OPTICAL BIO- SENSOR’S APPLICATIONS

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OPTICAL FIBER sensor:- A fiber-optic sensor detects changes in the light guided through an optical fiber when it is affected by external physical, chemical , biochemical , or any other parameters.

The attractive features of fiber –optic sensors are :-

I. High sensitivity.

II. Large bandwidth.

III. Operation at very high temperature ,pressure ,or voltage.

IV. Multiplexed or distributed measurement.

V. Long range operation.

VI. Small size , light weight , and great flexibility , allowing access to restricted areas.

VII. Resistant to chemically aggressive and ionizing environments.

VIII. Easy interface with optical data communication system and secure data transmission.

Classification of fiber-optical sensors

1)Based on sensing site or location :-

(A) Intrinsic (B) Extrinsic

2)Based on operating principle :-

(A)Intensity Modulated

(B) Phase Modulated

(C) Wavelength Modulated

(D) Polarization Modulated

3)Based on application:-

(A) Physical Sensors

(B) Chemical Sensors

(C) Biochemical Sensors

Immobilization

- Immobilization of the bio recognition element to enhance its local concentration can be brought about by physical methods of containment within semi permeable membranes, a selective adsorption of the element on a solid support, electrostatic interactions, and physical entrapment within a matrix.

- The simplest **physical method** is containment within semi permeable membranes.

- **containment** - attempt to stop spread of something
- **adsorption and accumulation of substance on surface.**

- ***Ionic Binding.*** *A* bio recognition element can be immobilized on a solid support by electrostatic interactions between them.

- ***Physical Entrapment.*** In this method, the bio recognition element or the sensor indicator (which changes its optical property on sensing) is entrapped within the body of a matrix such as poly acrylamide, polyvinyl alcohol, poly-vinyl chloride, epoxy, sol-gel processed glass, or a Langmuir-Blodgett film.

- ***Chemical Immobilization.*** This method involves formation of a covalent bond between the solid support or the optical sensor surface and a bio recognition element such as a protein (enzyme or antibody).

A **biosensor** is an analytical device, used for the detection of an analyte, that combines a biological component with a physicochemical detector.

- The sensitive biological element (e.g. tissue, microorganisms, organelles, cell receptors, enzymes, antibodies, nucleic acids, etc.), a biologically derived material or biomimetic component that interacts (binds or recognizes) the analyte under study.
- The ***transducer*** or the ***detector*** *element* (works in a physicochemical way; optical, piezoelectric, electrochemical, etc.) that transforms the signal resulting from the interaction of the analyte with the biological element into another signal (i.e., transduces) that can be more easily measured and quantified;
- Biosensor reader device with the associated electronics or signal processors that are primarily responsible for the display of the results in a user-friendly way. This sometimes accounts for the most expensive part of the sensor device, however it is possible to generate a user friendly display that includes transducer and sensitive element.

The biosensor system

- A biosensor typically consists of a bio-recognition component, bio-transducer component, and electronic system which include a signal amplifier, processor, and display.

- The recognition component, often called a bioreceptor, uses biomolecules from organisms or receptors modeled after biological systems to interact with the analyte of interest.

- This interaction is measured by the biotranducer which outputs a measurable signal proportional to the presence of the target analyte in the sample. The general aim of the design of a biosensor is to enable quick, convenient testing at the point of concern or care where the sample was procured.

Placement of biosensors

1)In-vivo: An in-vivo biosensor is one that functions inside the body. Biocompatibility concerns follow with the creation of an in-vivo biosensor. That is, an initial inflammatory response occurring after the implantation. The second concern is the long-term interaction with the body during the intended period of the device's use. Another issue that arises is failure. If there is failure, the device must be removed and replaced, causing additional surgery. An example for application of an in-vivo biosensor is insulin monitoring within the body.

2) In-vitro: An in-vitro biosensor is a sensor that takes place in a test tube, culture dish, or elsewhere outside a living organism. The sensor uses a biological element, such as an enzyme capable of recognizing or signaling a biochemical change in solution. A transducer is then used to convert the biochemical signal to a quantifiable signal. An example of an in-vitro biosensor is an enzyme-conductimetric biosensor for glucose monitoring.

3) At-line: An at-line biosensor is used in a production line where a sample can be taken, tested, and a decision can be made whether or not the continuation of the production should occur. An example of an at-line biosensor is the monitoring of lactose in a dairy processing plant.

