Design and Characterization of Planar Antennas on the Semi-Insulated GaAs for Rectenna Devices

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Abstract

This paper presents the design and characterization of the planar type antennas. A dipole type antenna has been designed to be used in the rectifying antenna (rectenna) devices. Normally, a rectenna consists of an antenna and a diode which can rectify microwave power to dc power. We present the novel coplanar waveguide (CPW) facilitated with antenna for future applications such as Intelligent Quantum (IQ) Chips. The return loss characteristic of antenna has been investigated by simulation. From our preliminary results, it is shown that an antenna with length, L=4mm and width, W=20µm showed high return loss characteristics up to -47dB at 15GHz. The obtain characteristics also showed that the dipole antenna can be directly integrated with other devices without any matching circuits for use like in approximity communication system.

Keywords: Dipole antenna, CPW, Rectenna, IQ Chips.

1. Introduction

Explosive growth of internets and wireless technologies starting in the late 21st century has opened up prospects towards an advanced ubiquitous network society. Rapid progresses are also being made in MEMS technology, nanotechnology and biotechnology. This also opens up new directions in the device research in addition to the continued efforts of scale down of Si CMOS device along the roadmap. The new device trends include trends toward the quantum nanotechnology, toward use of new materials (group-III nitrides, spin materials, ZnO, organics, carbon nanotubes etc), towards realization of new functions sensors and actuators, and use of new system architectures such as neural network, cellular automata, reaction-diffusion dynamics etc. and towards formation of new wireless networks such as those including smart dusts [1], RFID (radio frequency identification) chips and sensor networks [2].

As an application of quantum devices for the ubiquitous network society environments, the new smart chip called Intelligent Quantum (IQ) chip was proposed where quantum digital signal processors, memories, various sensors, transceivers etc are integrated on the chip [3]. They are expected to play key roles as tiny knowledge vehicles in the next generation ubiquitous network society. An IQ chip is a III-V semiconductor chip with sizes of millimeter square or below where nanometer scale quantum processors and memories are integrated. One of key elements to realize the concept of IQ chips is the wireless power supply which is generated by rectenna devices. A rectenna is a combination of a rectifying circuit and an antenna. The antenna receives the electromagnetic power and the rectifying circuit converts it to electric power.

An antenna plays an important rule in rectenna design. Several antennas have been used in rectenna such as strip dipole antenna [4], loop antenna [5], microstrip patch antenna [6] and coplanar waveguide-fed patch antenna. In this paper, we focused on the design and characterization of planar dipole antennas for the rectenna devices. The advantages of this type of planar antenna are its small dimension and the ease of manufacturing, making it a low-cost antenna. The antenna was designed using Commercial Electromagnetic Simulator Sonnet Suites. It is facilitated by CPW as transmission lines and designed on the un-doped semi-insulated (SI) GaAs substrate with a dielectric constant of 12.9.

2. Antenna Design

The structure of the proposed dipole antenna is shown in Fig. 1. It is facilitated by CPW as transmission lines. The dimensions of the gaps (A) and

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widths (B) for CPW were chosen. So that it can produce impedance characteristic of 50Ω. This structure also suits to the dimension of Ground-Signal-Ground (GSG) Cascade Microprober used in measurement process. The center conductor width was chosen to be 90µm, with the gaps between the center conductor and the ground lines chosen to be 60µm. The length (L) and width (W) of the dipole antenna was chosen to be 70µm. This length is chosen in the antenna structure in order to reduce the unwanted signal appears in output result. Beside that, it also can reduce specific area for making it a low cost antenna. So that, it's operating frequency will be in the range 0.5 GHz to 50 GHz.

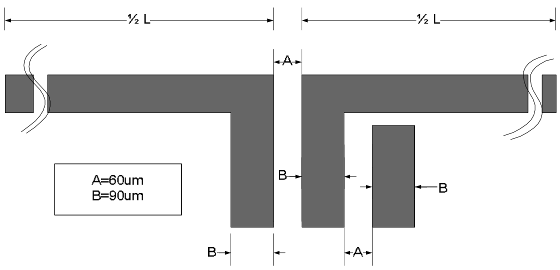


Fig. 1. Schematic of the dipole antenna.

