

Step. 2022

Probing OTA於Sub THz應用

-邱宗文 博士 (川升股份有限公司 創辦人)

大綱

➤ 天線系統量測新挑戰 – Why Probing OTA

➤ Probing OTA 實例分享

1) 文獻分享

2) Sub THz 設計介紹 – MW5e

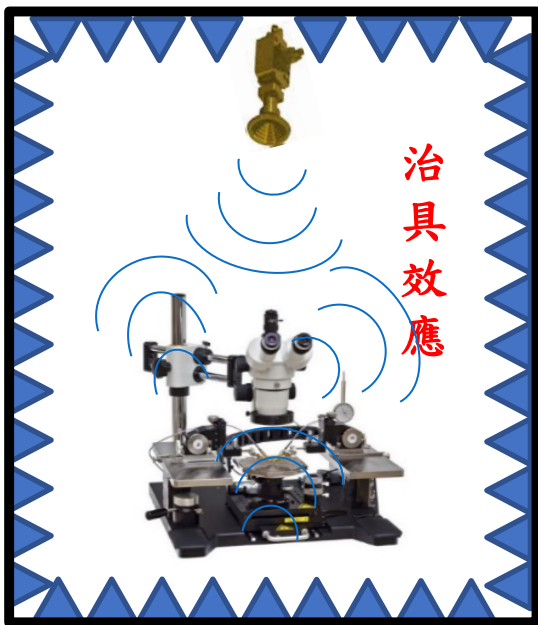
3) 量測結果

➤ 結論

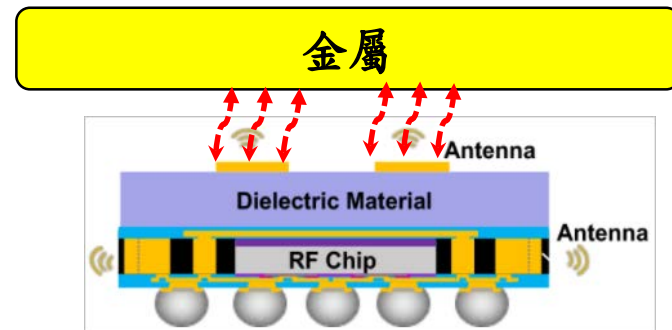
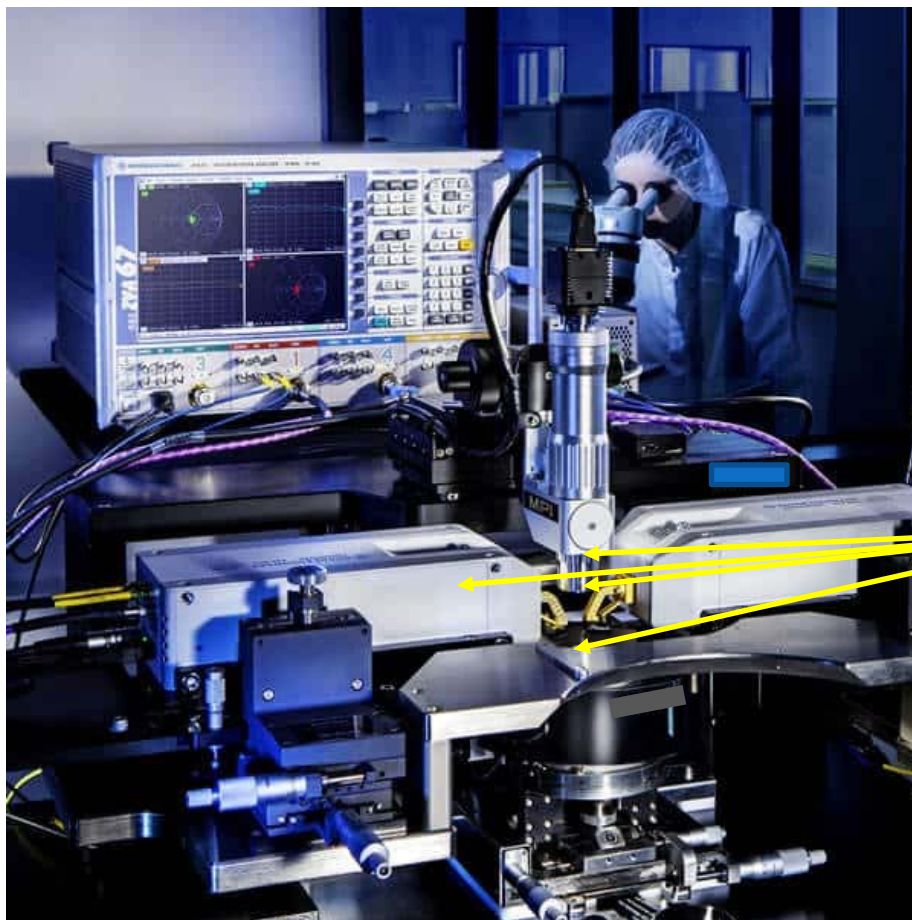
What is probing OTA? 晶圓測試的觀點出發

晶圓測試的思維開始...

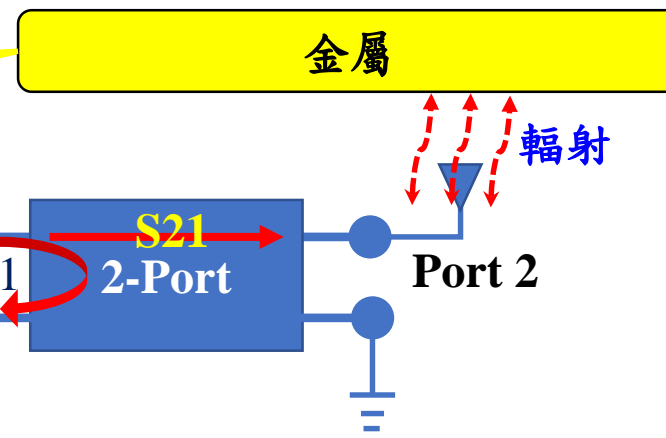
- 所有設備搬進暗室
- 外加horn antenna



Probe station + OTA = Probing OTA



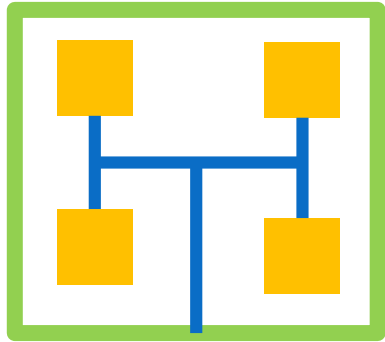
金屬反射/介質散射會顯著
干擾S參數量測的準確度



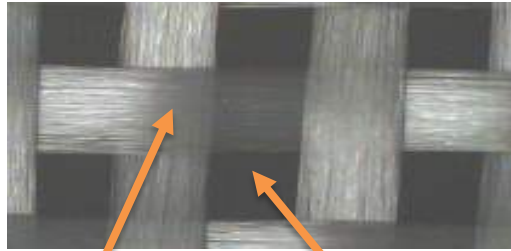
Why Probing OTA? 天線板/多層板研發

每個天線特性不同 → 波束形狀混亂
 傳輸線 → 相位不一 → 波束形狀混亂

板材特性是產品良率的關鍵!!!

