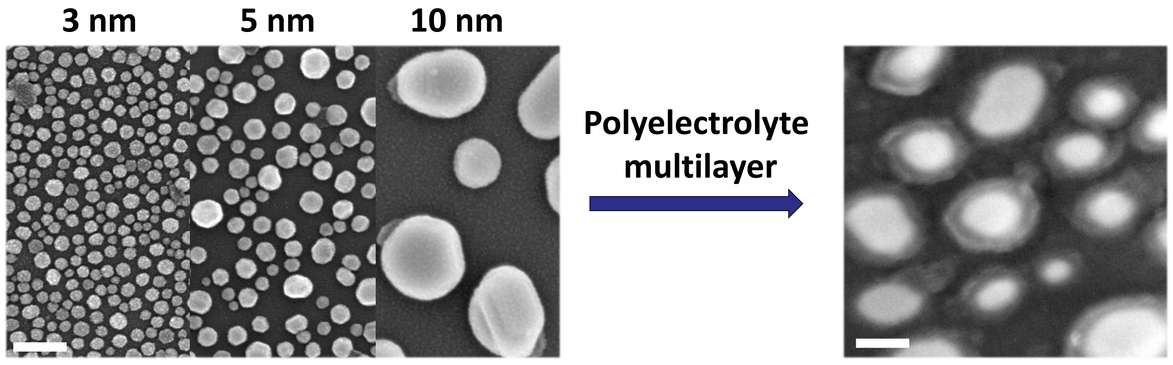
Nanostructured metal (e.g., gold) surfaces support localized surface plasmon resonance (**LSPR**), i.e., charge density oscillations exhibited as an **optical extinction band** in the visible range. The band is sensitive to changes in the refractive index near the nanostructures, exhibited as **changes in wavelength and extinction upon molecular binding**. Such systems can thus be used as optical transducers for **chemical and biological sensing**, employing appropriate recognition layers for specificity. Here we study **gold nano-island films** prepared by evaporation on transparent substrates and annealing, offering simplicity and low cost.

The LSPR **extinction** band arises from two distinct phenomena, **absorption** and **reflection**, both changing upon molecular binding. Both extinction (i.e., transmission expressed in optical density units) and reflection of LSPR transducers have been used in previous studies for monitoring adsorption of analytes, with little consideration of possible differences in sensitivity between the different modes. Our question is:

Which is more sensitive – transmission or reflection?

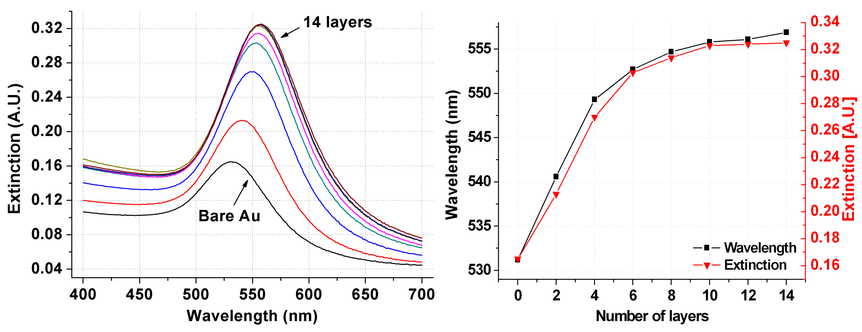
The system: gold nano-islands

3 to 10 nm (nominal thickness) vacuum-deposited Au on glass slides, annealed 10 h at 580 °C to create stable islands of 22 - 114 nm in average length.



Scanning electron microscopy at 15 / 10 kV, coated with 2-3 nm Cr; scale bar = 100 nm

