Develop Dual-Band CPW Asymmetric Monopole Antennas on the Aluminum Oxide Substrates

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***Abstract* — A novel asymmetric unilateral monopole CPW dual-band antenna is screen-printed on the high dielectric Aluminum Oxide ceramic substrate by the screen-printing technique in this letter. Owing to the high dielectric constant ceramic substrate and asymmetric unilateral structure are used, the size of the antenna can be minimized to only 20×10.8 mm^2. The proposed antennas reveal near omni-directional radiation patterns, and the optimum measured bandwidth are 11 % (at 2.455 GHz) and 11.6 % (at 5.425 GHz), the optimum measured return loss are –21.4 dB (at 2.455 GHz) and –19.1 dB (at 5.425 GHz), respectively.**

***Index Terms* — Ceramics, CPW, dual-band, monopole, omni-directional.**

I. INTRODUCTION

With rapid progress of modern wireless communication systems in the past, much attention has been paid to miniaturization, low profile, and multi-band or wide-band operations of the wireless communication devices. In [1], the authors pointed out that for the antenna design, the CPW structures could provide a larger impedance bandwidth and low radiation loss. In [2]-[3], all the antennas were fed by the coplanar waveguide (CPW) and revealed suitable radiation patterns. In [4], dual-band operation could be easily achieved by the use of an asymmetric CPW monopole antenna. In [5], the symmetric CPW Y-shaped monopole planar dual-band antenna has been achieved by the digging of slots, which revealed good radiation patterns and bandwidth, and could be used for WLAN 5.2/5.8 GHz applications. In [6], by the use of digging a slot at the corner of the simple rectangular shaped antenna to achieve a dual wideband operation, and both of the bandwidths of low frequency and high operation frequency could up to 1 GHz. And in [7], a curved shaped antenna reveals better impedance bandwidth.

As above mentions, in this letter, for the purpose of miniaturization and dual-band operation, it was found that the CPW structure is a suitable selection for the design of coplanar antenna, and the asymmetric structure can reduce about half of the size of the antenna. In the past, most of the wireless communication devices adopted FR4 as their substrates, which exhibited lower dielectric constant and quality factor than the ceramic substrates. Hence, in this letter, an asymmetric monopole dual-band CPW antenna is developed and screen-printed on the Aluminum Oxide (Al_2O_3) ceramic substrate, and due to the high dielectric constant (ε_r=9.8) of the Al_2O_3 ceramic substrates and the unilateral asymmetric structure of the antenna are adopted, the size of this asymmetric dual-band CPW antennas could be minimized to only 20×10.8 mm^2. Furthermore, the performance of the antenna could be improved obviously owing to the high quality factor (Q×f=300,000) of the Al_2O_3 ceramic substrate too. Finally, good and near omni-directional radiation patterns of the proposed antennas could be obtained, which could be used for the modern wireless WLAN communication applications.

Ⅱ. EXPERIMENTAL AND ANTENNA DESIGN

The geometry of the proposed CPW-fed asymmetric unilateral monopole dual-band antenna is shown in Fig. 1. In addition, the ceramic substrate exhibits dielectric constant ε_r=9.8 and thickness h=1 mm. At first, the mask is fabricated according to the design patterns. And then, by the use of the mask and Ag/Pd paste, the antenna pattern is screen-printed on the Al_2O_3 substrate. After the pattern is printed, the printed pattern is fired in an oven (750ºC/30min). The SMA connector then is soldered at the fed terminal of the antenna. Finally, the characteristics of the antenna are measured by an impedance analyzer in the chamber. According to 50 Ω CPW-line, the antenna is fed with width (W_f) 1.5 mm and gap (g) 0.5 mm. The dimension of the ground plane is 2.5×7 mm^2 (L_4×W_3), and the length L_1 will affect the high frequency center frequency strongly. The other dimensions of the proposed antenna are designed as: L_2=6.5 mm, W_1=8.7 mm, L_3=4 mm, and W_2=5.8 mm, respectively.

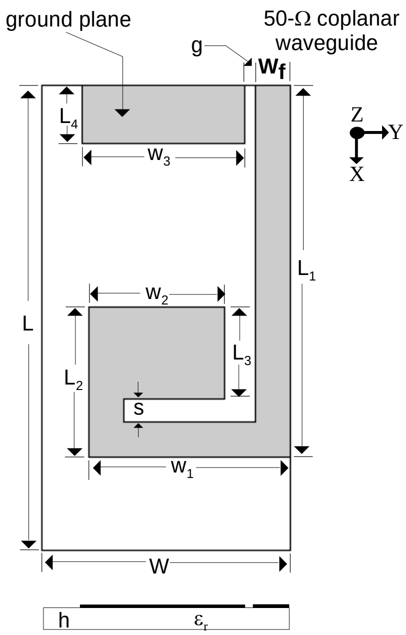

Fig. 1. Geometry of the CPW asymmetric monopole antenna.

