行政院國家科學委員會專題研究計畫 成果報告行政院國家科學委員會專題研究計畫 成果報告行政院國家科學委員會專題研究計畫 期中進度報告

適用於超寬頻通訊系統與新型感知通訊之射頻前端電路設計 2&3

研究成果報告(精簡版)「數學教/學案例」在數學師資培育之應用(第 1 年)

期中進度報告(精簡版)國際數學與科學教育成就趨勢調查 2007(4/4)甲

研究成果報告(完整版)

計 畫 類 別 ： 個別型個別型個別型
計 畫 編 號 ： NSC 97-2221-E-009-002-NSC 96-2628-S-415-002-MY2NSC 97-MOE-S-003-003-
執 行 期 間 ： 97 年 08 月 01 日至 98 年 10 月 31 日 96 年 08 月 01 日至 97 年 07 月 31 日 97 年 04 月 01 日至 98 年 09 月 30 日
執 行 單 位 ： 國立交通大學電信工程學系（所）國立嘉義大學數學教育研究所國立臺灣師範大學地球科學系（所）

計 畫 主 持 人 ： 周復芳姚如芬張俊彥
共同主持人：共 王健仁楊德清張幼賢、楊文金、洪志明、左台益、譚克平
同主持人：共同 曹博盛、張文華、許瑛玿、楊芳瑩、吳心楷
主 持 人 ： 楊瑞智、呂玉琴、林碧珍、李源順、任宗浩
張美玉、李哲迪
計畫參與人員： 此計畫無其他參與人員

報告附件：報告 出席國際會議研究心得報告及發表論文
附 件 ： 報 告 附 國外研究心得報告
件 ： 出席國際會議研究心得報告及發表論文
國外研究心得報告

出席國際會議研究心得報告及發表論文

處 理 方 式 ：本計畫可公開查詢期中報告不提供公開查詢本計畫可公開查詢

中 華 民 國 99 年 04 月 27 日 97 年 03 月 28 日 98 年 12 月 31 日

適用於超寬頻通訊系統與新型感知通訊之射頻前端電路設計

2&3- MEMS Planar Monopole Antenna for UWB Application - 結案報告

Abstract— **In this research, a compact micromachined planar monopole antenna is demonstrated. A high coupling structure is formed on the patch to offer better impedance matching in order to maintain UWB characteristics. The proposed antenna is fabricated on the HRS substrate (ρ_s = 15000 Ω -cm). The proposed antenna has shown a promising feature for the UWB system application.**

Index Terms—**MEMS, micromachining, UWB.**

I. Introduction

In recent years, the development of Ultra wideband (UWB) technology has grown rapidly. Various applications in different fields, such as domestic, military, and industrial have take the advantages of the wide impedance characteristic of UWB communication systems. For the federal communication commission (FCC)'s suggestion of UWB service applications [1], numerous research in UWB antennas have been proposed. A planar monopole antenna is one of the most commonly used antenna types for UWB applications owning to following attractive features such as simple structure, low profile, wide impedance-bandwidth and omnidirectional radiation patterns [2-5]. Another important system requirement on today's antenna is integrability [6]. The demand on the integrability implies the use of silicon as the substrate material, as it is the most common element in VLSI technology.

