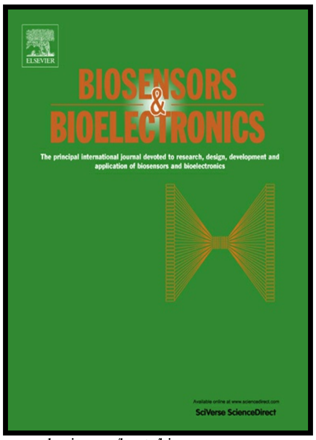

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Label-free Surface Plasmon Resonance Biosensing with Titanium Nitride Thin film

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Abstract:
In this report, titanium nitride thin film synthesized with reactive magneto-sputtering technique is proposed as an alternative surface plasmon resonance sensing material. The physical and chemical natures were initially studied by atomic force microscopy, X-ray diffraction and X-ray photoelectron spectroscopy. In virtue of white-light common-path sensing system, the wavelength modulated TiN films achieved tunable evanescent plasmonic field from 573nm to 627nm. The optimized TiN film with 29.8nm thickness exhibited good differential phase sensitivity (i.e. 1.932×10^{-7} RIU) to refractive index alteration, which is comparable to the performance of gold film. We have also attained direct measurement of biotin adsorption on the TiN and monitored sub-sequential biotin-streptavidin conjugation. It was found that TiN films have significantly higher binding affinity toward biotin than that of gold in experiments, so we are able to detect biotin directly to 0.22 μg/ml (0.90 μM) in label-free manner. The adsorption mechanism of biotin on TiN(200) are also explored with periodic density functional theory (DFT) via computer simulation and it was found that the exceptional biotin-TiN affinity may be due to the stacking formation of both N-Ti and O-Ti bonds. Also, the adsorption energy of biotin-TiN was found to be -1.85 eV, which was two times higher than that of biotin-gold. Both experimental and computational results indicate, for the first time, that the TiN film can be directly functionalized with biotin molecules, thus it serves as an alternative plasmonic material to existing gold-based SPR biosensors.

Keywords: Surface plasmon resonance; Titanium nitride; Biosensor; Biotin; Density functional theory;

1. Introduction

Surface plasmon resonance (SPR) is the light induced coherent electrons oscillation and electromagnetic waves propagation at the planar interface of dielectric-conducting media. Abundant scientific studies utilized surface plasmons (SPs) effect to convert photon energy into electron oscillation and make SPR attractive for use in many actual or potentially useful applications such as electronic devices (Schuller et al. 2010), biosensing (Homola et al. 1999), catalysis (Tian and Tatsuma 2005) and photochemistry (Uechi and Yamada 2008). Since the first attempt in biosensing application (Liedberg et al. 1983), the great potential of SPR sensing method has been receiving growing interest in scientific and commercial community. SPR based biosensors have been proven to have excellent capability in studying biomolecular interaction, chemical detection, medical diagnostics and immunoassays (Shankaran et al. 2007; Vo-Dinh and Cullum 2000). Most of these works used gold (Au) as the plasmonic materials. Au is the primary plasmonic media as the element supports plasmon resonance in the middle of the visible range, and exhibit good resistance to oxidation, non-toxic and readily fabricated into nanostructures. A few other elements are also possible candidates for application in plasmon resonance. Silver (Ag) exhibits excellent plasmon resonance performance at the blue end of the visible region (Weimer and Dyer 2001), but is susceptible to oxidation over short timescale. Furthermore, alkali metal elements such as lithium,