Quantum Semiconductor Based Photonic Biosensing

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In the quest for development of alternative methods of rapid detection of human/animal pathogens, we have been investigating photonic response of quantum semiconductor microstructures to the presence of viruses and bacteria specifically immobilized on semiconductor surfaces. The transducer effect of this approach is based on measuring the perturbation of a photoluminescence signal from arrays of epitaxial quantum dots or specially designed quantum well architectures capped with a layer of material containing bait-biomolecules. The modification of semiconductor band bending near the surface and reduction of the hole/electron ratio of surface carrier capture cross-section by an electric charge of biomolecules are the main mechanisms contributing to the detection. Most viruses and bacteria carry a net negative electric charge, for which an increase of the PL signal is expected upon immobilization of such particles on the surface of undoped, or lightly n-doped III-V semiconductor. In addition to a highly sensitive response, successful detection requires that the biofunctionalized architectures remain relatively stable in biological solutions used for transporting viruses or bacteria. Our theoretical calculations and experimental data point to thiolation of the GaAs surface as a practical means in achieving both biosensing functionality and stability, which are attractive for rapid detection of selected biomolecules. I will discuss the recent progress we accomplished in this respect and the perspectives of developing technology of devices for automated biodetection.