

Design of Package Cover for 60 GHz Small Antenna and Effects of Device Box on Radiation Performance

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Abstract- This paper shows the simulated performance of the small antenna with the effects of the package cover and the device box at 60 GHz band. The total thickness of the package has been reduced from 2.6 mm to 1.4 mm by using the designed cover. The gain is enhanced and the reflection is suppressed lower than -15 dB by using different ways of packaging. On the other hand, the small antenna is put in a 120 mm x 75 mm x 30 mm polycarbonate box in simulation. The radiation performance due to the dielectric box case in practical device has also been simulated and discussed.

I. INTRODUCTION

In millimeter wave applications, the performance of the small antennas for the mobile terminals is sensitive in package surroundings. For instance, the ways of setting the antenna redome and the effects of the cover or the device box will both affect the antenna performance. In order to meet the requirements of the practical commercial systems, it is important to optimize the effects of the surroundings in antenna design.

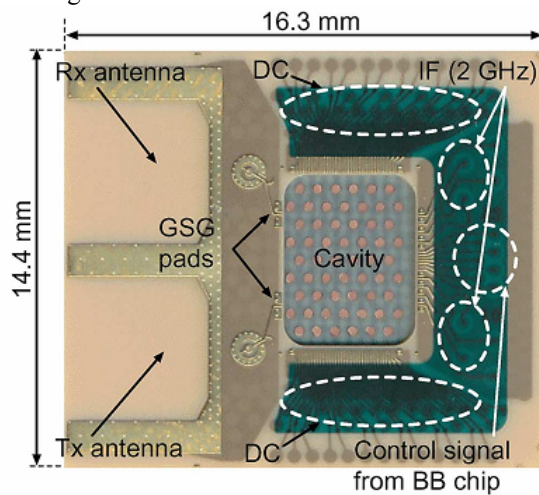


Figure 1. Photo of unpackaged antenna.

The authors take the example of the 60GHz small package with an end-fire radiation antenna [1], [2] to discuss the affects of the antenna cover and the device box in practice. Figure1 shows the photo and the size of the antenna. The side view of the configuration of the small antenna is shown in Fig.2. The 60GHz CMOS chip was mounted in the package made of low-cost, multilayered substrate and connected to the antenna by bonding wires or by the flip chip. The feeding circuit of the

antenna was made of a microstrip line (MSL) layer and a post-wall waveguide layer. The power is radiated from the side face of the substrate with the end-fire radiation direction.

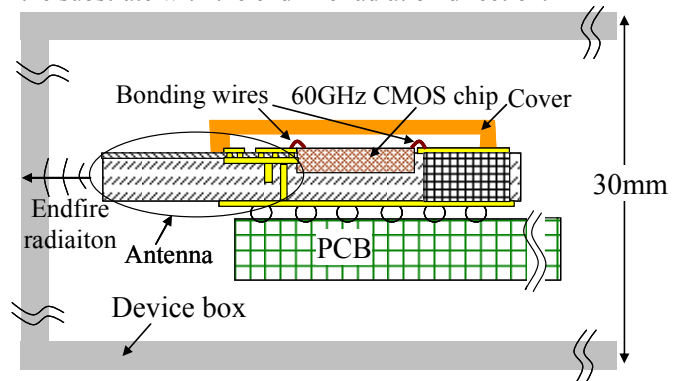


Figure 2. Side view of antenna package in device box

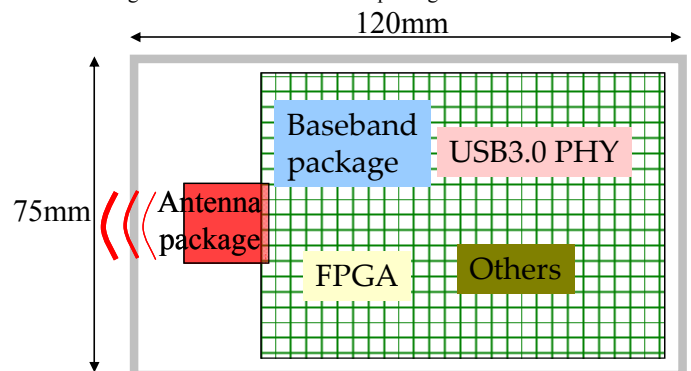


Figure 3. Antenna package mounted on PCB with other circuits in device box (Approximate size of the device box: 120mm x 75mm x 30mm)

