Optical Transducer

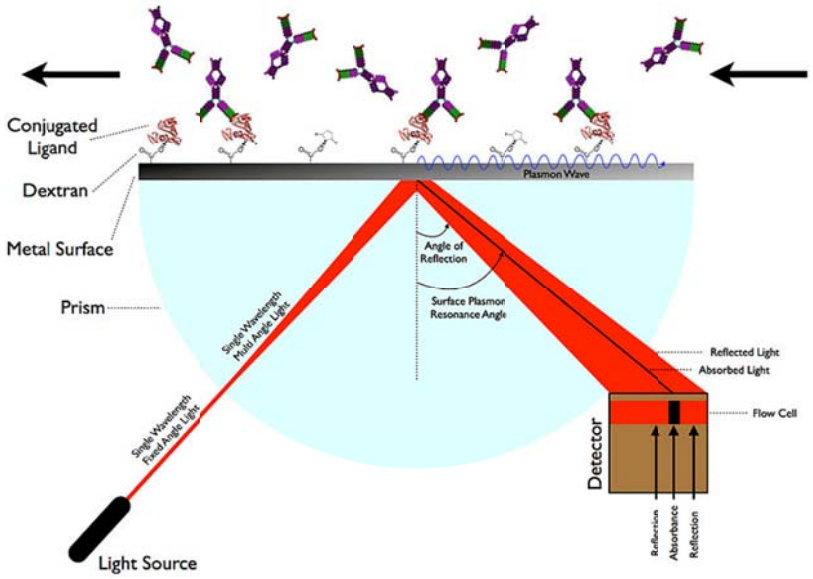
Optical transduction utilizes changes in optical properties such as phase, amplitude, and frequency, manifested because of the selective binding of an analyte with the bio-recognition element i.e. it converts chemical to light energy.

Principle

- Colorimetric for color: Measure change in light adsorbed as reactants are converted to products.
- Photometric for light intensity: Photon output for a luminescent or fluorescent process can be detected with photomultiplier tubes or photodiode systems

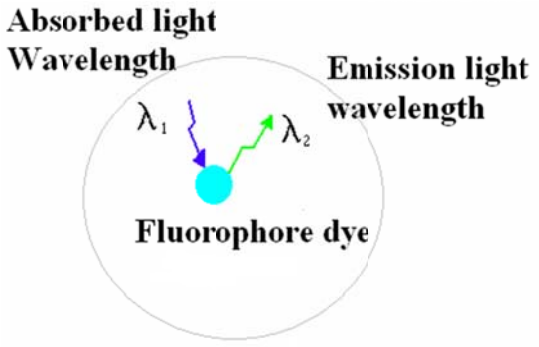
The governing thing is that enzymatic reactions alter the optical properties of some substances which allow them to emit light upon illumination in the form of some fluorescence, phosphorescence or chemiluminescence.

The SPR(Surface Plasmon Resonance) is an optical phenomenon due to a charge density oscillation at the interface of a metal and a dielectric, which has dielectric constants of opposite signs. For example, A thin layer of gold on a high refractive index glass surface can absorb laser light, producing electron waves (surface plasmons) on the gold surface. This occurs only at a specific angle and wavelength of incident light and is highly dependent on the surface of the gold, such that binding of a target analyte to a receptor changes the resonant frequency which produces a measurable signal.



[Source: http://en.wikipedia.org/wiki/File:Surface_Plasmon_Resonance_(SPR).jpg]

Fluorescence is a molecular absorption of light at one wavelength and its instantaneous emission of at longer wavelengths. Some molecules fluoresce naturally and others such as DNA can be modified for fluorescence detection by attachment of special fluorescent dyes.



Applications

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

Gold nanoparticles have been used as a new class of universal fluorescence quenchers to develop an optical biosensor for recognizing and detecting specific DNA sequences.

Quantam dots are used as inorganic fluorophores. QDs have fairly broad excitation spectra–from ultraviolet to red–that can be tuned depending on their size and composition. They are being used in virus tagging and cancer cells imaging for diagnostics purposes

A most promising transducer involving luminescence uses firefly luciferase (*Photinus*-luciferin 4-monooxygenase (ATP-hydrolysing), EC 1.13.12.7) to detect the presence of bacteria in food or clinical samples. Bacteria are specifically lysed and the ATP released (roughly proportional to the number of bacteria present) reacted with D-luciferin and oxygen in a reaction which produces yellow light in high quantum yield.

