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Variation of Transient-response in Open-ended Microstrip Lines with Optically-controlled Microwave Pulses

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In this paper we develop a method to observe faults in semiconductor devices and transmission lines by calculating the variation of the reflection function in a dielectric microstrip line that has an open-ended termination containing an optically induced plasma region. It is analyzed with the assumption that the plasma is distributed homogeneously in laser illumination. With the non linear material of degradation, the concentration of the carrier in the part of the material has changed. Since the input wave has produced the phenomenon of reflection, the input signal to the open-ended microstrip lines can be observed on reflection to identify the location of the fault. The characteristic impedances resulting from the presence of plasma are evaluated by the transmission line model. The variation of the reflection wave in the microwave system has been calculated by using an equivalent circuit model. The transient response has been also evaluated theoretically for changing the phase of the variation in the reflection. The variation of characteristic response in differentially localized has been also evaluated analytically.

Keywords: Induced plasma, Semiconductor, Transient response, Dielectric microstrip Lines, Optically-controlled microwave pulses

1. INTRODUCTION

Recently, the market for large flat-panel displays (FPDs), such as large liquid crystal displays (LCDs) and large plasma display panels (PDPs), has been growing, and manufactures have been increasingly interested in large-area, uniform-density plasma equipment for use in large FPDs. According to an industry analysis, more than 60 % of the production faults and more than 70 % of the purchases returned for repair are due to a failure of the plasma device. So it is critical to develop a system that can be used for real-time monitoring and fault detection with this plasma equipment[1-3].

At the same time, there has been considerable interest in the optical control of microwave and millimeter waves. This is due to the potential uses of new microwave and millimeter wave devices in high-speed signal processing, antenna beam scanning, phase shifters, modulators, and optical switches[4,5]. The rapidly growing market for microwave and millimeter communication systems requires new approaches that can allow more effective use of the available frequencies[6].

The impedance of materials changes as the temperature, heat, and other environmental conditions change By calculating the variation in the reflection of the input wave, we can observe the changing rate of the characteristics impedance and the size of phase. The quantitative analysis of an available frequency has on proper function. And at higher frequencies, either microstrip or dielectric waveguide structures become more attractive. Strip line configurations are especially important for the integration of electro-optic and microwave components[7].

In this study, we analyze the semiconductor plasma characteristics in a dielectric microstrip line with an optically induced plasma region by the way of calculating the variation in the reflection function. In this paper the frequency used in the microstrip transmission lines will be from 1 *GHz* to 128 *GHz*. The reflection characteristics are presented in the form of functions having frequency ω dependent variables.

2. EFFECTS OF PLASMA INDUCED LAYER

We consider a microstrip line on a semiconductor substrate, one end of which is open-ended and illuminated with a laser for the optical injection of carriers. Using an equivalent circuit model, we investigate the reflection characteristics of this line theoretically with respect to the illuminating light. Figure 1 shows the variation of plasma-induced in the microstrip line with on optically controlled microwave pulses.

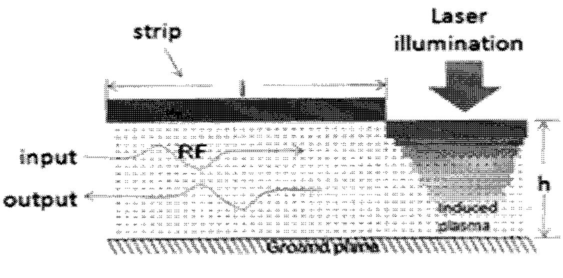

Fig. 1. The plasma-induced microstrip line with an open-ended termination for illumination.

When a semiconductor material is illuminated with a laser photon energy greater than the band gap energy of the semiconductor, the photons are absorbed, creating electron/

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hole pairs and resulting in a thin layer of plasma near the surface of the material. The presence of this electron-hole plasma in the semiconductor modifies the conductive and the dielectric properties of the semiconductor material[1,7]. The dielectric constant in the induced-plasma region of the semiconductor material can be analyzed by the equation of motion of charge carriers in the semiconductor using the classical electron-hole plasma theory implied by the Lorentz equation[8]. One end of the strip is connected to an input/output port and the other end is open, as illustrated in Fig. 1. The laser illumination induces electron-hole pairs in the semiconductor near the open end of the strip. The density of the induced carriers is assumed to follow an exponentially distribution 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[8].

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

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

where the subscripts p and I indicate the electron and hole and ε_s is the relative permittivity of materials. Also γ_i is the collision frequency and γ_i is related to the relaxation time of the carrier τ_i by $\gamma_i = 1/\tau_i$, ω_{pi} is the plasma angular frequency, q is the electron charge, m^* is the effective mass of the carrier, and N_p is the plasma density. The frequency and plasma dependence of the real component of the dielectric constant is fairly weak, while the imaginary component of the dielectric constant shows a strong variation with the frequency and density of the plasma[7].

