MOEMS based Micro Displacement Sensor for Anti-Theft Device in Vehicle Security System

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Abstract: Theft security of vehicle in common parking places has become a major part of concern. Since theft sensor work right at the moment theft either triggering alarm on the car and shut down of its ignition there by reducing thousands of vehicle crimes in year. Add –on to the vehicle security system along with need of efficient system development within the vehicle photonic crystal based MOEMS displacement sensor which replaces traditional sensor system with its high sensitivity and accuracy characteristics is analyzed here. Paper explores the detection of the micro leveldisplacement with a MOEMS structure. The measure of the micro optical elements, which operates the light passes via all the dimensional spaces establishes in MOEMS technology. These are pre-owned to detect stress, strain and other mechanical constraints founded on the movement. The mechanical substance of the rods are permitted to undergo alteration with realistic energy which then allows renovation into corresponding variations in electrical and optical properties of the device in the sealed system of observation. By means of these coupled-optical properties the MOEMS built mechanical structure can be used for flow-meter, leakage detection, blood-pressure monitoring, structural health monitoring among others. In this paper, we examined a model of a photonic crystal micro-displacement sensor with rods in air configuration by the actuation of the sensing layer, wavelength shift obtained is investigated for the frequency which curb the light flow within the sensing layer accurately. Analysis is carried out with FDTD simulation tool called MEEP. Result shows that vertical displacement of up and down slab with vertical passage of light through the slab exhibiting good agreement with accuracy and sensitivity characteristics of theft sensor.Wavlenggth shift of 0.001 is observed for each submicron range of up and down slab displacement, representing accuracy level of proposed design.

Keywords: Integratedoptics, opticalwaveguide, sensor, MOEMS.

Introduction

These day's vehicle stealing cases are greater than any further time, it has change to be necessary to give a automobile an outstanding security with the main concrete hostile to burglary device. Vehicle focal fastening framework promises the best guarantee to secure your vehicle from several types of burglary cases. It is a vehicle security device that deals fantastic coverage to our vehicle. However this structure couldn't demonstrate to give whole security and directness to the vehicle in the episode of theft. So a more fashioned framework makes operation of an inserted framework motivated around micro displacement sensor innovation.

It is well known fact thatThe photonics developed with the origination of the laser in 1960 and transmission, emission, modulation, amplification, and detection/sensing of light became feasible. Periodic scatterers current limitation directed the spectral surface to endure diffusion and eventually let it downfall exponentially with causes of wandering sinusoids to as a “photonic crystal” [1], and the regularity (al) of ultrafine semiconductor artificially permits informal fabrication of these “photonic” devices due to a easy communication of an effort like white light. The cyclic arrangement of semiconductor crystals possible by synthetic chemical separation has developed a recurring organization of atoms and molecules in the crystal lattice [2]. Someplace, the photonic crystal will miss a periodic arrangement when we design a short and the tall dielectric constants different hetero-layer structure and intermingle precise remarkably with different wavelengths of light. This collaboration run to the stipulation of knowing the several physical occurrences before the various applications of our proposal. The MEMS structure transforms as light curves into waveguides by way of multimodal structural analysis exists implemented ex-situ to state together the fabrication courses also the devices bring about from these developments. Optical MEMS: The technology of MEMS takes progressive in most recent updates amongst research private and has receive the kindness of the optical allied subsystems manipulator to anything exists currently come to be called micro-opto-electro mechanical systems(MOEMS) or also known as optical MEMS. These skill carters existence gradually [3] preowned in the fabrication of gas lasers and fiber-optical tide guides possible to be given that provision of tele-communication systems. The unlimited latent of optical schemes, made commerce segments profit, with goods spinoffs like LED/LCD displays, withdrawn biomedicine etc. Of supreme importance lies in the chemical-mechanical micromachining is based on optical MEMS technology, which is a method that is too used in integrated chip (IC) fabrication. Micromachining spin-offs directed to the production of machine-driven structure in the micron to millimeter kind. No rather ensured the skill of constituents on solo wafers were fulfilled was it recognized, all the objects suited basically applied trials for workshops on chip for booming miniature scale study for paths and academic understanding. The optical MEMS technology is used to avoid transmission obstacles and assigning and returning complex movement in period elements next to unevenly the period light of critical wavelength movements in the fiber on a minor telecom frequencies. MEMS and MOEMS: Permutation of electrical and mechanical buildings of certain smart ingredients above the Semiconductor individual substrate stays of any kind steered to nationalization of MEMS creating them micro-machines either micro-system of following group actuators. The Bodily measurement of the MEMS differs under 1-micron to some hundreds of microns. The key standards of the MEMS [4] is that by the smallest amount selected elements taking particular kind of manual functionality to stimulate a sealed method even if or not present lie origins that can travel. These commonly includes of the ingredients with assets taking high-level incorporation of multi physical purposes that permits single to act together through the universe bordering the system such as micro-sensors in air/water. MEMS make use of such constructions as fissures, cavity, crevices, channels, cantilevers, membranes, etc, and, in several way, follows motors or humble machine parts like levers, pulleys, crowbar etc in micro level. Extending the favorably vital system to MEMS is light tides, from now this platform of notional abstract effectively called optical MEMS or MOEMS.Now we want to shape the system on chips (SoC) on behalf of the recognition of our planned MOEMS on emulators. MOEMS is the unification of all these three-sided elements so excellently coincided by means of to convert identical amongst a few of the convoluted technologies. The photonic crystal knowledge be present activity several thus hazarding its coming on to place on anvil the finding ability of the dissimilarity of physical constraints like pressure, temperature, strain, stress etc. The main benefit lying now the usage of photonic crystal is that it is skilled of allowing harsh surroundings, short price, improved selectivity and great sensitivity. The important attitude of functioning of optical sensors is founded on the deviation of key of refractivity while distinction with high opinion to modification in detecting element similar strain and pressure practical for aim points [5]. This tolerates the variation of refractive index on the road to be transformed to alteration in frequency and wavelength of the light drive, even though in added processes hints to its alteration into a resultant variation in displacement. We demand to complete with a penalty area of the broadsheet, to design and act out photonic crystal grounded on MOEMS structure.

