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BANDWIDTH ENHANCEMENT ANTENNA USING HIGH PERMITTIVITY CERAMIC AND FR4 STACKED STRUCTURE

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1. Introduction

The microstrip patch antennas with high-permittivity material [1] have been proposed to be very effective for antenna size reduction. However, the impedance bandwidth obtained for such a microstrip patch antenna is usually very narrow and the antenna gain is also significantly decreased, which severely limits its practical applications. Therefore, the enhancement of the bandwidth and gain of a microstrip patch antenna with high-permittivity material is highly desirable. Much work has been devoted to increasing the bandwidth of microstrip antenna, and a extensively used technique is to increase the electrical thickness of the substrate [2].

Other techniques were proposed to broaden the bandwidth of patch antennas, including the use of multiplayer structure, as in stacked patch antennas [3]; the use of parasitic elements [4]; the use by modifying the inductance or capacitance of the radiating edges [5]; the use of L-probe proximity coupling [6]; and the use of U-slots in the patch [7]. In this study, the bandwidth enhancement of microstrip antenna with a 50Ω feed-line is reported. It is found that, by stacking two FR4 layer with a ceramic layer and adjusting two patches on the both sides of the high dielectric ceramic, the bandwidth and antenna gain can be enhanced. This is caused by that two similar radiation characteristics can be excited at frequencies close to each other. Thus, a wider impedance bandwidth formed by the two closely excited resonant modes is obtained. In this study, we present an enhanced bandwidth and good radiation of stacked patch antenna structure. Details of the proposed stacked antenna and experimental results are presented and discussed.

2. Antenna Design

The configuration of the stacked patch antenna is shown in Fig. 1. The stacked patch antenna consists of three layers. The top layer is a high-permittivity $BiNbO_4$ ceramic substrate (ε_r = 43) with a thickness of 2 mm, and is printed a rectangular patch with the dimensions of $L_1 \times W_1$ mm^2. The middle layer is a FR4 (ε_r = 4.2, h = 0.8 mm) substrate, and is printed a rectangular patch with the dimensions of $L_2 \times W_2$ mm^2. The bottom patch is proximity fed by a 50Ω stripline, which has a width of W_f (= 1.58 mm) and is fabricated on a grounded FR4 (ε_r = 4.2, h = 0.8 mm) substrate. For best impedance match, it is found that the end of the stripline has to extend beyond the radiating edge of the rectangular patch of top layer by L_x mm. Table 1 provides the dimensions of the two-layered patch antenna (one FR4 layer and one ceramic stacked, Antenna A) and the stacked patch antenna (two FR4 layer and one ceramic stacked, Antenna E).

3. Experimental Results And Discussion

Fig.2 shows the measured return loss for the antennas shown in Fig. 1. For Antenna A, only one TM_{10} mode is excited and only one frequency is excited. The impedance bandwidth, determined from 10 dB return loss, is 57 MHz (2406 - 2463 MHz) and the maximum return loss is 22.3dB. For Antenna E, the upper rectangular patch on the high-permittivity $BiNbO_4$ ceramic substrate is excited by the electromagnetically coupled from the lower rectangular patch. Both the upper and lower rectangular patches are driven in such a manner that TM_{10} mode is excited. Carefully adjusting the sizes of both upper and lower patches, an antenna with high return loss and two resonant modes excited at close frequencies can be obtained. As Fig.2 shown an optimum designed antenna with the broadband impedance bandwidth of 111 MHz (2384 - 2495 MHz) can be obtained. These results indicate that the impedance bandwidth can be enhanced from 2.3% (Antenna A) to 4.5% (Antenna E) by using stacked patches. The obtained bandwidths cover the bandwidth requirement (2400 - 2484 MHz) for wireless LAN application.

Radiation patterns for the frequencies within the obtained wide impedance bandwidth are also measured, and good broadside radiation patterns are obtained. Fig.3 shows the radiation patterns of Antenna E at the two resonant frequencies of 2411 and 2467 MHz. It verifies that the two frequencies have the same polarization planes and similar broadside radiation patterns. The antenna gain is measured by comparison with a calibrated standard horn. The results are shown in Fig.4. In the frequency range 2384 - 2495 MHz, where the return loss is below –10 dB, the gain is above 2.5 dBi within the whole range and a deviation less than 1.6 dBi.

4. Conclusions

Although the patch dimensions of microstrip Antenna A have a small size of 18 x 12 mm^2, the 57 MHz (2.3%) of impedance bandwidth is insufficient for wireless LAN application (2400 - 2484 MHz). In this study, the 111MHz (4.5%) of impedance bandwidth in the stacked structure are sufficient and cover the bandwidth requirement for wireless LAN application.

