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Innovation The Research Concept

Study of Refractive Index of RbI, NaBr, LiF and AgBr by Dispersion Relations

Abstract

This article deals the study of Polaritons, Phonons, Plasmons, (i.e. the coupled Photon and elementary excitation modes) which propagate along the interface of dielectric media. The predominant elementary excitations of dispersive dielectric media are Plasmons and Phonons, which may couple with electromagnetic wave (Photons) to give Polaritons modes. It is, therefore, interesting to study the spatial dispersion relation for different modes that propagate in different medium. The expression for the frequency dependent dielectric function due to Phonons, Plasmons and Polaritons, which are required to find the dispersion relations of surface Polaritons, Plasmons and Phonons for geometrical surfaces of Graphene and compounds have also been derived to study the refractive index of RbI ,NaBr,LiF and AgBr .

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Introduction

Coupling can also be an essential factor in designing the SP excitation and cannot be neglected in many applications. New designs for much improved control over the SPs may be achieved by investigating the sophisticated coupling mechanism, such as EIT, within the building block. Now after above study the auther investigate refrective index of materials by theoretical investigation.

Aim of the Study

The author investigated the refractive index of materials for electronic devices and surface properties for various field of sciences.

Review of Literature

The common motivation in realizing the electromagnetically induced transparency (EIT) effect in metamaterial systems is to deliver a sharp transmission resonance that can slow down light [*1*]. To achieve this, the design generally consists of two artificial resonant elements, a radiative bright resonator that strongly couples with the light in free space and a dark resonator that weakly couples to the incident light [*2*–5]

Another route is to control the SP interference [6-7] by two or more isolated couplers with different SP excitation phases or scattering parameters, including previously reported compact asymmetric gratings and plasmonic antenna couplers [8]. However, to achieve the desired functionality with high performance, simplifications were usually made where freedoms in controlling the SPs were also missed at the same time. For example, the coupling effects among the excitation units have been purposely excluded or minimized in previous studies [9-11].

Theoretical Investigation

The refractive index of a medium may be defined in terms of the magnitude of the wave vector of propagating Surface waves as

$$n = \frac{ck}{w} \qquad (1)$$

So that, from eqn. (1) on substituting the value of wave vector for Surface Plasmon-Polariton modes for polar-semiconductor vacuum interface, eqn. (1) becomes:

$$n^2 = \frac{c^2k^2}{\omega^2} = \frac{\varepsilon_L - \bar{\varepsilon}/\Omega^2}{1 + \varepsilon_L - \bar{\varepsilon}/\Omega^2} = \frac{\bar{\varepsilon}(1-1/\Omega^2)}{1+\bar{\varepsilon}(1-1/\Omega^2)} \qquad (2)$$

From eqn. (2), it is clear that the refractive index depends upon 'Ω' and hence on 'ω_p' The above relation has been plotted for LiF, NaBr, RbI and NaBr polar substances to study the variation of n^2 with Ω^2 as shown in fig. (1). For comparison, ε(Ω) vs Ω^2 has also been plotted on the same group. It is observed from the study of fig. (1) that as Ω^2 tends to the value:

$$\Omega^2 = \frac{\bar{\varepsilon}}{1+\varepsilon_L}$$

(3)
(i.e. Ω^2 = 0. for LiF)
$n^2 \rightarrow \infty$ (4)

There is thus a discontinuity in the n^2 versus Ω^2 curves. At this point, the frequency of the incident radiation matches exactly with the frequency of the predominant Surface excitations. This is thus a condition of resonance and strong coupling between Photons and Surface Plasmons takes place leading to Surface Polariton waves. At this critical condition ($n^2 \rightarrow \infty$) no light is transmitted through the medium, i.e., whole of the incident energy becomes localized at the Surface due to the coupling with the Surface excitations. This condition implies a vanishing phase velocity which means that there is absolutely no link of the Surface modes with the bulk of the active medium or the inactive medium. The total energy remains localized at the Surfaces and there is not leakage to the crystalline falling interior of the medium. At this particular value of Ω^2, the value of ε(Ω) is negative and is ε(Ω) =-1.0.

