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E: ISSN NO.: 2349-980X **Shrinkhla Ek Shodhparak Vaicharik Patrika**

Study of Surface Properties of Spherical InSb in Dielectric Medium

Abstract

Carbon nanotubes (CNT) has been seen as a potentially future material to provide an ultra-small device by their exceptional electronic, optical, thermal, and mechanical properties, make them a promising candidate for applications in micro and nano electronics (essential in an application type transistor CNTFET (Carbon Nanotube Field Effect Transistor)).. We present here surface properties of InSb of spherical geometry in different dielectric medium.

Keywords: Surface Property. Cnt, Spherical Geometric Excitation

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Introduction

The author investigated the spherical surface properties of InSb substance with Bloch Hydrodynamical Model by deriving spatial dispersion relation for Surface Plasmons ,Phonons and Polariton.Defferent dielectric medium can also be used for deferent radius of Spheres of polar semiconductors

Aim of Study

This study is at Femi level study of semiconductor to develop nanoscale electronic devices in technology and microbiology.

Review of Literature

The nanotechnologies represent a domain of the scientific research and the rapidly growing industry. This extremely fast development however implies the potential exhibition in manufactured nanomaterials dune more important population, for the workers in industrial environment and in research laboratories [1,2]Carbon nanotubes CNT are a new modification of carbon discovered in 1991 by Ijiima while looking at soot residues from a fullerene experiment. Carbon nanotubes are high aspect ratio hollow cylinders with diameters ranging from one to tens of nanometers, and with lengths up to several micrometers. CNTs are hollow cylinders composed of one or more concentric layers of carbon atoms in a honeycomb lattice arrangement [3]). It can be classified into SWCNT (Single Walled Carbon Nano Tube) and MWCNT (Multi Walled Carbon Nano Tube Both types are attractive for nanoelectronic applications of future, either as active element, or as interconnection element., this raises the scope for new integrated circuit technologies made from CNT transistors and interconnects [4, 5, 6].Semiconductor CNT can be used as active elements in field-effects transistors (CNTFETs). Since the first experimental demonstrations in 1998, the performances of these components did not stop improving. Intensive searches are in progress to develop the adapted technologies and estimate the static and dynamic characteristics of transistors at nanotube of carbon (CNTFET) [7].We have study the surface properties of InSb by using Hydrdynamical Model.

Dispersion Relation of Three Mode Coupling

Coupled SP-SOP modes arise on the surface of a polar semiconductor as a result of frequency and wave vector dependence of the lattice dielectric surface function of polar semiconductor. These coupled SP-SOP modes, on coupling with the incident EM radiation of comparable frequency lead to the coupled surface plasmon, polariton-phonon modes on the surface. The dispersion relation for these modes can be obtained with the help of Hydrodynamical model.

$$RX_1^{'}\left(ykR\right)\left(\frac{\varepsilon_\infty\left(k\omega\right)\Omega^2-\varepsilon_0\left(k\omega\right)\frac{\omega_t^2}{\omega_p^2}}{\Omega^2-\frac{\omega_t^2}{\omega_p^2}}\right)\left[\left[\left\{\bar{\varepsilon}\left(kw\right)-\left(\frac{\varepsilon_\infty\left(k\omega\right)\Omega^2-\varepsilon_0\left(k\omega\right)0\frac{\omega_t^2}{\omega_p^2}}{\Omega^2-\frac{\omega_t^2}{\omega_p^2}}\right)\Omega^2\right\}\right.\right.$$

$$\left(RZ_1\left(\delta kR\right)\right)'y_1\left(\alpha kR\right)+\varepsilon_B\left(k\omega\right)\Omega^2\left(Ry_1\left(\alpha kR\right)\right)'Z_1\left(\delta kR\right)\Big]-1\left(1+1\right)X_1\left(\gamma kR\right)$$

$$Z_1\left(\delta kR\right)\left[\bar{\varepsilon}\left(k\omega\right).\varepsilon_B\left(k\omega\right)\right]=0 \quad (1)$$

