A 42-GHz Wideband Cavity-Backed Slot Antenna with Thick Ground Plane

Jong-Moon Lee, Young-Heui Cho, Cheol-Sig Pyo, and Ik-Guen Choi

ABSTRACT—We investigate the characteristics of a wideband and high-gain cavity-backed slot antenna in terms of the reflection coefficients, radiation patterns, and gain. A cavity-backed slot antenna structure includes baffles, reflectors, and thick ground planes. The measured gain and bandwidth of a 10-dB return loss in a cavity-backed 2×2 array slot antenna with $h_1 = 2$ mm, $d = 2$ mm are 15.5 dBi and nearly 27%, respectively, at 42 GHz. Baffles and reflectors are used to increase antenna gain, thus reducing the coupling among the slots on the thick ground plane.

Keywords—Slot antenna, wideband, microstrip antenna, thick ground plane.

I. Introduction

The active integrated antenna is an interesting subject of study with many examples and has been a growing area of research in recent years [1]. For the integration of a high power amplifier and aperture-coupled patch antenna, a thick ground plane is necessary for heat dissipation [2]. A microstrip line facilitates the integration of these active devices. The stripline planar array antenna for 12-GHz satellite TV has the form of a stripline for waveguide transition [3]. The impedance bandwidth was improved by using grounded metal baffles [4]. The effect of the reflector dimensions (depth and width) on antenna characteristics is significant, especially on the axial ratio and center frequency [5]. Also, the structure of the high

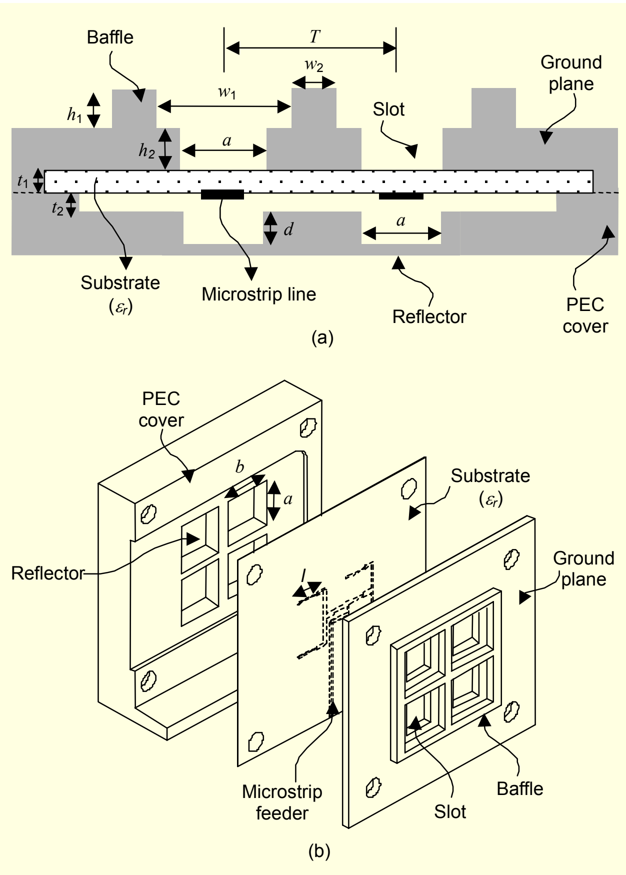

Fig. 1. Geometry of a 2×2 cavity-backed slot array antenna: (a) side view and (b) perspective view, where $a = 4$ mm, $b = 3.5$ mm, $w_1 = 6$ mm, $w_2 = 1$ mm, $T = 7$ mm, $d = 2$ mm, $h_1 = 2$ mm, $h_2 = 1$ mm, $l = 1.5$ mm, $t_1 = 0.127$ mm, $t_2 = 0.5$ mm, and $\varepsilon_r = 2.2$.

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gain antenna introduced experimentally the effect of a superstrate layer for high gain on a microstrip patch antenna [6]. In this letter, we describe a feasible structure for the easy design of an active integrated antenna and the characteristics of a wideband slot antenna with a reflector and baffle.

II. Design of Cavity-Backed Slot Antenna

Figure 1 illustrates the geometry of the 2×2 cavity-backed slot array antenna at 42 GHz. The microstrip feeder, shown in Fig. 1(b), is fabricated on a Rogers RT/duroid 5880 (ε_r=2.2, thickness=0.127 mm) substrate. Note that the microstrip feeder, shown in the dashed line in Fig. 1(b), is placed on the bottom side of the substrate. The distance between the baffle and reflector, $d+h_1+h_2$, is determined using $d+h_1+h_2 \approx \lambda_g/4$, where λ_g is the guided wavelength for the TE_{10} mode and f= 42 GHz. We assume that the TE_{10} mode is excited within both the baffle and reflector, as shown in Fig. 1. The length of the microstrip probe, l in Fig. 1(b), is obtained using $l \approx \lambda/4$, where $k=\omega\sqrt{\mu_o\varepsilon_o\varepsilon_r}=2\pi/\lambda$.

We chose a 0.1 mm-width microstrip probe in order to improve the reflection characteristics. We optimized the dimensions of the baffle as $w_2+h_1+h_2 \approx \lambda_o/2$ and selected the distance between slots as $T \approx 1\lambda_o$ in terms of the antenna gain and sidelobe level.

This antenna structure obtained more wideband characteristics than a conventional aperture coupled antenna, and it improved antenna gain, therefore reducing the level of the side and back lobes. The fabrication cost of this antenna is lower than that of other microstrip antennas because it was designed using a single substrate without a ground plane.

