D.C. magnetic field in SPP coupling at surface of AGCL tube

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Abstract - *Non-radiative surface plasmons in both thin and thick films can couple to electromagnetic radiation in the presence of surface roughness or a grating. Alternatively, prism coupling can be used to enhance the momentum of incident light. Since attenuated reflection (ATR) method and variations upon it have been used by several workers in a large variety of applications. During the last decades, there has also been a significant advance in understanding of surface plasmons in the non-retarded regime the problem of determining the dispersion ω (q) of the non-retarded surface plasmon. A hydrodynamical model with a continuous decrease of the electron density at the metal surface and found that a continuous electron-density variation yields two collective electronic excitations. In present work surface characteristics is being drawn for AgCl nanotube.*

Key Words: surface radiation, two and three mode coupling, surface plasmons, nanotubes etc.

1.INTRODUCTION

Ritchie predicted the existence of self-sustained collective excitations at metal surfaces [1]. It had already been pointed out by Pines and Bohm [2, 3] that the long-range nature of the Coulomb interaction between valence electrons in metals yields collective plasma oscillations similar to the electron-density oscillations observed by Tonks and Langmuir in electrical discharges in gases [4], thereby explaining early experiments by Ruthemann [5] and Lang [6] on the bombardment of thin metallic films by fast electrons. Ritchie investigated the impact of the film boundaries on the production of collective excitations and found that the boundary effect is to cause the appearance of a new *lowered* loss due to the excitation of *surface* collective oscillations [1]. Two years later, in a series of electron energy-loss experiments Powell and Swan [7] demonstrated the existence of these collective excitations, the quanta of which Stern and Ferrell called the *surface plasmon* [8].

Since then, there has been a significant advance in both theoretical and experimental investigations of surface plasmon, which for researches in the field of condensed matter and surface physics have played a key role in the interpretation of a great variety of experiments and the understanding of various fundamental properties of solids. These include the nature of Van der Waals forces [9–11], the classical image potential acting between a point classical charge and a metal surface [12–15], the energy transfer in gas–surface interactions [16], surface energies [17–19], the damping of surface vibration modes [20, 21], the energy loss of charged particles moving outside a metal surface [22,23] and the de-excitation of adsorbed molecules [24]. Surface plasmon have also been employed in a wide spectrum of studies ranging from electrochemistry [25], wetting [26] and bio-sensing [27–29] to scanning tunnelling microscopy [30], the ejection of ions from surfaces [31], nanoparticles growth [32,33], surface plasmon microscopy [34, 35] and surface-plasmon resonance technology [36–42]. Renewed interest in surface plasmon has come from recent advances in the investigation of the electromagnetic properties of nano-structured materials [43, 44], one of the most attractive aspects of these collective excitations now being their use to concentrate light in sub-wavelength structures and to enhance transmission through periodic arrays of sub-wavelength holes in optically thick metallic films [45, 46].

The so-called field of plasmonics represents an exciting new area for the application of surface and interface Plasmons, an area in which surface-plasmon based circuits merge the fields of photonics and electronics at the nano-scale [47]. Indeed, surface-plasmon Polaritons can serve as a basis for constructing nano-scale photonic circuits that will be able to carry optical signals and electric currents [48,49]. Surface Plasmons can also serve as a basis for the design, fabrication and characterization of sub-wavelength waveguide components [50–64]. In the framework of plasmonics, modulators and switches have also been investigated [65, 66], as well as the use of surface Plasmons as mediators in the transfer of energy from donor to acceptors molecules on opposite sides of metal films [67].

2. STUDY OF EFFECT OF D.C. MAGNETIC FIELD

The presence of a D.C. magnetic field has effect on coupling of phonon-plasmons and polaritons.

