

# A Hybrid Organic-Semiconductor Optical Biosensor

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The use of III-V semiconductors in conjunction with organic nanomaterials has shown to be a promising approach for the development of novel biosensors. One particularly appealing platform involves the use of GaAs surfaces functionalized with biomolecular receptors where the recognition of biochemical reactions is achieved via optical means. The prospective GaAs biosensors provide a simple and effective means of label-free detection of specific biological analytes.

Undoped GaAs substrates were treated with thiol-derivatized aptamers following conventional liquid-phase deposition techniques based on GaAs-S chemistry. Specifically, a clean, oxide-free substrate was incubated in a  $\mu\text{M}$  solution of T10ATP (5'-HS-TTTTTTTTTTACCTGGGGGAGTATTGCGGAGG AAGGT-3') (or its mutant counterpart MUT10ATP (5'-HS-TTTTTTTTTTACCTGTGGGAGTATTGCG TAGGAAGGT-3)) and PBS for 48 hrs at room temperature (RT). Subsequently, the aptamer-modified substrates were treated with MCH (mercaptohexanol) to remove any nonspecifically adsorbed oligonucleotides.

The hybridization of aptamer-modified GaAs surfaces was conducted in a mM solution of ATP (adenosine 5'-triphosphate) in PBS (referred to as ATP+(MCH+T10ATP) and ATP+(MCH+MUT10ATP)). To validate the specificity of the detection process, a portion of the T10ATP-modified sample was treated with a mM solution of GTP (guanosine 5'-triphosphate) in PBS (referred to as GTP+(MCH+T10ATP)).

Immediately following the hybridization process, RT photoluminescence (PL) measurements were conducted on the samples. As absorption of the laser beam occurs close to the GaAs surface, the intensity of the resulting PL signal is strongly controlled by the properties of the surface and thus, can be used to indicate the binding of specific analytes.

Figure 1 shows PL spectra of aptamer-treated GaAs samples. As indicated in the figure, the PL intensity following deposition of the T10ATP is quenched compared to the untreated substrate. The observed decrease in the PL intensity upon exposure to the thiolated oligonucleotides is attributed to a shift in the Fermi level of the GaAs due to the formation of bonds between the charged T10ATP or MUT10ATP molecules and the GaAs surface. Following the MCH treatment the measured PL intensity remained virtually the same as that of the aptamer-modified samples. On the other hand, in the presence of the target ATP molecules, the peak PL intensity of the MCH+T10ATP modified sample increased while the intensity of the mutated MCH+MUT10ATP sample did not change. Moreover, there was no change observed in the peak PL intensity of the MCH+T10ATP modified sample in the presence of GTP molecules. The enhanced PL signal of the ATP+(MCH+T10ATP) sample demonstrates the successful recognition of the ATP target by the T10ATP receptors. The increase in PL intensity as a result of the hybridization reaction corresponds to a shift in the position of the GaAs Fermi level due to a change in the charge distribution at the sample surface. Further evidence that the observed PL enhancement is a direct consequence of successful biorecognition is provided by the control experiments performed using the mutant aptamer MUT10ATP or the GTP. Since the mutant aptamers cannot hybridize with the ATP there is no change in the PL intensity following the exposure of the MCH+MUT10ATP sample to ATP. Similarly, since the GTP molecules cannot bind to the T10ATP receptors, there is no corresponding change in the PL signal.

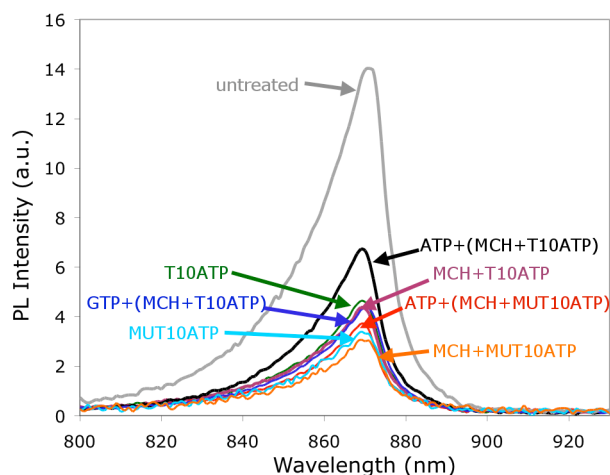


Fig. 1 PL spectra of various aptamer-modified GaAs samples.

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