3. Simulation Results and Discussion

The antenna structure is constructed on a semi-insulating GaAs substrate with thickness of 650µm, a dielectric constant of ε_r=12.9 and a loss tangent of tan δ=0.001. The metal of the antenna is gold with a thickness of 0.05µm. The structure was simulated using Commercial Electromagnetic Simulator Sonnet Suites which is full wave EM simulation software. Throughout this stage, the dependence of antenna dimension on resonant frequency in microwave region was determined. Namely, the return loss characteristics were evaluated.

Fig. 2 shows the return loss characteristics of the antenna as a function of frequency for various values of width. It is observed that as the width of antenna decrease, return loss also decrease but it shows a maximum peak at width of 20µm. The resonant frequency is maintained at 1st and 3rd harmonic

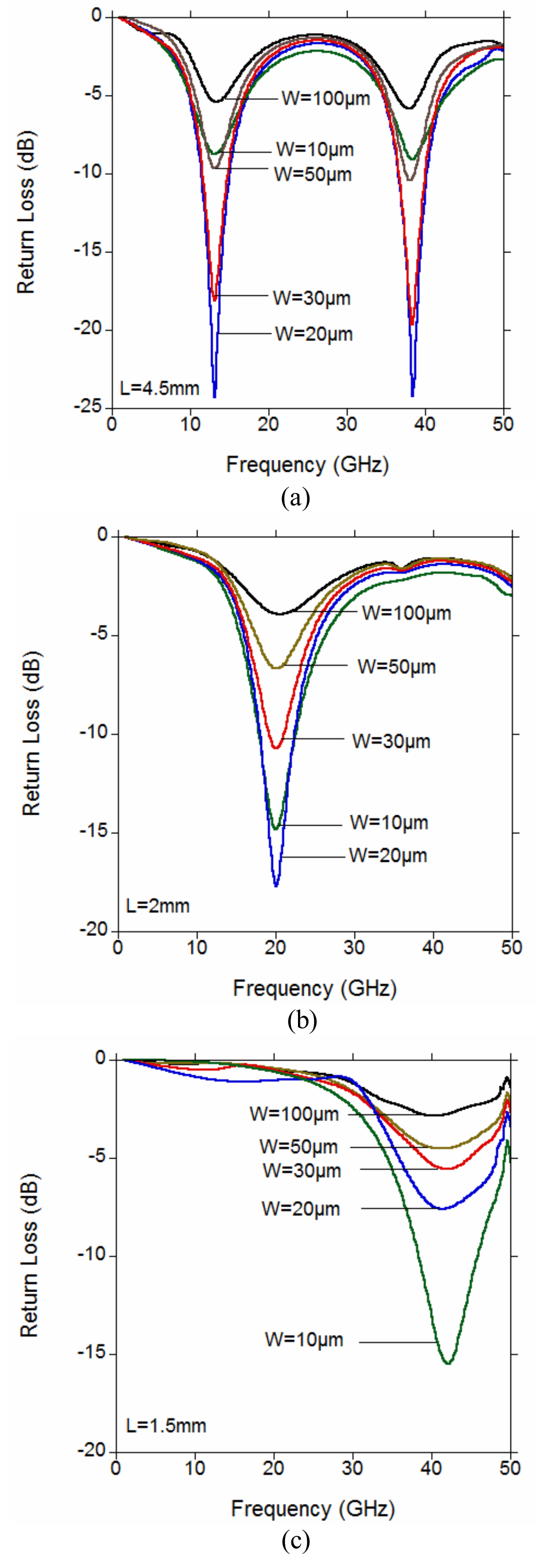
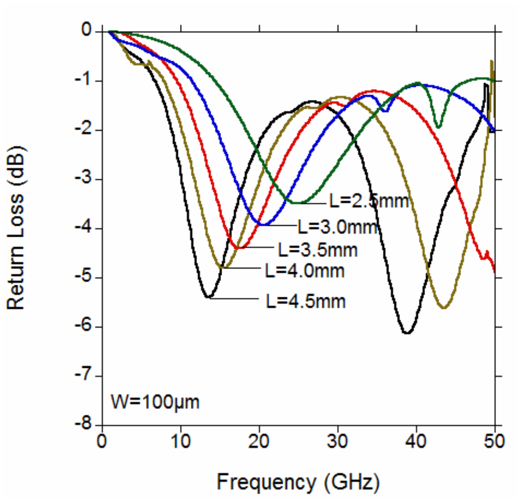
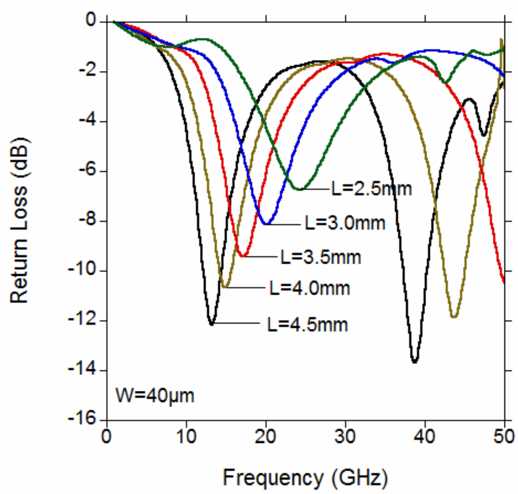