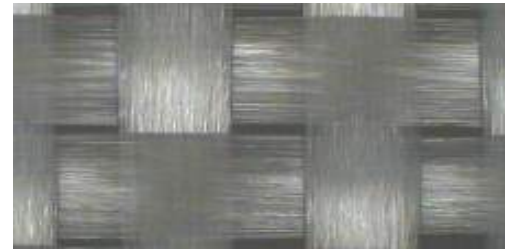


Original glass fabric



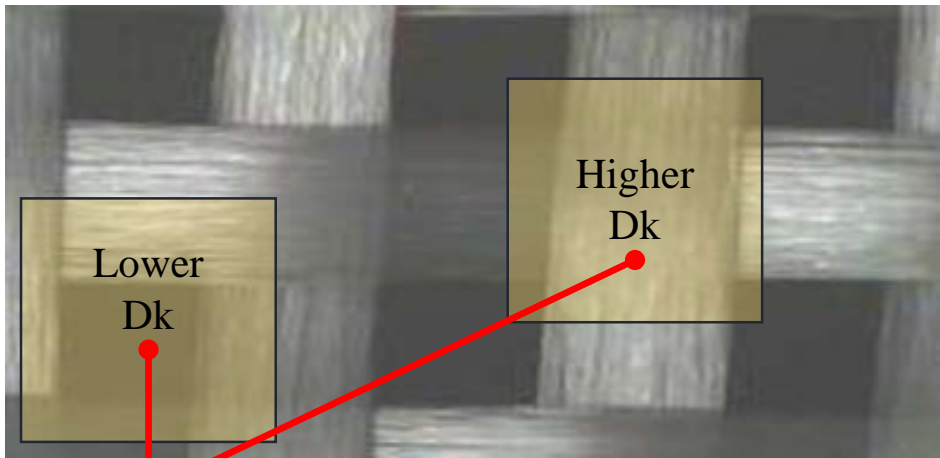
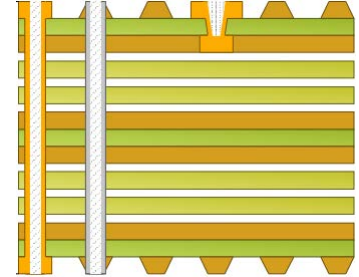
Higher Dk Lower Dk

Spread glass fabric



Uniform Dk

CAF debug

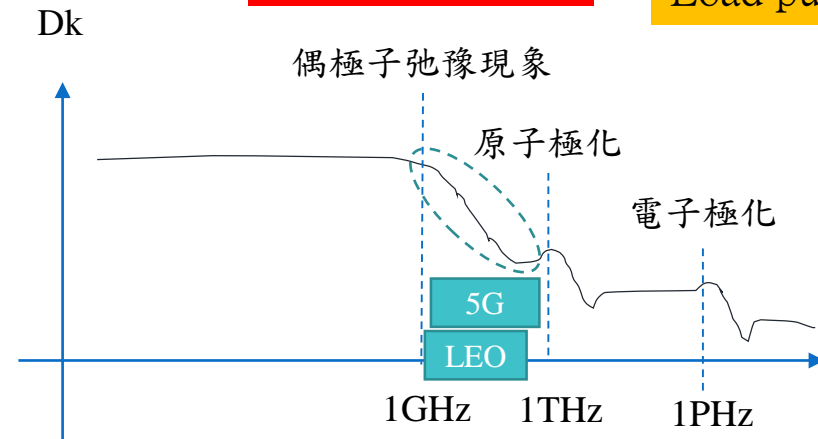


同尺寸天線在不同位置因Dk不同造成共振頻率不同

LEO frequency bands 落在Dk對頻率極敏感頻段
 需要Dk更穩定的板材製程 ← 關鍵玻纖編織技術

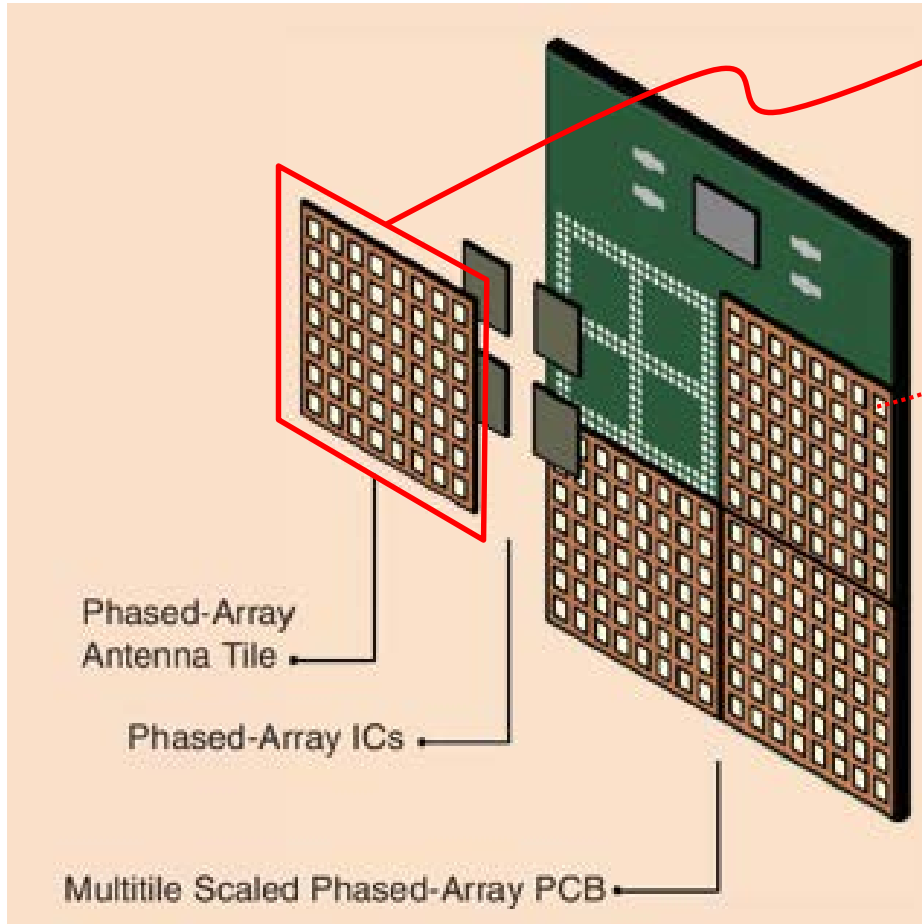
Dk隨頻率變化關係圖

Load pull & G/T



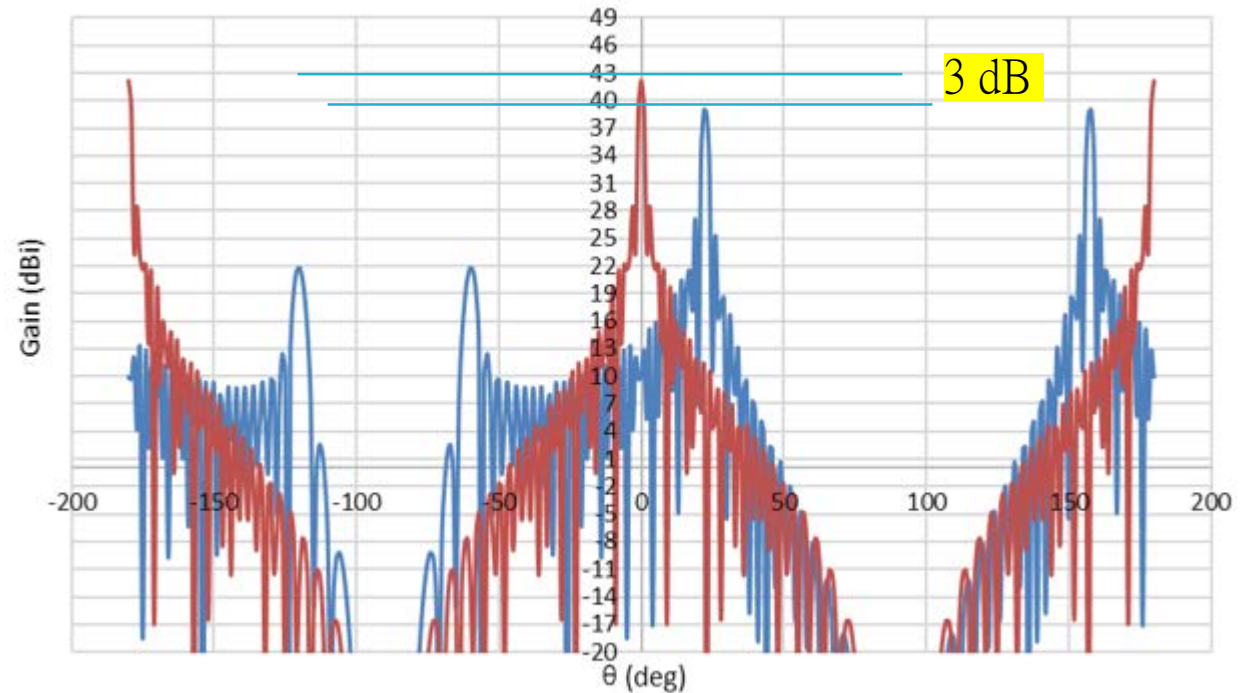
Why Probing OTA? Phased Array design

還沒打上BFIC即能預測採用的天線陣列其波束掃描範圍
Beam-Modeling → 減少打 BFIC 試誤次數



Beam-modeling 範例

Beam Coverage = 44°



— 64 x 64 Out-phased array — 64 x 64 In-phased array

Sadhu, B., Gu, X., & Valdes-Garcia, A. (2019). The More (Antennas), the Merrier: A Survey of Silicon-Based mm-Wave Phased Arrays Using Multi-IC Scaling. *IEEE Microwave Magazine*, 20, 32-50.

