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摘要：分析了影响相位调制的表面等离子体共振（SPR）传感器灵敏度及动态范围的各种因素。搭建了差分干涉SPR相位检测系统，使用matlab软件模拟了若干因素对该类传感器的灵敏度和动态范围的影响，并使用3种厚度的金膜进行了实验验证，同时实时测量了牛血清白蛋白与其抗体之间的反应过程。结果显示，入射角度对于灵敏度和动态范围没有影响，而入射光波长、所选金属的介电常数和金膜厚度这3个因素是起作用的。这3个因素中，金膜厚度是比较重要且最易调节的一个。选定金膜后，通过调节入射角和反应物浓度，将抗原抗体反应导致的相位变化限制在系统的线性范围内进行了实时检测。结果表明，对于波长为633 nm的光源，在测量牛血清白蛋白与其抗体之间的反应过程中，兼顾灵敏度和动态范围的最优金膜厚度为48 nm，此时动态范围为0.013 6RIU，灵敏度为 6.67×10^{-7} RIU/0.01°。

关键词：生物传感器 表面等离子体共振 相位调制 动态范围 灵敏度

Optimization and validation of the differential interferometric surface plasmon resonance sensor

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Abstract: The sensitivity and dynamic range are main performance parameters of a Surface Plasmon Resonance (SPR) biosensor with phase modulation. In this paper, the main effect factors on sensitivity and dynamic range of the sensor were analyzed, and the influence of nonlinear change of phase difference on the results of real-time monitoring biological reaction was analyzed. A high resolution SPR system based on a Mach-Zehnder configuration was set up. The phase difference curves of a series gold membrane thicknesses and incident angles were simulated by matlab software, and the effect of several factors on the resolution and dynamic range were evaluated. In addition, the real-time monitoring of binding reaction between Bovine Serum Albumin (BSA) and BSA antibodies was also demonstrated. Obtained results show that the influence of membrane thickness is significant and nonlinear, but the incident angle shows little effect on the resolution and dynamic range. The influence of narrow dynamic range on biology reaction measurement can be minimized by optimizing some parameters, such as membrane thickness, incident angle and reactants concentration. Experimental results show that the sensitivity and dynamic range can be optimized by adjusting gold membrane thicknesses. This paper analyzed several influence factors of the sensitivity and dynamic range of phase modulation SPR biosensors. For a light source with 633 nm wavelength, the most optimal membrane thickness is 48 nm when the reaction between BSA and its antibody is measured. In this situation, the dynamic range is 0.013 6RIU and the sensitivity is 6.67×10^{-7} RIU/0.01°.

Keywords: biosensor surface plasmon resonance (SPR) phase modulation dynamic range sensitivity

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