3. PROPOSED TRANSIENT RESPONSE IN MICRO-STRIP LINE

A transmission line is a distributed-parameter network and must be described by circuit parameters that are distributed throughout its length. In most analyses of this type of device, with microwave switches having gaps of strips to be illuminated, only the conductance in the discontinuity of the line is taken into consideration while the conductance is neglected[9]. Here in our proposed model, the capacitance and the conductance are both taken into account. Supposing that the equivalent terminal impedance at the open end is represented as Z_L, then we can derive that $Z_L = R + 1/j\omega C_L$ and we can also set down a transmission line model, as shown in Fig. 2, with Z_L and the characteristic impedance Z_o.

By the transmission line equations, the input impedance Z_{IN} can be deduced from Z_L, Z_o and other parameters. Then the reflection wave function can be calculated by using the circuit model for our suggested system, which has induced plasma with optically controlled pulses. In most microstrip configurations, the transmission loss is neglected because of the compactness of the entire circuit. That is, the total attenuation of the line is insignificant because of the short line length. If the attenuation is primarily due to the dielectric loss, the dielectric constant ε becomes a complex quantity, and from Eq.(1) and Maxwell's equations we can get

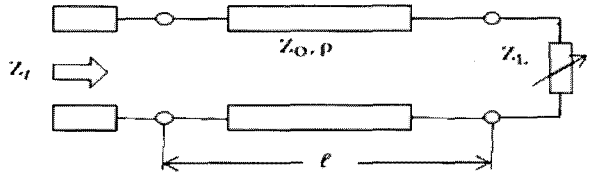

Fig. 2. Transmission line model of the microstrip line containing the equivalent terminal impedance.

$$\varepsilon = \varepsilon_o \varepsilon_{pr} \tag{3}$$

The conductivity[4] is given by

$$\sigma = \frac{N_p q^2 \tau_i}{m^*(1 + \omega^2 \tau_e^2)} \tag{4}$$

Sections of transmission lines can be designed to provide inductive or capacitance impedance and are used to match an arbitrary load to the internal impedance of a generator for maximum power transfer. The required length as circuit elements becomes practical in the UFH range. In most cases a transmission line segment can be considered lossless[9]. The characteristic impedance of this line Z_o is

$$Z_o = \sqrt{\frac{R + j\omega L}{G + j\omega C}} \tag{5}$$

The formula for the input impedance Z_{IN} is

$$Z_{IN} = \frac{Z_o(Z_L + jZ_o \tan\beta l)}{Z_o + jZ_L \tan\beta l} \tag{6}$$

$$Z_{IN} = \frac{Z_o[R + j(Z_o \tan\beta l - \frac{1}{\omega C})]}{(Z_o + \frac{\tan\beta l}{\omega C}) + jR\tan\beta l}, \tag{7}$$

where β is the imaginary part of the propagation constant and R, L, G, and C of parallel-plate transmission line are distributed. The capacitance per unit length is $C = \varepsilon * l/h_L$ and the resistance per unit length is $R = l/\omega * [\omega\mu/2\sigma]^{1/2}$, while l is the length of the strip and ω is the width of the strip[9].

The reflection characteristics as well as the amplitude in time and the frequency are calculated from Z_{IN} and the characteristic impedance of the transmission model. The reflection coefficient in the input termination is then given by

$$\tau_{in}(\omega) = \frac{Z_{IN}(\omega) - Z_o(\omega)}{Z_{IN}(\omega) + Z_o(\omega)} \tag{8}$$

The microwave signal is input to the port, and the reflected signal is then calculated through a directional coupler connected to the same port. The input microwave is almost totally reflected in the dark state, and increasing the frequency reduces the amplitude of the reflection.

4. VARIATION OF TRANSIENT RESPONSE IN INDUCED-PLASMA LAYER

To estimate theoretically the characteristic response of our optically controlled microwave pulse system in time, we use the Fourier transformation method. The Fourier transform for our model of microstrip lines has defined as[10],

$$f(t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} \tau_{in}(\omega)e^{j\omega t}\,d\omega \tag{9}$$

The two relations couple the time and frequency dependent responses for liner microwave circuits in our model. First, we consider the pulse-modulated sinusoid signal for estimating the input, which has the amplitude-modulating carrier shifts angular frequency ω to $(\omega\text{-}\omega_o)$. Then, our new proposed model has

$$F_o(\omega) = \int_{-\infty}^{+\infty} \tau_{in}(t)e^{j(\omega-\omega_o)t}\,dt = F_o(\omega-\omega_o) \tag{10}$$

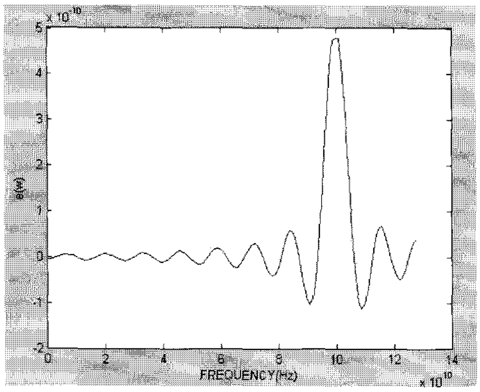

Fig. 3. The characteristic response in the frequency reflection coefficient in the input signal.