Building a multilayer: Transmission spectroscopy

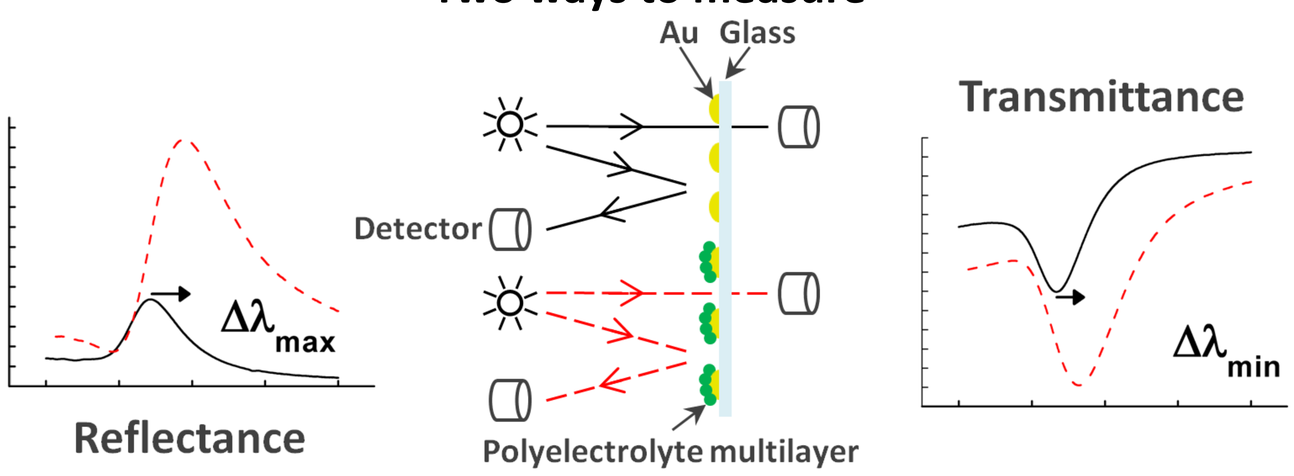


Polyelectrolyte multilayers were grown on slides of various nominal Au thicknesses, until the peak wavelength in extinction mode no longer shifted.

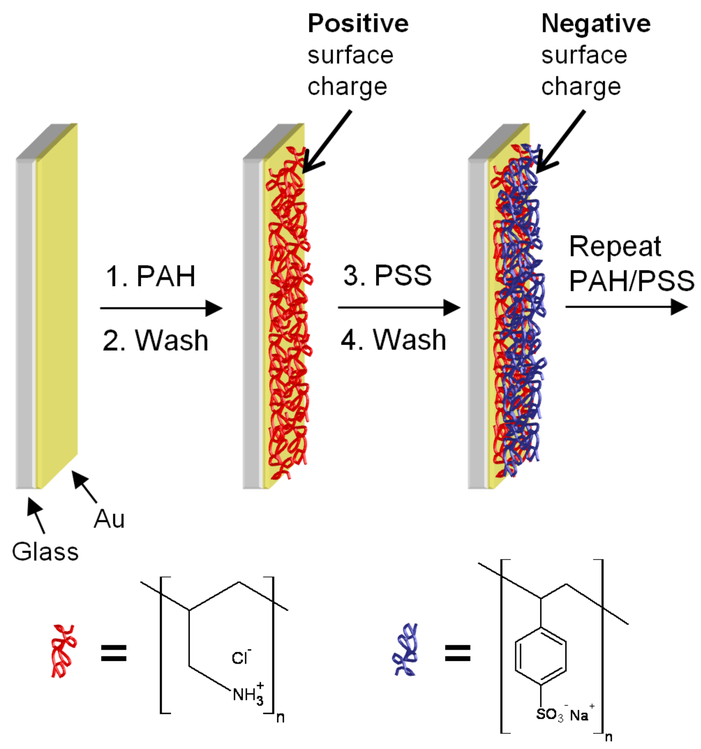
Left: Changes in the extinction spectrum with layer growth; **right**: Change in the surface plasmon peak, for 3 nm (nominal thickness) islands.

Adsorption solution: 0.1 M NaCl in H_2O; number of layers: 3 nm – 14; 4 nm – 18; 5 nm – 20; 6, 7.5, 9, 10 nm – 40.

