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HIGH SELECTIVITY AND SENSITIVITY BIOCHEMICAL SENSOR BASED ON QUANTUM CONFINEMENT

Abstract

Presented will be highly sensitive, target specific biochemical sensor based on the well understood phenomenon of charge tunneling between two quantum confined systems. Its operation relays on the matching of electron density of states in the detector nanostructure (for instance quantum dots (QDs), nanowires, nanotubes) and the density of states in the target molecule (to be detected). The fundamental mechanism behind this device design is that efficient charge transfer will occur only between a detector nanostructure and a target molecule with matching density of states distribution. This new approach to biochemical sensing is unique. Theoretically, this type of sensor is much more selective in detecting biochemical agents than sensors based on changes in conductivity, which is the case for most current sensors. The signal from a device based on charge tunneling, e.g. a change in capacitance, will occur only if a specific molecule, with specific energy levels present next to a detector nanostructure with matching energy levels. Changes in conductivity in conventional sensors, however, can be affected by many other molecules, even those that are very different in structure.

The desired density of states distribution (to be the same as in the molecule that will be detected) in the nanostructure, for instance QD, can be achieved by quantum confinement, through nanostructure size, shape, composition, and external parameters, as for instance pressure, and voltage. A possible typical sensor design involves fabrication of QD arrays sandwiched between parallel metal strips (charge collectors) bonded to a substrate. The 5 μm wide metal strips are 10 to 50 μm apart; they conduct information to a computerized acquisition system when a charge transfer occurs between the QD and the analyte. The population of QDs sandwiched between the metal strips is a common group of identical QDs ranging in size from 1 to 50 nm. Each separate QD-group will contain a QD of different size or shape and, therefore, a different set of energy levels. The sensor could have broad application in engines diagnostic and space exploration, because it can provide continuous biochemical monitoring.