4)In line: The biosensor can be placed within a production line to monitor a variable with continuous production and can be automated. The in-line biosensor becomes another step in the process line. An application of an in-line biosensor is for water purification.

5)Point-of-concern: There is a challenge to create a biosensor that can be taken straight to the “point of concern”, that is the location where the test is needed. The elimination of lab testing can save time and money. An application of a point-of-concern biosensor can be for the testing of HIV virus in third world countries where it is difficult for the patients to be tested. A biosensor can be sent directly to the location and a quick and easy test can be used.

Main Components Of An Optical Biosensor

(i) A light source.

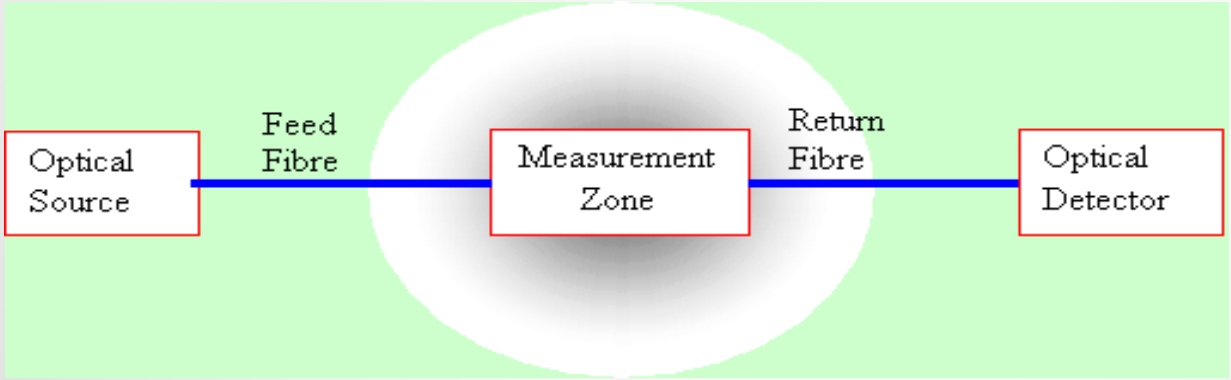
(ii) An optical transmission medium (fiber, waveguide, etc.) .

(iii) Immobilized biological recognition element (enzymes, antibodies or microbes) .

(iv) Optical probes (such as a fluorescent marker) for transduction.

(v) an optical detection system.