Fig. 2. Return loss characteristics as a function of frequency for various values of width. (a) L=4.5mm. (b) L=3mm. (c) L=1.5mm

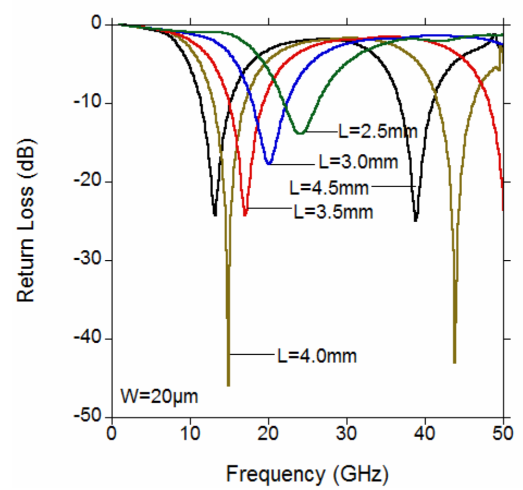
Fig. 3 shows the return loss characteristics of the antenna as a function of frequency for various values of length. It is observed that as the length increase, return loss decrease down to -47dB at 15GHz as can been seen in Fig. 3 (c). However, as expected the resonant frequency of 1st and 3rd harmonic shift toward lower frequency when the length increase.



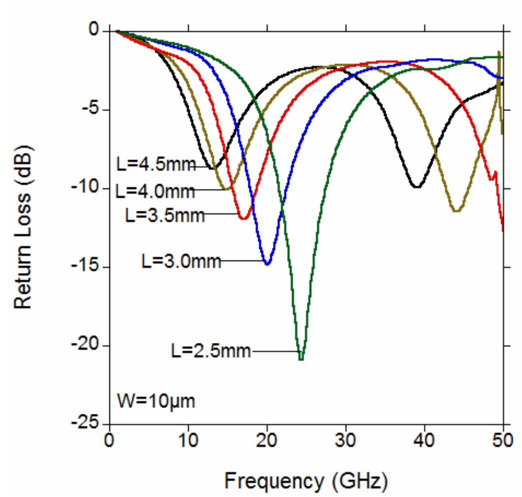
(a)



(b)