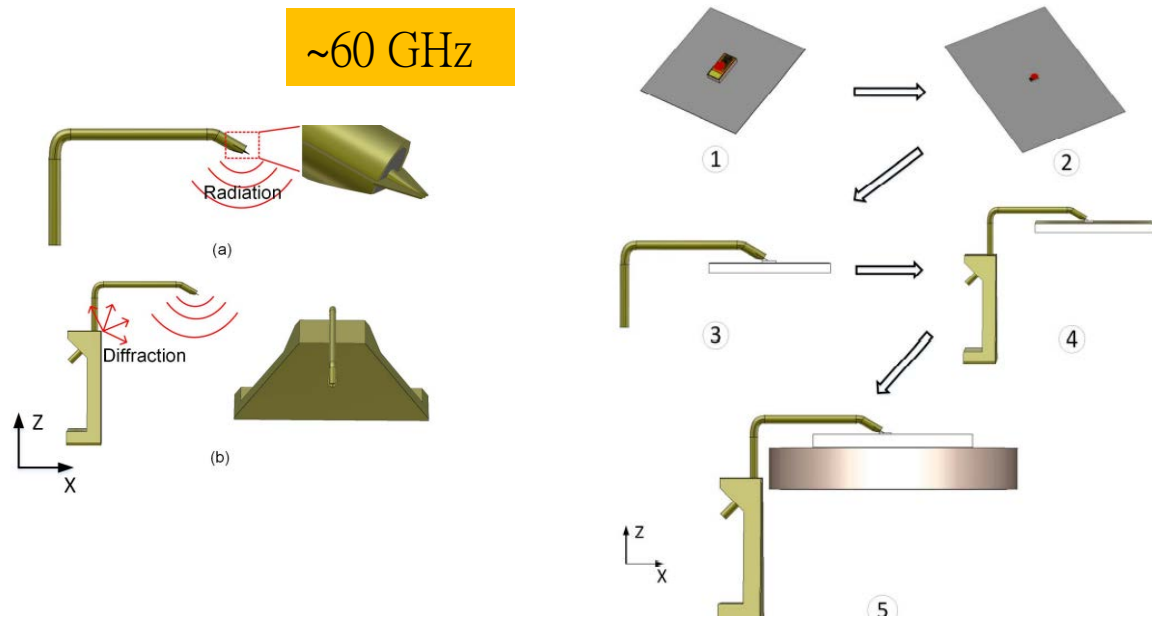
大綱

- 天線系統量測新挑戰 – Why Probing OTA
- **Probing OTA 實例分享**
 - 1) 文獻分享
 - 2) Sub THz OTA 介紹 – MW5e
 - 3) 量測結果
- 結論

參考文獻-探針散射效應

Antenna-on-Chip Radiation Pattern Characterization – Analysis of Different Approaches

O. Liu, U. Johannsen, M. C. van Beurden, A. B. Smolders



The Influence of the Probe Connection on mm-Wave Antenna Measurements

Ad C. F. Reniers, A. Rainier van Dommele, A. Bart Smolders, *Senior Member, IEEE*, and Matti H. A. J. Herben, *Senior Member, IEEE*

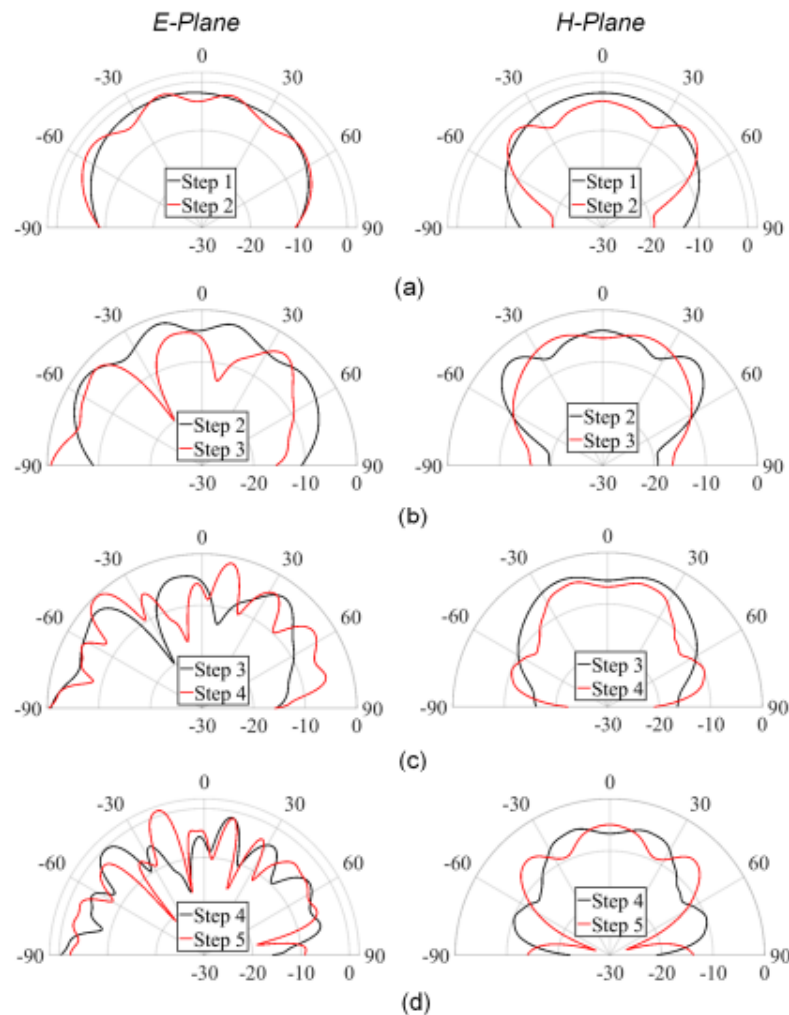
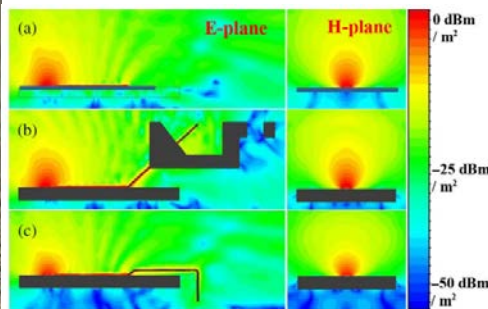
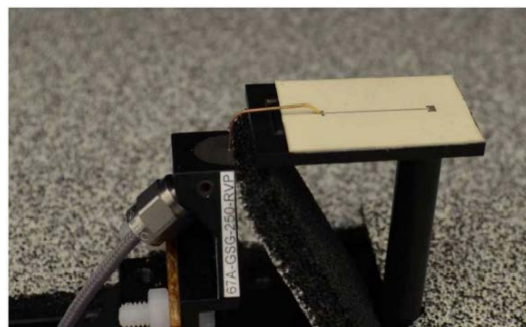
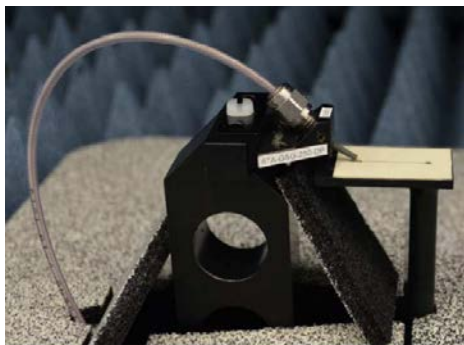
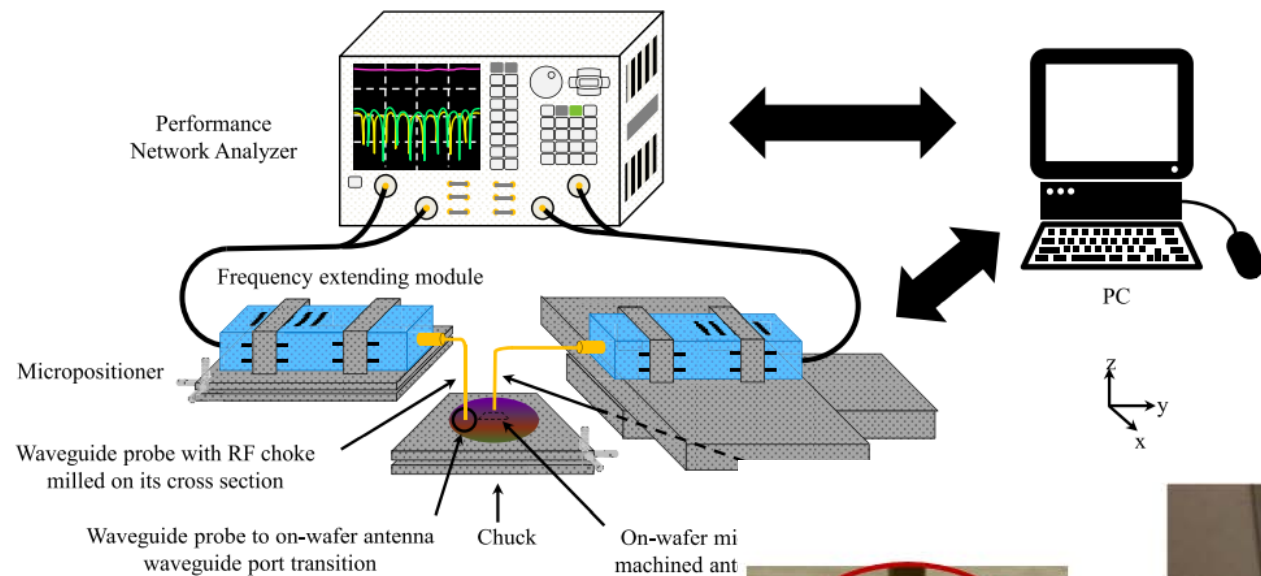


