Gap-Coupled Miniaturized Antenna on IPD Process for WLAN Tablet Computer

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***Abstract* - This paper presents a 2.4GHz 10-inch tablet computer antenna design on IPD process. The antenna radiation efficiency and miniaturized area are optimized by metal region and clean region. The metal region comprises μm gap between the open radiating strip and the short grounded strip. The miniature 10mm × 10mm antenna area can provide 1.25dBi peak gain and 80% radiation efficiency for WLAN 2.4GHz tablet computer.**

***Index Terms* — Antenna, Miniaturized, Tablet.**

1. Introduction

In general, most of WLAN antennas are designed on PCB for low cost and easy integration for commercial applications. In order to match input impedance for miniaturization, chip capacitor/inductor is added for impedance matching [1]. As the area extension of the silicon manufacturing process, these chip antennas can be realized and capacitors/inductors are directly integrated on chip. The IPD (integrated passive device) process can achieve metal pattern with μm gap/width and nm thickness for capacitor layer, which is a low-cost and low-loss choice for WLAN antenna design. IPD antenna designs have been proposed for 60GHz band because the given area is suitable for locating several radiators [2-3]. However, the limited area (10mm × 10mm) is a challenge at 2.4GHz band for miniaturization and radiation efficiency. In previous works, most of miniature antennas on PCB can achieve about 60-70% radiation efficiency [4]; however, the miniaturized 2.4GHz IPD antenna can maintain 60% radiation efficiency [5]. In this work, the miniaturized mechanism is a coupling technique of radiator and an inductor is located on the chip. Fig. 1(a) shows that the IPD antenna is mounted on the 10-inch PCB by shorting bumps, and the coaxial line is fed on the CPW line on the PCB. Fig. 1(b) shows the coupling technique by two coupled strips, one is open radiating strip with an inductor in series and another is short grounded strip. Furthermore, the etched area is called clean region, and the IPD profile is shown in Fig. 1(c). Note that the coupled open/short strip can reduce first resonance toward low frequency utilizing magnetic coupling [6]. In addition, the proposed antenna with both appropriate metal region (coupled open/short strip) and clean region can be optimized to obtain 80% radiation efficiency.

2. Antenna Design

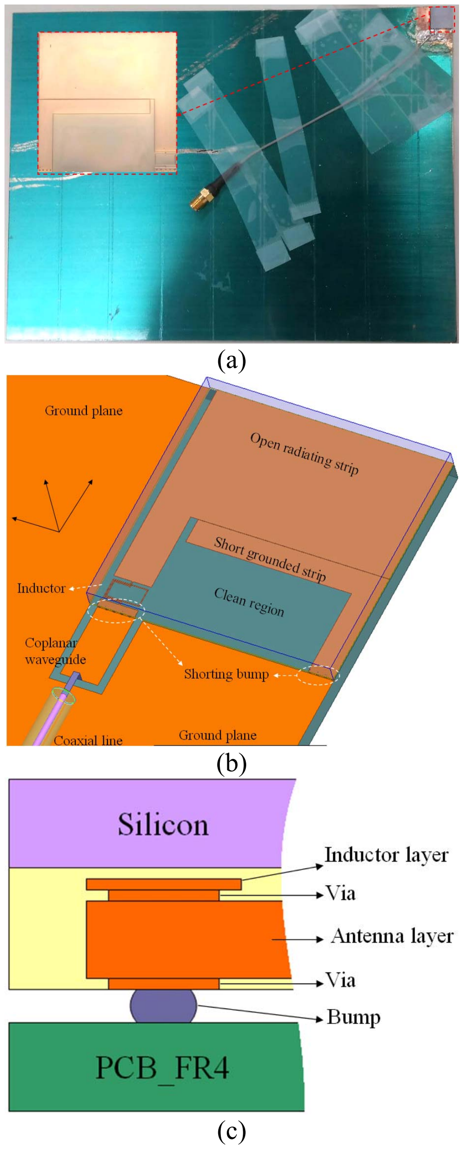

Fig. 1. Antenna geometry. (a) The IPD mounted on PCB. (b) The antenna geometry. (c) The IPD profile.

