Sensor with Quantum Dot to Detect the Gas

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***Abstract*— In this paper we will study Sensor with Quantum Dot to Detect the Gas. As quantum dot is a semiconductor nanostructure that confines the motion of conduction band electrons, valence band holes, or excitons (bound pairs of conduction band electrons and valence band holes) in all three spatial directions. he confinement can be due to electrostatic potentials (generated by external electrodes, doping, strain, impurities), the presence of an interface between different semiconductor materials (e.g. in core-shell nanocrystal systems), the presence of the semiconductor surface (e.g. semiconductor nanocrystal), or a combination of these.A quantum dot has a discrete quantized energy spectrum.The corresponding wave functions are spatially localized within the quantum dot, but extend over many periods of the crystal lattice.A quantum dot contains a small finite number (of the order of 1-100) of conduction band electrons, valence band holes, or excitons, i.e., a finite number of elementary electric charges.Small quantum dots, such as colloidal semiconductor nanocrystals, can be as small as 2 to 10 nanometers, corresponding to 10 to 50 atoms in diameter and a total of 100 to 100,000 atoms within the quantum dot volume.Self-assembled quantum dots are typically between 10 and 50 nm in size.Quantum dots defined by lithographically patterned gate electrodes, or by etching on two-dimensional electron gases in semiconductor heterostructures can have lateral dimensions exceeding 100 nm.At 10 nm in diameter, nearly 3 million quantum dots could be lined up end to end and fit within the width of a human thumb.**

Keywords*— *Sensor, Quantum Dot

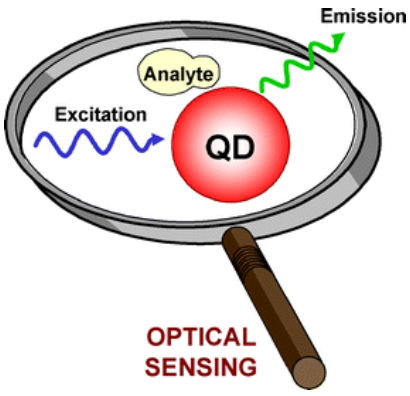
I. INTRODUCTION

Quantum-dot-based photoelectron chemical sensors are powerful alternatives for the detection of chemicals and biochemical molecules compared to other sensor types, which is the primary reason as to why they have become a hot topic in nanotechnology-related analytical methods. These sensors basically consist of QDs immobilized by a linking molecule (linker) to an electrode, so that upon their illumination, a photocurrent is generated which depends on the type and concentration of the respective analyte in the immediate environment of the electrode. The present review provides an overview of recent developments in the fabrication methods and sensing concepts concerning direct and indirect interactions of the analyte with quantum dot modified electrodes. Furthermore, it describes in detail the broad range of different sensing applications of such quantum-dot-based photoelectrochemical sensors for inorganic and organic (small and macro-) molecules that have arisen in recent years. Finally, a number of aspects concerning current challenges on the way to achieving real-life applications of QD-based photochemical sensing are addressed.

II. QUANTUM DOT

The target strand binds to a dye-labelled reporter strand thus forming a FRET donor–acceptor ensemble. The QD also functions as a concentrator that amplifies the target signal by confining several targets in a nanoscale domain. Unbound nanosensors produce near-zero background fluorescence, but on binding to even a small amount of target DNA (approx50 copies or less) they generate a very distinct FRET signal. A nanosensor-based oligonucleotide ligation assay has been demonstrated to successfully detect a point mutation typical of some ovarian tumours in clinical samples.

Semiconductor quantum dots (QDs) are inorganic nanoparticles that exhibit unique size-dependent optical and electronic properties; in particular, they are strongly luminescent. Their surface can be chemically modified, by either covalent or non-covalent approaches, in order to interface them with molecular units endowed with specific physical and chemical properties. Photoinduced electron- and energy-transfer processes between quantum dots and attached molecular species offer versatile strategies to modulate the photophysical properties of these nanoassemblies in response to a chemical stimulation. Hence, QD–molecule conjugates are appealing platforms for developing luminescent sensors according to a modular design. In this review we discuss the principles underlying the rational construction of this kind of multicomponent species, and we illustrate selected examples of luminescent QD-based sensors taken from the recent literature.



The hybrid sensor consists of anti-TNT specific antibody fragments attached to a hydrophilic QD via metal-affinity coordination. A dye-labeled TNT analogue prebound in

the antibody binding site quenches the QD photoluminescence via proximity-induced FRET. Analysis of the data collected at increasing dye-labeled analogue to QD ratios provided an insight into understanding how the antibody fragments self-assemble on the QD. Addition of soluble TNT displaces the dye-labeled analogue, eliminating FRET and resulting in a concentration-dependent recovery of QD photoluminescence. Sensor performance and specificity were evaluated.