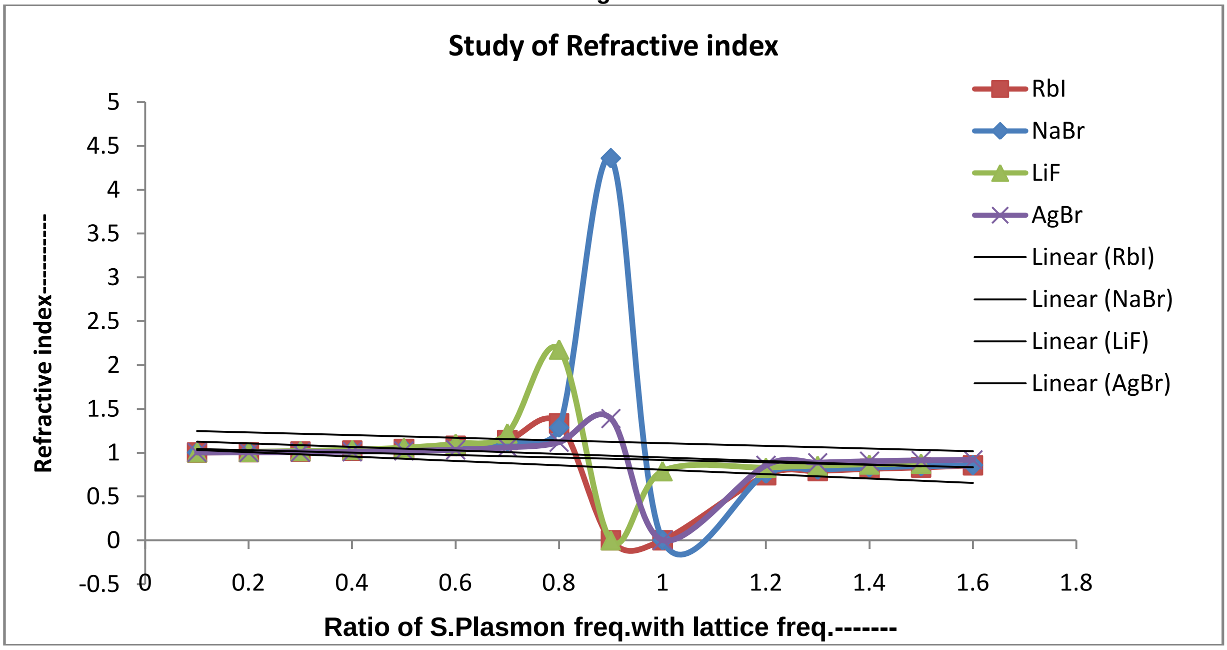
However, as frequency, there comes a value when n^2 becomes zero. At this point Ω^2=1, and the Surface modes become radiative Brewster modes and the phase velocity becomes infinite. For higher values of frequency ε(Ω)>0, i.e. the dielectric function ε(Ω) becomes positive Surface modes. The condition n^2=0 is that of per feet transmission. The Surface modes at this frequency are perfectly radiative and all the energy is radiated into the medium. Thus, there is one incident wave in the surface inactive medium and on transmitted medium in the active medium, i.e. radiative Brewster models are sustained.

The dispersion of an electromagnetic wave traveling in vacuum is given by n^2=1 and this is shown on the figure as the higher light- line. This indicates that the difference between the Fano and Brewster regions corresponds to n^2>1 or n^2<1.

Table no:-1 Study of Refractive Index with Respect to Plasmon Freq. Ratio

Plasmon Freq. Ratio	Refractive Index RBI	Refractive Index NaBr	Refractive Index LiF	Refractive Index AgBr
0.1	1.001249	1.001124	1.000937	1.000571
0.2	1.005184	1.004662	1.00388	1.002362
0.3	1.012438	1.011174	1.009285	1.005635
0.4	1.024379	1.021861	1.018117	1.010938
0.5	1.04388	1.03923	1.032371	1.019382
0.6	1.077632	1.069045	1.056541	1.03338
0.7	1.144994	1.127594	1.102919	1.059143
0.8	1.335064	1.285714	1.220982	1.118649
0.9	#NUM!	4.358899	2.179449	1.38904
1	0	0	0	0
1.2	0.743689	0.760886	0.789076	0.85442
1.3	0.789396	0.804705	0.829435	0.885006
1.4	0.815379	0.829396	0.851847	0.901414
1.5	0.83205	0.845154	0.866025	0.911584
1.6	0.856024	0.856024	0.875748	0.918465

Figure: 1



Above figure 1 give the variation of the ratio of Surface Plasmon frequency ratio versus refractive index. It is seen that the refractive index of all the materials (like RbI, NaBr, LiF and AgBr) increases gradually with increasing Plasmon frequency ratio until the ratio becomes 0.7. After this value of 0.7 of the ratio the refractive index of all above materials starts increasing abruptly. RbI reaches the maximum value at the ratio 0.8. Similarly NaBr, LiF and AgBr reach the maximum value at the ratio 0.9. It is important to note here that at the frequency ratio 1.0, there is no value of refractive index. So this value is undefined value which is unacceptable. RbI has unacceptable value at 0.9. Further if frequency ratio increases then refractive index of all above mentioned materials goes on decreasing and the index become constant at Plasmon frequency ratio of 1.6.For comparison ε_L (ω) vs ω^2 curve is also plotted on the same fig.

Result and Conclusion

A study of fig (1) reveals that as ω^2 tends to the value (i.e. ω^2=1.19 for LiF), $n^2 \rightarrow \infty$. At this point, the frequency of the incident radiation matches exactly with the frequency of Optical Phonon modes. This is thus a condition of resonance and strong coupling between the incident Photons and surface Optical Phonons takes place leading to surface Polariton modes. At this value of the incident frequency (ω=1.09), no light is transmitted through the medium, i.e. the whole energy is localized at the Surface of the medium. There is no leakage to the interior bulk of the active medium (Polar semiconductor), or to the bulk of the bounding medium.

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