In the practical device, this antenna should be covered and mounted on PCB with other circuits as Fig.3.[3] The performance of the antenna will be affected by these surroundings. These influences should be estimated in advanced. On the other hand, it can also be utilized to enhance the performance of the antenna. In this paper, the gain enhancement and the reflection suppression affected by the cover using four different ways of packaging have been shown. The affect of the thickness of the cover and the cover position has been discussed. The radiation performance due to the dielectric box in practical mounting has also been simulated and discussed.

II. GAIN PERFORMANCE WITH PACKAGE COVER

Usually the package cover is used to protect the chip, the printed circuits and the bonding wires in the package. However, the performance of the small antenna is affected by the package cover. In other words, it can be utilized to facilitate fine adjustments on the antenna performance in packaging. Generally, the cover is the thinner the better and it is better to keep a stable performance in the antenna gain at certain frequency band.

TABLE I
DIFFERENT COVERS

Case No.	Schematic diagram	Total thickness
① w/o cover		1mm
② 1.6mm cover		2.6mm (cover 1.6mm)
③ 0.4mm cover		1.4mm (cover 0.4mm)
④ two-step cover		1.4mm (cover 0.4mm)

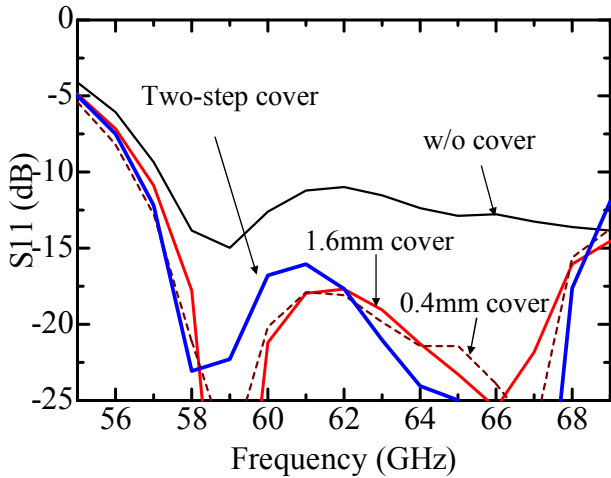


Figure 4 Reflection with different covers

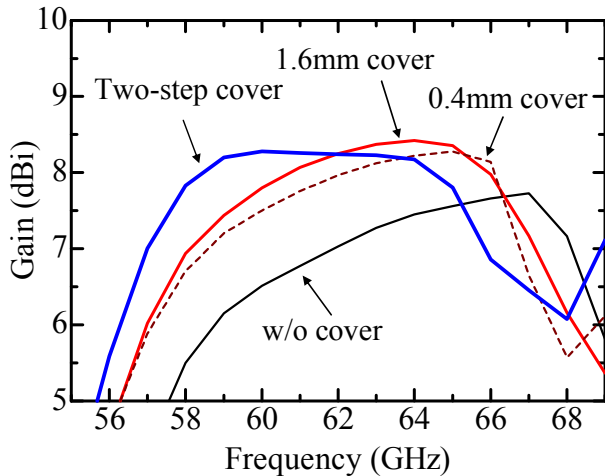


Figure 5 Gain with different covers

In table I, Case ① to Case ④ show the schematic diagrams and estimated total thickness of the antennas respectively. The location of the antenna part in the package is shown in Fig.2. Case ① is the 1mm-thick unpackaged antenna without cover. Case ② is the 2.6mm-thick conventional antenna package with 1.6mm cover. Case ③ and Case ④ reduce the cover thickness to 0.4mm. Case ③ is the 1.4mm-thick antenna package with 0.4mm cover. Case ④ is the antenna package with a two-step cover. The input impedance is set as 50Ω in the input GSG pad in the simulation. The covers are set between the postwall waveguide and the slab waveguide in order to suppress the higher mode in transition.