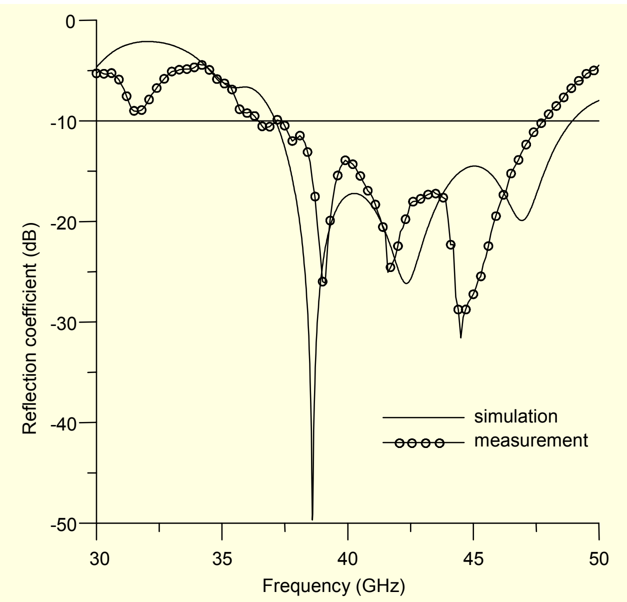

Fig. 2. Behavior vs. frequency of the reflection coefficient for a 2×2 cavity-backed slot array antenna.

III. Experimental Results

The proposed slot antenna in Fig. 1 is simulated using CST MicroWave Studio 4.2 based on the finite integration method. The far-field measurements were performed in an anechoic chamber. Figure 2 presents the behaviors of the simulated and measured reflection coefficients for the 2×2 cavity-backed slot

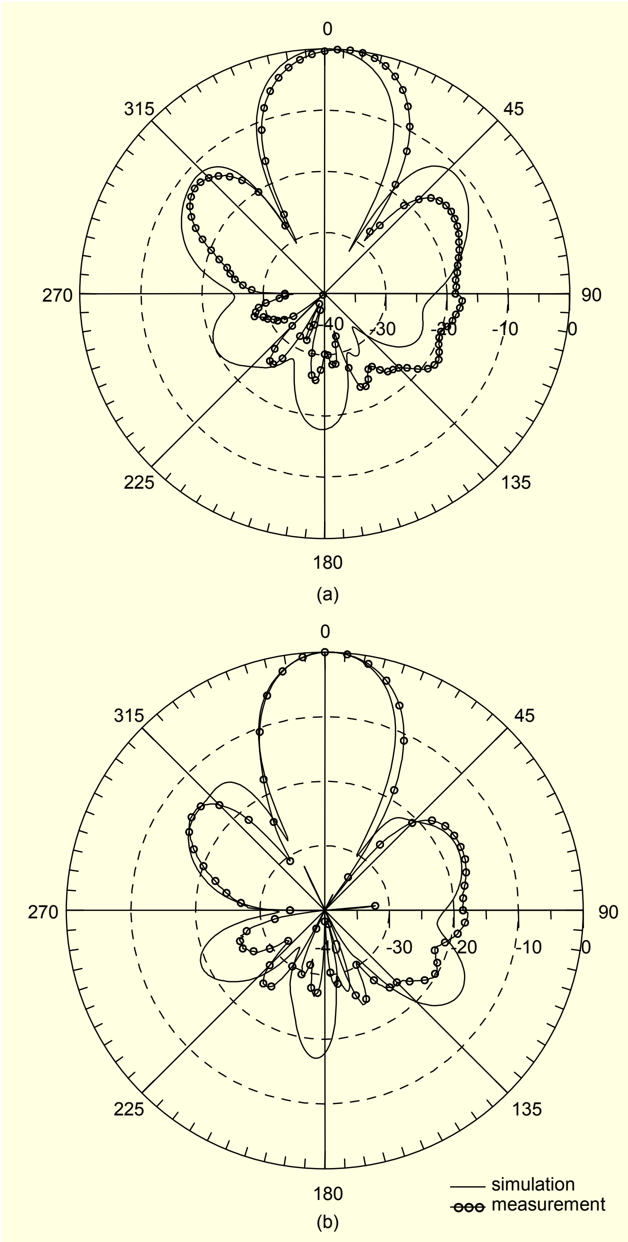

Fig. 3. Behaviors of radiation patterns at 42 GHz in (a) H-plane radiation and (b) E-plane radiation.

array antenna. The measurements indicate that the approximate bandwidth of a 10-dB return loss is 11.4 GHz (36.5 to 47.8 GHz), which is almost 27% at a center frequency of 42 GHz. The measured bandwidth of a 10-dB return loss of the cavity-backed slot antenna where $h_1=0$ mm and $d=2$ mm is almost 31% at 42 GHz.

Figure 3 shows the radiation patterns in the *H*- and *E*-planes at $f=42$ GHz for the 2×2 cavity-backed slot array antenna. The simulated results of the radiation patterns agree with those obtained by the far-field measurements. In the measured antenna gain of the 2×2 cavity-backed slot array antenna, $h_1=2$ mm, $d=2$ mm and $h_1=0$ mm, d$=2$ mm are 15.5 dBi and 12.55 dBi, respectively, when $f = 42$ GHz. Note that the simulation, not considering the loss tangent of the substrate, gives the antenna a gain of 16.1 dBi while the measured loss of the microstrip feeder is about 0.6 dB. The measured cross-polarization level is –27 dBi when $f=42$ GHz.

IV. Conclusion

In conclusion, the baffle in a ground plane enhances the antenna gain by about 3 dBi. The reflector within a PEC cover improves the reflection and radiation characteristics of a wideband cavity-backed slot antenna. The PEC cover also suppresses the surface wave scattering from the substrate, due to the perfect shielding of the microstrip feeder.

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