

Modeling and Characterization of Schottky Diode on AlGaAs/GaAs HEMT Structure for Rectenna Device

Norfarariyanti Bte Parimon, Siti Suhaila Bte Mohd Yusof, Abdul Manaf Bin Hashim*

Material Innovations and Nano-Electronics (MINE) Group, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

* e-mail: manaf@fke.utm.my{Abdul Manaf Bin Hashim}

Abstract

The modeling and characterization of Schottky diode on AlGaAs/GaAs HEMT structure for rectenna device is presented. The rectenna device can be used as a wireless power supply where it can capture microwave power and convert to the dc power to generate the others devices or circuits on a chip. Design and simulation of Schottky diode on AlGaAs/GaAs HEMT structure was carried out. From the simulated results, it was found that the operating frequency of the Schottky diode is tunable based on the length of coplanar waveguide.

Keywords: Schottky diode, Rectenna, HEMT structure, IQ chip.

1. Introduction

As a possible application of quantum devices for the ubiquitous network society environments, we are focusing on a contribution to a development of new smart chip called an intelligent quantum (IQ) chip in terms of wireless microwave power transmission. Wireless power transfer is a promising technique for the long-term power supply of wireless applications [1]. The main component for the wireless power transfer is rectifying antenna (rectenna). The antenna receives the electromagnetic power and the rectifying circuit converts it to electric power [2].

In general, portable devices have small dimensions. Therefore, the rectenna should have small dimensions as well. This result in small antenna area and consequently, a low amount of received power. Because of these limitations, wireless power transfer is mainly suitable for low-power application, e.g., IQ chip. For this purpose the behavior of the antenna and rectifying circuit have to be modeled at and around the operating frequency [2].

In this paper, to fulfill the concept of IQ chip, the antenna and the rectifying circuit have to be designed

on the same substrate because the impedance matching circuit is omitted in this rectenna device.

2. Design of Rectenna

The general schematic of a rectenna is shown in Fig. 1. This report highlights and focuses on the rectifying circuit which is the main component that determines the power conversion efficiency of the rectenna. The impedance matching circuit is omitted between antenna and rectifying circuit. The diode rectifies the incident RF signal and the capacitor and the resistor produce a DC output by filtering out the high frequency part of the rectified signal. Finally, the power conversion efficiency for the future fabricated of rectenna will be defined as the ratio of dc power to received power which is the most important parameter for the model [3].

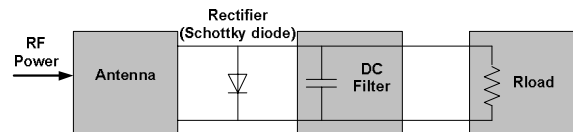


Fig. 1. A block diagram of rectenna.

Our objective is to produce a Schottky diode which has certain operating frequency, so that it can act as a tunable rectifier. We are in progress to develop accurate model which consider other material properties such as resistivity, carrier mobility and Schottky barrier height. At the same time, comparison with actual fabricated device will be carried out. The performance of fabricated Schottky diode in term of power conversion will also be evaluated.

3. Simulation, Result and Discussion

Fig. 2 shows the schematic structure of Schottky diode from plane section layout. The coplanar waveguide (CPW) was selected as a microwave

transmission line. In our preliminary study, we started with a design on how the length of CPW can affect the resonant frequency and admittance of the device.

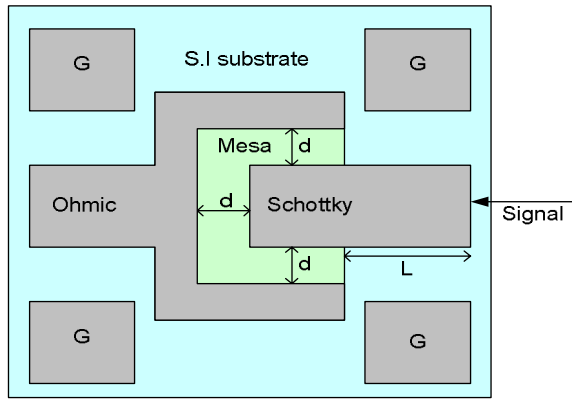


Fig. 2. Plane section layout of Schottky diode.