III. ELECTRONIC CHARACTERISTICS OF A QUANTUM DOT

Electronic characteristics of a quantum dot are closely related to its size and shape. For example, the band gap in a quantum dot which determines the frequency range of emitted light is inversely related to its size. In fluorescent dye applications the frequency of emitted light increases as the size of the quantum dot decreases. Consequently, the color of emitted light shifts from red to blue when the size of the quantum dot is made smaller. This allows the excitation and emission of quantum dots to be highly tunable. Since the size of a quantum dot may be set when it is made, its conductive properties may be carefully controlled. Quantum dot assemblies consisting of many different sizes, such as gradient multi-layer nanofilms, can be made to exhibit a range of desirable emission properties..

In a semiconductor crystallite whose radius is smaller than the size of its exciton Bohr radius, the excitons are squeezed, leading to quantum confinement. The energy levels can then be modeled using the particle in a box model in which the energy of different states is dependent on the length of the box. Quantum dots are said to be in the 'weak confinement regime' if their radii are on the order of the exciton Bohr radius; quantum dots are said to be in the 'strong confinement regime' if their radii are smaller than the exciton Bohr radius. If the size of the quantum dot is small enough that the quantum confinement effects dominate (typically less than 10 nm), the electronic and optical properties are highly tunable.

Splitting of energy levels for small quantum dots due to the quantum confinement effect. The horizontal axis is the radius, or the size, of the quantum dots and ab* is the Exciton Bohr radius.

Fluorescence occurs when an excited electron relaxes to the ground state and combines with the hole. In a simplified model, the energy of the emitted photon can be understood as the sum of the band gap energy between the occupied level and the unoccupied energy level, the confinement energies of the hole and the excited electron, and the bound energy of the exciton (the electron-hole pair):

IV QUANTUM DOT

Quantum dot manufacturing relies on a process called "high temperature dual injection" which has been scaled by multiple companies for commercial applications that require large quantities (hundreds of kilograms to tonnes) of quantum dots. This is a reproducible production method that can be applied to a wide range of quantum dot sizes and compositions.

The bonding in certain cadmium-free quantum dots, such as III-V-based quantum dots, is more covalent than that in II-VI materials, therefore it is more difficult to separate nanoparticle nucleation and growth via a high temperature dual injection synthesis. An alternative method of quantum dot synthesis, the “molecular seeding” process, provides a reproducible route to the production of high quality quantum dots in large volumes. The process utilises identical molecules of a molecular cluster compound as the nucleation sites for nanoparticle growth, thus avoiding the need for a high temperature injection step. Particle growth is maintained by the periodic addition of precursors at moderate temperatures until the desired particle size is reached.[21] The molecular seeding process is not limited to the production of cadmium-free quantum dots; for example, the process can be used to synthesise kilogram batches of high quality II-VI quantum dots in just a few hours.

Another approach for the mass production of colloidal quantum dots can be seen in the transfer of the well-known hot-injection methodology for the synthesis to a technical continuous flow system. The batch-to-batch variations arising from the needs during the mentioned methodology can be overcome by utilizing technical components for mixing and growth as well as transport and temperature adjustments. For the production of CdSe based semiconductor nanoparticles this method has been investigated and tuned to production amounts of kg per month. Since the use of technical components allows for easy interchange in regards of maximum through-put and size, it can be further enhanced to tens or even hundreds of kilograms

V. APPLICATIONS

Quantum dots are particularly significant for optical applications due to their high extinction coefficient.[28] In electronic applications they have been proven to operate like a single electron transistor and show the Coulomb blockade effect. Quantum dots have also been suggested as implementations of qubits for quantum information processing.

The ability to tune the size of quantum dots is advantageous for many applications. For instance, larger quantum dots have a greater spectrum-shift towards red compared to smaller dots, and exhibit less pronounced quantum properties. Conversely, the smaller particles allow one to take advantage of more subtle quantum effects.

Being one-dimensional, quantum dots have a sharper density of states than higher-dimensional structures. As a result, they have superior transport and optical properties, and are being researched for use in diode lasers, amplifiers, and biological sensors. Quantum dots may be

excited within a locally enhanced electromagnetic field produced by gold nanoparticles, which can then be observed from the surface plasmon resonance in the photoluminescent excitation spectrum of (CdSe)ZnS nanocrystals. High-quality quantum dots are well suited for optical encoding and multiplexing applications due to their broad excitation profiles and narrow/symmetric emission spectra. The new generations of quantum dots have far-reaching potential for the study of intracellular processes at the single-molecule level, high-resolution cellular imaging, long-term in vivo observation of cell trafficking, tumor targeting, and diagnostics.

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