The input sinusoidal components of the microstrip lines with optically controlled microwave pulses can be written as

$$e(\omega) = \int_{-\frac{T}{2}}^{\frac{T}{2}} e^{-j\omega t}\sin(\omega_o t)\,dt \tag{11}$$

The transient response to an input wave is shown in Fig. 3, and the response of the spectrum density to an input microwave is shown in Fig. 4. We have used the high frequencies to evaluate the carrier density theoretically. Fig. 5 depicts the response to a graded variation in the input microwave, and Fig. 6 depicts the response of the Fourier transform to a variation in the input microwave with equivalent model under microstrip lines. The frequencies used in the paper are from 1 *GHz* to 128 *GHz*, and the carrier frequency ω_o is 100 *GHz*. The calculated variation of *e(w)* is also shown in Fig. 5 and Fig. 6.

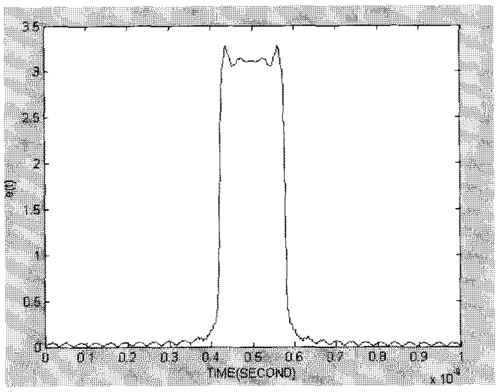

Fig. 4. Transient response in the time domain of optically controlled microwave pulses.

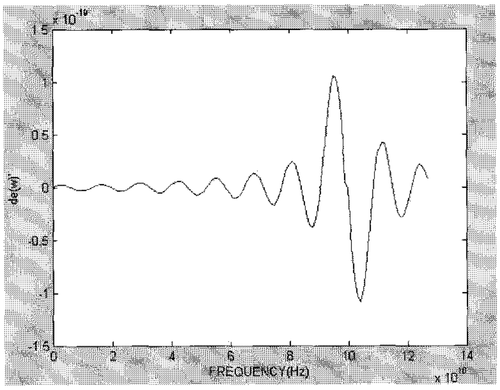

Fig. 5. Characteristics response to changing frequency of input wave.

The frequency dependence of the reflection coefficient in an optically controlled layer offers a measure of the carrier frequency ω_o and the plasma density. The characteristic response for the pulse-modulated signal, which is our equivalent model transient response, can be written as

$$O(\omega) = \tau_{in}(\omega)e(\omega) \tag{12}$$

where $\tau_{in}(\omega)$ is the dielectric variation in the plasma-induced layer and *e(w)* is the characteristics response to the frequency reflection variation.

Figure 7 shows the response of the reflection wave in our model in the dielectric plasma region, which has optically controlled microwave pulses. The signal disturbed in 16 *GHz*, which has compared with carrier shifts angular frequency. Figure 8 depicts the response of the Fourier transform of the reflection and displays the characteristics of the transiently responded signal in time pulse as a result of shift. Comparing Fig. 4 and Fig. 8, we can see that the input wave has been reflected and had changed both the shifted energy towards with 16 *GHz*.

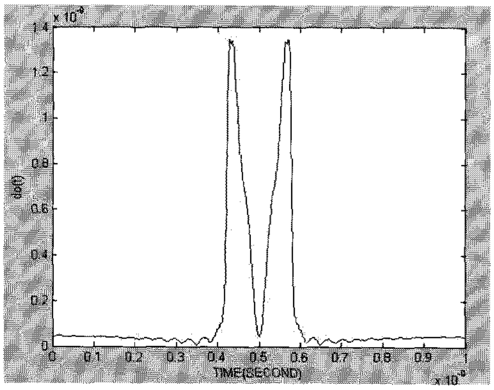

Fig. 6. Transient response in time to a changing frequency in the input modulated signal.