Two ways to measure

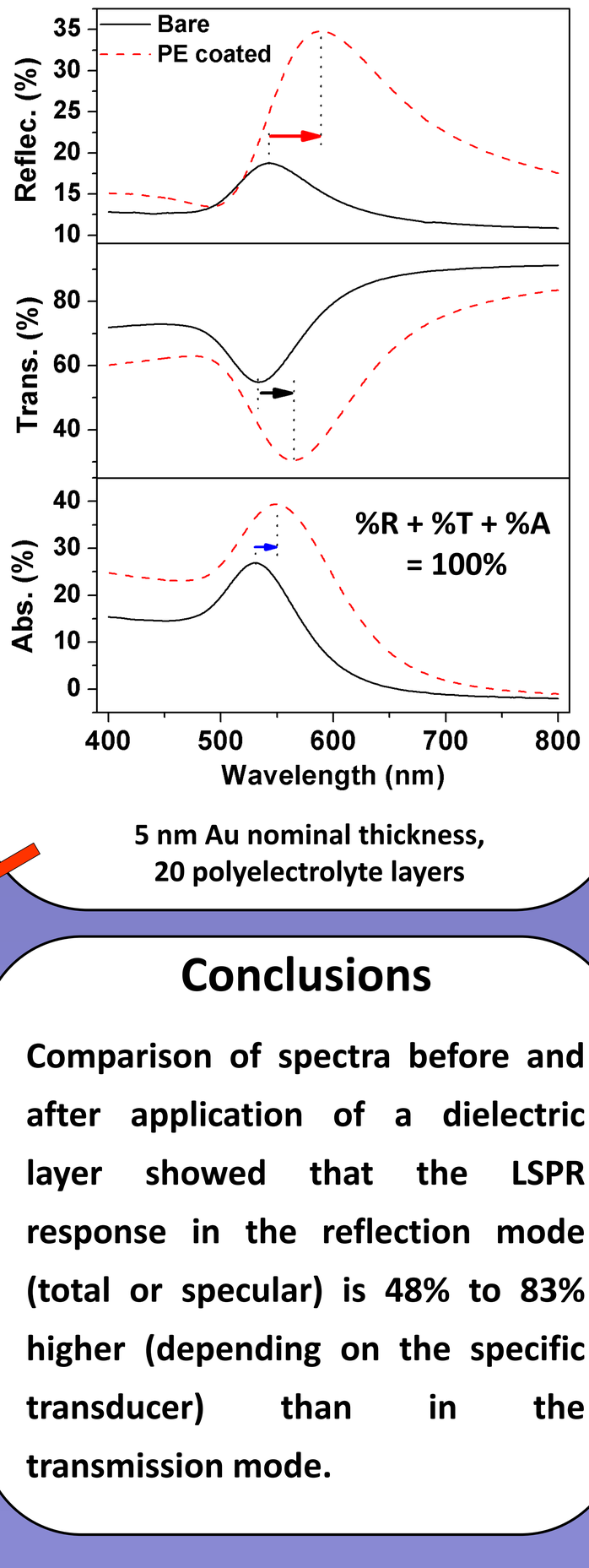


Polyelectrolyte multilayers



Each PAH/PSS bilayer is 2.09 ± 0.03 nm thick; n = 1.56 in the visible range.

Transmission and reflection

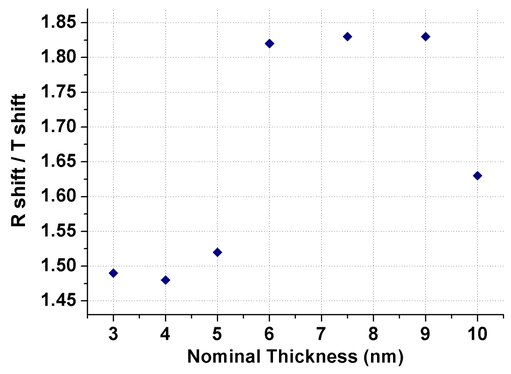


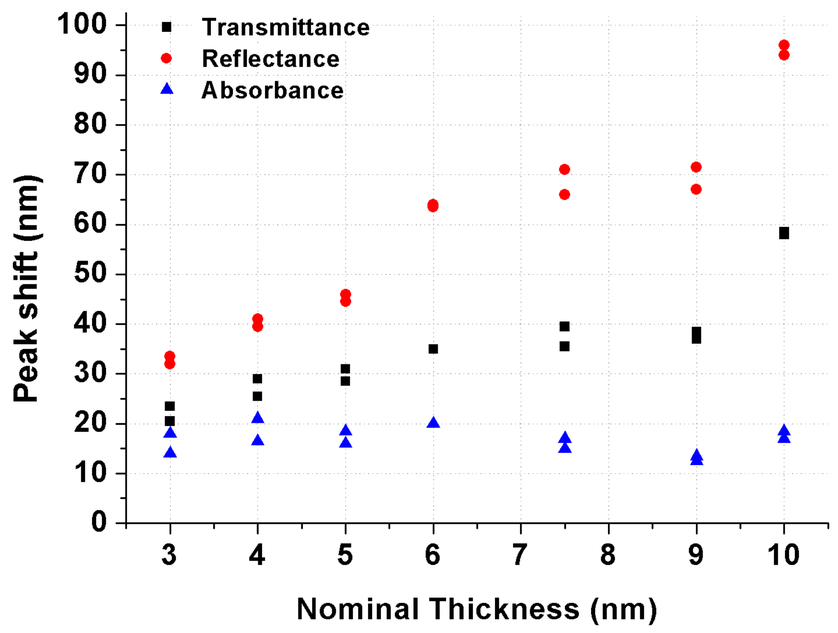
5 nm Au nominal thickness, 20 polyelectrolyte layers

Sensitivity in reflection and transmission

Right: LSPR peak shifts of the three optical components - transmittance, reflectance and absorbance - for slides of various gold island sizes, in response to polyelectrolyte multilayer adsorption.

Below: Ratio of peak shifts in reflection and transmission modes





Conclusions

Comparison of spectra before and after application of a dielectric layer showed that the LSPR response in the reflection mode (total or specular) is 48% to 83% higher (depending on the specific transducer) than in the transmission mode.