Fig. 8. Step by step analysis of the radiation pattern in the E and H planes at 60 GHz. (a) Step 1 to step 2. (b) Step 2 to step 3. (c) Step 3 to step 4. (d) Step 4 to step 5.

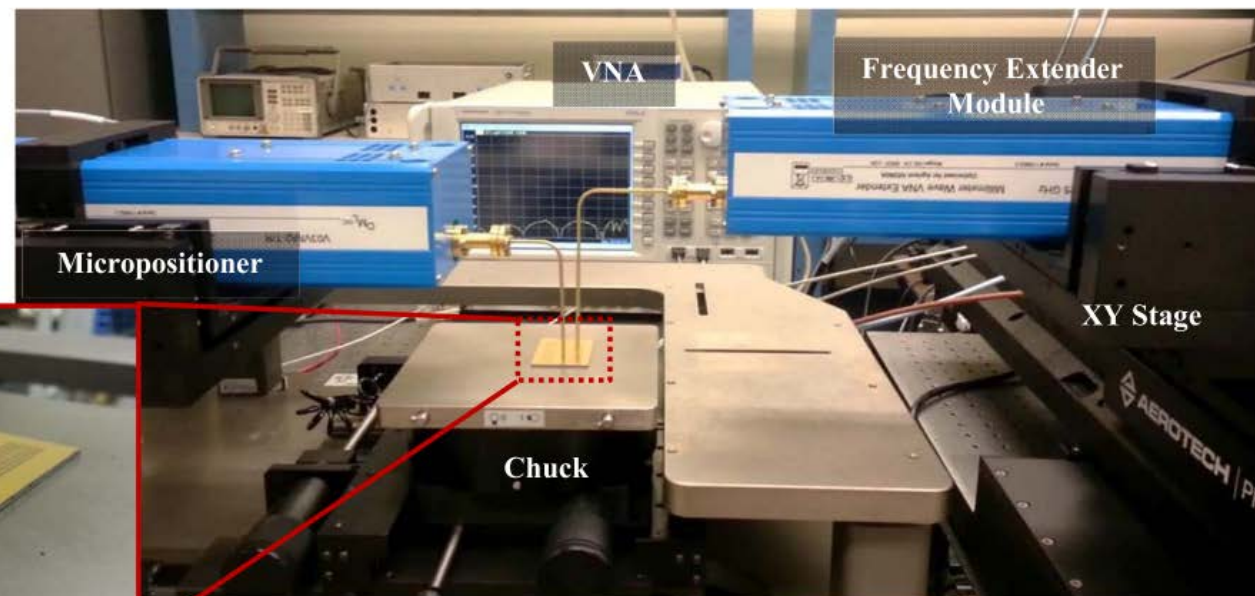
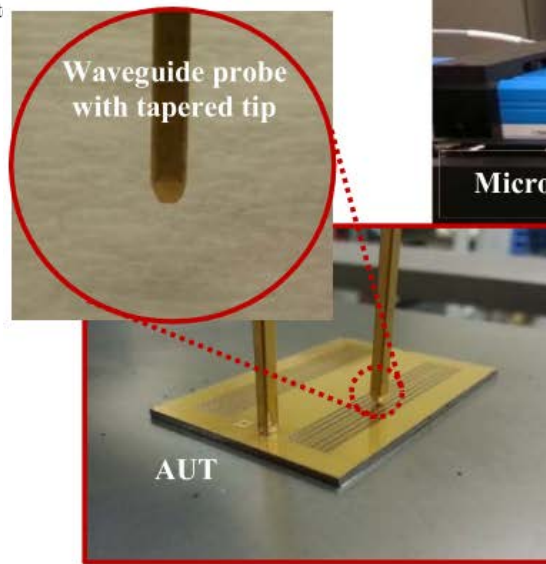
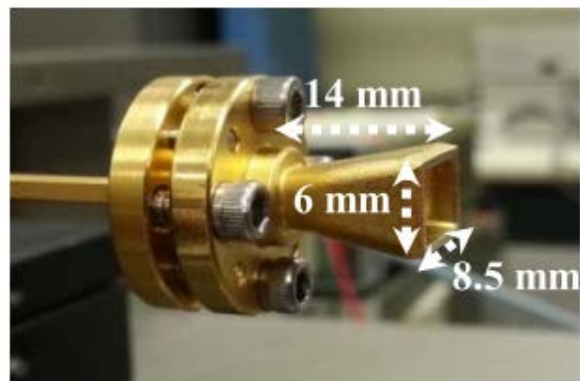
參考文獻-近場

A Submillimeter-Wave Near-Field Measurement Setup for On-Wafer Pattern and Gain Characterization of Antennas and Arrays

Armin Jam, *Student Member, IEEE*, and Kamal Sarabandi, *Fellow, IEEE*



245-GHz



參考文獻-直接遠場

H. Gulan⁽¹⁾, S. Beer⁽¹⁾, S. Diebold⁽¹⁾, C. Rusch⁽¹⁾, A. Leuther⁽²⁾, I. Kallfass^(1,2) and T. Zwick⁽¹⁾

(1) Karlsruhe Institute of Technology (KIT), Institut für Hochfrequenztechnik und Elektronik (IHE)
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Email: heiko.gulan@kit.edu

(2) Fraunhofer Institute for Applied Solid State Physics (IAF)
Tullastrasse 12, 79108 Freiburg, Germany

