Study of transient response in dielectric microstrip line with opto-microwave pulses

Xue Wang*, Ji-Hyoung Kim**, Ji-Hun Yun**

ABSTRACT

We study on the transient response in non-uniform microstrip lines with optically controlled microwave pulses. The transient response of the microwave pulses in plasma layer has been evaluated by reflection function of dielectric microstrip lines. The variation of characteristic response in plasma layer with localized pulses has been evaluated analytically. Reflection the change of the reflection amplitude has been observed.

Key Word

Non-uniform layer, Micro-strip Lines, Transient Response, Optically Controlled Microwave, Semiconductor layer

Ⅰ. INTRODUCTION

The dielectric constant of the optically illuminated semiconductor takes the complex form at microwave and millimeter-wave frequencies, and this can be useful in the design of optically controlled wave phase shifters and attenuators etc [1,2]. There has been considerable interest in the optical control of microwave. This is due to the potential use of new microwave in high-speeding signal processing, antenna beam scanning, phase shifters, modulators and optical switch [3,4].

In this study, we analyze the semiconductor plasma characteristics in the dielectric microstrip line with optically induced plasma region by the way of calculating the variation of the reflection function. We have modeled the dielectric/plasma waveguide using a more accurate non-uniform dielectric profile characterizing the plasma created by an absorbed optical beam. The frequency used in the microstrip transmission line in this paper is from 1GHz to 256GHz. The reflection characteristics are presented in the form of functions having frequency ω dependent variables.

We have modeled the dielectric/plasma waveguide in the non-uniform layer using the multipoint boundary-value routine COLSYS.

Ⅱ. Distribution Effect in Non-uniform Layer

The dielectric constant in the plasma- induced layer semiconductor material can be analyzed by the equation of motion of charge carriers in the semiconductor considering the classical electron-hole plasma theory as predicted by the Drude-Lorentz equation. One end of the strip is connected to an input/output port and the other end is open-terminated as shown also in figure

* 원광대학교 전자재료 공학과 석사과정
** 원광대학교 정보통신공학과 석사과정(rlawlgud6212@nate.com)
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1. The laser illumination induces electron-hole pairs in the semiconductor near the open end of the strip. The density of the induced carrier is assumed to be exponentially distributed from the surface to the interior.

The plasma region ΔZ is assumed to have a uniform density of free carriers. The relative permittivity of plasma induced in a semiconductor is given by [5]

$$\varepsilon_p = \varepsilon_s - \sum_{i=e,h} \frac{\omega_{pi}^2}{\omega^2 + \gamma_i^2}(1 + j\frac{\gamma_i}{\omega})$$

$$= \varepsilon_{pr} - j\varepsilon_{pi} \tag{1}$$

$$\omega_{pi}^2 = \frac{N_p \times q^2}{\varepsilon_o \times m^*} \qquad (i=e,h) \tag{2}$$

where the subscripts and indicate the electron and hole and is the relative permittivity of materials. Also ɣi is collision frequency and ɣi is related to the relaxation time of the carrier τi, by ɣi = 1/τi, ωpi is the plasma angular frequency, q is the electron charge, m* is the effective mass of the carrier, and Np is the plasma density. The frequency and plasma dependence of the actual component of the dielectric constant is fairly weak, whereas the imaginary component of the dielectric constant shows a strong variation with frequency and density of plasma [6].

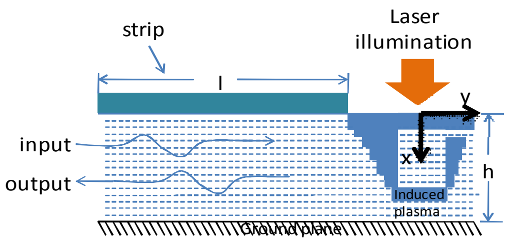

Fig 1. The plasma induced non-uniform layer with an open-ended illuminated termination.

The analysis begins with the solution to the diffusion equation for excess carriers due to an incident laser beam of power Po watts/cm2 at the surface x=0. In steady state, the excess carriers N(x) satisfy Where LD is the carrier diffusion length, is the spontaneous carrier lifetime, and R is the pump due to the incident laser beam. Since the light injected into the semiconductor waveguide is attenuated, R(x) is the position dependent pump rate. η is the internal efficiency, αι is the light absorption coefficient, hɣ is the photon energy, and Po is the light power at x=0.