Ⅲ. Results and Discussion

Fig. 2 shows the simulated S_{11} results of the proposed antenna due to the variation of L_1. It is found that L_1 affects high frequency (f_H) strongly, but for low frequency (f_L), no evident effect could be found, and the detailed results are shown in Table I, in addition, the other parameters of the proposed antenna are: L_2=6.5 mm, g=0.5 mm, h=1 mm, ground plane=2.5×7 mm^2, W=10.8 mm, and L=20 mm, respectively. Fig. 3 shows the optimum simulated and measured S_{11} results of this asymmetric dual-band CPW antenna, and the selected optimum parameters are: W=10.8 mm, L=20 mm, W_f=1.5 mm, g=0.5 mm, L_1=16 mm, L_2=6.5 mm, L_3=4 mm, L_4=2.5 mm, W_1=8.7 mm, W_2=5.8 mm, and W_3=7 mm. It is found that the measured f_L is 2.455 GHz (2.3~2.59 GHz) and the measured f_H is 5.4 GHz (5.11~5.74 GHz), all of them could cover the operation bands of WLAN (2.4~2.48 GHz and 5.15~5.35 GHz). The optimum simulated and measured bandwidth (BW) are 14.8 % and 11 % for f_L and 15.3 % and 11.6 % for f_H, and the optimum simulated and measured S_{11} are −22.4 dB and −21.4 dB for f_L and −35.7 dB and −19.1 dB for f_H, respectively. And the measured results are acceptable agreed with the simulated ones.

Fig. 4 shows the measured radiation patterns at the frequencies of 2.4 and 5.2 GHz. It could be observed that all of them reveal near omni-directional radiation patterns. Finally, as Fig. 5 shows, the measured peak gains for f_L and f_H are 0.2 dBi and 3.48 dBi, respectively.

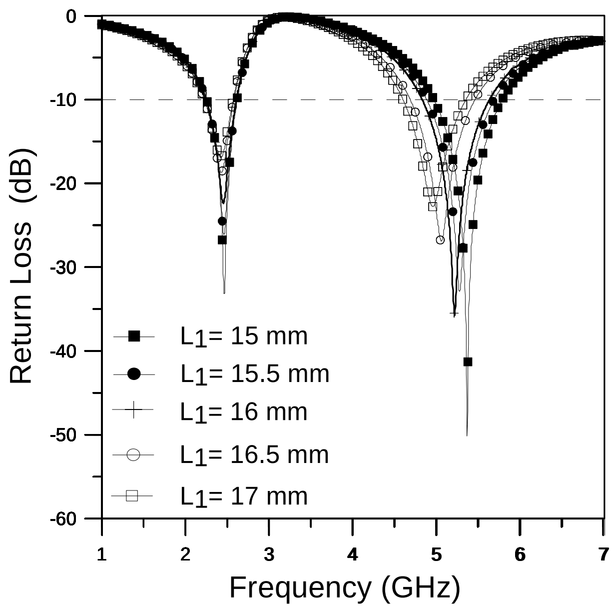

Fig. 2. The simulated S_{11} results due to the variation of L_1.

TABLE I

THE SIMULATED Results OF THE PROPOSED ANTENNA DUE TO THE VARIATION OF L_1

L_1 (mm)	f_L (GHz)	f_H (GHz)	BW of f_H (GHz/%)
15	2.47	5.38	0.82/15.2
15.5	2.47	5.295	0.81/15.3
16	2.45	5.18	0.8/15.4
16.5	2.43	5.08	0.98/19.3
17	2.42	4.98	0.76/15.3