220~325 GHz

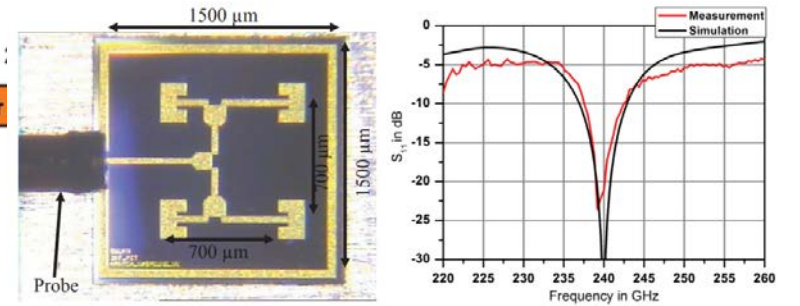
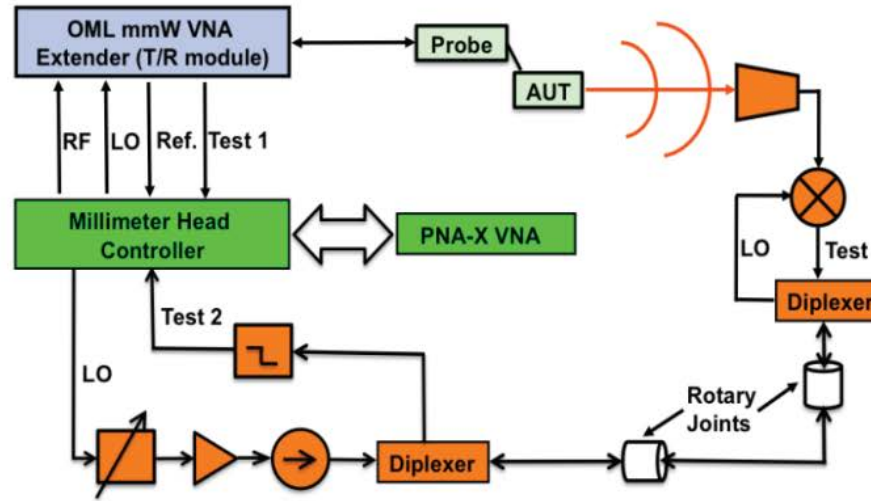
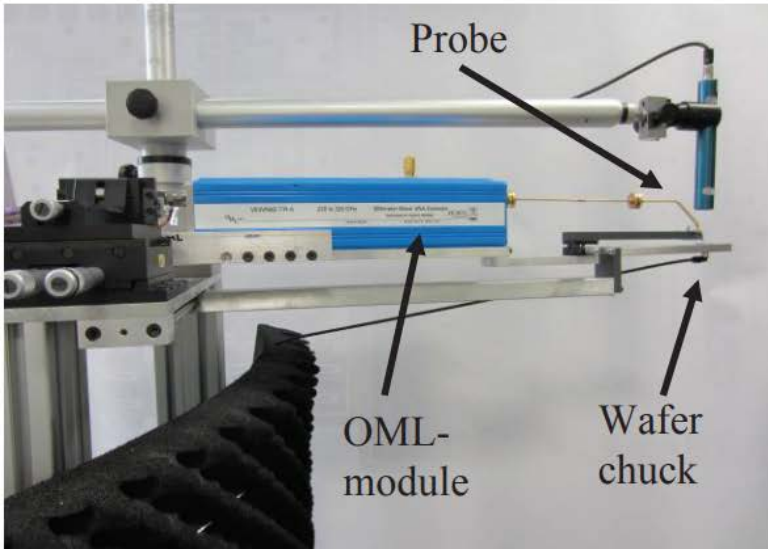


Fig. 3: Photograph of the 2x2 Patchantenna (left) and its simulated and measured return loss (right)

Probe Based Radiation Pattern Measurements for Highly Integrated Millimeter-Wave Antennas

Stefan Beer, Thomas Zwick

75~100GHz

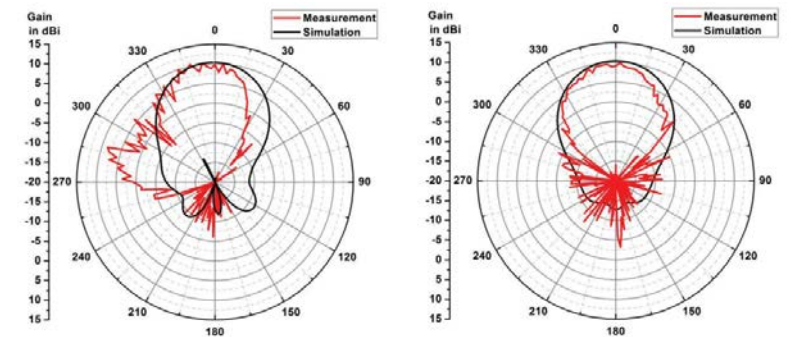
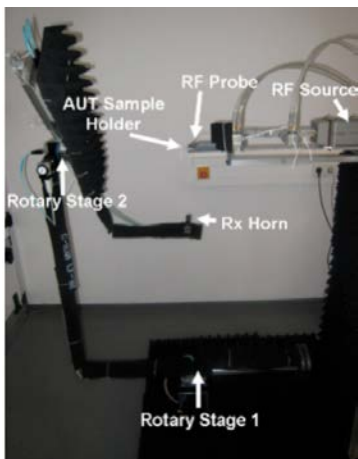
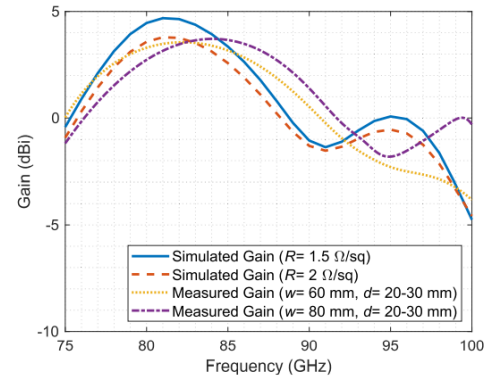
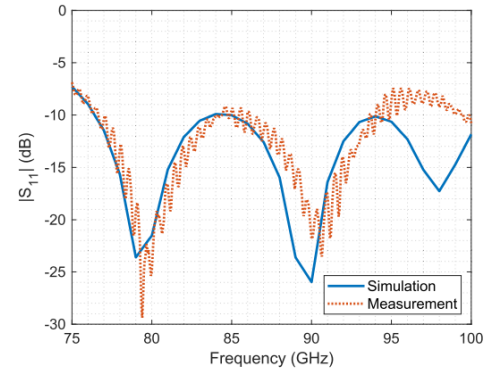
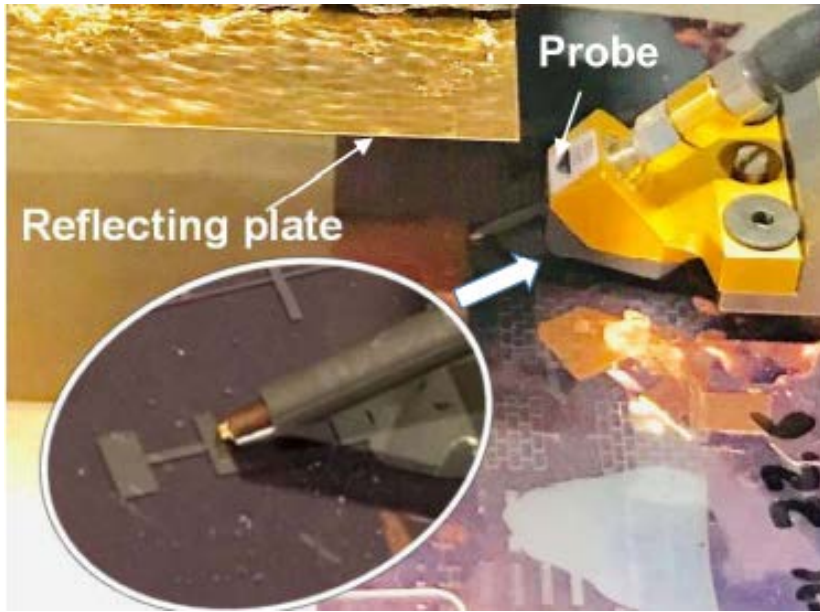


Fig. 4: Simulated and measured radiation pattern at 240 GHz in E-plane (left) and H-plane (right)

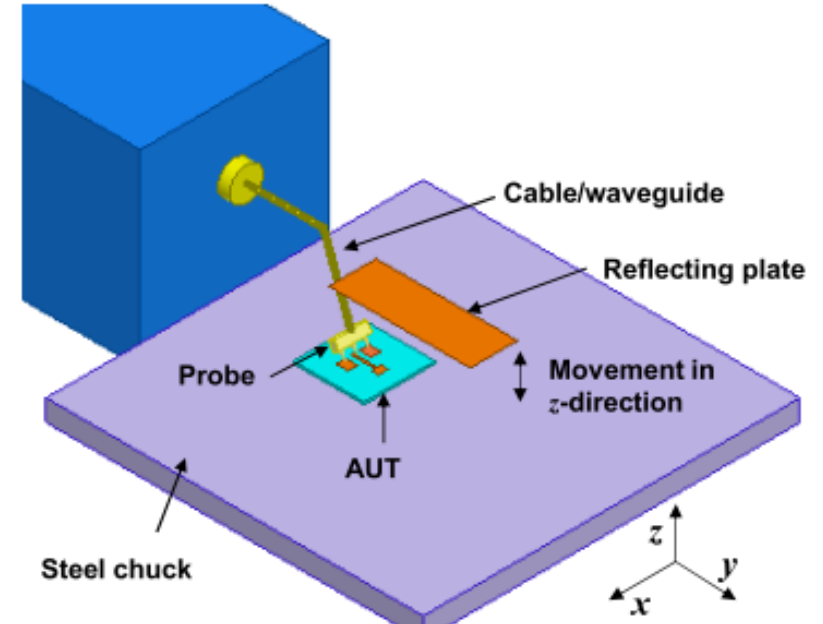
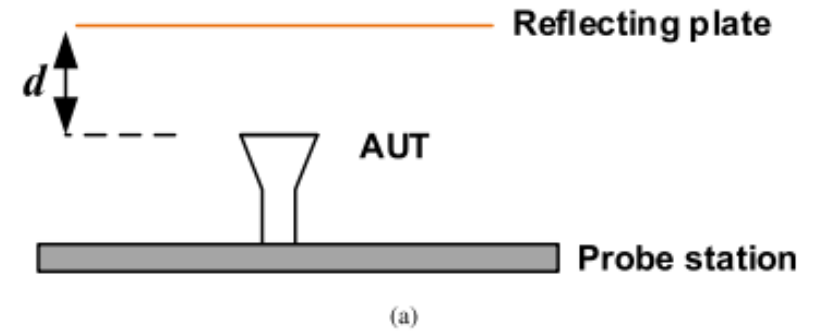
參考文獻-One Ant.