The equation (1) is the required dispersion relation for the surface plasmon phonon polariton coupled modes in the case of spatial dispersion relation polar semiconducting sphere for k≠0 embedded in a bounding non- dispersive dielectric medium for dielectric constant $\varepsilon_B(k\omega)$. Now we will take case when k→0 then from equation (1) become as -

$$Rl_1^{'}\left(rR\right)\left(\varepsilon_\infty\Omega^2-\varepsilon_0\omega_t^2/\omega_p^2\right)\left[\left\{\bar{\varepsilon}\left(\Omega^2-\varepsilon_0\omega_t^2/\omega_p^2\right)\Omega^2\right\}\right.$$

$$Rh\left(\delta R\right)'i_1\left(\alpha R\right)+\varepsilon_B\Omega^2\left(\Omega^2-\omega_t^2/\omega_p^2\right)\left(RI_1\left(\alpha R\right)\right)'h_1\left(\alpha R\right)\Big]$$

$$-l\left(1+1\right)\bar{\varepsilon}\varepsilon_B\left(\Omega^2-\omega_t^2/\omega_p^2\right)^2 I_1\left(\gamma R\right)h_1\left(\delta R\right)=0 \quad (2)$$

Equation (2) is the dispersion relation for spherical surface plasmon-phonon and polariton coupled modes for polar semiconductor in the case of k=0

The uncoupled surface plasma frequency may also be obtained from equation (5.101) by neglecting the contribution due to surface optical phonon modes, i.e. setting $\omega_t = 0$ and $\varepsilon_\infty = \bar{\varepsilon}$, so that equation (2) gives –

$$\left[\left(\frac{1+1}{1}\right)\frac{i_{l+1}\left(\gamma R\right)}{i_{l-1}\left(\gamma R\right)}+1\right]\left(\frac{\omega_{SP}}{\omega_p}\right)^2=1-\frac{\left(\varepsilon_B-\bar{\varepsilon}\right)\left(1+1\right)}{\bar{\varepsilon}l+\varepsilon_B\left(1+1\right)}\frac{i_{l+1}\left(\gamma R\right)}{i_{l-1}\left(\gamma R\right)} \quad (3)$$

The dispersion relation (3) for coupled SP-SOP modes at a spherical polar semiconductor surface matches exactly with the relation obtained who have plotted the reduced surface mode frequency ($^{\omega}/_{\omega_p}$) with respect to radius R taking l=1.

The SP mode decreased with increase in radius, whereas the SOP mode remains constant, i.e. it is independent of frequency. For both the coupled mode branches also, the surface mode frequencies decrease as radius increases. For the InSb sphere bounding by vacuum, we have

$$\varepsilon_0=17.70 \qquad \varepsilon_\infty=15.60,\ \bar{\varepsilon}=\frac{\varepsilon_0+\varepsilon_\infty}{2}=16.65,\ w_t=1.39x10^{12}\sec^{-1}$$

$n_o = 2.0x10^{17}/cc$ (at room temp. 300^0K) and $\omega_p = 6.18\ x\ 10^{12}$ then

$$Z=\left(\frac{\omega_p}{\omega_t}\right)^2=\left(4.46\right)^2=19.89,\quad \alpha=3.7\times10^{-2}/A^o$$

From equation (3), we get

$$y^2=\left(aZ+b\right)y-aZ$$

Using the above data and the dispersion relation, We have calculated the frequencies of two coupled modes have been listed in table 1 to 3, we have

Table 1

The values of ($^{\omega}/_{\omega_t}$) for different values of R:- ($^{\omega}/_{\omega_t} = 4.46, k = 0$ and $k = 0.02$ per Å, $l = 1$ mode)

R(Å)	k=0		k=0.02 per Å	
	√(y1)= (ω1/ωt)	√(y2)= (ω2/ωt)	√(y1)= (ω1/ωt)	√(y2)= (ω2/ωt)
20	6.231	1.012	6.293	0.997
40	6.180	1.012	6.261	0.997
60	6.148	0.013	6.250	0.997
80	6.124	1.013	6.248	0.997
100	6.110	1.013	6.245	0.997
200	6.077	1.013	6.240	0.997

Table 2

The values of ($^{\omega}/_{\omega_t}$) for different values of 'K' (with $R = 100$ Å, $^{\omega}/_{\omega_t} = 4.46, l = 1$ and $l = 2$ modes)

K(Å)	l=1 mode		L=2 mode	
	√(y1)= (ω1/ωt)	√(y2)= (ω2/ωt)	√(y1)= (ω1/ωt)	√(y2)= (ω2/ωt)
0	6.204	0.998	6.306	0.998
0.01	6.199	0.998	6.289	0.998
0.02	6.241	0.998	6.314	0.998
0.03	6.292	0.998	6.325	0.998
0.04	6.326	0.998	6.352	0.998
0.05	6.342	0.998	6.356	0.998
0.06	6.325	0.998	6.377	0.998

Fig. 1
Curve between ω/ω_t and 'R' (with $\omega_p/\omega_t = 4.46$,l=1)