Photonic crystals [7] firstly, were abstracted as a earnings to understand two main optical changing aspects like the limitation and tricking of light in a majority measurable as detected in Nano scale properties. The whole impairment of natural emission of coherent ray of white light wandering above a wide frequency series optical waveguide prepared by enclosement line defect. Photonic built semiconductor band-cavity arrangements require no single the capability to direct and keep light but then too have projected a different conservation ecological unit for significant powered light-matter dealings in a charming saturation bombing, which mark them proper for a variety of innovative outstanding applications. Photonic semiconductor crystals exists as a regularity anisotropic pitch of dielectric constants someplace there is a gathering of mixtures to permit a non-calculated prefiguring. In photonic crystal, the defect engineering related need directed to the making of waveguides, micro-cavities, resonators, couplers and filters. Now we ensure created a rods in air construction in photonic crystal intended for the square lattice.

Concept and Design Approach

Finite Difference Time Domain (FDTD) method is executed in this task using the simulator MEEP, a very excellent computational electromagnetism imitator available as an open source tool. The Finite Difference Time Domain method reduces accurately, the four time domain Maxwell's equation in any media described by the user. The procedure bisects the wave vectors in time and space and reduces the electric and magnetic induction elements in space. MEEP is an emulator achieved from MIT group of researchers for arranging, modelling and simulating various photonic crystal structures in conjunction with the band gap material array. It is a time domain planted tool and integrates the FDTD method in a relaxed to right of entry terminal codes in Linux environment. The transmission and the reflection spectrum [6] are found as a data element column-wise and with the MEEP tool, the data is mined in a dot out (.out) format for plotting. MEEP cracks the Pointing vector (Equation 1) and computed the fluxes [9].

Where, 'P' is power, 'E' and 'H' are electric and Magnetic fields, and 'ω' is the frequency.

$$\frac{dD}{dt} = -\nabla \times H - J - \sigma_D D \qquad D = \varepsilon E \text{ ------------------------ } (2)$$

$$\frac{dB}{dt} = -\nabla \times E - J_B - \sigma_B B \qquad B = \mu H \text{ ----------------------- } (1)$$

Perfectly matching layer is used to provide absorbing boundary condition in either z or r direction. PML is sort of material which contains set of conductivities$\sigma(r)$, $\sigma(\emptyset)$, $\sigma(z)$

$$\sigma_\phi(r) = \frac{1}{r}\int_0^r \sigma_r(r)dr$$

The found output of MEEP is inferred as the transmission spectrum [5], which on alteration with stress impelled displays as a unique identity for the operation of sensors

The planned design of the micro-displacement pressure sensor comprises of a two dimensional, square lattice semiconductor band gap based photonic crystal with a line defect created in rods-in-air configuration.