WORKING PRINCIPLE



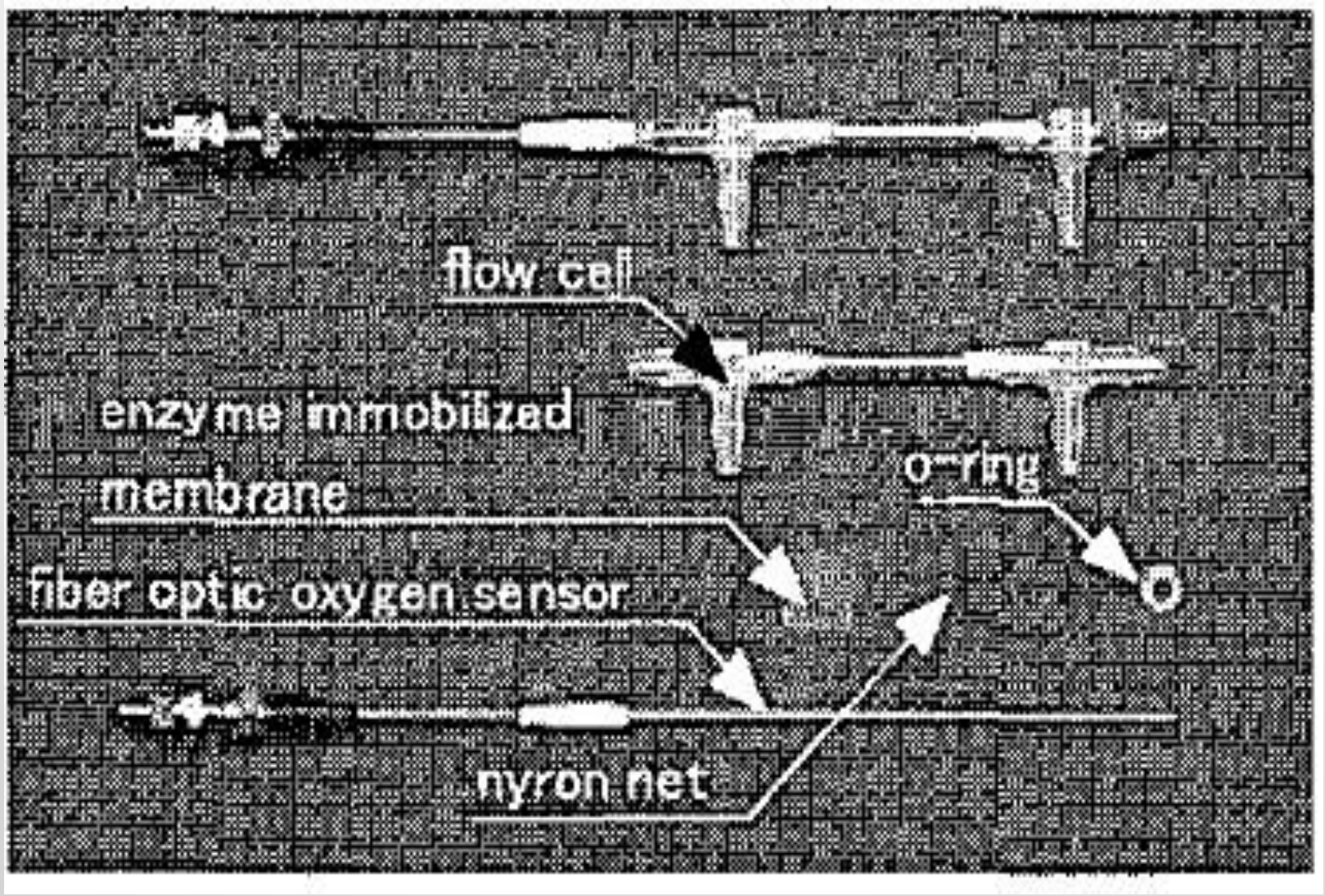
- LIGHT BEAM CHANGES BY THE PHENOMENA THAT IS BEING MEASURED.
- LIGHT MAY CHANGE IN ITS FIVE OPTICAL PROPERTIES i.e INTENSITY, PHASE, POLARIZATION,WAVELENGTH AND SPECTRAL DISTRIBUTION.

Applications:-

1. BIO-OPTICAL GAS-SENSOR (SNIFFER DEVICE) WITH A FIBER OPTIC OXYGEN SENSOR
2. OPTICAL BIO-SNIFFER (BIOCHEMICAL-GASSENSOR) FOR DIMETHYL SULFIDE VAPOR
3. MONITORING ETHANOL VAPOR WITH HIGH SENSITIVITY & SELECTIVITY
4. OPTICAL SENSOR IN THE APPLICATION OF BIO-DETECTION
5. OPTICAL BIO-SENSOR FROM DNA AND NANO STRUCTURES
6. A HEMISPHERICAL OMNI- DIRECTIONAL BIO-INSPIRED OPTICAL SENSOR
7. OPTICAL TACTILE SENSOR ORIENTED ON BIO-APPLICATION
8. OPTICAL BIO-CHEMICAL SENSORS ON SNOW RING RESONATORS

BIO-OPTICAL GAS-SENSOR (SNIFFER DEVICE) WITH A FIBER OPTIC OXYGEN SENSOR

- Used for detecting the oxygen consumption in human body .
- Immobilized by FM03-One of xenobiotic metabolizing enzymes for catalysing the oxidation of odorous.
- The performance of the sensor is evaluated, such as sensitivity, calibration behaviour and selectivity.
- The bio-optical sniffer is possible to detect the oxygen consumption induced by FOM3 enzymatic reaction with TMA application.

