Measurement of Cancer Cell Detection using Photonic Sensor

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Abstract - This Paper tells about the early detection of cancer cell by using photonic band gap method, we are using the dielectric constant as an optical parameter for system level determination. Here we are comparing the normal cell result with the cancerous cell result. The input dielectric constant values of normal cell varies from 1.8225 to 1.8769, where in for cancer cell it varies from 1.9376 to 1.9628.The output is the frequency shift.

***Keywords* - Dielectric constant, Cancer cell , Photonic Biosensor, Photonic Band gap.**

1. Introduction

Cancer is the leading cause of death in many countries. The earlier cancer can be detected, the better the chance of a cure. Currently, many cancers are diagnosed only after they have metastasized throughout the body. Effective, accurate methods of cancer detection and clinical diagnosis are urgently needed. Photonic biosensors are devices that are designed to detect a specific biological analyte by essentially converting a biological entity (i.e, protein, DNA, RNA) into an electrical signal that can be detected and analyzed. For a cell to retain its original state the content of the cell should be optimum but, for a cancer cell the content is beyond the limit i.e cancer is caused due to change in protein content of a cell.

In recent years, early detection of cancer cell can be done by photonic biosensor, which gives information about cell in real time, and, it is compact and portable.
Photonic crystals are a class of material which acts as a sensor. When we plot a graph of transmission spectrum vs frequency without creating defect then some part of frequencies are not passed, if we create a defect or by changing material we plot the graph then some part of that restricted frequencies is also passed so in this way photonic crystal is acting as a sensor.

In a system level analysis, for a particular band the whole light is confined to that particular waveguide, so we consider those band values and plotted resonant frequency v/s k-points, and, this is done for different cancer cell including a normal cell reference. Then comparing the obtained band shift with the reference, we can conclude that cell is cancerous or not.

2. Design and Modelling

Modelling and simulation are mathematical models that allow representing the dynamics of the system via simulation, allows exploring system behaviour in an articulated way which is often either not possible, or too risky in the real time. In the system level design we use 2-D photonic crystal where in the 3rd dimension is given as no size the configuration has four layers namely silicon layer as a substrate, silicon dioxide layer as a core material, silicon layer as a cladding material, then a bio-layer where in we place a sample for detection.

We use silicon rods in air configuration. In this application we create a line defect (i.e, we have created a wave guide). We place a sample in the wave guide and light is passed through it, the spectrum is obtained at the other end of the waveguide which is unique for different cells. We use the dielectric constant of different cancerous cell from data base obtained [1] for computation of both time domain and frequency domain analysis. In frequency domain the band gap structures are obtained where as in time domain the transmission spectrum of both reflected waves and transmitted waves with different time period is obtained. These results plotted and analysed.

3. Square Lattice

A typical specimen consisting of a square lattice of dielectric columns is shown in Figure 1. A two dimensional photonic crystal is periodic along two if its axes and homogeneous along the third axis. We consider the columns to be infinitely tall. For certain values of the column spacing this crystal can have a photonic band gap in the xy plane. Inside this gap no extended states are permitted and incident light is reflected. Unlike the multilayer film this two dimensional photonic crystal can prevent light from propagating in any direction within the plane.

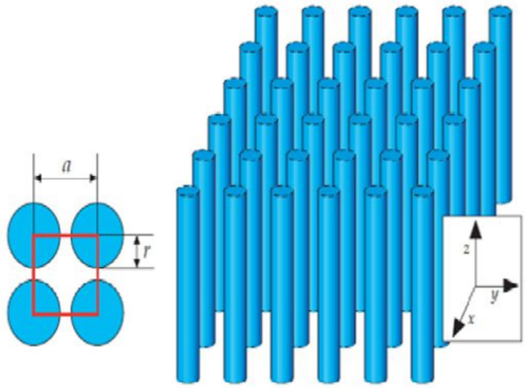

Fig.1. A two dimensional photonic crystal of a square lattice

4. Simulated Results

Table 1. cancer cell with dielectric constant

Cancer cell	Dielectric constant
Normal Cell	1.8225
HeLa	1.937660
PC12	1.946025
MDA-MB-231	1.957201
MCF-7	1.962801
Jurkat	1.932100