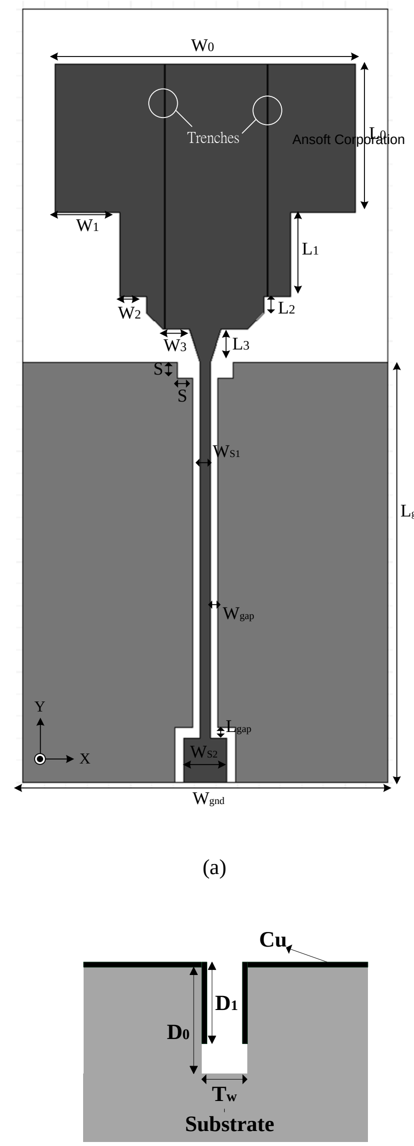
This paper presents a novel planar monopole patch antenna using MEMS technology for UWB radios. The proposed antenna consists of trench structure with high electric field coupling structure to provide better impedance matching in desire bandwidth. All simulations have been carried out with the Ansoft HFSS v11 software. The proposed antenna is fabricated on high-resistivity silicon (HRS) substrate which the fabrication process of the antenna is considerably simple and compatible with the CMOS fabrication process.

II. Antenna Design

The geometry of the proposed micromachined planar monopole antenna for ultra-wideband (UWB) application is shown in Fig. 1(a). As shown in fig. 1(a), the antenna is designed through the optimization of the bevel angle on the radiating patch and two high coupling slots on the patch. Both the beveling and high electric field coupling slot technique on the radiating patch are utilized to improve bandwidth characteristic over the desired frequency band. In addition, ground plane also has bevels for better impedance matching. The CPW-fed is utilized in this design. The radiating patch, the ground plane, and the signal line are all fabricated in the same surface on 525 μm-thick HRS substrate with dielectric constant of 11.9. The simulation is conducted using Ansoft High Frequency Structure Simulator (HFSS). The overall size of the proposed antenna is $35 \times 17\ mm^2$. The optimized dimensions of the proposed antenna are shown in following : W_0 = 14 mm, L_0

Manuscript received October 9, 2001. (Write the date on which you submitted your paper for review.) This work was supported in part by the U.S. Department of Commerce under Grant BS123456 (sponsor and financial

= 6.7 mm, W_1 = 3 mm, $W_2 = W_3$ = 1.25 mm, L_1 = 3.8 mm, L_2 = 0.75 mm, L_3 = 1.5 mm, L_{S2} = 2 mm, W_{GAP} = 0.4 mm, W_{S1} = 0.5 mm, W_{S2} = 2 mm, L_{GAP} = 0.5 mm, L_{GND} = 19mm, W_{GND} = 17 mm, and S = 0.7 mm. The cross-section view of the slot structure is shown in fig.1 (b). The designed geometric parameters of the slot are T_W = 20 µm, D_0 = 200 µm and D_1 = 80 µm. T_W is the slot width, D_0 represents the slot depth and D_1 is overlapped metal length within the slot.



(b)

Fig. 1. Schematic view of the MEMS planar monopole antenna (a) Top view (b) cross-section view of the trench structure

III. Fabrication

The proposed antenna in this work is fabricated on 525-µm-thick high resistivity silicon (HRS) substrates (ρ_s = 15000Ω -cm). Fig.10 illustrates the fabrication process flow of the antenna. In order to fabricate the antenna; firstly, the desired trench position is defined by photolithography then the trench is formed through Inductively Coupled Plasma (ICP) etching [see Fig. 8(b)]. The etching selectivity between photoresist and silicon is 1:50, therefore the desired 250 µm trench depth can be easily achieved. Thirdly, metallization is firstly done through sputtering technology, a thin 200 nm titanium-adhesion-layer and a 500 nm copper-seed-layer will be sputtered [see Fig. 8(c)]. In the next step, the desired metal deposited position is patterned by the use of photoresist AZ 4620, then followed by the electroplating of Cu about 2µm [see Fig. 8(d)]. In the last step, the metal layer above the unwanted position is removed by using "lift-off" technology to remove the photoresist at the unwanted position together with the metal above it, then the removal of Cu will be executed by the use of Cu stripper which removes the Cu in the unwanted position [see Fig. 8(e)]. The fabricated process of the proposed antenna is considerably simple in which only two masks are required. Moreover, it can be done through standard CMOS process, showing the advantage of capability of system on chip (SOC).