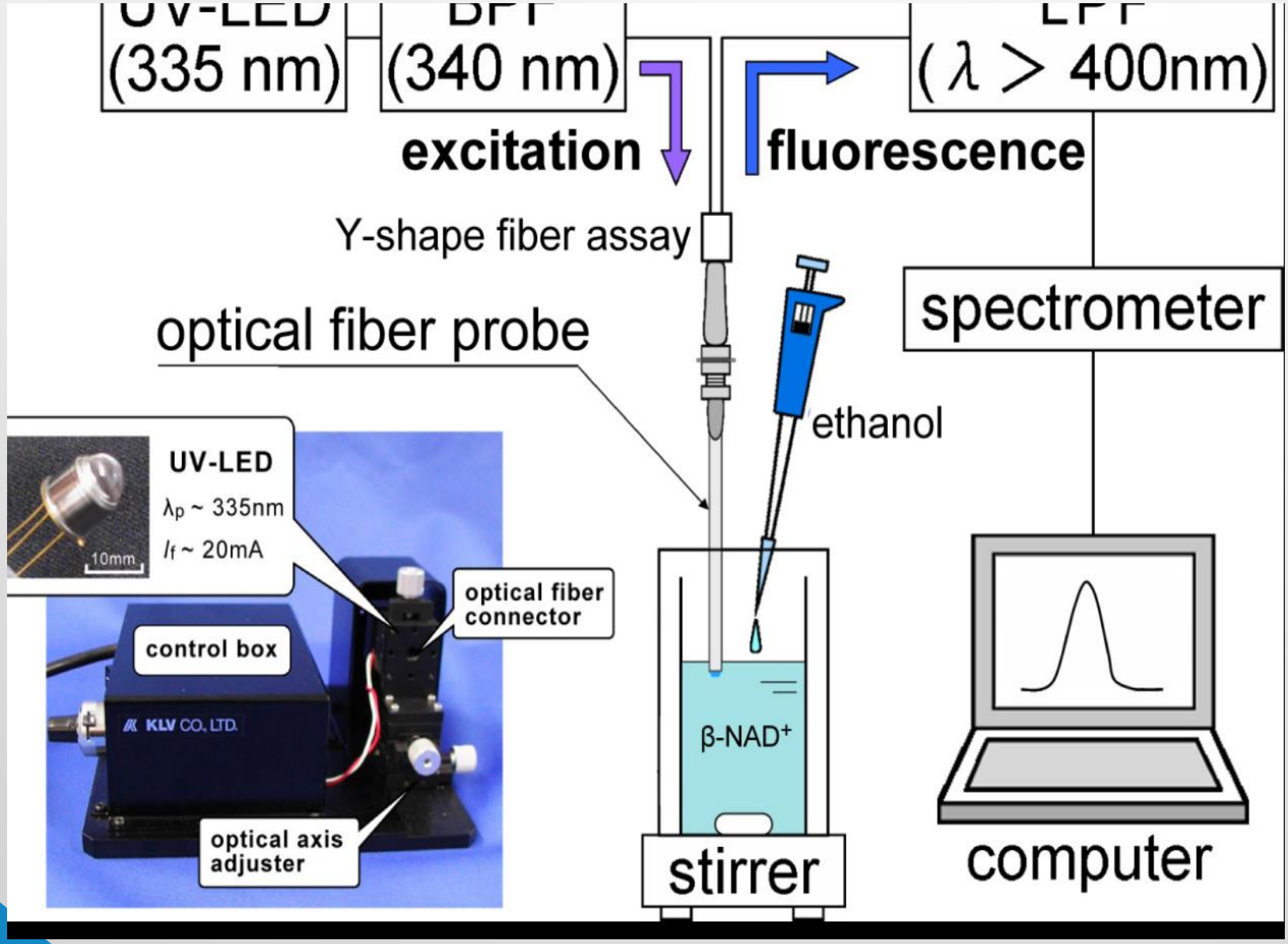

flow cell
enzyme immobilized
membrane
o-ring
fiber optic oxygen sensor
nyron net

OPTICAL BIO-SNIFFER (BIOCHEMICAL GASSENSOR) FOR DIMETHYL SULFIDE VAPOUR

- This optical gas-sensor for dimethyl sulfide is constructed by immobilizing flavin-containing mono oxygenase (FMO) to an oxygen-sensitive optical fiber .
- The sniffer is calibrated against gaseous DMS over the range of 10 - 100 ppm.
- The sniffer was used to measure DMS vapor from 2.1 to 126 ppm with gas-selectivity based on the FMO substrate specificity
- This sniffer is also applied to detect gaseous DMS from the seaweed sample as the food application

USING UV-LED LIGHT FOR MONITORING ETHANOL VAPOR WITH HIGH SENSITIVITY & SELECTIVITY

- This fiber optic bio-sniffer (biochemical gas sensor) for alcohol gas monitoring with high sensitivity and high selectivity was fabricated and tested.
- The bio-sniffer is a gas sensor that uses molecular recognition of enzyme to improve selectivity.
- In order to construct this bio sensor simplified system suitable for on-site applications, a high-intensity ultraviolet light emitting diode (UV-LED) is utilized as an excitation light.
- This bio-sniffer for is useful for continuous alcohol monitoring and showed high selectivity.
- The calibration range is 0.30-300 ppm which is suitable for evaluation of capacity to metabolize alcohol.