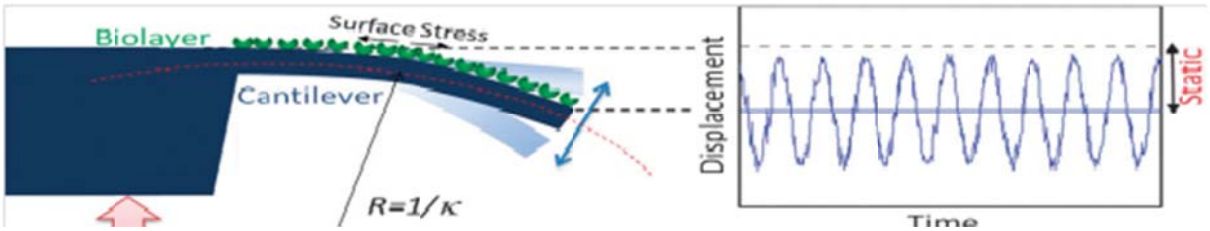
$$\text{ATP} + \text{D-luciferin} + O_2 \xrightarrow{\text{luciferase}} \text{oxyluciferin} + \text{AMP} + \text{pyrophosphate} + CO_2 + \text{light (562 nm)}$$

MECHANICAL TRANSDUCER

Mechanical Transducer is one which converts mechanical energy into electrical energy.

Mechanical Transducers are usually cantilever shaped. Smaller size of mechanical transducers produces outstanding mass resolution in a single atom which is an advantage from quartz crystal.

In this case, the bio molecules form a monolayer on the upper side of the micro cantilever that generates surface stress producing static mechanical bending with curvature which causes cantilever to oscillate with respect to the equilibrium position.



[Source:Biosensors based on nanomechanical systems,Javier Tamayo, PriscilaM. Kosaka,]

Applications

Biosensors based on mechanical transducers can specifically detect single-base mismatches in oligonucleotide hybridization. In these assays nucleic acids are immobilized on a side of a cantilever (active side). Exposure of the cantilever to a sample containing complementary nucleic acid gives rise to a cantilever bending (deflection) of a few nanometers. Deflection can be measured by an optical system in which a laser beam reflects on cantilever.

Conclusions

Various types of transducers have been discussed after thorough study is made. Their application in bio-nanotechnology has also been described. It is concluded that nano transducers provide much better results over conventional sensors. Further scope is their controlled production and better detecting techniques which can enhance the use these in medical purposes. There seems to be bright future for detection once the appropriate technology is developed.

List of references

1. Se-Chul Park, Eun-Jin Cho, “A calorimetric biosensor and its application for detecting a cancer cell with optical imaging”, World Congress on Medical Physics and Biomedical Engineering 2006, IFMBE Proceedings Volume 14, 2007, pp 637-640
2. Kewal K. Jain,“Nanotechnology in clinical laboratory diagnostics”, Jain PharmaBiotech, Blaesiring 7, CH-4057 Basel, Switzerland
3. DorotheeGrieshaber, Robert MacKenzie, “Electrochemical Biosensors - Sensor Principles and Architecture”, Utilization of Electrochemical Sensors and Biosensors in Biochemistry and Molecular Biology)
4. Javier Tamayo, Priscila M. Kosaka, “Biosensors based on nanomechanical systems”,Chem. Soc. Rev.,2013
5. [Online].Available:http://www.tms.org/pubs/journals/JOM/0010/Kumar/Kumar-0010.html
6. [Online].Available:http://www.wisegeek.org/what-is-a-piezoelectric-transducer.htm
7. [Online].Available:http://www.sciencedirect.com/science/article/pii/S073497500400028X
8. [Online].Available:http://archives.sensorsmag.com/articles/1299/14_1299/
9. [Online].Available:http://www.ndted.org/EducationResources/CommunityCollege/Ultrasonics/EquipmentTrans/piezotransducers.htm
10. [Online].Available: http://www.lsbu.ac.uk/water/enztech/calorimetric.html
11. [Online].Available:http://www.cem.msu.edu/~cem835/Lecture04.pdf
12. [Online].Available: http://en.wikipedia.org/wiki/Biosensor
13. [Online].Available: http://en.wikipedia.org/wiki/Biotransducer
14. [Online].Available: http://www.sciencedirect.com/science/article/pii/S1367593106000548