(c)

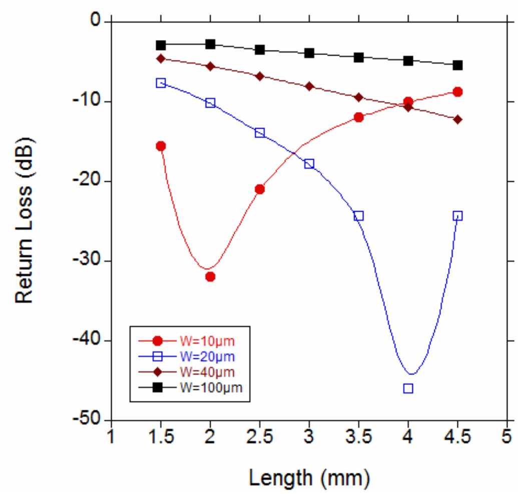


(d)

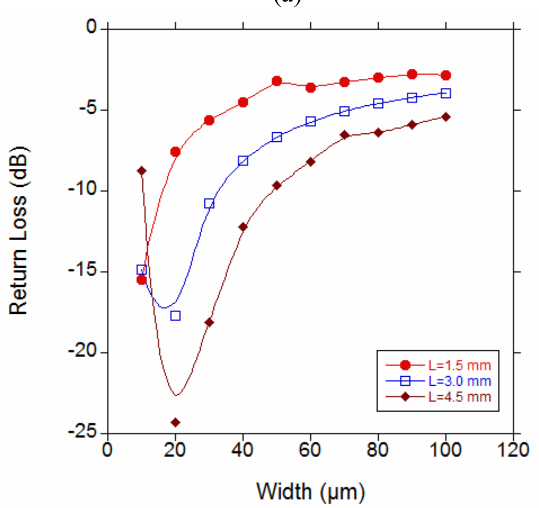
Fig. 3. Return loss characteristics as a function of frequency for various values of length. (a) W=100μm. (b) W=40μm. (c) W=20μm (d) W=10μm.

Fig. 4 (a) and (b) show that the return loss of 1st harmonic decrease when the width (W) of antenna decrease. However, it shows a maximum peak at the width of 20μm. In other hand, the return loss increase when the width of antenna is smaller than 20μm. Similar characteristics were also obtained for the 3rd harmonic.

Fig. 5 summaries the result obtained in Fig. 2 and Fig. 3. Confirmed that the desired resonant frequency can be obtained by selecting the width and length of antenna according to the obtained curve.



(a)



(b)

Fig. 4. Return loss characteristics as a function of (a) length and (b) width for various values.

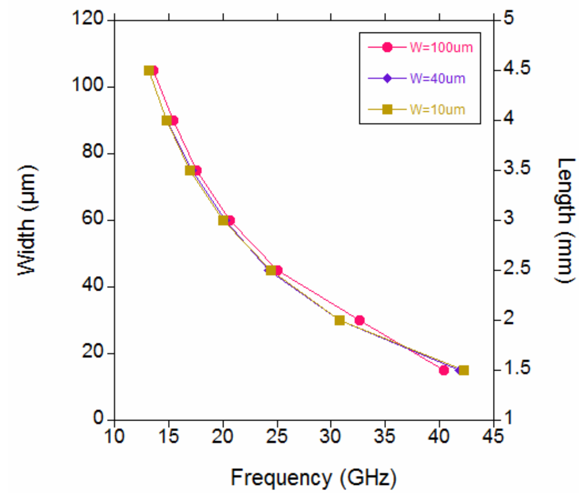


Fig. 5. The dependence of width and length of the dipole antenna**.**

4. Conclusion

In this paper, a dipole antenna with CPW-feed has been analyzed to be used in rectenna devices. To verify our simulation result, the fabrication of the antenna structure will be carried out. At this moment, the formulation for the antenna structure still in progress. The result from the fabrication process and the formulation will be presented in the conference.

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