Figure 4 and 5 show the estimated reflection and gain. The package covers increase the effect radiation area in thickness and enhance the gain of the antenna. The reflection S11 has been suppressed from -10 dB to -15 dB since the higher order mode is suppressed. According to the S11 and gain of Case ② and case ③, a thinner cover reduces the total thickness of the antenna while the antenna performance of the main beam does not change so much. On the other hand, a two-step cover as case ④ is introduced to enhance the gain in lower frequency band and get a small variation in gain characteristic. However, it results the impact by the higher order mode in higher frequencies.

Assuming 1W excitation, Fig. 6 shows the simulated far field radiation pattern at 60 GHz in the linear scale. The antennas are holding an end-fire radiation in the main beam while the side lobes and the backward radiation are affected by different covers.

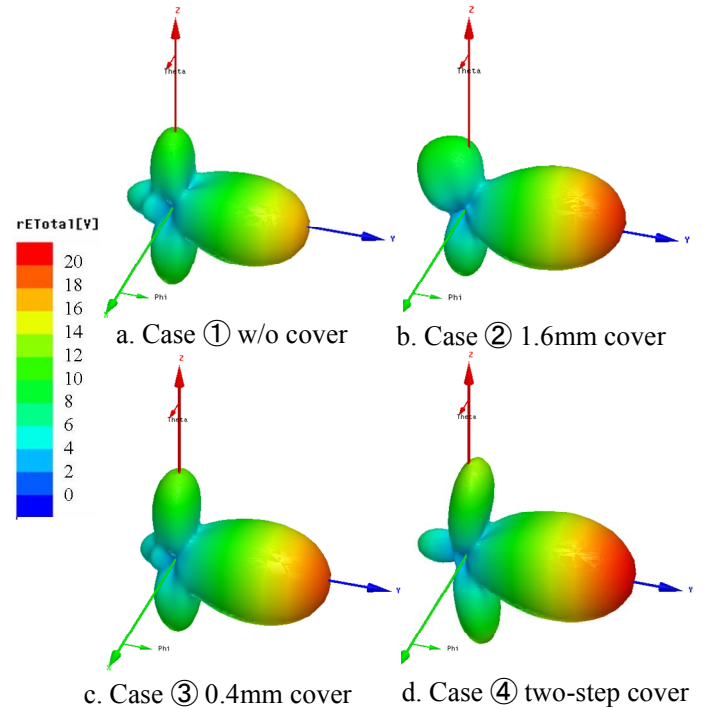


Figure.6 Far field radiation pattern of antenna package at 60GHz

III. EFFECTS OF DEVICE BOX

In the practical device, the antenna performance is also largely affected by the device box. For instance, in the demonstration system of Sony[3], this antenna package is put at the edge of a rectangular polycarbonate box with 120mm long, 75mm wide and 30mm high. Figure 7 and 8 show the estimated reflection and gain of the antenna packages with the consideration of this condition. Figure 9 shows far field radiation pattern at 60 GHz. Compare with the w/o box cases in Sect.II, it affects little to the reflection while largely to gain and radiation pattern. The antenna with the two-step cover has a higher gain and can hold a flat gain performance in two channels of 60 GHz system.