The proposed antenna for size reduction can be explained in Fig. 2. Fig. 2(a) shows a directional coupler terminated with 50Ω at all ports. Fig. 2(b) shows a band-pass filter with open port 2/4 from the directional coupler that can excite a resonance. Fig. 2(c) is the proposed resonator with port-3 shorting, and the resonance of the band-pass filter becomes a stop band and generates additive two resonances. The first t-

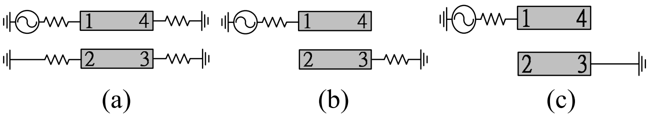

Fig. 2. The miniaturized mechanism. (a) directional coupler, (b) band-pass filter and (c) proposed resonator.

wo resonances are lower and upper than the stop-band frequency, respectively. The miniaturized mechanism of proposed resonator can reduce the first resonance utilizing gap coupling between the open radiating strip and the short grounded strip. In other words, the first resonance is limited by the gap width of manufacturing process.

In the commercial PCB designs, additive pi-/tee-matching networks utilizing chip capacitor/inductor is used for antenna matching. However, the proposed IPD antenna can directly utilize μm gap between open and short coupled strip and chip inductor. Therefore, the proposed antenna is achieved by 10mm × 10mm antenna size.

In additions, in order to maintain the antenna radiation efficiency in a finite area, not only the large clean region but large metal region is required for optimization. Consequently, the appropriate metal region and clean region are 5.2mm × 9.4mm and 3.5mm × 6.9mm, respectively. Therefore, the antenna radiation efficiency can achieve about 80%.

Fig. 3 shows the measured and simulated return loss. Note that the simulated result has the wider 2.4-2.58GHz bandwidth; however, the measured result covers WLAN 2.4-2.5GHz bandwidth. The reduced bandwidth is inferred due to the stress of the flexible coaxial line and the stress of the IPD bump mounted on the PCB.

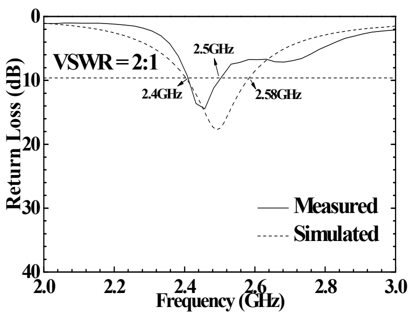

Fig. 3. The antenna return loss.

3. Radiation characteristics

The radiation characteristics are measured by a 2-D far-field chamber. The 2-D antenna radiation pattern in Fig. 4 shows the good agreement with measured and simulated result. Fig. 5 shows the measured antenna peak gain is 1.25dBi at 2.44GHz, and the simulated antenna radiation efficiency is about 80% in WLAN operating band. The 2-D measurement cannot obtain enough data for radiation efficiency; however, the full-wave solver HFSS has a good estimation for radiation efficiency in RF band.

4. Conclusion

A 2.4GHz 10-inch tablet computer antenna is designed on IPD process. The radiation efficiency and miniaturized area can be, respectively, optimized by the appropriate metal/ clean region and μm gap between coupled open/short strip. The 10mm × 10mm antenna area can provide 80% radiation efficiency and 1.25dBi peak gain for WLAN 2.4GHz impedance bandwidth.

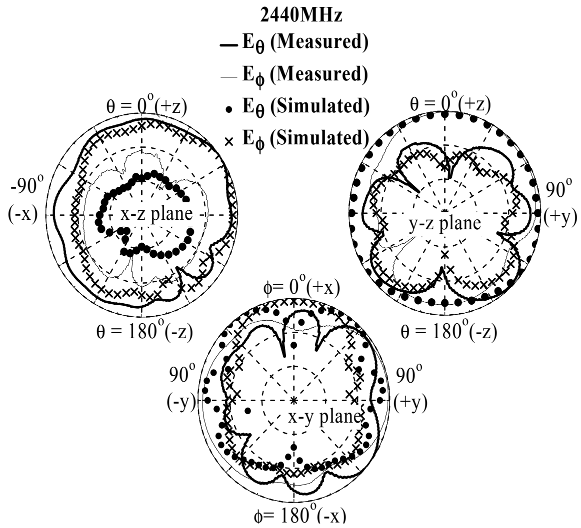

Fig. 4. The 2-D antenna radiation pattern.

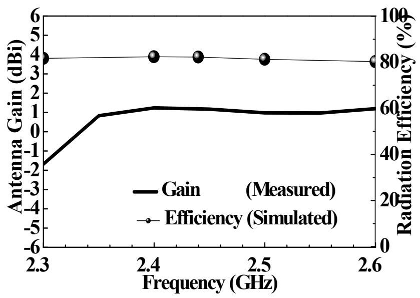

Fig. 5. The antenna peak gain and radiation efficiency.

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