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Surface Properties of Semiconductors Tubes in Dielectric Medium

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Abstract

Surface Plasma wave (SPW) is sensitive probe of optical properties of cylindrical surfaces of Nanosubstances. The purpose of these reports is to demonstrate the use of SPW to study the reflective, absorptive properties of nano size substances of solid materials of semiconductors by deriving the spatial dispersion relation for three modes coupling with the help of computational methods. This study is important in electronic communication, medical sciences and computer applications.

Keywords: Surface Plasma Waves, Nano Substances and Computational Methods.

Introduction

Surface plasma waves are electromagnetic modes localized at the interface between two media with permittivities of opposite sign such as those formed by a dielectric and materials. Phonon and SPW couple each other under certain conditions at the inter surfaces of substances. Localized Plasmon's modes are responsible for the variation of reflective and absorptive properties of substances[1,2] and propagating surface Plasmon's modes in the undersurfaces are the cause of strong angular dependence of the films reflective when measured under specific conditions[3]. Also nano material films shows an enhanced optical transmission due to the excitation of surface Plasmon modes[4]. Carbon nanotubes have remarkable electrical and mechanical properties. Collective electron excitation in a carbon nano tubes can provide important information about their structural and electronic properties. Using electron energy loss spectroscopy, Pichler et al[5] experimentally studied the electron excitations in single walled carbon nanotube and measured the Plasmon energies. In recent years, many experimental and theoretical workers have been done to study high frequencies excitation by Fetter[6] used a simple Hydrodynamic model. Wei and Wang[7] studied the dispersion relation quantum ion acoustic wave oscillations in single walled carbon nanotubes with modified hydrodynamic model which was developed by Hassetal[8, 9].

The hydrodynamic model isused to find the spatial dispersion relation of two mode coupling between surface Plasmon and phonon on the cylindrical surfaces of carbon, Si, In As, Ga As and Ge surfaces at Nano scale radius. This dispersion relation for two mode coupling gives most important physical properties of surface of substances and materials in dielectric surroundings. This coupling SP-SOP mode depends upon frequency and wave vector of carbon and other nano materials on the cylindrical surfaces [10,11 and 12]. The another derived spatial dispersion relation for three modes coupling (surface Plasmon, polariton and phonon) at cylindrical surfaces at nano size radius for carbon, Ge, SiC materials which is given as-

$$RX_l'(\gamma kr)\left[\varepsilon_\infty(k\omega)\Omega^2-\varepsilon_0(k\omega)\frac{\omega_t^2}{\omega_p^2}\right]\times$$

$$\bar{\varepsilon}(k\omega)\left[\Omega^2-\frac{\omega_t^2}{\omega_p^2}-\left(\varepsilon_\infty(k\omega)\Omega^2\right)-\varepsilon_0(k\omega)\frac{\omega_t^2}{\omega_p^2}\Omega^2\right]\times$$

$$y_l(\alpha kR).(RZ_l(\delta kR))'+\left(\Omega^2-\frac{\omega_t^2}{\omega_p^2}\right)\Omega^2\varepsilon_B\left[(Ry_l(\alpha kR))'Z_l(\delta kR)\right]$$

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$$-\left(\Omega^2-\frac{\omega_t^2}{\omega_p^2}\right)l^2\bar{\varepsilon}(k\omega)\varepsilon_B(k\omega)X_l(\gamma kR)y_l(\alpha kR).Z_l(\delta kR)=0 \qquad (1)$$