Here it is investigated that here is dependence of surface plasmon frequency on the orientation and strength of an applied D.C. magnetic field in non retardation limit, or short wave length limit. According to the local field theory, the dielectric function of a solid depends on the frequency ω and propagation constant k and is denoted as $\varepsilon_1(k\omega)$. The D.C. magnetic field can be written as:-

$$B=\left(\overline{B}_x^0,\overline{B}_y^0,\overline{B}_z^0\right)$$

And without the loss of generality, we can write the propagation vector as:-

$$\left(\overline{0},\overline{k}_y,\overline{k}_z\right)$$

The dielectric function can be written as:-

$$\varepsilon_{ij}=\varepsilon_L\delta_{ij}-\frac{\omega_P^2}{\omega^2(\omega^2-\omega_c^2)}\delta_{ijk}\left[\omega^2\delta_{ij}-\omega_{cj}\pm i\delta_{ijk}\omega\omega_{ck}\right] \quad (1)$$

$$\omega_P^2=\frac{4\pi ne^2}{m^*}$$

(2)

ε_L =background dielectric functions of non-local k dependence dielectric function which is given by:-

$$\varepsilon_L(k\omega)=1+\frac{4\pi e^2}{k^2}\sum_k\frac{f_0(k)-f_0(K-k)}{\varepsilon(k+K)-\varepsilon(K)-\hbar(\omega)} \quad (3)$$

$$\omega_c=\frac{e}{mc}B^0$$

Here ω_c is cyclotron frequency.

δ_{ij} = kronical delta function.

As magnetic field is applied along Z direction, we have $\omega_{cz}=\omega_c$ and $\omega_{cx}=\omega_{cy}=0$ then

$$\overline{\varepsilon}_B(\omega)=\varepsilon_L-\overline{\varepsilon}\frac{\omega_P^2}{\omega^2-\omega_c^2} \quad (4)$$

$$\varepsilon_L=\frac{\varepsilon_\infty\omega^2-\varepsilon_0\omega_t^2}{\omega^2-\omega_t^2} \quad (5)$$

If the bounding medium is ε_B then from the dispersion relation of three mode coupling can be expressed as

$$A\Omega^8+B\Omega^6+C\Omega^4+D\Omega^2+E=0 \quad (6)$$

Where

$$A=\left[\left(\varepsilon_\infty-\varepsilon_\infty^2-\varepsilon_0\varepsilon_\infty\frac{\omega_t^2}{\omega_p^2}-\varepsilon_0\frac{\omega_t^2}{\omega_p^2}\right)-RX_l'(\gamma kR)y(\alpha kR)(RZ_l(\delta kR))'+\varepsilon_\infty\left(Ry_l(\alpha kR)\right)'Z_l(\delta kR)\right]$$

$$B=\left[\begin{array}{l}\left\{\begin{array}{l}\left(\varepsilon_\infty\frac{\omega_c^2}{\omega_p^2}-2\varepsilon_\infty\frac{\omega_t^2}{\omega_p^2}+\varepsilon_\infty^2\frac{\omega_c^2}{\omega_p^2}+\varepsilon_\infty^2\frac{\omega_t^2}{\omega_p^2}+\varepsilon_0\frac{\omega_c^2}{\omega_p^2}.\frac{\omega_t^2}{\omega_p^2}(\varepsilon_\infty+1)+\right)\\+\varepsilon_0\left(\frac{\omega_t^2}{\omega_p^2}\right)^2\left(\varepsilon_\infty+1+\varepsilon_0\right)\end{array}\right\}RX_l'(\gamma kR)y(\alpha kR)(RZ_l(\delta kR))'\\+\left\{\left(\varepsilon_\infty\frac{\omega_c^2}{\omega_p^2}-\varepsilon_0\frac{\omega_t^2}{\omega_p^2}-\overline{\varepsilon}\right)\right\}\left(Ry_l(\alpha kR)\right)'RZ_l(\delta kR)\\+\left\{\varepsilon_\infty l^2\overline{\varepsilon}X_l'(\gamma kR)y_l(\alpha kR)Z_l(\delta kR)\right\}\end{array}\right]$$

