Integration of Metal-Semiconductor-Metal Photoarrays for the Quantification of Animal's Vitamin and Protein

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Biotin is required for cellular metabolism of carbohydrate, fat and protein. It is also involved in the production of amino acids and glucose, and in the catalysis of fatty acid synthesis. Streptavidin, a protein presented in the egg white, is specific binding to the biotin and interfering with the animal's nutrition. In this study, an on-chip metal-semiconductor-metal (MSM) photodetector is proposed and integrated with the biotin biomolecule for the purpose of biosensing. This design based on the photocurrent detection can overcome the fluorescence detection method with the problems of expensive, complex and large external optical systems. An on-chip electronic data acquisition concept also improves both the speed and the reliability for biosensing.

The MSM photodetector photoarray with the dense metal lines is fabricated by the standard semiconductor process. The layout of the MSM devices is illustrated in Fig. 1, and it consists of 300nm finger-type gold lines on the Si(100) n^+ type substrate. The ratio of dark (Id) current and photocurrent (Ip) under the Halogen lamp is shown in Fig. 2. The performance of the device is strongly relied to the ratio of Ip and Id, and the ratio in Fig. 2 without further optimization is 312.5 at 4.7V operation. The detection concept for the animal's vitamin or protein is based on the photoconductivity of MSM electrodes. As to the biotin binding, the silicon dioxide at 72nm is deposited onto the MSM device area. The bottom-up molecular immobilization in Fig. 3 first immerses the device into the 20mM APTES solution. In order to ensure the successful APTES immobilization, the fluorescence rhodamine isocynate molecule is linked to the APTES surface. The red fluorescence (λ_{ex}=540 nm, λ_{em}=573 nm) in Fig. 4 clearly suggests the above reaction. The APTES-modified surface is immersed into the NHS-biotin solution to immobilize the biotin molecule. Then, the fluorescence streptavidin-FITC molecule with the very strong and specific affinity with biotin is immobilized. The green fluorescence image (λ_{ex}=492 nm, λ_{em}=518 nm) in Fig. 5 is demonstrated for the successful bioreaction. The chemiluminescence binding streptavidin will be used to avoid external exciting light of which traditional fluorescence method is seen. More detailed quantification results for the sensing will be given in the conference.

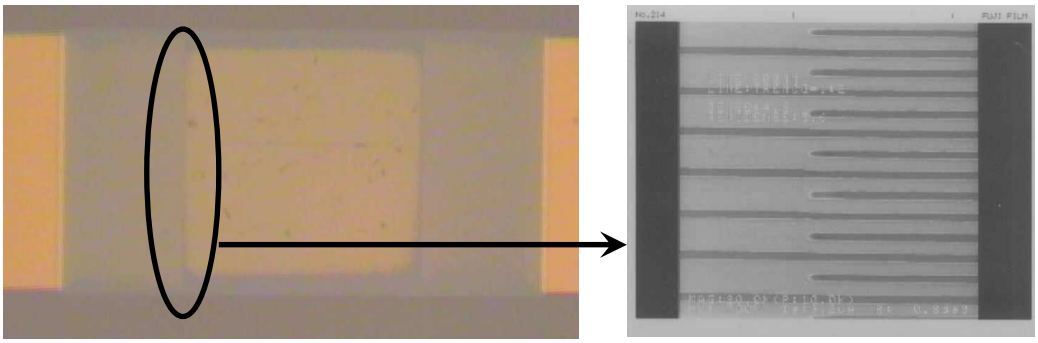

Figure 1. OM and SEM images for the structure of MSM photodetector.

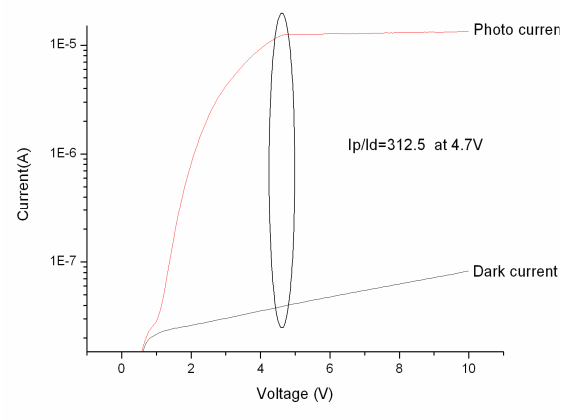

Figure 2. I-V measurement of dark current and photocurrent for MSM photodetector.