Where X_l, Y_l & Z_l are solutions of Bessel's differential equations and X_l^1, Y_l^1 & Z_l^1 are derivatives of X_l, Y_l & Z_l which is function of α, β, γ, δ and radius of cylinders ω_t & ω_p are frequencies of transverse wave (phonons) &plasmons on the surface of cylinders, Ω is frequency ratio of transverse wave and polariton waves, ε_0 ε_∞ & ε_B are the dielectric constants for lower frequency, higher frequency and Bulk dielectric medium respectively and $\bar{\varepsilon}=(\varepsilon_0+\varepsilon_\infty)/2$ is average medium between interfacesNow if radius of cylinder is taken as infinity then eq. (1) become as

$$\Omega^6\left(\frac{\omega_p}{\omega_t}\right)^2\varepsilon_\infty-\left[\varepsilon_0+\left\{\bar{\varepsilon}+(1+\varepsilon_\infty)k^2\right\}\left(\frac{\omega_p}{\omega_t}\right)^2\right]\Omega^4$$
$$+\left[\left\{(1+\varepsilon_0)+\bar{\varepsilon}\left(\frac{\omega_p}{\omega_t}\right)^2\right\}k^2+\bar{\varepsilon}\right]\Omega^2-\bar{\varepsilon}k^2=0 \qquad (2)$$

Eq.(2) is cubic in Ω^2, and when omega vs. k is plotted for C, Si, GeAs, InSb,Ge and, three coupled modes are obtained. The uncoupled modes are obtained. The uncoupled pure plasmon, pure optical phonon and photon modes have also been plotted. The uncoupled pure surface plasmon mode may be obtained from equ (2) by taking the contribution due to phonons and photons to be zero, i.e. by taking ω_t =0 and k→0 ,so that the dispersion relation (2) reduces to :

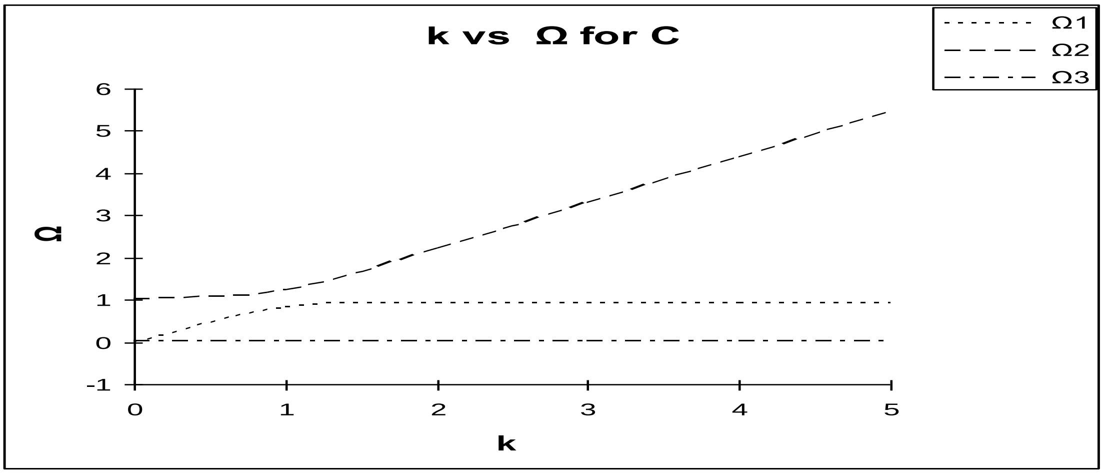
$$\Omega=\sqrt{\frac{\bar{\varepsilon}}{(1+\varepsilon_\infty)}} \qquad (3)$$