$$C=\left[\begin{array}{l}\left\{\begin{array}{l}\frac{\omega_c^2}{\omega_p^2}.\frac{\omega_t^2}{\omega_p^2}(\varepsilon_0+\varepsilon_\infty-2\varepsilon_0^2)+\left(\frac{\omega_t^2}{\omega_p^2}\right)^2\left(\varepsilon_\infty-\varepsilon_0\varepsilon_\infty\frac{\omega_c^2}{\omega_p^2}-\frac{\varepsilon_0\omega_c^2}{\omega_p^2}-\frac{\varepsilon_0\omega_t^2}{\omega_p^2}-\varepsilon_0^2\right)\\+\frac{\omega_t^2}{\omega_p^2}(\varepsilon_0+\varepsilon_0\varepsilon_\infty)\end{array}\right\}y(\alpha kR)(RZ_l(\delta kR))'\\+\left\{\left(\varepsilon_\infty\frac{\omega_c^2}{\omega_p^2}\frac{\omega_t^2}{\omega_p^2}-\overline{\varepsilon}\frac{\omega_c^2}{\omega_p^2}-\varepsilon_\infty\frac{\omega_t^2}{\omega_p^2}\right)\right\}\left(Ry_l(\alpha kR)\right)'Z_l(\delta kR)\\+\left\{(-\varepsilon_\infty\frac{\omega_c^2}{\omega_p^2}-\varepsilon_0\frac{\omega_t^2}{\omega_p^2}-\overline{\varepsilon}-\varepsilon_\infty\frac{\omega_t^2}{\omega_p^2})\right\}l^2\overline{\varepsilon}X_l(\gamma kR)y_l(\alpha kR)Z_l(\delta kR)\end{array}\right]$$

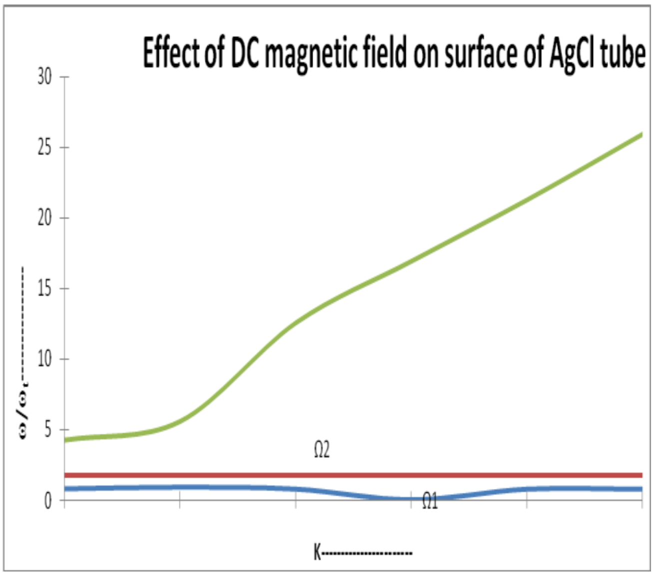
$$D=\left[\begin{array}{l}+\left\{\frac{\omega_c^2}{\omega_p^2}\frac{\omega_t^2}{\omega_p^2}\left(-\varepsilon_\infty\frac{\omega_t^2}{\omega_p^2}-\varepsilon_0\frac{\omega_t^2}{\omega_p^2}-\varepsilon_0\varepsilon_\infty\right)+\left(\frac{\omega_t^2}{\omega_p^2}\right)^2\left(\frac{\omega_c^2}{\omega_p^2}\varepsilon_0-\varepsilon_0\varepsilon_\infty\right)\right\}y_l(\alpha kR)RZ_l(\delta kR)'\\+\left\{\varepsilon_\infty\frac{\omega_c^2}{\omega_p^2}\frac{\omega_t^2}{\omega_p^2}+\varepsilon_0\left(\frac{\omega_t^2}{\omega_p^2}\right)^2+\overline{\varepsilon}\frac{\omega_t^2}{\omega_p^2})\right\}Ry_l(\alpha kR)'Z_l(\delta kR)\\+\left\{\varepsilon_0\frac{\omega_c^2}{\omega_p^2}\frac{\omega_t^2}{\omega_p^2}+\overline{\varepsilon}\frac{\omega_c^2}{\omega_p^2}+\varepsilon_\infty\frac{\omega_c^2}{\omega_p^2}\frac{\omega_t^2}{\omega_p^2}+\varepsilon_0\left(\frac{\omega_t^2}{\omega_p^2}\right)^2+\overline{\varepsilon}\frac{\omega_t^2}{\omega_p^2}\right\}l^2\overline{\varepsilon}X_l(\gamma kR)y_l(\alpha kR)'Z_l(\delta kR)\end{array}\right]$$