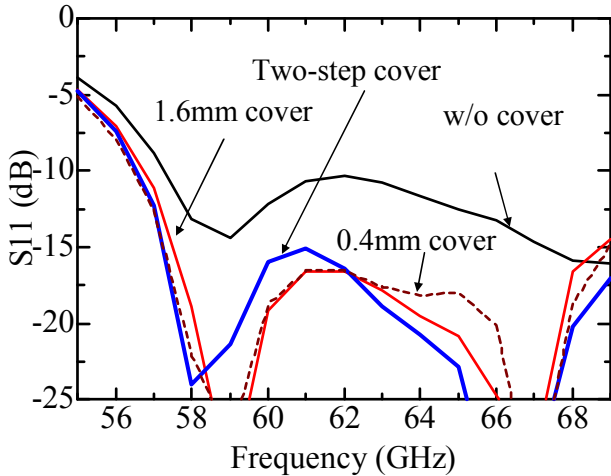


Figure 7. Reflection with different covers in polycarbonate box

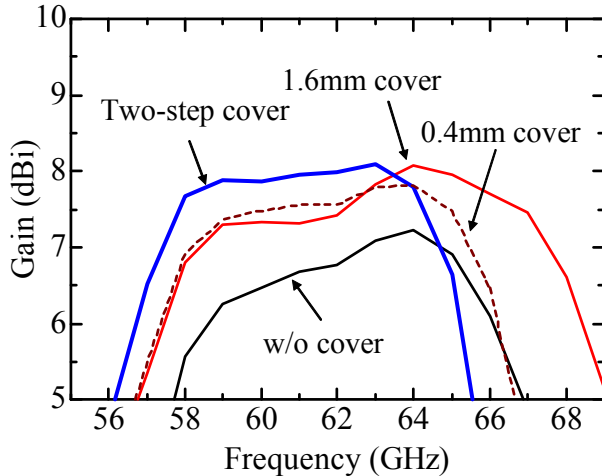


Figure 8. Gain with different covers in polycarbonate box

IV. CONCLUSIONS

Effects of the package cover and the device box on the radiation performance both should be estimated and it can also be utilized to enhance the performance of the antenna. By optimizing the cover, the authors designed the thin cover to reduce the total thickness of the antenna from 2.6 mm to 1.4 mm with at most 2 dBi gain enhancement and the reflection kept suppressed lower than -15 dB. The radiation performance

is also affected by the dielectric box in the practical device. The small antenna is put in a 120 mm x 75 mm x 30 mm polycarbonate box in simulation. The overall optimization as well as the experimental verification is left for the future study.

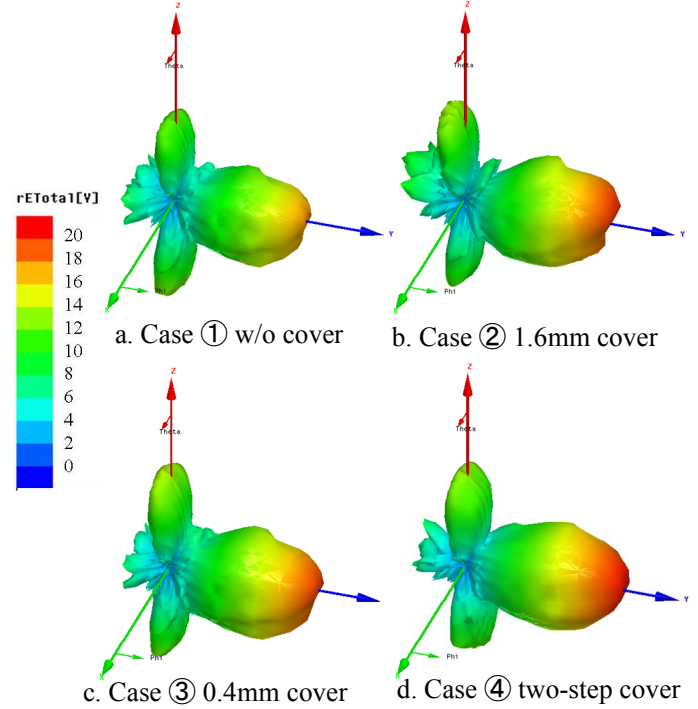


Figure.9 Far field radiation pattern of antenna at 60GHz in polycarbonate box

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