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Calculations Of Transmission Probability And Its Application To Photofield Emission

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ABSTRACT::*In this report, we present calculation of transmission probability D(W) and its application to photofield emission current in metals. Transmission probability will be deduced by solving Airy's differential equation. The deduced formula will be then incorporated with current density formula..*

KEYWORDS:*Transmission Probability, Photofield emission, applied field;*

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I. INTRODUCTION

In this report, wehave calculated the transmission probability *D(W)* by solving by solving the Airy's differential equation and matching the wave functions inside and outside the surface at *z* = 0.0. The transmission probability thus developed has been applied to find photofield emission current (PFEC) in metal W[1]. Group theoretical method is used to find the basis functions to calculate initial state wavefunction [2].

II. CALCULATION OF TRANSMISSION PROBABILITY *D(W)*

The transmission tunneling probability *D(W)* used in Photofield emission has been calculated by solving the Airy's differential equation and matching the wave functions inside and outside the surface at *z* = 0.0. The standard form of Airy's differential equation is

$$\frac{\partial^2\psi}{\partial\xi^2}+\xi\psi=0 \qquad (1)$$

where $\xi=\left(\frac{2meF}{\hbar^2}\right)^{\frac{1}{3}}\left(z+\frac{E}{eF}\right)$. Putting $\alpha=\left[\frac{\hbar^2(eF)^2}{2m}\right]^{\frac{1}{3}}$ we can write $\xi=\left(\frac{E+eFz}{\alpha}\right)$. The two linearly independent solutions of Airy's differential equation are $A_i(-\xi)$ and $B_i(-\xi)$ which can be combined to form traveling waves moving away from the surface and is given by

$$\psi_a=B_i(-\xi)+i\,A_i(-\xi)=\frac{1}{\sqrt{\pi}(\xi)^{\frac{1}{4}}}\exp\left[\frac{2}{3}\xi^{\frac{3}{2}}+\frac{\pi}{4}\right]. \qquad (2)$$

The wave function outside the metallic surface can be written as

$$\psi_{out}=T.\psi_a. \qquad (3)$$

By matching ψ_{in} and ψ_{out} at *z* = 0 surface plane, we get $1+R=T\psi_a$, where *R* and *T* are the reflection and transmission coefficient. Finally, we can write, the expression for transmission probability *D(W)* as,

$$D(W)=\frac{W^{\frac{1}{4}}\sqrt{\pi}}{(\hbar eF)^{\frac{1}{6}}}\left(\frac{2ik_i}{ik_i+\chi}\right)(2m)^{\frac{1}{12}}\exp\left[-i\left(\frac{2}{3}\frac{W^{\frac{3}{2}}\sqrt{2m}}{\hbar eF}+\frac{\pi}{4}\right)\right]. \qquad (4)$$

Above eq. (4) is now used to evaluate photofield emission current as had been done earlier by Thapa and Das.[2]

III. RESULT AND DISCUSSIONS

We discuss here the results of photofield emission current (*PFEC*) in the case of metal *W*.A free electron model potential has been used for photofield emission calculation. We have plotted transmission probability *D(W)*against energy of the electrons below the vacuum level for different values of applied fields

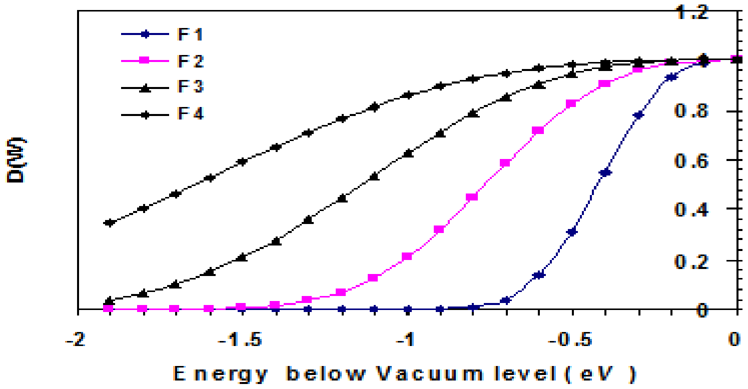

Fig. 1. Variation of transmission probability *D(W)* against energy of the electrons for different values of applied fields (F1 = 0.514 X 10^{11} *V/m*, F2 = 3.08 X 10^{11} *V/m*, F3 = 10.28 X 10^{11} *V/m* and F4 = 30.84 X10^{11} *V/m*).

The values of transmission probability *D(W)* against the energy of the electrons below vacuum level for different values of applied static field. From Eq. (4), we find that *D(W)* is exponential in nature. It is clear from Fig.1 that *D(W)* is showing an exponential behaviour and step like nature decreases with the increase in applied field thereby indicating that transmission of electrons in photofield emission is more easier at higher applied field to contribute to *PFEC*.

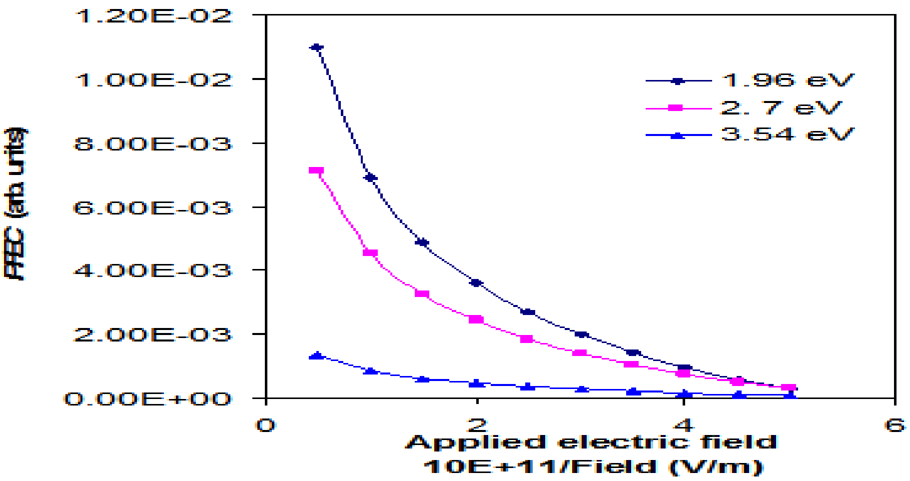

Fig. 2. Plots of currentas a function of field *F*for three values of photon energies $\hbar\omega$ = 1.96 *eV*, 2.70 *eV* and 3.54 *eV* .

In Fig. 2, we show the results of photofield emission current (*PFEC*) as a function of the applied electric field for the three values of photon energy $\hbar\omega$ = 1.96 *eV*, 2.70 *eV* and 3.54 *eV*. We have chosen the initial state energy E_i = 1 *eV* below Fermi level and $\theta_i = 45^0$. Here also, we find that *PFEC* decreases for high values as the field decreases showing higher order of magnitudes of *PFEC* for low photon energies and lowest for high photon energy. However, the trends of the behaviour of *PFEC* in all the cases of photon energies is similar that is, it is decreasing exponentially as the applied field decreases from high towards low values. This behaviour of *PFEC* against the applied field appears to exhibit the characteristics as obtained experimentally in the case of tantalum [3] and tungsten [4].

IV. CONCLUSIONS

It is seen that as the applied field increases, the value of *D(W)* almost becomes flat and parallel to the x-axis implying that the step potential magnitude is reduced thereby. This allows easy transmission of electrons. Further the nature of variation of PFEC is exponential which is attributed to the contribution due to the exponential term in *D(W)* .

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