$$L_D^2 \frac{d^2N}{dx^2} - N = -\tau R(x)$$

$$R(x) = \frac{\eta\alpha_l}{h\gamma} P_o e^{-\alpha_l x} \tag{3}$$

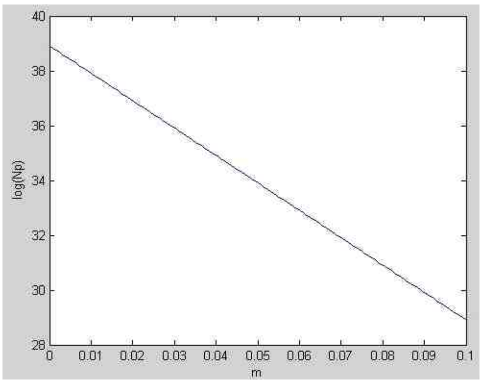

Fig 2. The density of the induced carrier in plasma layer with αιLD>>1.

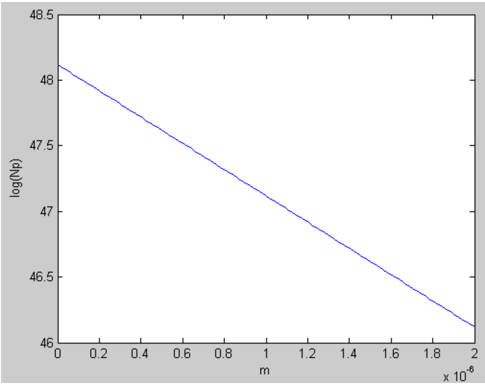

Fig 3. The density of different plasma layer with $\alpha_\iota LD<<1$.

If the diffusion length LD is small compared to the absorption depth $1/\alpha_\iota$, then the excess carrier diffusion becomes Nx = Noe-x/Lo where No=τη Po/hɣ. In Fig. 3 the density of the induced carrier has digressive from few dB in different plasma layer. In both of the limiting cases discussed above, the carrier density has an exponential dependence. Since the dielectric constant is proportional to the square of the plasma frequency, the corresponding dielectric constant will be proportional to the carrier density. So we can get the figure of the density of the plasma in the above different situation. And the first part data was used to analyze the transient response in different layer.

Ⅲ. Proposed Transient Response

A transmission line, on the other hand, the capacitance and the conductance are also both taken into account in our equivalent model for analyzing with optically controlled waves. The reflection characteristics of this line are theoretically investigated with respect to the illuminating light using an equivalent circuit model [11]. The variation in microstrip line based on optically controlled microwave pulses with our equivalent model is shown in Fig. 4.

Supposing that the equivalent terminal impedance at the open end is represented as ZL, then we can derive the ZL = R+1/jωC and a transmission line model can be also expressed as shown in Fig. 4 with ZL and the characteristic impedance Zo. By the transmission line equations, the input impedance ZIN can be deduced from ZL, Zo and other parameters. Then the reflection wave function can be calculated by the circuit model through our suggested system, which has induced plasma with optically controlled pulses. In most microstrip configurations, transmission loss is neglected due to the compactness of an entire circuit. The total attenuation of the line is insignificant due to the short line length [13].

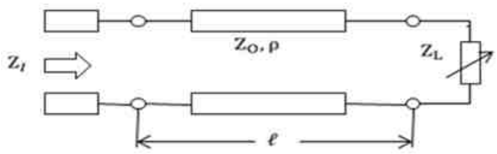

Fig 4. Transmission line model of non-uniform plasma layer

If the attenuation is primarily due to the dielectric loss, the dielectric constant ε becomes a complex quantity. In the Maxwell's equation, we can ε=εoεpr with the carrier density and capacitance per unit length C= ε*l/h and the resistance per unit length is R = l/ω*[ωμ/2σ]1/2, with l is the strip length and ω is the wide of the strip. Assuming input termination reflects some of energy originally sent down the line except for the completely matched condition. The Amplitude in time and frequency are calculated by ZIN and the characteristics impedance of the transmission model.

The microwave signal is input to the port and the reflected signal is calculated through a directional coupler connected to the same port with optically controlled waves. The input microwave is almost totally reflected in the dark state, and increasing the frequency reduces amplitude of the reflection. The characteristics response for the pulse modulated signal, which is our equivalent model transient response with optically-controlled wave pulses based on microstrip lines, can be written by [14]

$$O(\omega) = \rho_{in}(\omega)e(\omega)$$

(4)

where ρin(ω) is dielectric variation in the plasma-induced layer and e(w) is characteristics response in the frequency reflection variation. We assume also that the intensity in the presence of electron-hole plasma region has illuminated in microstrip line.