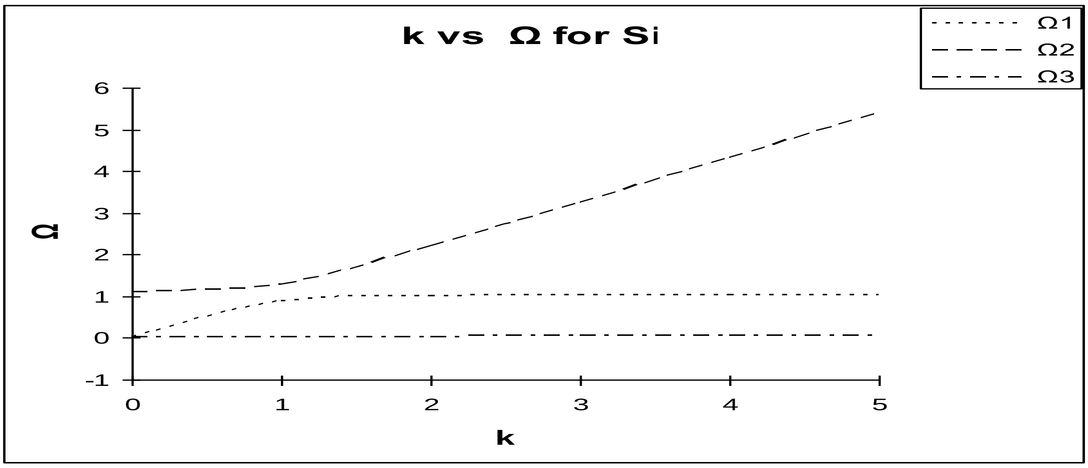
Similarly, the pure surface optical phonon mode is obtained by taking ω_P=0 and k→infinite, so that eq. (2) reduces to:

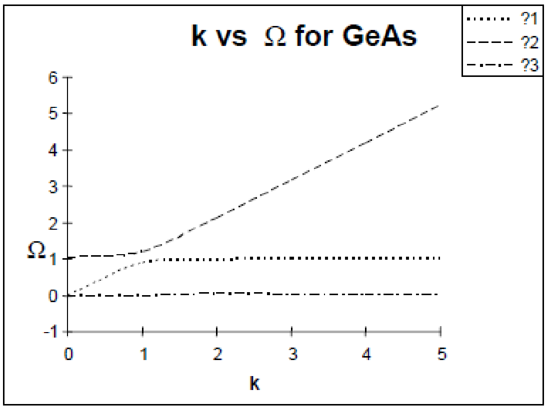
$$\Omega=\sqrt{\frac{(1+\varepsilon_0)}{(1+\varepsilon_\infty)}\left(\frac{\omega_t}{\omega_p}\right)} \qquad (4)$$

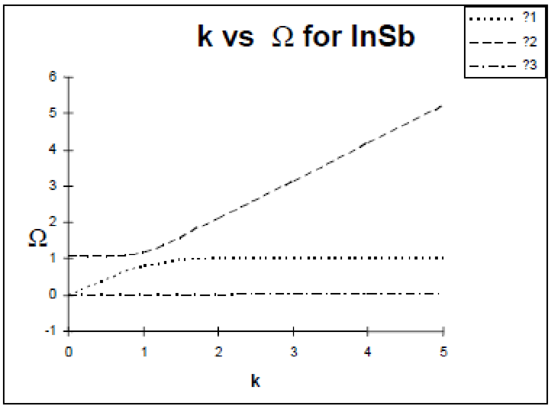
Pure photon mode is obtained by ω_P=0, as well as ω_t =0, and is given by:

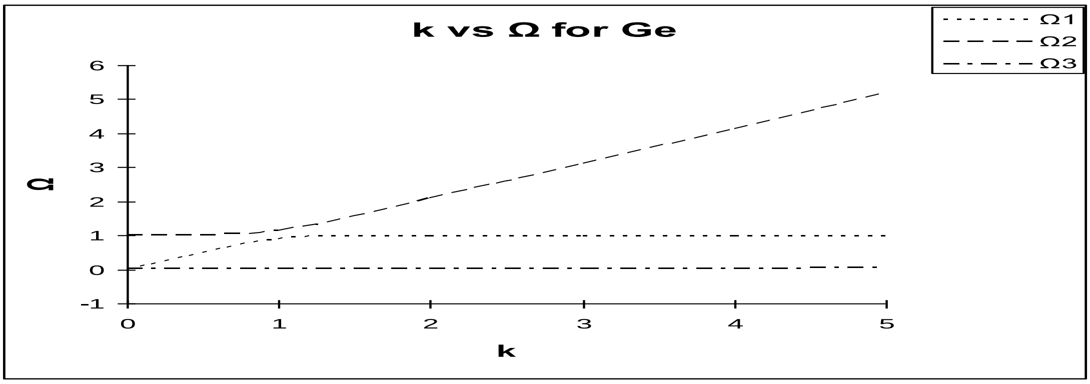
$$\Omega=\sqrt{\frac{(1+\varepsilon_\infty)}{\varepsilon_\infty}}k \qquad (5)$$





