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Absorbance-Based Integrated Optical Sensors

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Abstract Optochemical sensors have had a huge expansion and in recent years interesting sorts of optical sensor have been developed which make use of the integrated circuit microelectronic technology and the optical technological advances achieved in the telecommunications industry. These devices are based on optical fibers, planar wave-

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Luminescence Lifetime-Based Imaging of Sensor Arrays for High-Throughput Screening Applications

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Abstract This review highlights optical imaging technologies for the fluorescent read out of sensor arrays. Chemosensor arrays for the determination of pH, oxygen partial pressure or metal ions found particular applications in biomedical and environmental analysis. On the other hand, the monitoring of biomolecular interactions, e.g. of DNA sequences or proteins, is an important tool in pharmaceutical research and medical diagnosis. Microwell plate-based assays provided the possibility to analyze a large number of samples in parallel in a very short time. The development of microarray technologies was a step forward in miniaturization of high-throughput (or multiplexed) assay formats. The analysis of both microwell plate and microarray-based assays are subject of this survey, focussing on fluorescence lifetime imaging methods.

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Cataluminescence-Based Gas Sensors

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Hollow Waveguide Infrared Spectroscopy and Sensing

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Abstract Infrared (IR) hollow waveguides (HWGs) were first utilized in gas sensing applications in the early 1990's and have since been coupled to both FT-IR spectrometers and laser light sources. However, gas sensing with hollow waveguide modules has yet to achieve maturity for widespread use or device commercialization. We review this emerging field with emphasis on technology and application areas where we believe these devices are ideally suited, and discuss the advantages and limitations of using HWGs for chemical sensing, including their optical properties and waveguide losses. As new HWG technologies based on photonic bandgap materials are emerging, relevant applications of

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Combinatorial Method for Surface-Confined Sensor Design and Fabrication

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Abstract The procedure for the combinatorial fabrication of new sensing materials for cations and anions based on self-assembled monolayers (SAM) is discussed. A library of different sensitive substrates is generated by sequential deposition of fluorophores and small ligand molecules onto an amino-terminated SAM coated glass. The preorganization provided by the surface avoids the need for complex receptor design, allowing for a combinatorial approach to sensing systems based on individually deposited small molecules. Additionally the sensing system has been miniaturized to the microscale using microcontact printing and integrating the sensory SAMs on the walls of microchannels.

1 Introduction

Combinatorial methods are being widely implemented in the field of optical sensor development. The combinatorial concept is based on the relative ease of production of a large number of potential targets, of which it is hoped that some will exhibit the desired specifications of the researcher. This combinatorial approach is clearly different from the 'classical' rational design and individual creation of specific targets, in that the stress is not on the initial, specific design of the desired system, but on the testing of the large number of resultant targets to determine successful hits. Linked to a proper screening methodology and data processing, it allows for the facile search and

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The Interplay of Indicator, Support and Analyte in Optical Sensor Layers

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Abstract It has been recognized since the pioneering times of fiber-optic sensing development that the best indicator dye is worth nothing without a (polymer) support fitted

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Challenges in the Design of Optical DNA Biosensors

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Abstract The field of biosensors and biochips for nucleic acid diagnostics has developed significantly over the last decade. High-throughput techniques offering the advantages of sensitivity and selectivity combined with rapid analysis to provide reproducible and accurate results are highly sought after in the areas of medical diagnostics, forensics, environmental monitoring, and bioterrorism. This chapter gives a short review of the necessary considerations for the preparation of immobilized nucleic acid films on a solid sensor substrate and the development of techniques utilized for the detection of selective hybridization of target binding materials. The fundamentals of fibre optic and surface plasmon resonance optical sensor platforms are outlined, followed by key developments

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Gold Nanoparticles in Bioanalytical Assays and Sensors

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Abstract In this review we report two major applications of gold nanoparticles in the field of bioassay and sensing. The first application is a unique, sensitive, and highly specific immunoassay system for antibodies using gold nanoparticles. The assay is based on the aggregation of gold nanoparticles that are coated with protein antigens in the presence of their corresponding antibodies. Aggregation of the gold nanoparticles results in an absorption change at 620 nm that is used to calibrate the amount of antibodies. The effects of pH, temperature, and the concentration of protein A-coated gold nanoparticles on the sensitivity of the assay were investigated. A dynamic range of two orders of magnitude and a limit of detection of 1 μg/mL of anti-protein A were observed.