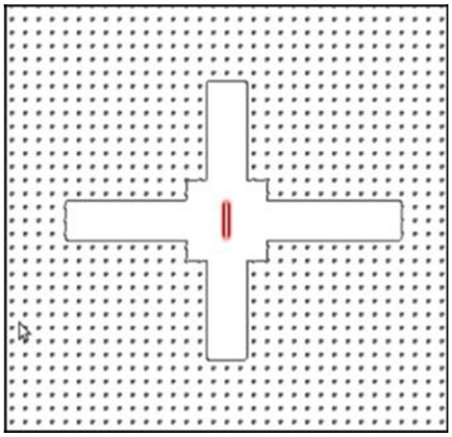

Figure 1.1: Complete Structure of Photonic Crystal

The design parameters incorporated are:

- Rods in air configuration.
- Radius of rods r = 0.19µm.
- Square Lattice.
- Wavelength of light 1350nm
- Lattice constant 'a'=1µm.
- Dielectric constant of the Air is 1
- Light source: Unit Gaussian Pulse with center frequency at 0.4, width of the pulse is 0.3.

This model comprises of a waveguide fixed between two dielectric slabs while monolithically intact, as the fresh semiconductor does not allow EM wave interactivity. Both dielectric slabs are dynamically exchanging motion with admiration to each other when the pressure is exerted. The structure of the model is enumerated in the Fig. 1.1 with utmost separation allowed between dielectric slabs.

Working Principle

The light in use in the usage of Gaussian pulse [13] is permitted to enter via the photonic crystal at on the side end and the spectrum analyzer is sited at the opposite end. At whatever time the pressure is placed to be applied to the Photonic crystal structure, the dislocation of the slabs undertakes modification. Because of the variation in the movement, we have understood the physical features that disturbs the character of the electromagnetic tides in to creating variations in dielectric waveguide and the bio-organic analysts (if any) during light is allowing through it. There is recognized electromagnetic properties producing red or blue shifts, which moves [7] the wavelength changing the transmission spectrum, at the same period while tasking mechanical distortions of the dielectric slab.

Result and Discussion

The records for transmission spectrum is shown below. There, transmission spectrum is examined for the zero micron displacement of the silicon slabs and also taking 0.1 micron step increment in the displacements from 0.1 micron till 0.5 micron displacement as shown below. Consider the micro displacement different scheme of the silicon block of the slab with admiration to the other blocks of the slab. Simulation is carried out with movement of four slab individually and light source kept at opposite end of moving slab for each four combination. Each individual slab is moved for 0 to 0.5µm displacement and transmission spectrum is monitored. Peak frequency obtained in transmission spectrum to respective combination in which light confinement is controlled.