Normal Cell

Our standard structure is a square lattice with a line defect. The defect is taken to be as a reduced radius Bio sensor with half the radius of normal rods. The dielectric constant of this is taken to be 1.35. Then the background material is air. i.e: The dielectric constant is 1. This is our basic structure and we have simulated. Then we found the band structure. The figures are shown below

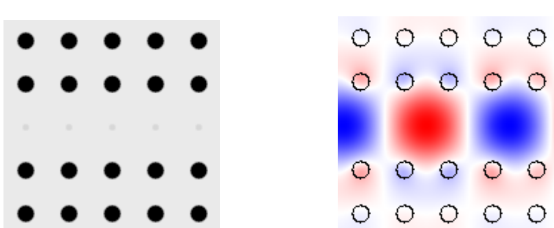

Fig.2. Basic structure.

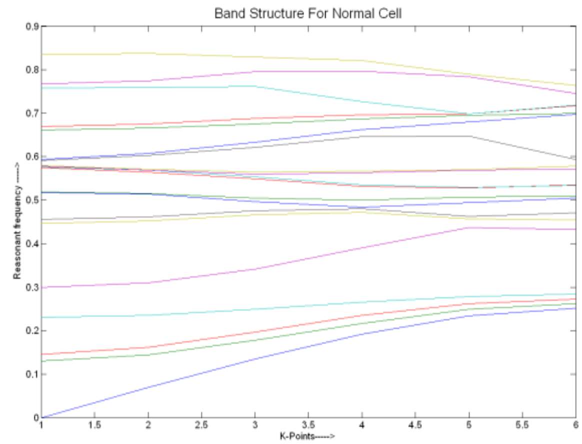

Fig.2.1. Band structure of line defect.

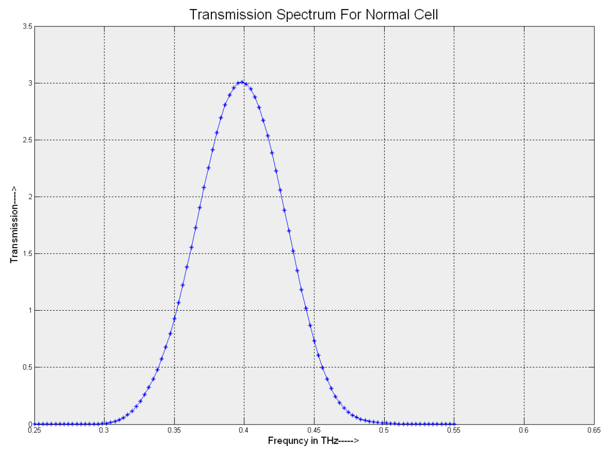

Fig.2.2. Transmission Spectrum for Normal Cell

HeLa

HeLa is a Cancerous Cell line which is extracted from Cervix, which has a dielectric constant of 1.937660. So when we place the sample cell on the crystal we will observe a change in the background in the band gap and transmission spectrum by using above mentioned tools. This change is shown in Figure 3.

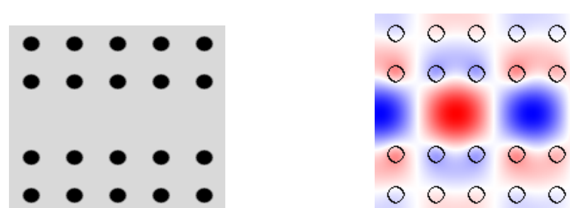

Fig.3. HeLa Background

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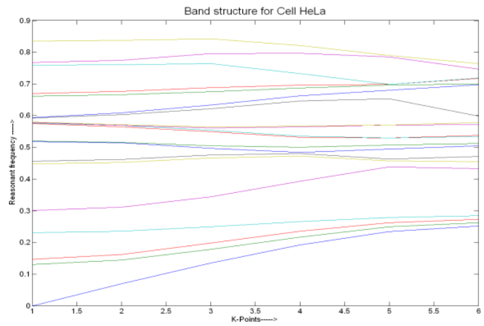

Fig 3.1. Band structure of HeLa.