IV. Results and Conclusions

In the measurements, the proposed antenna should be fed with a 50-Ω SMA connector at the end of the CPW-fed. However, owing to the mistake in designing the CPW-fed, the SMA connector cannot be soldered on the fed-in side. The photograph of the fabricated antenna is shown in fig. 3(a) and the microphotograph of the trench in the cross-sectional view is shown in fig. 3(b). In this research, only simulation results are carried out. Fig. 4 shows the simulated return loss of the proposed antenna. The proposed antenna has shown the

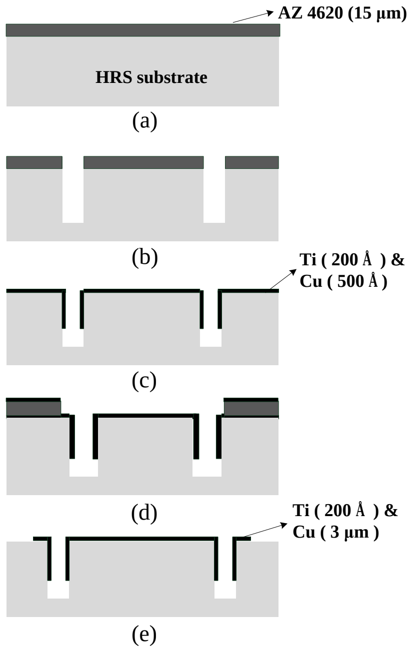
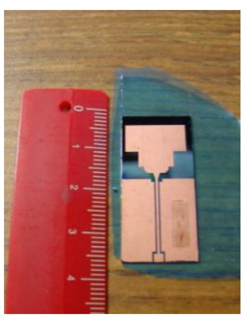
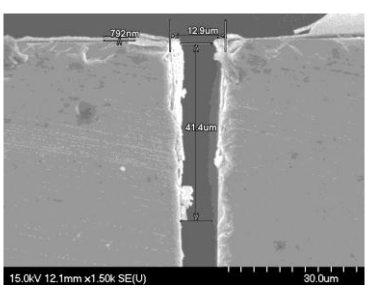


Fig. 2. Fabrication process flows for the EOCPW line: (a) HRS substrate (b) Lithography (mask-1) then ICP deep etching and PR removal. (c) sputtering of Ti & Cu. (d) Lithography (mask-2) then electroplating of Cu (e) Photoresist lift-off then stripping of Cu in unwanted position.



(a)



(b)

Fig. 3. (a) The photograph of the fabricated antenna (b) the microphotograph of the trench in the cross-sectional view

impedance-bandwidth for 10-dB return loss from 2.89 GHz to

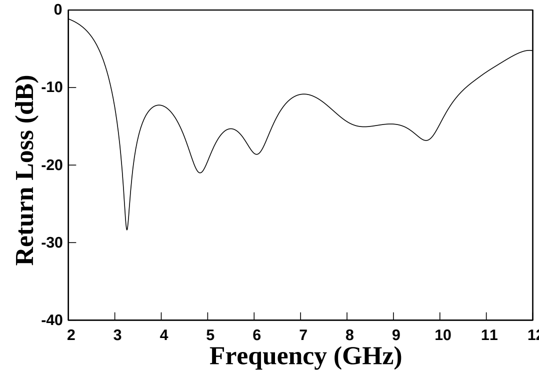


Fig. 4. Simulation result of return loss of the proposed mems antenna.

10.74 GHz covering the whole UWB bands. The

The simulated normalized radiation patterns at *YZ*-plane and *XZ*-plane at 3.5GHz, 6.85GHz, and 10GHz of the proposed antenna are displayed in Fig. 5, respectively. The antenna exhibits omnidirectional diagram in *XZ*-plane with low frequency dependence. In addition, the maximum measured gains of the proposed antenna at 3.50, 6.85, and 10 GHz are about 0.77, 0.97, and 1.92 dBi, respectively.