(335 nm)
(340 nm)
(λ > 400nm)
excitation
fluorescence
Y-shape fiber assay
spectrometer
optical fiber probe
ethanol
UV-LED
λp ~ 335nm
If ~ 20mA
10mm
optical fiber connector
control box
KLV CO., LTD.
optical axis adjuster
β-NAD+
stirrer
computer

working

- When ethanol solution was added into the measuring cell, an emission with the peak wavelength of 491nm was generated immediately.
- This signal is the fluorescence of NADH, produced by the enzymatic reaction .
- EtOH+ NAD+ −A−D—H→ acet aldehyde + NADH+H
- The value of the fluorescence intensity was related to ethanol concentrations.

OPTICAL SENSOR IN THE APPLICATION OF BIO-DETECTION

- It consists of excitation module, optical detection module and signal processing module.
- The sensor has highly sensitive and applied to detect protein concentration in urine arranging from 0.01mg/ml to 0.3 mg/ml.
- Biomarkers have been of vital importance in diseases diagnosis and monitoring.
- Certain disease, i.e. kidney problem, they can excrete some special biomarkers, albumin, and creatinine, in their urine. By identifying these special biomarkers, the biomarker-related diseases can be diagnosed.

- If there is biomarker in test sample, the sample will emit certain wavelength fluorescence when the sample is mixed with selected dye.
- The emitted fluorescence intensity is proportional to the biomarker concentration in sample.
- The detected fluorescence intensity will be changed into electrical signal and processed.

OPTICAL BIO-SENSOR FROM DNA AND NANO STRUCTURES

- This type of optical device can be placed inside living cells and detect trace amounts of harmful contaminants by means of near infrared light.
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- New quantum optic method to research the bio-systems was carried out by using physical Nano-systems that have clearly and strongly intensity optical properties such as quantum wire, quantum dot, or Nano particles
- By combine bio-systems with Nano physical systems (bio-Nano systems), then analyze the changes of optical properties of new bio physical systems through their optical spectra

- Biosensors The paramount role of biosensors has covered a board range of clinical diagnosis, treatment method, and bio- medical studies.
- By the help of this sensor the double stranded DNA coil has a helical configuration is detected.
- The working condition and properties of this new optical sensors also could be investigation with taking in to account the influence of the surrounding living environmental such as temperature, pKa, pressure, and ionic strength etc.
- At present there are several new quasi one dimensional Nano structures are founded such as Si Nano wire, Al Nano pipe.

A HEMISPHERICAL OMNI-DIRECTIONAL BIO INSPIRED OPTICAL SENSOR

- Flying insects possess a surprisingly competent vision and navigation system, which enables them to control various man oeuvres in their flight.
- The hemispherical Omni-directional optical sensor inspired by the compound eye of flying insects.
- This is inspired vision systems has been to made use of optical flow information for flight tasks.
- Numerous designs of self-guided vehicles utilized the knowledge achieved on insects' abilities in various systems such as Micro-Air-Vehicles, and UAVs.
- An ommatidia cell contains light sensitive cells, a lens, and nerves to brain and able to detect a tiny portion of visual field, combining these tiny portions, makes a complete image