75~100 GHz



On the One-Antenna Gain Measurement Method in Probe Station Environment at mm-Wave Frequencies

Jianfang Zheng[✉], Juha Ala-Laurinaho, and Antti V. Räsänen, *Life Fellow, IEEE*



參考文獻-非接觸式

Non-Contact Probes for Device and Integrated Circuit Characterization in the THz and mmW Bands

Cosan Caglayan*, Georgios C. Trichopoulos, and Kubilay Sertel
The ElectroScience Laboratory, The Ohio State University
1330 Kinnear Rd, Columbus, OH 43212
E-mail: {caglayan.1, trichopoulos.1, sertel.1}@osu.edu

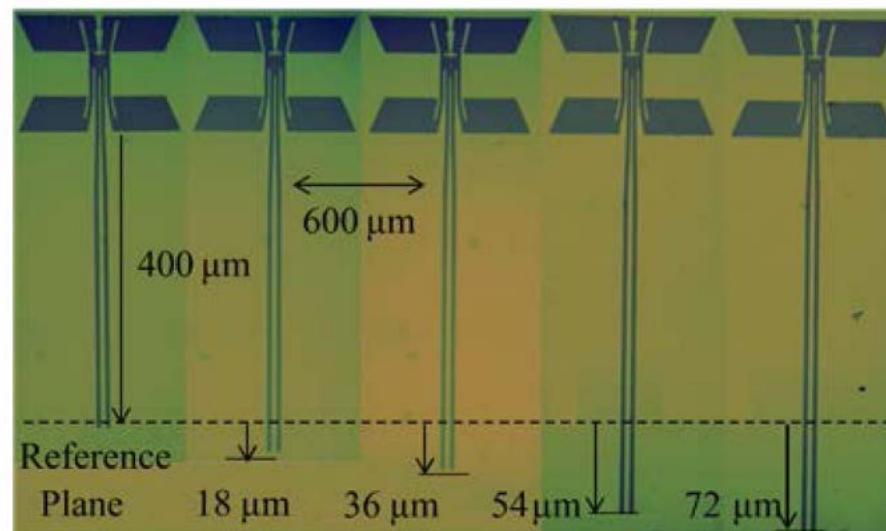
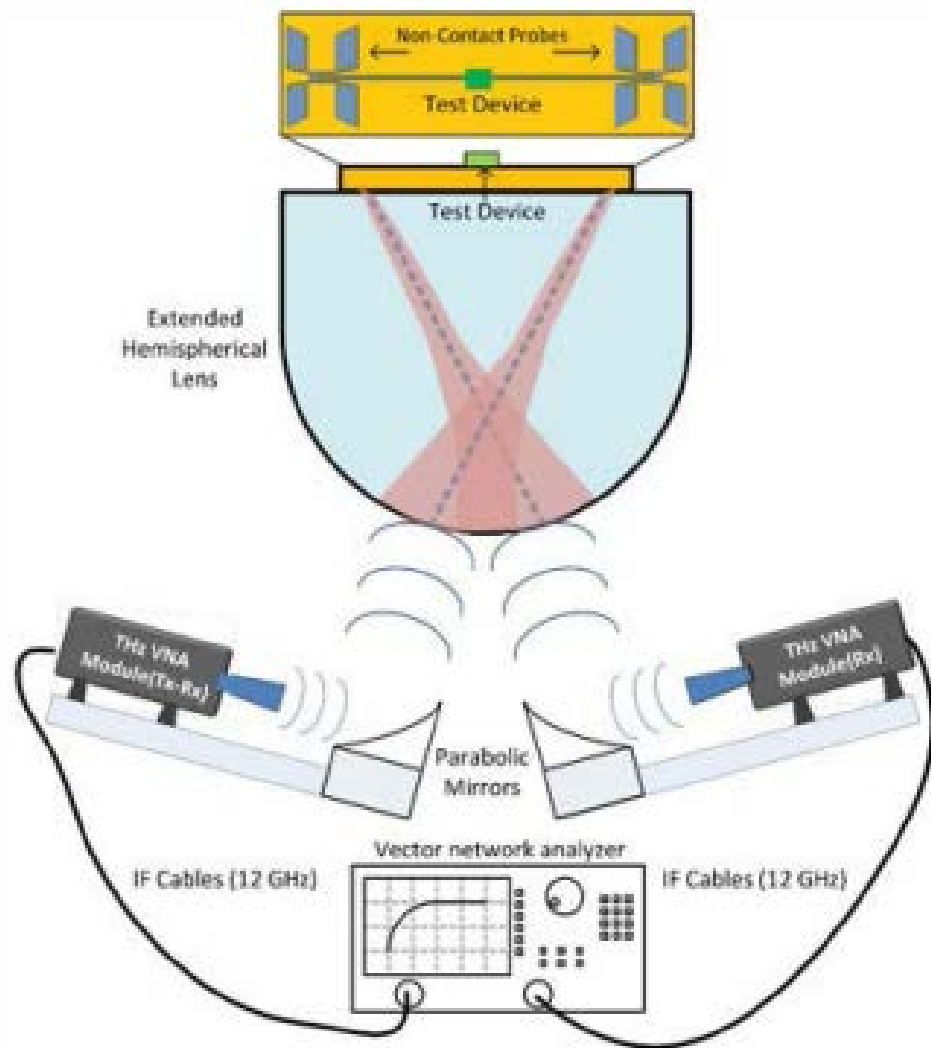
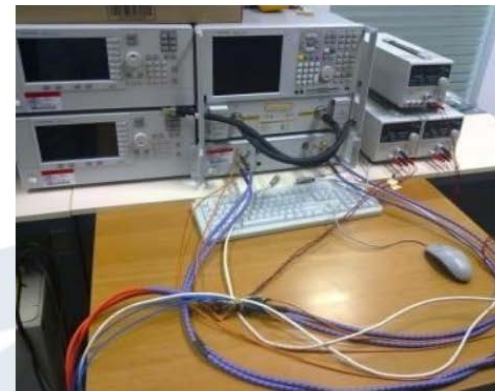
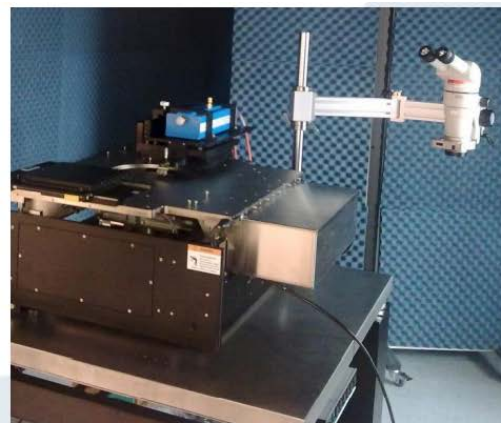
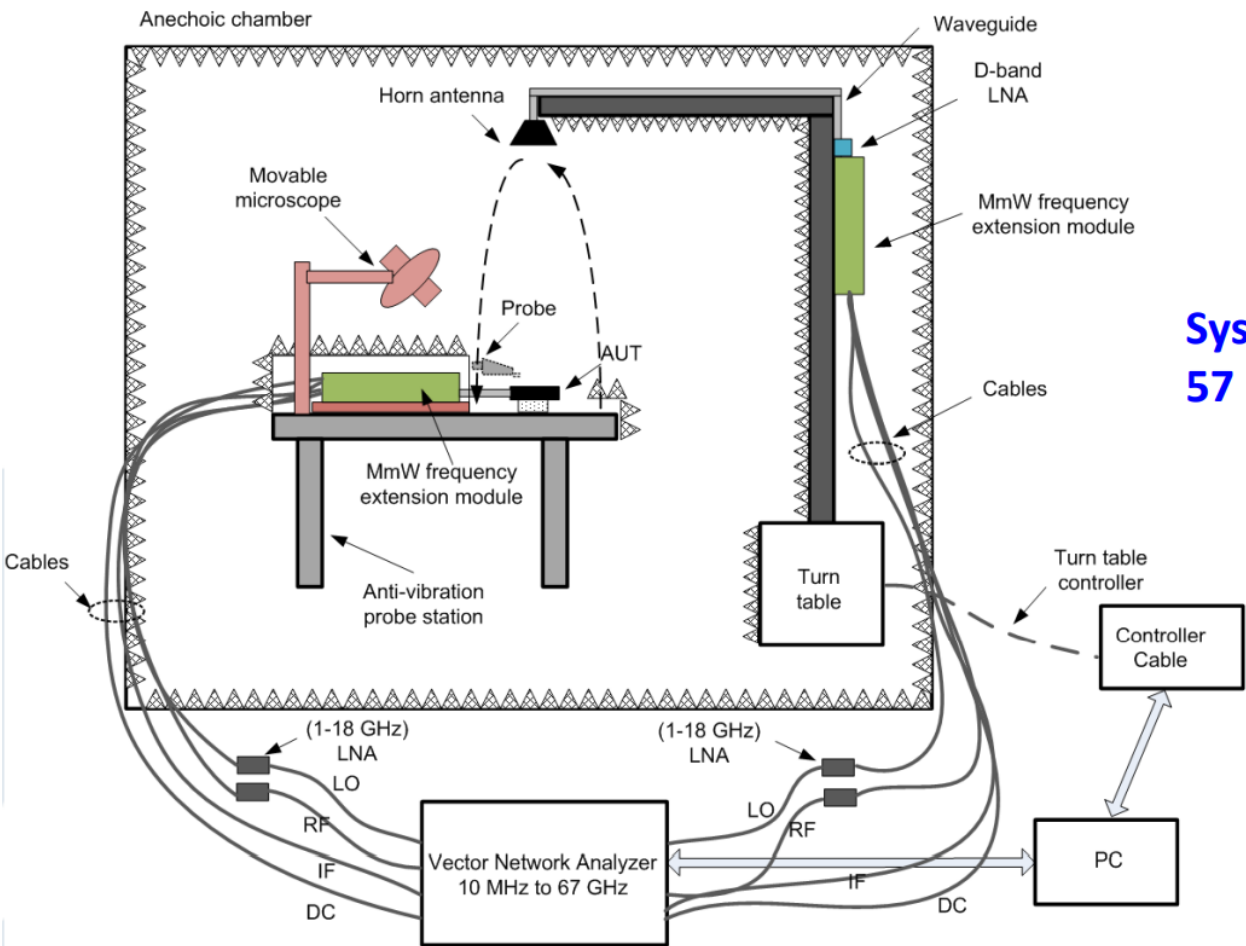