If we assume αιLD>>1 then the characteristic of variation in microstrip lines with optically controlled microwave pulse. The reflection of the input microwave was about a few dB largest at the maximum density of the plasma in the surface of the semiconductor, as the density of the plasma increased below the reflection reduced and was closed to a few dB.

The phase of the reflection of the microwave in the surface of the semiconductor is gotten. The maximum phase was about -25dB in the depth. If the diffusion length LD is small compared to the absorption depth 1/ αι. The reflection of the input microwave was about -25dB largest at the maximum density of the plasma in the surface of the semiconductor, as the density of the plasma increased below the reflection reduced. In Fig. 8 we can see that the maximum phase was about -25dB in the depth.

The two relations couple the time and frequency dependent responses for liner microwave circuits in our equivalent model. First, we have considered the pulse-modulated sinusoid signal for input estimation, which has the amplitude modulating carrier shifts angular frequency ω to (ω-ωo).

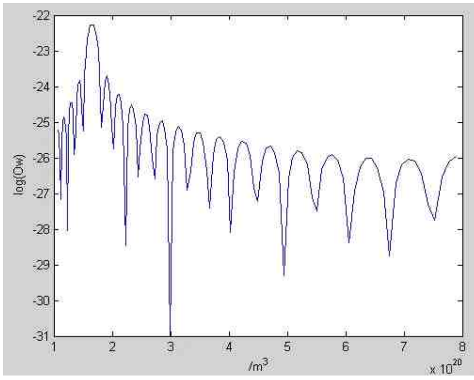

Fig 5. The response in different density of the plasma with αιLD<<1.

For the analysis in variation of transient response in open-ended microstrip lines with optically-controlled microwave pulses, we have driven differentially localized O(w) for variation response using by pulse-modulated sinusoid signal. Evaluating for the differential of the reflection wave function we can observe the phase change of the energy in the reflection wave directly. The localized variation of O(w) can be deduced by

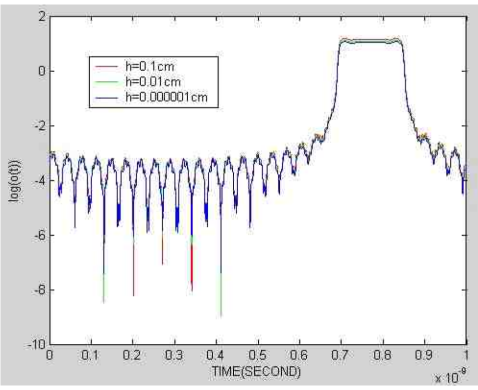

Fig 6. Transient response in different depth of plasma layer in time by shifted signal with variable constant with αιLD>>1.

The response of the variation of the reflection wave, which has pulse-modulated sinusoid signal, is shown in Figure 5. In Fig 5, depicts the response of the Fourier transform of the reflection wave in the depth of 0.1cm, 0.01cm and 0.01x10-4cm of plasma layer and displays the characteristics of transiently responded signal in time pulse as a result of shift. In Fig.6 the magnitudes have the small difference in the depth of 0.1cm, 0.01cm and 0.01x1-4cm of plasma layer and the largest magnitude is about 1dB in time domain from 0.75ns to 0.85nm by shifted signal with variable constant when

We give the wave that the dielectric materials were in normal run-time under our condition. If the actual measurement exceeds the limits, the site of the material is on abnormal state and needed for further measurement.

Ⅳ. CONCLUSION

With optically controlled microwave in the open-ended microstrip lines, the transient response beeb observed. We calculate the density of the slab induced carrier in different plasma layer. The amplitude modulating carrier frequency shifts 16GHz towards on modulated-response. Since our result has real-time response in induced non-uniform plasma layer, it can be used for decision defect or fault on semiconductor device and electrical circuit. And the best design of this system is that we can directly observe the phase of the reflected change in quantity.

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저자약력

Xue Wang

2007년 원광대학교 전기 전자 및 정보공학부 (공학사)
2009년 원광대학교 전자 재료 공학과 (공학석사)

<관심분야> 광통신시스템, 정보통신시스템기술

Ji-Hun Yun

2009년 원광대학교 전기 전자 및 정보공학부 (공학사)
2009년~현재 원광대학교 정보통신공학과 (석사과정)

<관심분야> 광통신시스템,, 전력선통신, 가시광통신

Ji-Hyoung Kim

2008년 원광대학교 전기 전자 및 정보공학부 (공학사)
2008년~현재 원광대학교 정보통신공학과 (석사과정)

<관심분야> 광통신시스템, 정보통신시스템기술, 전력선통신