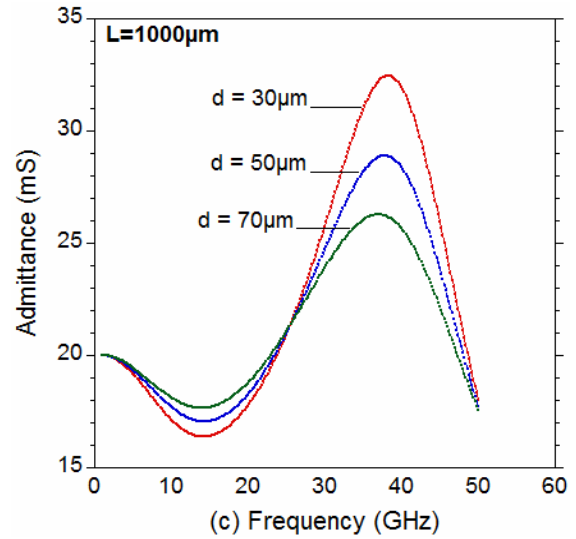
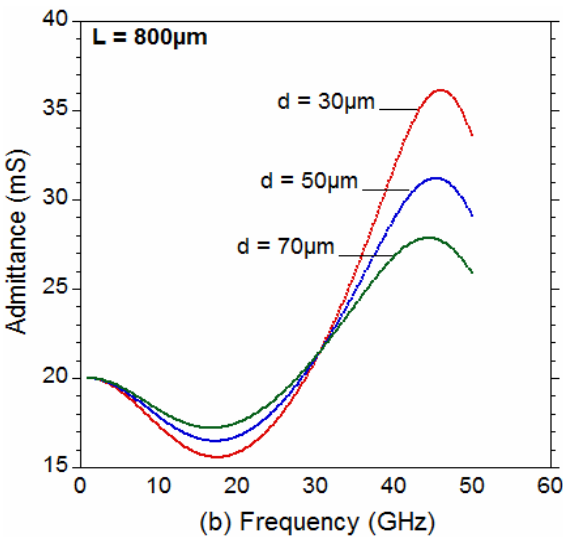
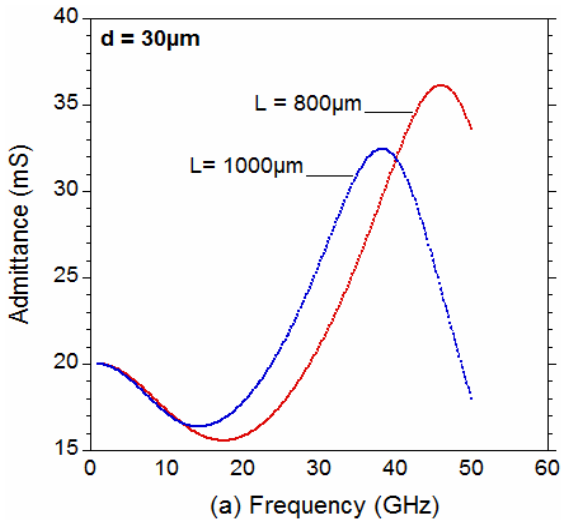


Fig. 3. Calculated admittance characteristics as a function of frequency (a) dependence of CPW length on resonant frequency, (b) and (c) dependence of distance between ohmic-Schottky contact.

Fig. 3(a) shows, the simulation of the Schottky diode for the different length of signal, $L=800\mu\text{m}$ and $1000\mu\text{m}$ with distance between ohmic and Schottky contact, $d=30\mu\text{m}$. The first harmonic resonance frequency of the Schottky diode are 38 GHz and 47 GHz respectively. These simulated result of Schottky with L is higher can operating in lower frequency with lower admittance as expected.

Fig. 3(b) and (c) are the result from comparison of distance between ohmic and Schottky contact for the $L=800\mu\text{m}$ and $L=1000\mu\text{m}$. The first harmonic resonance frequency obtained from the different of distance between ohmic and Schottky for $d=30\mu\text{m}$, $50\mu\text{m}$, $70\mu\text{m}$. For the $L=800\mu\text{m}$, resonance frequency obtained is 47GHz, 45GHz, 43GHz and when $L=1000\mu\text{m}$, the resonance frequency show 37GHz, 35GHz, 33GHz respectively. The simulated result shows the higher distance between ohmic and Schottky contact produces the lower admittance and frequency as expected.

4. Conclusion

Finally, Schottky diodes with range of resonance frequency between 33GHz to 47GHz and low-power application have been demonstrated. From the preliminary simulated results, it was found that operating frequency of the Schottky is tunable.

5. References

[1] W.C.Brown, "The history of power transmission by radio waves", *IEEE Trans. Microwave Theory Tech.*, vol.32, no.9, pp. 1230-1242, Sep. 1984.

[2] J.A.G.Akkermans, M.C.van Beurden, G.J.N Doodeman and H.J Visser, "Analytical Models for Low-Power Rectenna Design", *IEEE Antennas and Wireless Propagation Letters*, Vol.4, pp. 187-190, 2005.

[3] J.Gutmann Ronald and M.Borrego Jose, "Power Combining in Array of Microwave Power Rectifiers", *IEEE Trans. on MTT*, vol, MTT-27, no. 12, December 1979.