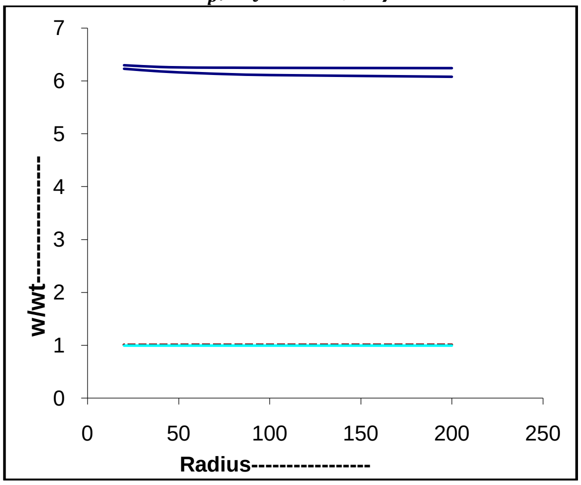


Fig.2
Curve between ω/ω_t and 'K' (with R=100Å)

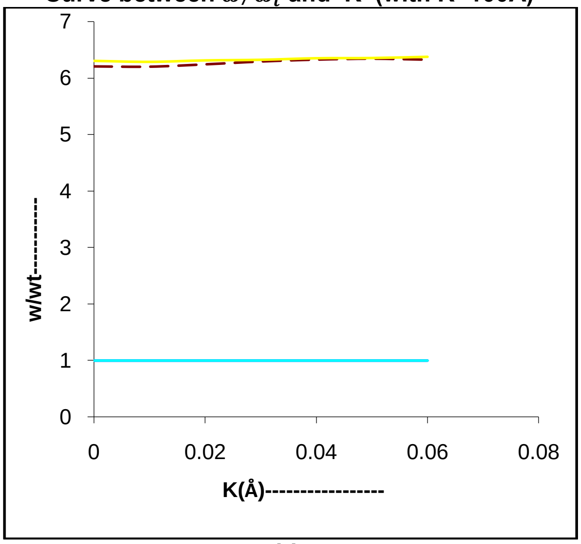
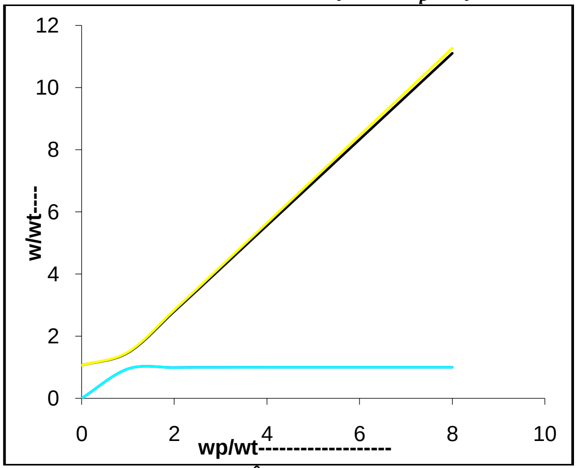


Table 3
Values of ω/ω_t for different values of ω_p/ω_t [with R = 100Å,ω_p/ω_t=4.46, l=1 and l=2 modes.]

√Z= $\frac{\omega_p}{\omega_t}$	l=1 mode		L=2 mode	
	√(y1)= (ω1/ωt)	√(y2)= (ω2/ωt)	√(y1)= (ω1/ωt)	√(y2)= (ω2/ωt)
0	1.057	0.000	1.057	0.000
1	1.466	0.947	1.484	0.948
2	2.800	0.990	2.840	0.990
3	4.178	0.998	4.239	0.996
4	5.562	0.998	5.642	0.998
5	6.948	0.998	7.048	0.998
6	8.334	0.998	8.459	0.998
7	9.721	0.998	9.861	0.998
8	11.108	0.998	11.268	0.998

Fig. 3
Curve between ω/ω_t and ω_p/ω_t



(with K=.01Å R=100Å, l=1 mode)

Conclusion

From fig. (1). it seems that as we increase the radius, the spatial effects for the larger wave vectors, tends to disappear more rapidly, as compared to similar one**.** Fig. (2) shows the dispersion curves for the coupled SP and SOP waves in InSb sphere of radius 100Å. This dispersion curves shows that the frequency of the upper mode varies very slowly with the wave vector $\overline{K}$ and frequency of the lower mode is almost constant and equal to the frequency of pure SOP mode. Further, there exists a band gap between the two modes showing that the coupled modes with frequencies lying in this region cannot be excited. Fig.(3) shows that the frequency of upper modes varies linearly with electronic concentration, while the frequencies of lower mode increases at lower electronic concentration. The above study is most important in field of science and Technology.

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