$$E=\left[\begin{array}{l}\left\{\varepsilon_0\left(\frac{\omega_t^2}{\omega_p^2}\right)^3\frac{\omega_c^2}{\omega_p^2}+\varepsilon_0\varepsilon_\infty\frac{\omega_c^2}{\omega_p^2}\frac{\omega_t^2}{\omega_p^2}\right\}y_l(\alpha kR)RZ_l(\delta kR)'\\+\left\{\varepsilon_0\left(\frac{\omega_c^2}{\omega_p^2}\right)^2\left(\frac{\omega_t^2}{\omega_p^2}\right)-\overline{\varepsilon}\left(\frac{\omega_c^2}{\omega_p^2}\right)\frac{\omega_t^2}{\omega_p^2}\right\}Ry_l(\alpha kR)'RZ_l(\delta kR)'\\+\left\{-\varepsilon_0\frac{\omega_c^2}{\omega_p^2}\left(\frac{\omega_t^2}{\omega_p^2}\right)^2-\overline{\varepsilon}\frac{\omega_c^2}{\omega_p^2}\frac{\omega_t^2}{\omega_p^2}\right\}l^2\overline{\varepsilon}X_l(\gamma kR)y_l(\alpha kR)Z_l(\delta kR)\end{array}\right]$$

Eq. (6) is the required dispersion relation of magneto Plasmon phonon and polariton in the cylindrical polar semiconductor for k≠0 in the presence of D.C.magnetic field. Now we shall study the characteristic of above equation under certain condition.

Table – AgCl Tube

K	ω/ω_t (Ω_1)	ω/ω_t (Ω_2)	ω/ω_t (Ω_3)
0.5	0.820065	1.751066596	4.3035
1	0.934434	1.765634722	5.632747
1.5	0.799211	1.770890062	12.60261
2	0.041907	1.771801761	16.97191
2.5	0.79816	1.772226835	21.3056
3	0.797985	1.772465295	25.95984



Figure

RESULTS AND CONCLUSION

From figure it is clear that the lower coupled mode is lies below the pure photon mode and is thus non–radiative, where as the upper mode is radiative. The bound, non-radiative lower coupled mode propagated for a certain range of frequency. It tends towards the uncoupled surface phonon frequency given by $\omega = 1.09$ for high values of wave vector $\bar{K}$ on the low wave vector side, the bound non–radiative mode exists up to frequency $\omega = 1.0$ below which it merges with the pure photon mode and becomes radiative. Thus, the bound, non–radiative surface polariton mode exists for the frequency range $\omega = 1.0$ to $\omega = 1.09$. The upper mode tends to the pure photon mode even for low value of wave vector $\bar{K}$ for every small values of wave vector; it tends towards the pure surface optical phonon frequency. The mixed phonon-photon character is most prominent in the region where the uncoupled modes cross. The existence of bound, non – radiative surface phonon–polariton mode for a certain range of frequencies and the radiative mode for the other, can be well explained on the basis of frequency – dependence of the lattice dielectric function $\varepsilon_l(\omega)$.

Many new structures were found for example existence of bands of frequencies for which surface modes do not exist and the wave propagates, the increase in the number of these bands with the application of the magnetic field (without the magnetic field there was only one band), the relation of polarizability with clearness of these bands and the frequency for which the surface becomes a high pass filter. These new features which were not seen in the case of zero applied fields will prove to be very useful in the theoretical and experimental studies of surfaces in the presence of a magnetic field.

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