- The final image is made number of cells are, the better image with higher resolution will be achieved
- The number of 128 phototransistors (upgradable to 256) are distributed in modular sensor cards to cover a hemispherical surface.
- This sensor can be considered as an alternative for CCD-camera based visual systems covering 360 degrees field of view.
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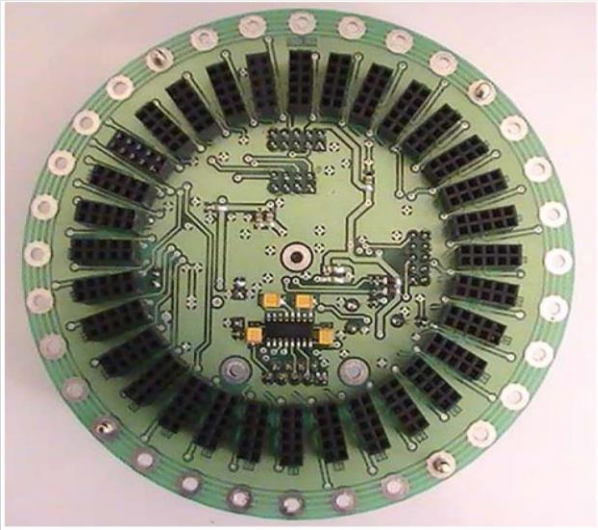

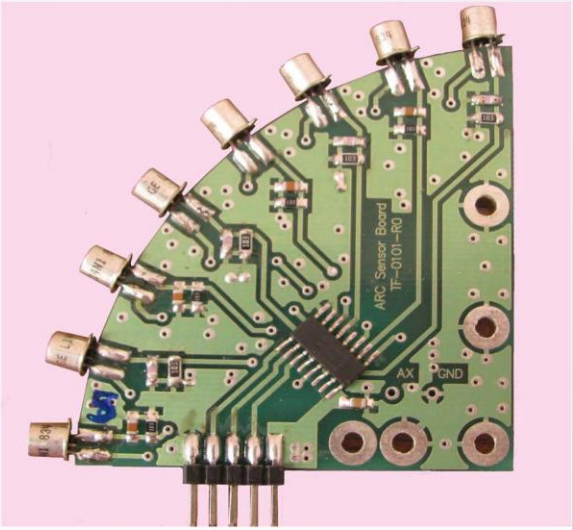

OPTICAL TACTILE SENSOR ORIENTED ON BIO-APPLICATION

- A new class of optical pressure sensors in a robot tactile sensing system based on PDMS (Poly-dimethyl-siloxane) .
- The sensor consists of a tapered optical fiber, where optical signal goes across, embedded into a PDMS-gold Nano composite material
- By applying different pressure forces onto the PDMS-based Nano composite, changes of the optical transitivity of the fiber can be detected in real time due to the coupling between the gold Nano composite material and the tapered fiber region.
- The intensity reduction of the transmitted light is correlated to the pressure force magnitude.
- Sensor in medical robotic applications .
- Especially for sensing system to measure tactile information such as softness and smoothness of biological tissues.

- These tactile sensors, which are capable of detecting contact force, vibration, texture, and temperature.

OPTICAL BIO-CHEMICAL SENSORS ON SNOW RING RESONATORS

- This ring resonator based bio-chemical sensors on silicon nanowire optical waveguide (SNOW.)
- The core of the waveguide is hollow and allows for introduction of biomaterial in the center of the mode, thereby increasing the sensitivity of detection.
- A sensitivity of 243 nm/refractive index unit (RIU) is achieved for a change in bulk refractive index.
- The sensor is able to detect monolayer attachments as small as 1 °A on the surface of the silicon nanowires.

Glucose Biosensor

- The user carries a wallet sized case that contains the testing equipment
- A lancet pierces the skin on the finger
- The user places this blood sample on a test strip and inserts it into the reader

Final summary

Biological Applications

- Immuno sensors; HIV, Hepatitis, other viral disease, drug testing, environmental monitoring.
- DNA Sensors; Genetic monitoring, disease
- Cell-based Sensors; functional sensors, drug testing.
- Point-of-care sensors; blood, urine, electrolytes, gases, steroids, drugs, hormones, proteins, other…
- Bacteria Sensors; (E-coli, streptococcus, other): food industry, medicine, environmental, other.
- Enzyme sensors; diabetics, drug testing, other.

Environmental Applications

- Detection of environmental pollution and toxicity.
- Agricultural monitoring.
- Ground water screening .
- Ocean monitoring.

Advantages of Optical Biosensors

- Selectivity and specificity.
- Remote sensing.
- Isolation from electromagnetic interference.
- Fast, real-time measurements.
- Multiple channels/multi parameters detection.
- Compact design.
- Minimally invasive for *in vivo* measurements.
- Choice of optical components for biocompatibility.
- Detailed chemical information on analytes.

Thank you