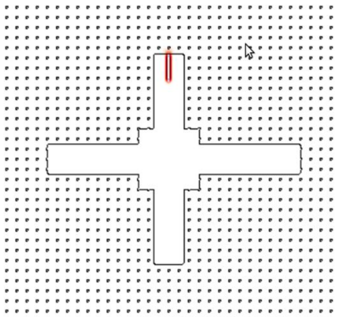

Fig 2.1 Down slab 0μm displacement with source at up

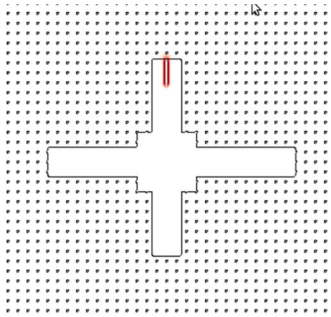

Fig 2.2 Down slab 0.1μm displacement with source at up

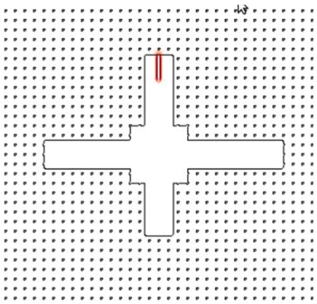

Fig 2.3 Down slab 0.2μm displacement with source at up

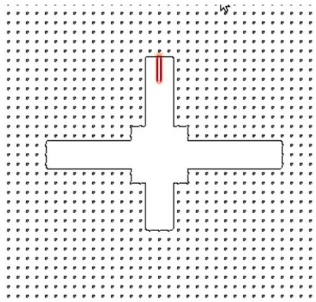

Fig 2.4 Down slab 0.3μm displacement with source at up

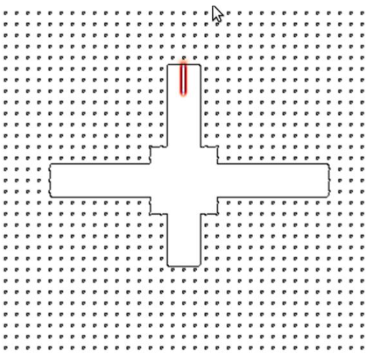

Fig 2.4 Down slab 0.4μm displacement with source at up

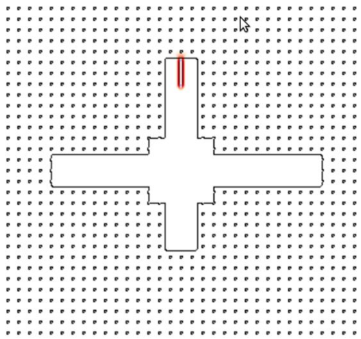

Fig 2.5 Down slab 0.5μm displacement with source at up

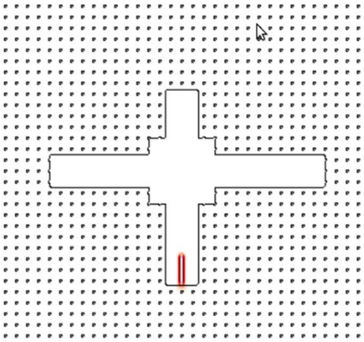

Fig 2.6 Up slab 0.5μm displacement with source at down

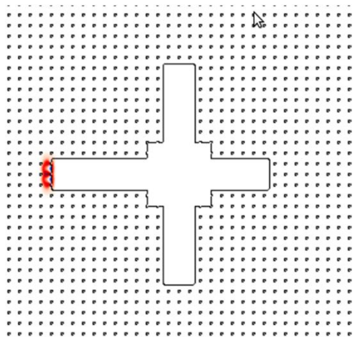

Fig 2.7 Right slab 0.5μm displacement with source at left

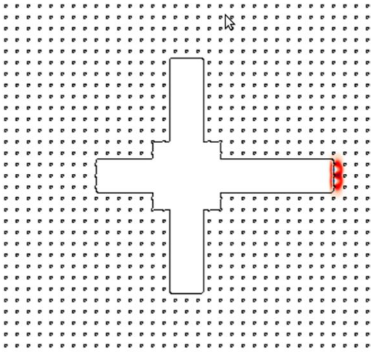

Fig 2.Left slab 0.5µm displacement with source at right

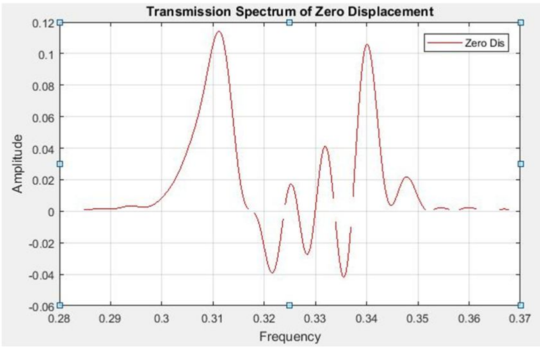

Fig 2.8 Down slab 0 µm displacement

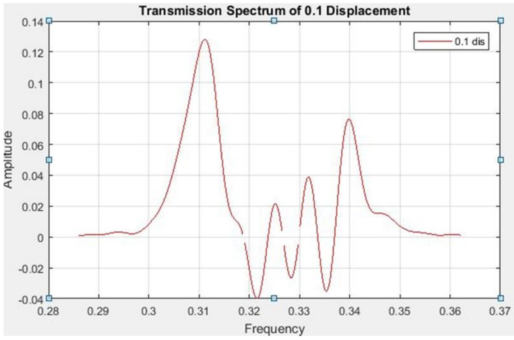

Fig 2.9 Down slab 0.1µm displacement

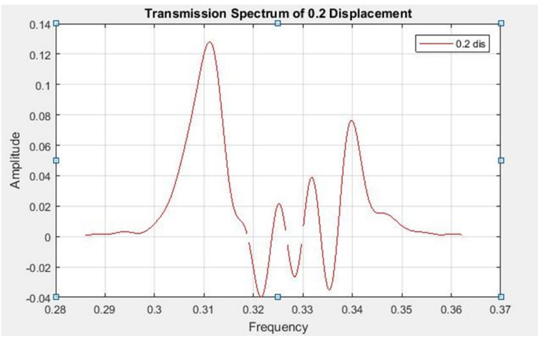

Fig 3.0 Down slab0.2µm displacement

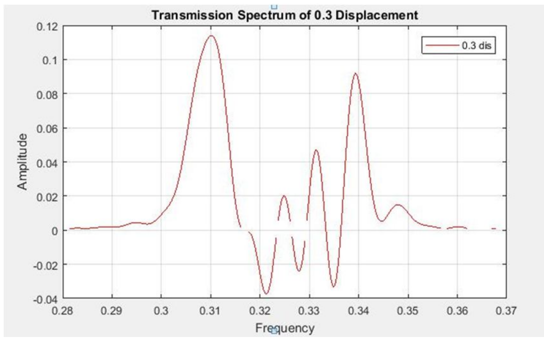

Fig 3.1 Down slab 0.3µm displacement

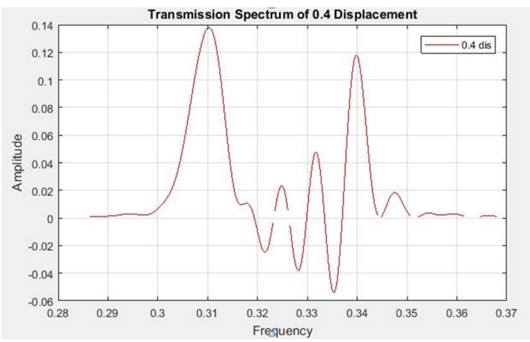

Fig 3.2Down slab0.4µm displacement

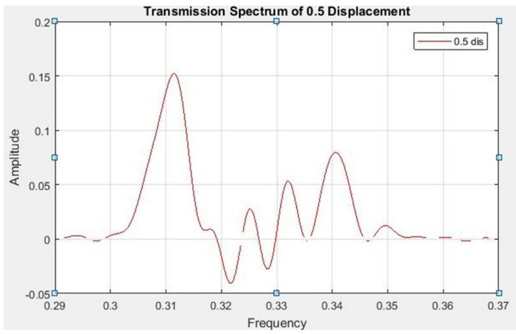

Fig 3.3 Down slab 0.5µm displacement

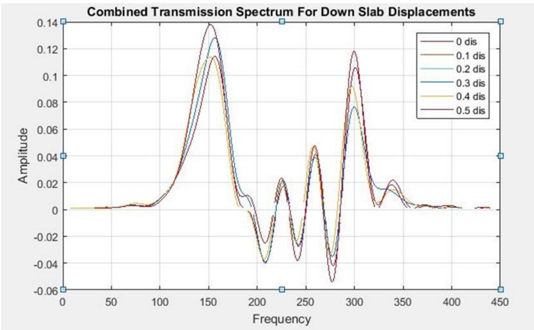

Fig 3.4 Combined transmission spectrum for down slab 0 to 0.5μm displacement