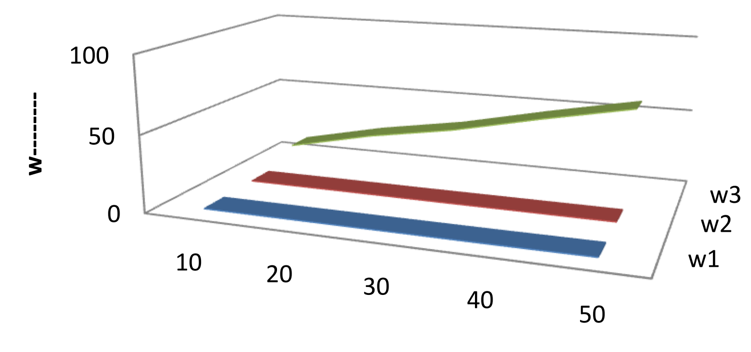






Result for Three Mode Coupling Length on Cylindrical Type of Semiconductor are Given Below

Material	Coupling length Å	$\Delta\omega=\omega_1-\omega_2$
C	5.71948	1.02329
Si	6.38571	.970566
InSb	6.29571	.96913
GeAs	5.802376	.734888
Ge	5.3187631	.603783



	10	20	30	40	50
w1	0.6501	0.6486	0.6483	0.6482	0.8481
w2	1.1607	1.1575	1.03818	1.03798	1.03789
w3	10.6681	23.3565	33.034	45.932	57.6918

Graph between W and K vs. Ω for MgCl

The above figures shows that for high values of wave vector, the coupled surface polariton modes tends to constant values Ω_1=.0062 and Ω_2=1.102921, Ω_1=.01544 and Ω_2=.9999, Ω_1=.00237 and Ω_2=.9999, Ω_1=.0017082 and Ω_2=1.05151, Ω_1=.002125 and Ω_2=1.044866 for C, Si, InSb, GeAs, Ge respectively. At these frequency $n^2 \rightarrow$ infinite, and $\varepsilon(\Omega)$. This is a condition of resonance, and at these points, the incident E.M. wave frequency matches exactly with the frequencies of coupled surface polariton mode of nano substances. As a result, the total incident E.M.energy is propagated along the surface as surface polariton waves and no light is reflected or transmitted through the medium for above frequencies of substances. For the frequencies for which $\varepsilon(\Omega)$ lies between '-1' and '0', and hence the refractive index 'n' becomes imaginary then all the incident energy is reflected back into surrounding medium. For $\varepsilon(\Omega)$ $n^2<1$, the radiative Brewster mode is satisfied. This condition is satisfied for frequency region between Ω=.0062 and Ω=.503231, Ω=.01544 and Ω=.4508225, Ω.00237 and Ω=.480613, Ω=.0017082 and Ω=.396685, Ω=.002125 and Ω=.4402471 for C, SiC, InAs, GaAs and Garespectively and Ω > 1.102921, Ω > .9999, Ω > .9999, Ω > 1.05151 and Ω > 1.044866 for C, Si, InSb, GeAs, Ge respectively. For these frequencies, the incident energy can be filtered or transmitted through the medium. Thus, it is clear that as a result of the simultaneous existence of surface plasmons and surface optical phonons, which lead to coupled surface plasmon-phonon-polariton modes, the polar semiconductor medium act as a band pass filter and as a high pass filter for incident E.M. wave. It is clear that for particular frequency substances become active for devices and deactive for other frequencies for respective medium fall on nano substances for defferent radius of tubes of MgCl, This is usefull in medical sciences, saving important documents in electronic devices and computer components and other devices

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