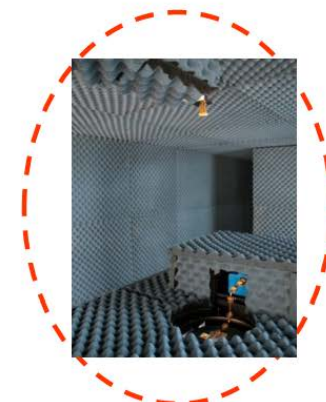
Fig. 2. Close-up view of the 5 offset-short non-contact calibration standards for the 500-750 GHz band with on-chip butterfly antennas (actual separation between the probes is 600 μm as indicated).

60~300GHz
300GHz~3THz

參考資料-新加坡大學

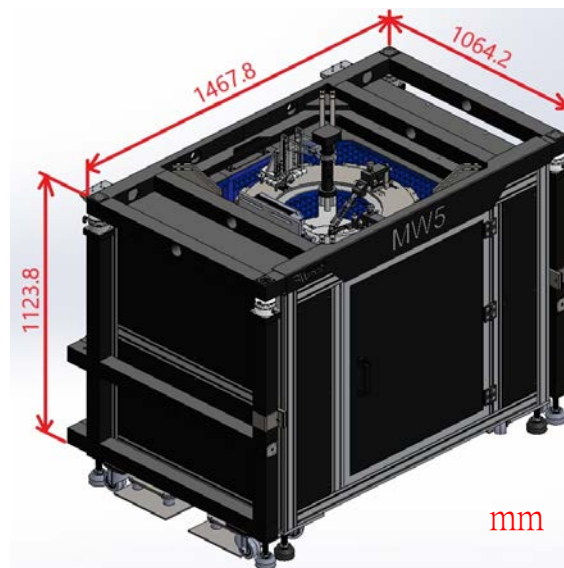
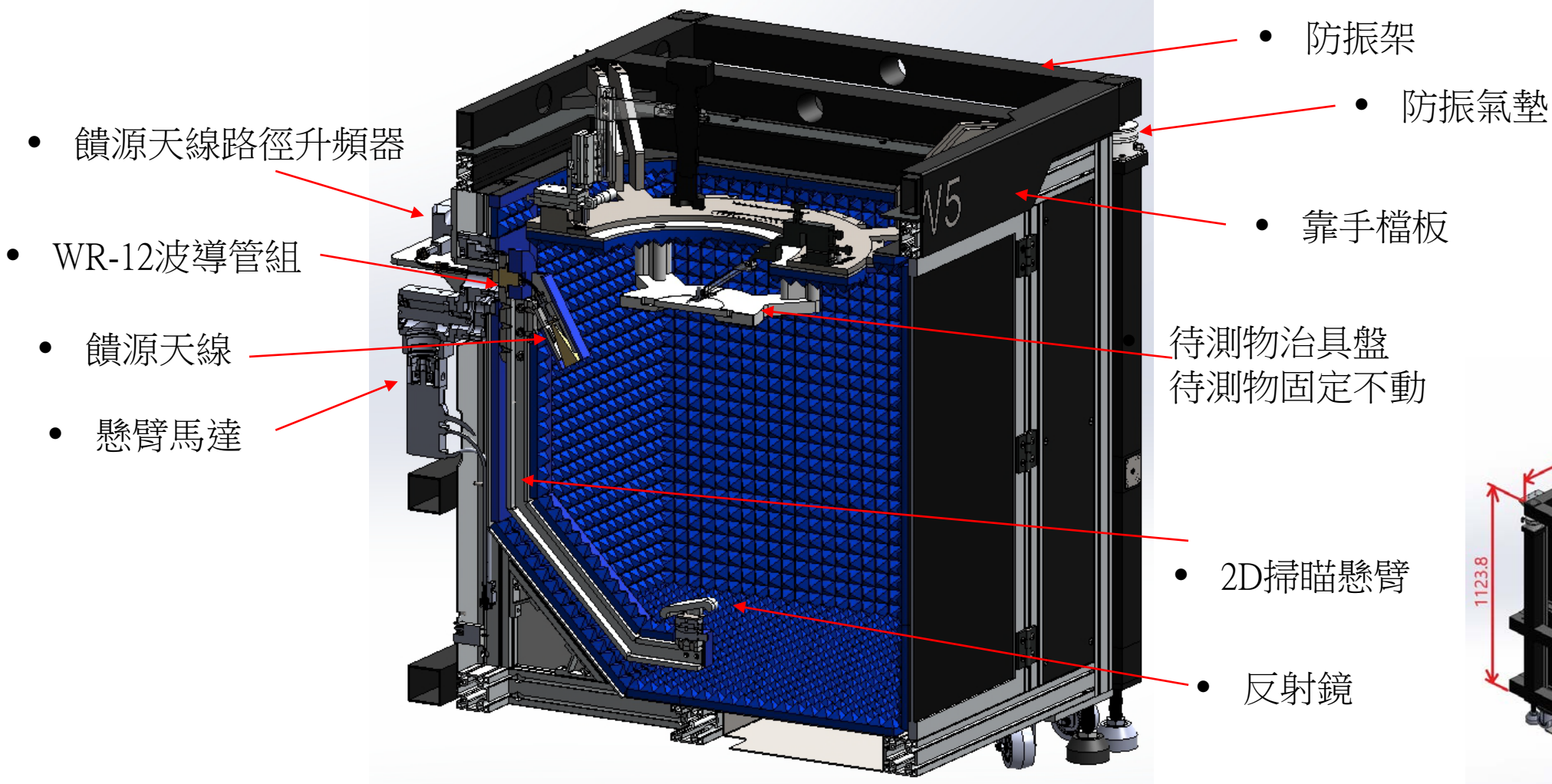