The second application of nanoparticles is luminescence nanosensors, which have their potential use as site-specific probes in samples of limited dimensions. Novel methods of nanosensor fabrication to obtain nanosensors with improved analytical properties are reported. A new approach for controlled synthesis of fluorescence nanosensors for pH measurements is also presented. Gold nanoparticles were used as a supportive matrix for the sensing component. Polymer layers that include the active sensing element were deposited on the gold nanoparticles surface using an electrostatic-based layer by layer deposition method. Polymer layers of alternating charges were deposited on the particle surface through attractive electrostatic interactions. Such method enabled a more precise control of the size, size distribution and density of fluorophores on each particle. The study shows that this is an effective way to fabricate particle-based fluorescent nanosensors that are stable and effective in measuring the pH in aqueous media.

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Reverse Symmetry Waveguide for Optical Biosensing

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Abstract The present chapter deals with a novel design of planar optical waveguide biosensors. The principle of reverse symmetry is based on making the refractive index (RI) of the waveguide substrate less than the RI of the medium covering the waveguiding film, which is usually an aqueous solution (RI ~ 1.33). This is opposed to the conventional sensor geometry, where the substrate is glass or polymers with RIs of approximately 1.5. The reverse configuration can be used to tune the penetration depth of the evanescent electromagnetic field into the cover medium up to infinity; thus the waveguide can be tailor-made so that biological objects with any size can be probed by the evanescent field. This is an important improvement compared with, for example, surface plasmon resonance sensors, where the penetration depth is fixed by the choice of metal.

1 Introduction

For almost 20 years, the optical waveguide sensor has been used for the label-free, evanescent-field detection of chemical or biological reactions taking place in the close vicinity of the waveguide surface. This includes numerous applications within the fields of chemical and biological sensing, where in

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Materials for Luminescent Pressure-Sensitive Paint

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Abstract Pressure-sensitive paint (PSP) is applied to the areodynamics measurement. PSP is optical sensor based on the luminescence of dye probe molecules quenching by oxygen gas. Many PSPs are composed of probe dye molecules, such as polycyclic aromatic hydrocarbons (pyrene, pyrene derivative etc.), transition metal complexes (ruthenium(II), osumium(II), iridium(III) etc.), and metalloporphyrins (platinum (II), palladium(II), etc.) immobilized in oxygen permeable polymer (silicone, polystyrene, fluorinated polymer, cellulose derivative, etc.) film. Dye probe molecules adsorbed layer based PSPs such as pyrene derivative and porphyrins directly adsorbed onto anodic oxidised aluminium plat substrate also developed. In this section the properties of various oxygen permeable polymer for matrix and various dye probes for PSP are described.

1 Pressure-Sensitive Paint

Surface pressure distribution measurement is of fundamental importance in the experimental study of aerodynamic problems in the fields of avionics, car, rocket, aerospace, and aircraft design [1]. The conventional methods based on pressure taps or transducers have a number of limitations. The most serious problem is that their very nature limits them to providing information only at discrete points on the surface of a substrate. A new approach to surface pressure distribution measurement, the use of pressure-sensitive paint (PSP), has recently developed that offers the potential of revolutionizing the nature of such measurements in the field of aerodynamics. This method employs the oxygen sensitivity of fluorescent materials in the form of a paint, in conjunction with image processing techniques, to map the pressure field over

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Optical Sensing of Enantiomers

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Abstract The optical sensing of enantiomers is a current topic. During the last decade many different applications for optical sensing of enantiomers have been reported in the literature. The principles of distinction of enantiomers using amide and cyclodextrin phases, molecularly imprinted polymers and fluorescence sensors are depicted in this chapter. Label-free methods, like surface plasmon resonance and reflectometric interference spectroscopy, can be adopted for polymer-based chiral amides, cyclodextrines and molecularly imprinted polymers. These materials derived from chromatographic methods are used for enantiomeric separation in the aqueous phase as well as in the gaseous phase. Calixarene and 1,1′-binaphthyl fluorophores as well as fluorescent cyclodextrins could be established as sensing materials for fluorescence measurements. Examples for the most commonly used methods—enantioselective fluorescence quenching or enhancement—are presented.

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Optical Sensors for Ions and Protein Based on Digital Color Analysis

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Abstract A novel colorimetric method, digital color analysis (DCA), was proposed using a digital color analyzer and was applied to various quantitative analyses using chromaticity coordinates and suitable sensors for visual colorimetry based on the characteristics of human visual perception by virtual simulations based on digital color information. On the basis of DCA, we developed a visual colorimetric sensor for Li^+, NH_4^+ and protein determination by the mixing of two kinds of lipophilic dyes, whose optimum mixing ratio