Protein Microarray Analysis using Surface Optical Wave Resonance in Photonic Band Gap Multilayers

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Abstract: A label-free optical method of analyzing protein reactions in microarrays is demonstrated. The technique is based on the resonant excitation of surface optical waves in photonic band gap multilayers.

Introduction: Microarray assay methods are an essential tool in biological research, particularly in the areas of genomics and proteomics [1]. Here we present a label-free method of analyzing microarrays based on surface optical wave (SOW) resonance in photonic band gap multilayers. The technique offers a number of advantages over existing technologies. First, it is highly sensitive. The SOW resonance is similar to surface plasmon resonance—a phenomenon already frequently used for biological and chemical sensing [2]. However, the SOW resonance width is almost two orders of magnitude narrower than that of surface plasmon resonance leading to very high surface sensitivity. Second, the method is label free; it does not require the use of fluorescent, colorimetric, or radioactive tags to detect binding. The use of labels is problematic in a number of ways; not least of which is that its presence can alter a protein's binding properties [3]. Finally, the method is capable of high throughput and it is compatible with existing microarrayer technology and chemical immobilization methods.

Experimental configuration: The sensing method employed here is based on SOW resonance. SOWs exist at the surface of a photonic band gap material at frequencies within the forbidden band gap. The modes are non-radiative; they cannot be directly excited by incident light but rather require the use of prism or grating coupling. In the prism configuration used here (shown schematically in Figure 1), the coupling of light to SOWs in the PBG material attached to the reflecting face of the prism is manifest by the absence of light in the reflected beam. This reflectivity drop only occurs in the narrow angular range over which phase matched coupling occurs. This coupling angle is very sensitive to changes in the dielectric loading at the surface such that the presence of a layer of biomolecules at the surface will cause a shift in coupling angle. By recording the coupling angle as the focused laser spot is raster scanned across the PBG sample a surface profile of the microarray can be obtained. A scan of a protein microaraay is shown in Figure 2.

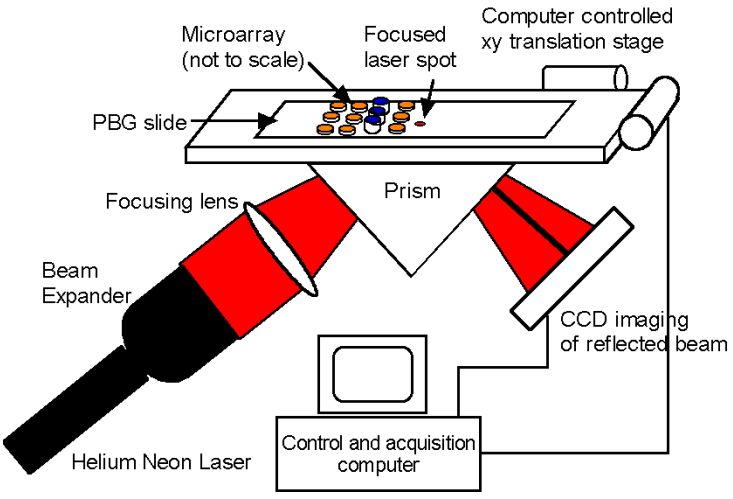

Figure 1. Schematic of the SOW microarray reader

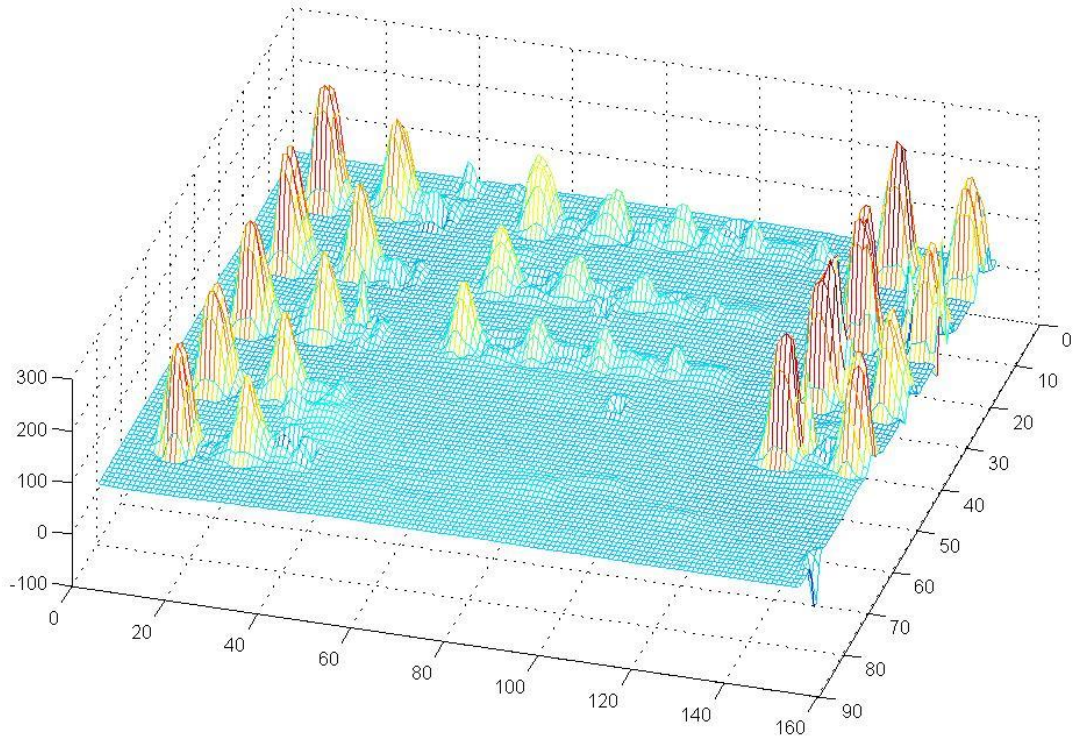

Figure 2 Experimental data from a scan of a protein array.

The sequence of a typical microarray experiment to detect antibody-antigen binding involves taking scans of the antibody microarray before and after exposure to a sample containing antigens. Binding is determined by the increased mode shift (peak height) of spots where antibody-antigen reactions have occurred.

Photonic Band Gap Multilayers: For the experiments described here we use a one-dimensionally periodic PBG material composed of alternating layers of high and low refractive index materials (TiO_2 and SiO_2 respectively) deposited on a glass slide substrate. Although this simple system does not possess a photonic band gap in all propagation directions, it is an excellent choice for sensing applications because such multilayers can be fabricated accurately and their surface optical wave properties are well understood [4,5]. In order to bind biomolecules to the surface of the PBG slide a chemical immobilization layer is added.

Conclusion: A new method of microarray analysis based on SOW resonance is described. Results will be presented that demonstrate both the high sensitivity of the method and the ability to characterize selective antibody-antigen binding reactions.

References

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