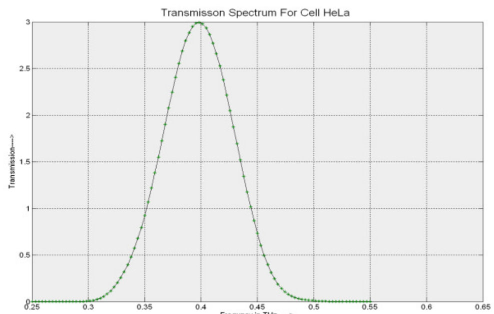

Fig 3.2.Transmission Spectrum of HeLa

MCF-7

MCF-7 is a Cancerous Cell line extracted from the Human Breast, which has a dielectric constant of 1.962801. So when we place the sample on the crystal sensor we will observe a change in the background in the band gap and transmission spectrum by using above mentioned tools. This change is shown in Figure 4.

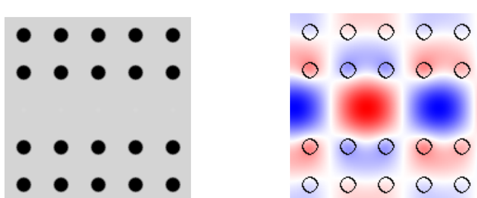
Fig 4.MCF-7 Background.

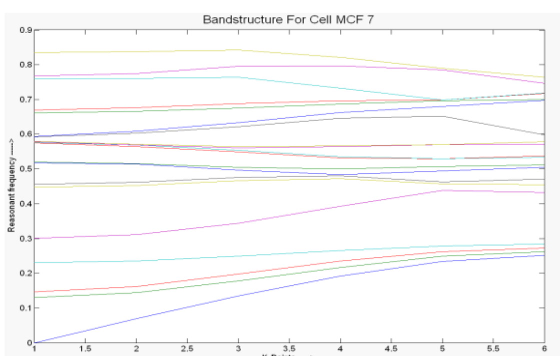

Fig.4.1. Band structure of MCF-7.

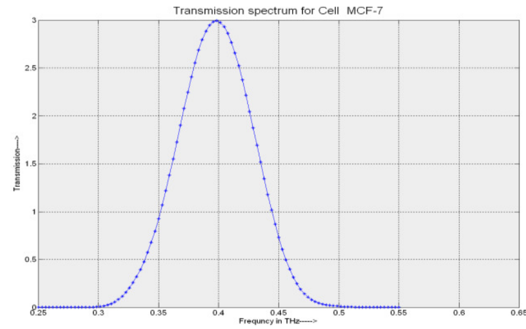

Fig.4.2.Transmission spectrum for MCF-7

Similarly it is done for other cancerous cells, the combined graphs of band structures and Transmission spectrum is as shown below

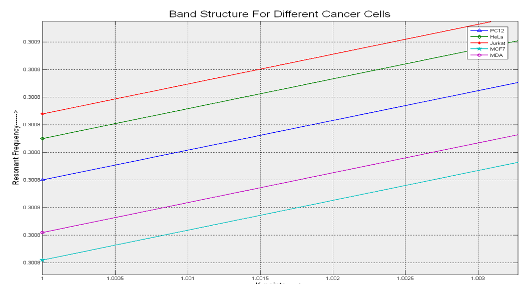

Fig.5. Integration of all waveguide modes

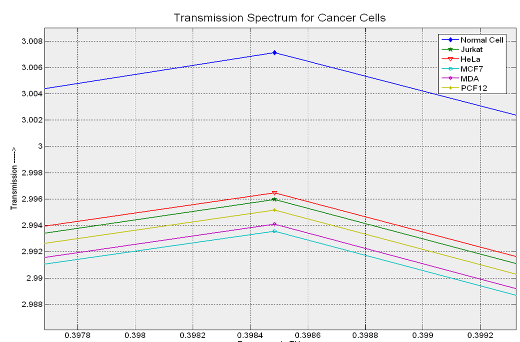

Fig.6. Transmission spectrum for Different Cancer cells

5. Conclusion

The spectrum obtained for different cell is always unique. The efficient method to detect the cancer cell in early stage is done using this biosensor. Since the resolution is in range of 10^{-5} to 10^{-2}, this sensor can sense even that minute change, hence the sensitivity and accuracy is more.

Acknowledgment

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