Transmission Surface Plasmon Spectroscopy for Monitoring Molecular Binding to Gold Island Films

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Evaporation of ultrathin (1.3 – 10 nm nominal thickness) gold films onto quartz, mica or glass leads to the formation of a layer of rather uniform gold islands on the transparent support.[1,2] The morphology of ultrathin Au island films of various thicknesses was studied using AFM and SEM imaging (Figure 1). The surface plasmon (SP) absorption characteristic of such films is highly sensitive to the surrounding medium, with the plasmon band changing in intensity and wavelength upon binding of various molecules to the surface.[2-4] The binding process can be followed quantitatively by measuring the changes in the gold SP absorption, using transmission UV/vis spectroscopy (Figure 2). The method, termed Transmission Surface Plasmon Resonance (T-SPR) spectroscopy, is shown to be applicable to both chemically and physically adsorbed molecules, in liquid or gas phase, with measurements carried out either *ex situ* or *in situ* (real time measurements).[3,4] Indirect binding to a molecular layer on the Au surface produces a similar response. A direct relationship is shown between the plasmon intensity change (PIC) and the surface coverage, suggesting possible use in sensing applications. The sensitivity of T-SPR spectroscopy in detecting molecular binding to the gold depends strongly on the film preparation conditions, and may be comparable to that obtained in surface plasmon resonance (SPR) sensing.

A major obstacle toward sensing (especially biosensing) application of this new method is the poor adhesion of the evaporated Au to the transparent substrates. To overcome this problem, two systems were studied: (i) glass slides modified with 3-mercaptopropyl tirmethoxysilane, and (ii) polystyrene slides; both substrates show superior adhesion to evaporated Au. Au island films evaporated on these substrates were characterized by AFM, XPS and transmission UV-vis spectroscopy. It is shown that the two substrates provide stable interfaces with evaporated ultrathin (1-5 nm) Au island films, as well as sizeable SP absorption bands appropriate for sensing applications. Control over the morphology and optical properties of the Au films is achieved by varying the evaporation parameters.

[1] G. Kalyuzhny, A. Vaskevich, S. Matlis, I. Rubinstein, *Rev. Anal. Chem.* **18** (1999) 237-242.
[2] G. Kalyuzhny, A. Vaskevich, G. Ashkenasy, A. Shanzer, I. Rubinstein, *J. Phys. Chem. B* **104** (2000) 8238-8244.
[3] G. Kalyuzhny, M. A. Schneeweiss, A. Shanzer, A. Vaskevich, I. Rubinstein, *J. Am. Chem. Soc*. **123** (2001) 3177-3178.
[4] G. Kalyuzhny, A. Vaskevich, M. A. Schneeweiss, A. Shanzer, I. Rubinstein, submitted.

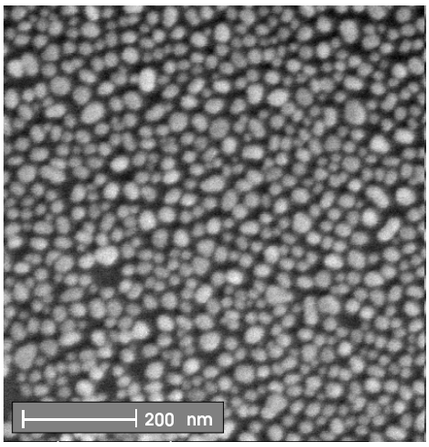

Figure 1. Environmental SEM image of an ultrathin Au island film evaporated on mica (5.0 nm nominal thickness, annealed 4 h at 250°C).

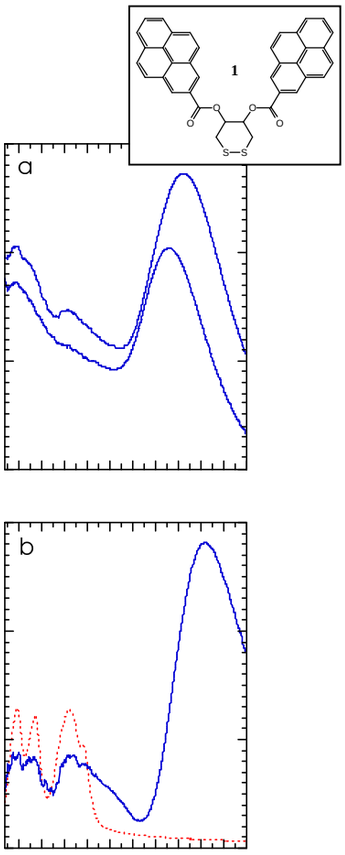

Figure 2. (a) Transmission UV/vis spectra of Au evaporated on quartz (2.5 nm nominal thickness, unannealed) before (bottom curve) and after (top curve) 49 min immersion in 2 mM solution of **1** in $CHCl_3$. (b) Difference spectrum, obtained by subtraction of the curves in a. Dashed line: a blank spectrum of a thick layer of **1** on quartz (original spectrum divided by 6).