V. Conclusion

In this paper, a compact MEMS antenna for promising ultrawideband application has been demonstrated. A high electric coupling structure is utilized for improving bandwidth characteristic over the desired frequency band. Moreover, all the fabrication process of the proposed antenna is considerably simple and compatible with the CMOS fabrication process which is conducive to the SOC concern.

VI. 計畫成果自評

本計畫原定完成一個應用在UWB頻帶的CMOS製程相容天線，但應饋入端設計不良導致量測上出現困難，此問題已經過重新設計，經由矽基板上的餽入端和印刷電路板上的餽入端共同設計，以便達到量測上的需求。

VII. 參考文獻

[1] Wu, X.H., Chen, Z.N., and Chia, M.Y.W.: ‘Note on antenna design in UWB wireless communication systems’. IEEE Conf. Ultra Wideband System Technology, 2003, pp. 503–507

[2] M.J. Ammann and Z.N. Chen, A wide-band shorted planar monopolewith bevel, IEEE Trans Antennas Propag 51 (2003), 901–903.

[3] K.H. Chung, T.Y. Yun and J.H. Choi, Wide-band CPW-fed monopole antenna with parasitic elements and slots, Electron Lett 40 (2004), 1038–1040.

[4] N.P. Agrawall, G. Jumar, and K.P. Ray, Wide-band planar monopole antennas, IEEE Trans Antennas Propag 46 (1998), 294–295.

[5] S.-W. Su, K.-L. Wong, C.-L. Tang, Ultra-wideband square planar monopole antenna for IEEE 802.16a operation in the 2–11-GHz band 42 (2004), 463–466.

[6] I. Papapolymerou, R. F. Drayton, L. P. B. Katehi. “Micromachined Patch Antenna”, IEEE Transactions on Antenna Propagations, ~01.46n, o.2, pp. 275-283, February 1998.

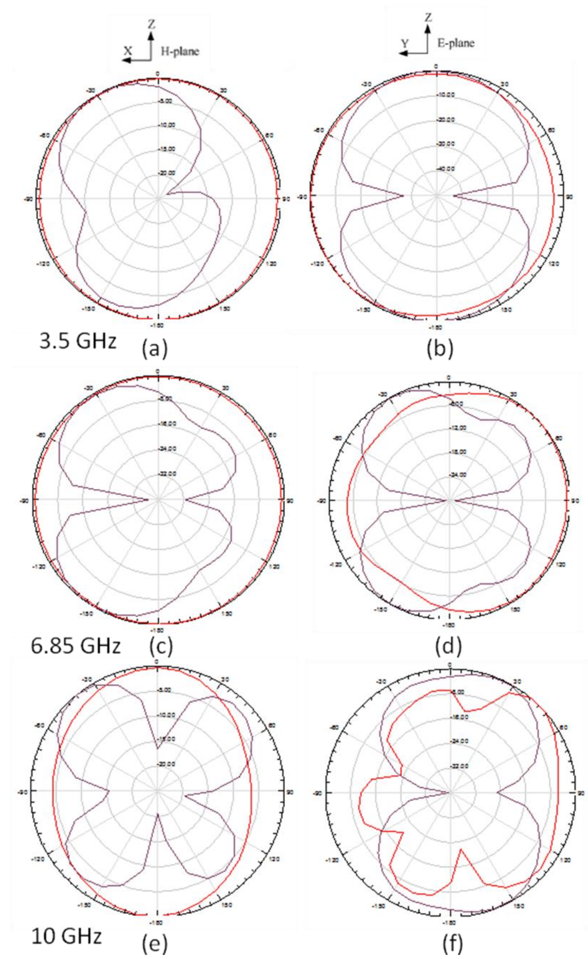


Fig. 5. Simulation raditaion pattern of the proposed antenna at 3.50, 6.85, and 10 GHz, respectively.