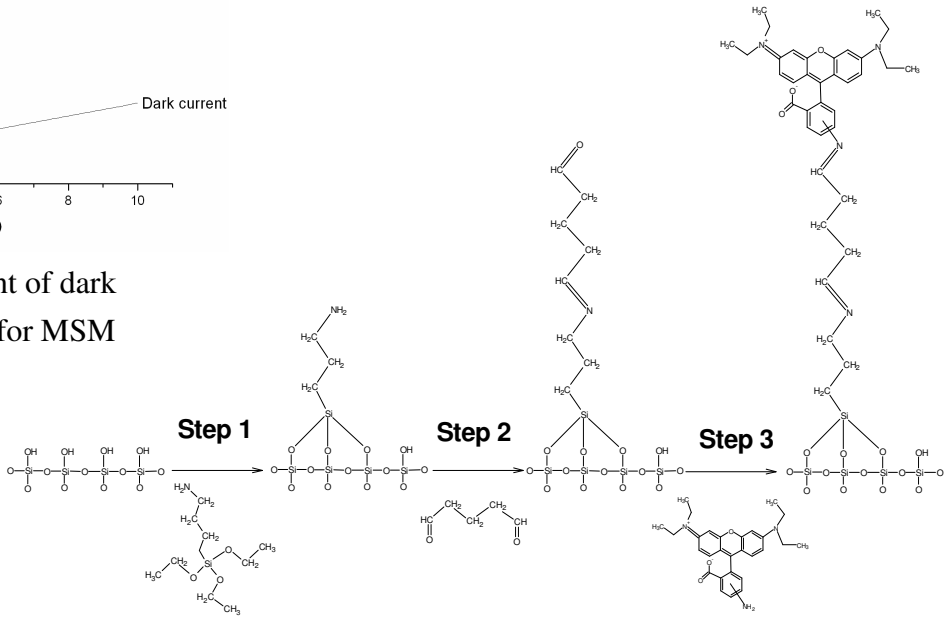

Figure 3. The immobilization procedures for the red fluorescent molecule.

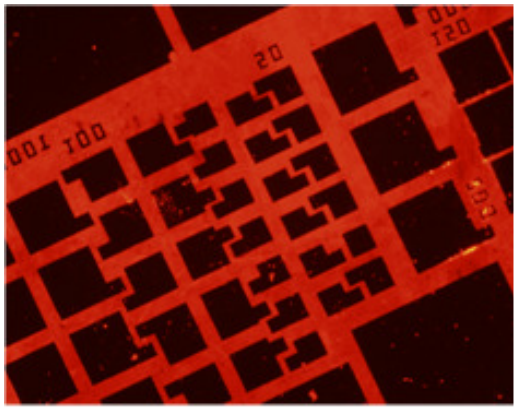

Figure 4. The red fluorescence image for the rhodamine isocynate molecule binding onto the APTES surface.

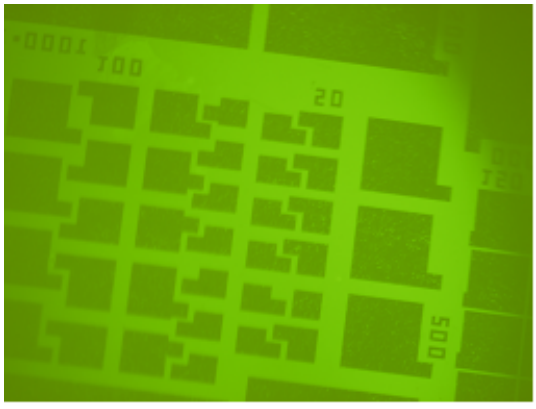

Figure 5. The green fluorescence image for the streptavidin-FITC protein binding onto the biotin biomolecule.