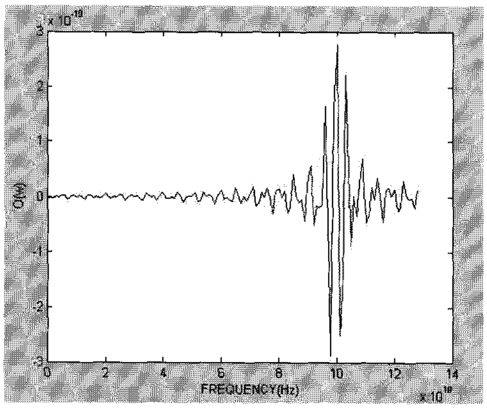

Fig. 7. The characteristics of transient response with shifted signal using ε_s=11.8, m_e=0.259*m_o, m_h= 7.71*10^{12}, γ_e=4.52*10^{12}, γ_h=7.71*10^{12} and N_p= 1.0*10^{21}/m^3.

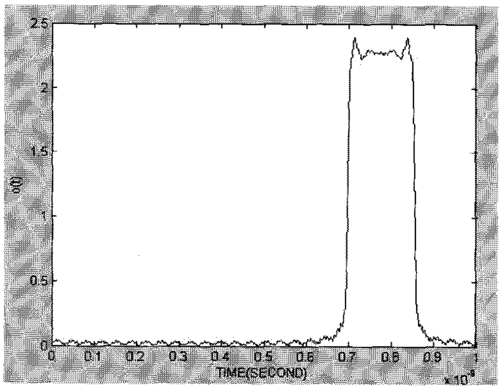

Fig. 8. Transient response in time domain by shifted signal with variable constant.

The pulse-modulated sinusoid signal represents the frequency characteristics versus carrier density at the open end of the line. The amplitude-modulating carrier frequency shifts 16 *GHz* towards on delayed modulated response frequency. Figure 7 shows the characteristics of the transient response to an optically controlled microwave pulse with a shifted input signal using various parameters.

To analyze the variation of transient response in open-ended microstrip lines with optically controlled microwave pulses, we has been driven differentially localized *O(w)* for variation response using by pulse-modulated sinusoid signal. By calculating the derivative 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 determined by

$$O'(\omega) = \frac{d(O(\omega))}{d\omega} \tag{13}$$

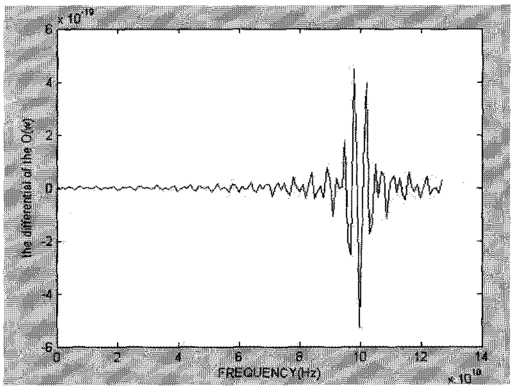

Fig. 9. Characteristics response to optically controlled microwave pulse as a function of the frequency of the output wave.

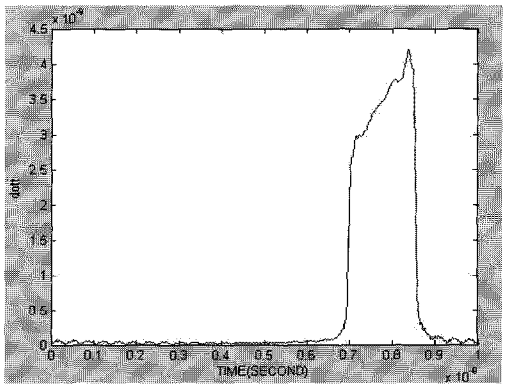

Fig. 10. Transient response in differentially localized *o(w)* with shifted frequency.

The response of the variation of the reflection wave, which has a pulse-modulated sinusoid signal, is shown in Fig. 9. Fig. 10 depicts the response of the Fourier transform of the differential variation of the reflection wave in optically controlled microwave pulses.

In Fig. 9 the phase on either side of the frequency 100 *GHz* is quite different. The amplitude is smaller for frequencies less than 100 *GHz* than for frequencies greater than 100 *GHz*, so we can see that the rectangular wave acts tilt of the situation in Fig. 10. It can be seen that the phase of the energy changes from a minimum magnitude of 3x10^{-9} at 0.68 *ns* to a maximum value of 4.2x10^{-9} at 0.85 *ns*. The variation of the shifted level is an average about 3.5x10^{-9}.

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

5. CONCLUSION

As the temperature and the input wave frequency change we can observe the reflection measurements in an open-ended microstrip line with laser illumination. We used a frequency range from 1 *GHz* to 128 *GHz*. The importance of the variation is that it can predict. By evaluating the variation in the reflection coefficient $O(w)$, we can observe the change in the reflection amplitude. The variation in the shifted level is, on average, about $3.5x10^{-9}$. We also explain the characteristics of a plasma layer induced by microwave pulses by changing the response. The amplitude-modulating carrier frequency shifts 16 *GHz* towards a modulated-response.

Real-time response in induced 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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