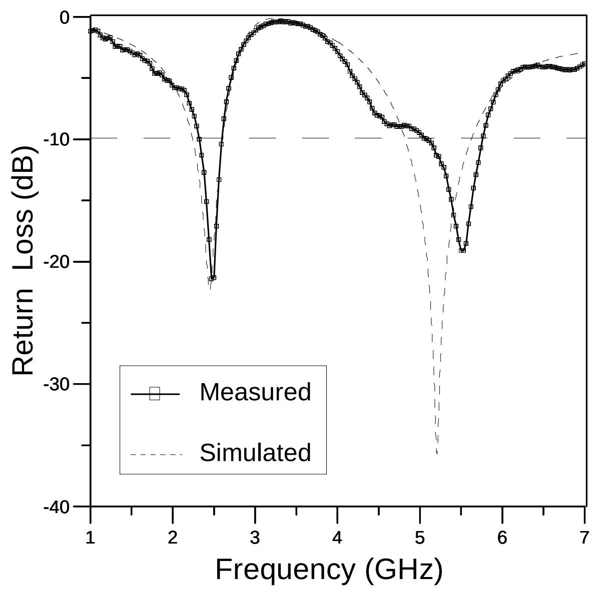

Fig. 3. The measured and simulated S_{11} results.

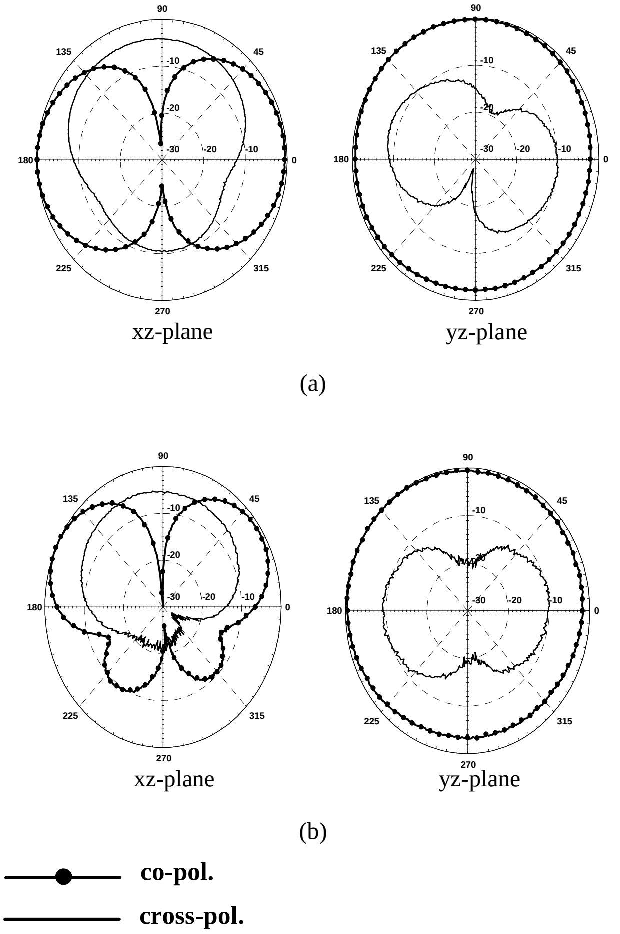

Fig. 4. The radiation patterns of (a) 2.4 (b) 5.2 GHz.

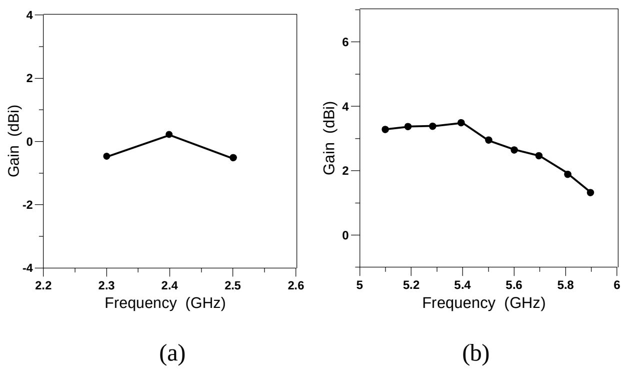

Fig. 5. The peak gains of (a) 2.3~2.5 (b) 5.1~5.9 GHz.

IV. CONCLUSION

By the use of screen-printing technique and Ag/Pd paste, a CPW-fed asymmetric unilateral monopole dual-band antenna is presented on the Al_2O_3 ceramic substrate. Owing to high dielectric constant of the ceramic substrate and asymmetric unilateral structure are adopted, the dimension of the proposed antenna could be minimized to only 20×10.8×1 mm^3. The proposed antenna reveals dual-frequency operation (2.4/5.2 GHz) and near omni-directional radiation patterns, the optimum measured bandwidth are 11 % (at 2.455 GHz) and 11.6 % (at 5.425 GHz), and the optimum measured return loss are −21.4 dB (at 2.455 GHz) and −19.1 dB (at 5.425 GHz), respectively. Hence, this antenna is suitable for the applications of modern WLAN wireless communication.

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