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Table 1 Dimensions of the fabricated single-layered patch antenna (A) and stacked patch antenna (E)

Antenna	L_1 (mm)	W_1 (mm)	L_2 (mm)	W_2 (mm)	L_x (mm)
A	12.0	18.0	-	-	5.3
E	11.5	17.3	29	35	6.5

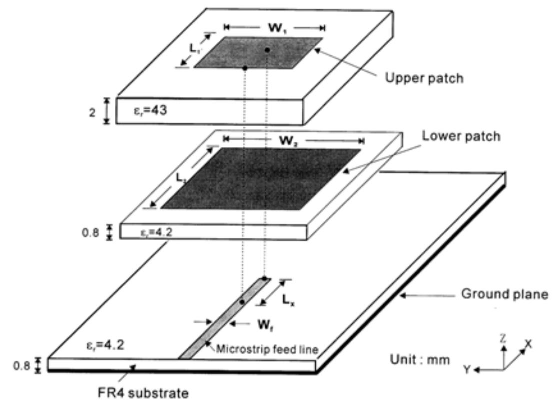

Fig.1 Geometry of the stacked patch antenna with high permittivity ceramic substrate.

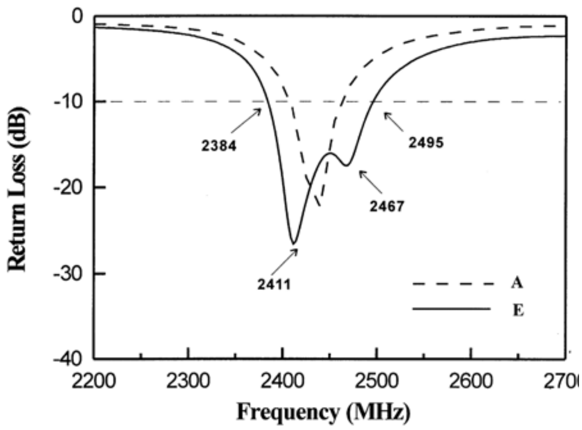

Fig.2 Measured return loss (S_{11}) against frequency for the different antenna (A: no-stack, E: stacked)

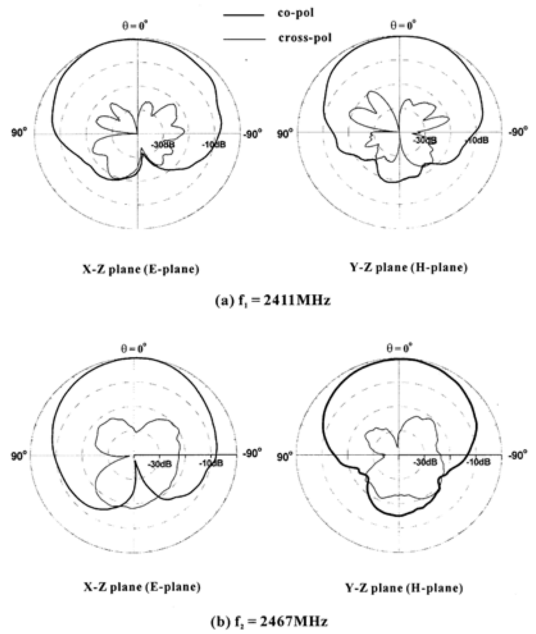

Fig.3 Measured radiation patterns at 2411 and 2467 MHz for the antenna E.

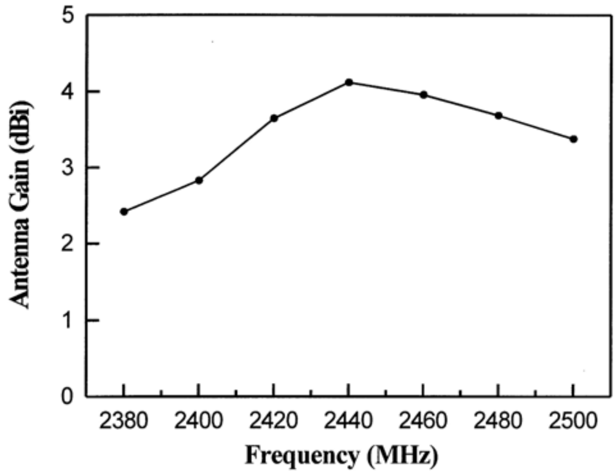

Fig.4 Measured antenna gain in the broadside direction against frequency for the antenna E.