2009 iWAT 研討會 心得分享

美國洛杉磯當地時間，2009 年 03 月 02 日早上九點，我們一行人到了這一次 iWAT 所舉辦的會議地點，Santa Monica 市的 Doubletree Hotel。

第一天我們聽取了一些關於左手物質傳輸線為基礎所製作的天線，特別是第一位，所報告的是”A compact Metamaterial-inspired mmW CPW-fed antenna”利用 CPW 饋入架構，再以寄生電容、電感等參數值等效出左手物質的特性。其中最令我感到興趣的，就是利用 couple 效果，以及等效電感的方式，一方面可以省去要焊接上 lump 元件的麻煩，另外，可以經由改變幾何架構，去微調我們所需要的一些參數值，關於這一點，對我自己的研究多了一些新的想法和方式可以去嚐試。一來可以改動天線特性，二來可以讓整個天線更趨於印刷平面化，而不需要多加任何電路元件。

而在每一位報告者報告完之後，會有提問時間。可以看到就是一些大師級的人物，所提問的方式也不盡相同，可以觀察到的，歐美國家的人，問問題會比較客氣，也比較有禮貌，相較之下，亞洲地區的國家比較不會注重到這方面。再來就是，很多提問者，他們所提的問題，所切入的角度也讓我很意外，也許是我自己想得不夠多，思考的不夠仔細，因為這些提問者的問題，真的是一針見血。常常有些地方是報告者輕描淡寫的帶過，而這些提問者卻可以在這些地方，找出一些可能會有的問題或是有相互矛盾的地方。相形之下，可以比較的出來，為何他們是大師，而我可能還只是個學生，學得不夠專精。

中午，在簡短吃過中餐之後，便是我們 poster session 開始的時候。在這一場 session，來參觀的人數並不算太多，但是仍有不少教授級的來賓到場觀看這些 posters。由於第一天是同行的同學和學長的 poster，所以就先觀摩學長和同學如何和一些教授級的人物做對答，一來可以當作隔天，換我 poster 的時候如何作應對，二來可以多訓練一下自己的英文能力。此外，在這一場 session 當中，也有其他臺灣來的作者，一是宜蘭大學的同學，另一位是國防大學的學生。在這裡，也可以看到各國不同的風格，有些作者的海報會做得很精美，而有些作者則是用一些 A4 的紙張，最後再一張一張放在每報板的上面。相比之下，可以看得出用心的程度。

第二天，上午也是先去參加 talk session，這一場的主題是”Measurement Issues of Small Antennas, ” 這一方面的主題對於我所作的研究：chip antenna 很有幫助，因為 chip antenna 也是 small antenna 的其中一部分，要如何去量測 chip antenna 的參數，就現今的量測技術而言，仍然是一大挑戰。另外，如何在模擬的時候，把一些環境的外在因為考慮進去，也是一個很大的課題。像是在量測 chip antenna 時，probe 的影響要如何納入模擬當中，會如何影響天線的特性…..等等，都是值得去思考的問題。在這一場的 talk 當中，我也獲得不少相關的資訊，當然，也有從一些提問者的問題，發現有些量測的考量是可以更加嚴謹的。

中午，開始 poster session，由於我是第二天的場次，對於即將面對一些外國教授的發問，我顯得有些緊張。一直到 poster session 告一個段落的時候。我大約被將近 20 位來賓提問題。我發現，大部分提問者的問題都還蠻接近的，也因此，我回答的問題也很多都是重複的問題。當然，也有很多是我之前沒有想到的問題，在這些提問者的問題當中，我可以得知說，哪些地方是我可以再多加以研究的，哪些地方是我可以再改進的，可能模擬時可以更加深入，或是量測上的考量可以再更多一些……等等，都是我可以再努力的部分。

兩天下來，我所學到的東西真的不少，不管是研究方面，或者是其他做事的小細節，想法，態度等等，著實都讓我學到很多。這一次出國，不但對我的研究有了很大的幫助，對我的外語能力也有很大的激勵。相信在未來，我可以做出更多更好的研究主題。