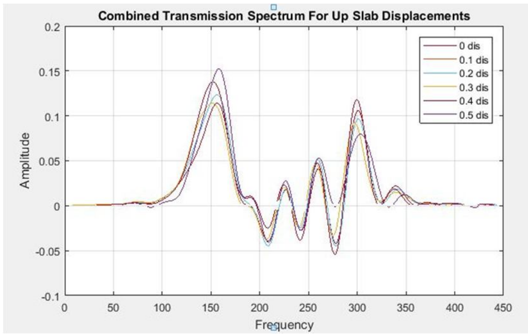

Fig 3.5 Combined transmission spectrum for up slab 0 to 0.5μm displacement

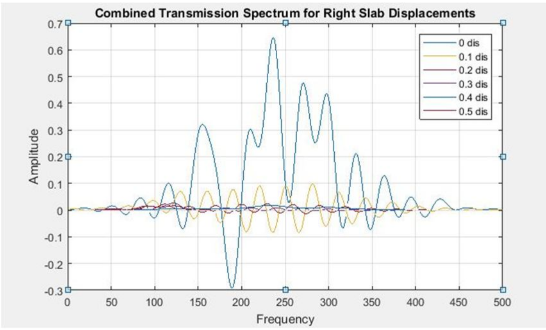

Fig 3.6 Combined transmission spectrum for left slab 0 to 0.5μm displacement

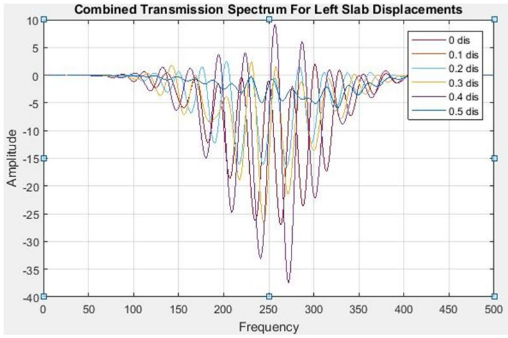

Fig 3.7 Combined transmission spectrum for right slab 0 to 0.5μm displacement

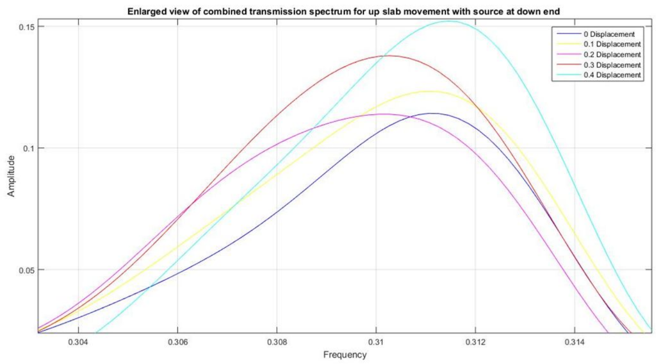

Fig 3.8 Illustratesenlarged view of combined transmission spectrumfor up slab 0 to 0.4μm displacement

Table 1.1 Displacement and corresponding wavelength shift for Left slab

Displacement	Wavelength	Amplitude	Wavelength shift
0	0.3058	0.64	0
0.1	0.3012	0.098	0.0046
0.2	0.3076	0.0249	0.0064
0.3	0.3289	0.0257	0.0213
0.4	0.3067	0.0178	0.0222
0.5	0.3290	0.016	0.0223

Table 1.2 Displacement and corresponding wavelength shift for Right slab

Displacement	Wavelength	Amplitude	Wavelength shift
0	0.300	3	0
0.1	0.2941	3.8	0.0059
0.2	0.2617	4.5	0.0324
0.3	0.2808	4	0.0191
0.4	0.3012	8	0.0204
0.5	0.2915	-5	0.0097

Table 1.3 Displacement and corresponding wavelength shift for down slab

Displacement	Wavelength	Amplitude	Wavelength shift
0	0.3205	0.108	0
0.1	0.3194	0.124	0.0011
0.2	0.3204	0.123	0.0001
0.3	0.3276	0.125	0.0072
0.4	0.3225	0.109	0.0051
0.5	0.318	0.151	0.0045

Table 1.4 Displacement and corresponding wavelength shift for up slab

Displacement	Wavelength	Amplitude	Wavelength shift
0	0.3205	0.109	0
0.1	0.3194	0.122	0.0011
0.2	0.3197	0.121	0.0003
0.3	0.3225	0.105	0.0028
0.4	0.3215	0.14	0.0010
0.5	0.3214	0.16	0.0001

Conclusion

The paper contributes vision into the possibility of a precise effect for the virtual reality and sculpting of an MOEMS based micro displacement sensor via photonic crystal for detection. The noticeable spectrum of the waveguide can properly adapt, proficiently represent, it will point out the functioning of displacement sensor in submicron range. Obtained result will shows consistent shift in wavelength for up slab movement and down slab movement when source kept at end of down slab and end up slab respectively. For each 0.1 micron displacement of slab shift in wavelength of 0.001 is obtained will exhibits high sensitivity and accuracy which is visible in figure 3.4 as illustrated above. And confinement of light was showing good agreement when keeping the source at down slab end and up slab end and good quality factor is achieved with this approach. Wavelength shift of 0.02 is achieved for each micron displacement of right and left slab movement when source kept at left slab end right slab end respectively where we can see value of shift in wavelength for micron displacement higher compared to vertical movement of source which is more feasible here. Proposed work discussed here will facilitate in the anti-theft sensor device fabrication for vehicle security system with high accuracy and sensing with power saving condition.

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