Sys
57

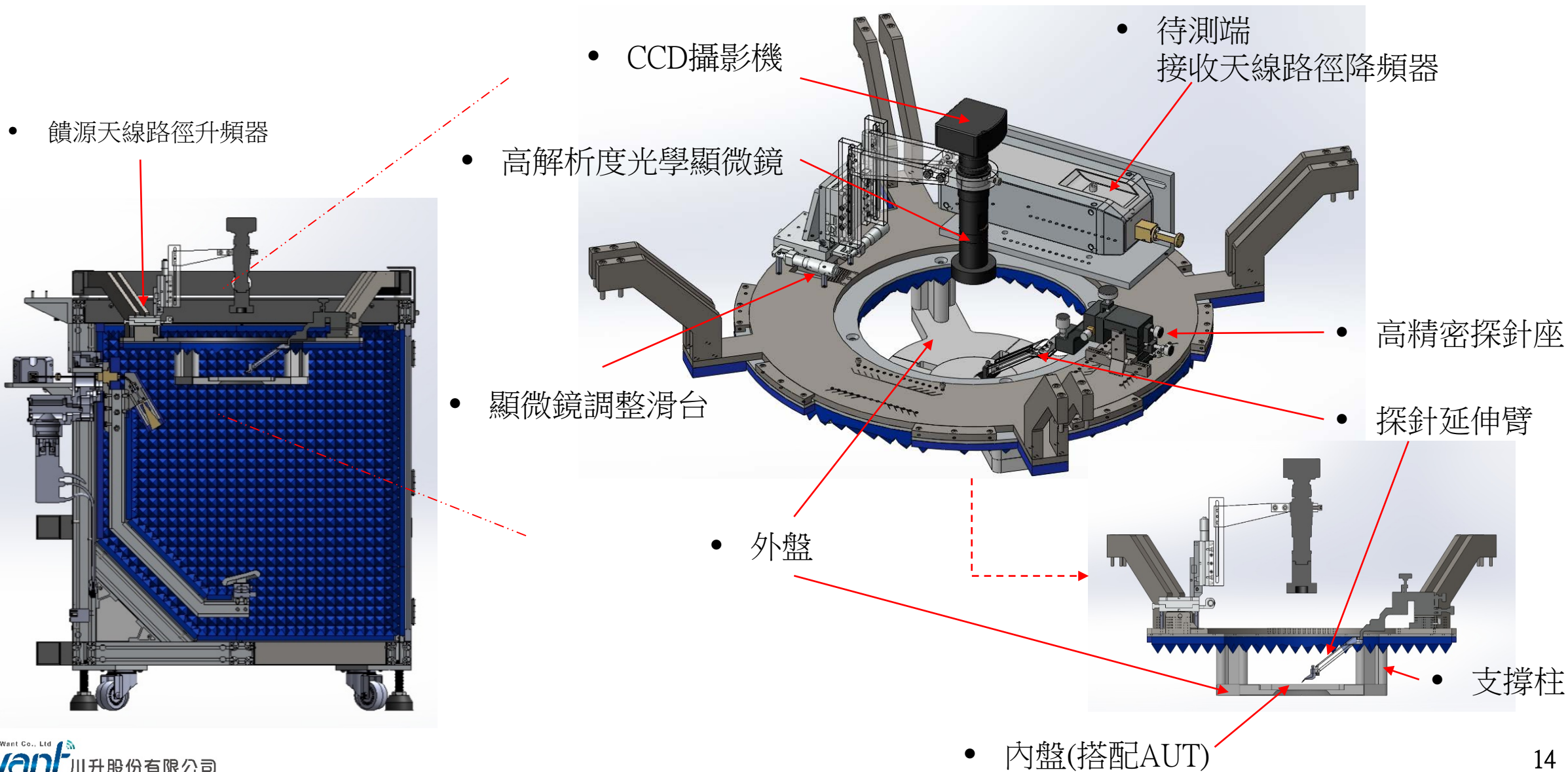


資料來源NUS

MW5e-架構



MW5e-針台



MW5e-微波電路設計



- WR12旋轉波導

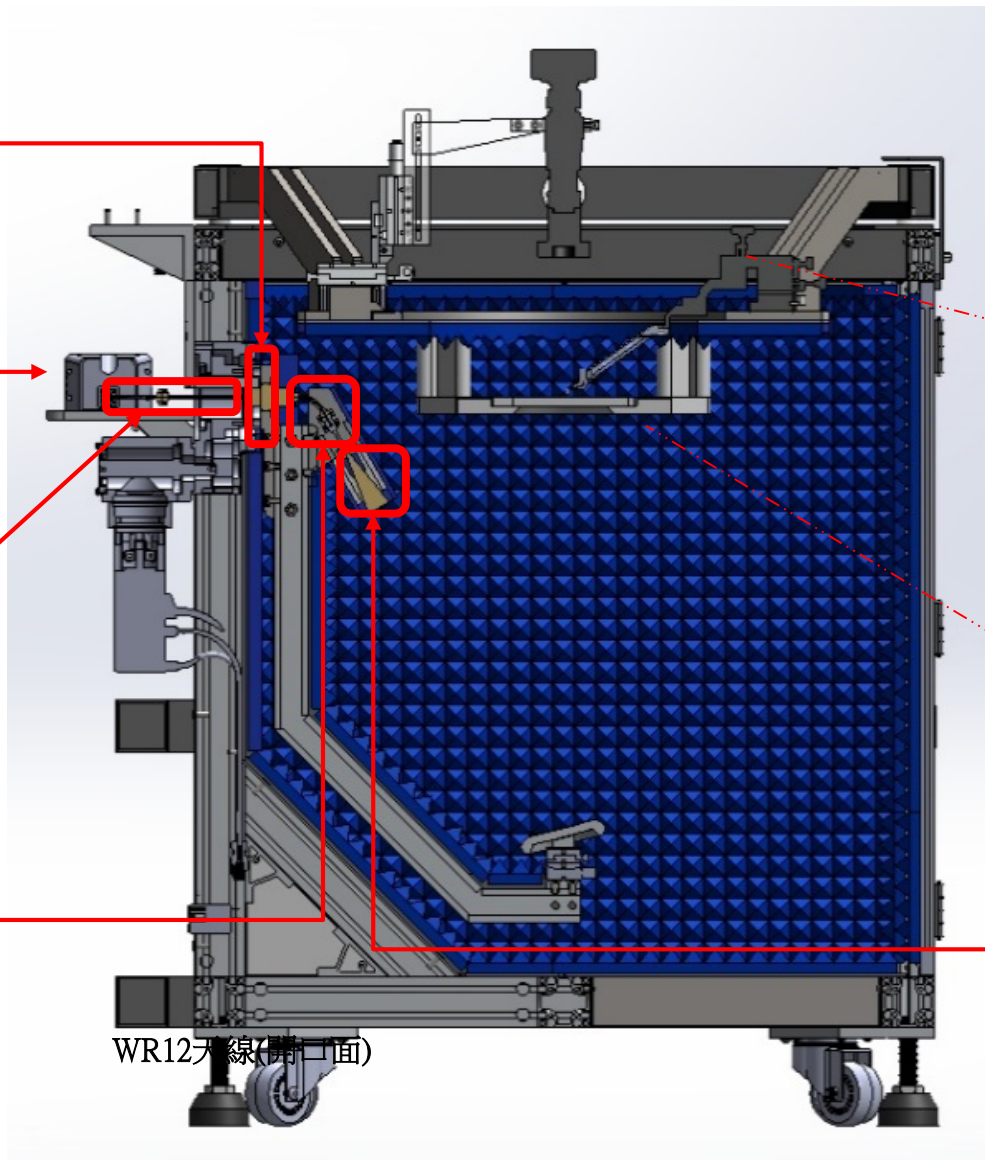
- 饋源天線路徑升頻器



WR12全硬直波導(4")
+
WR12柔性波導(4")



- WR12彎曲60°波導

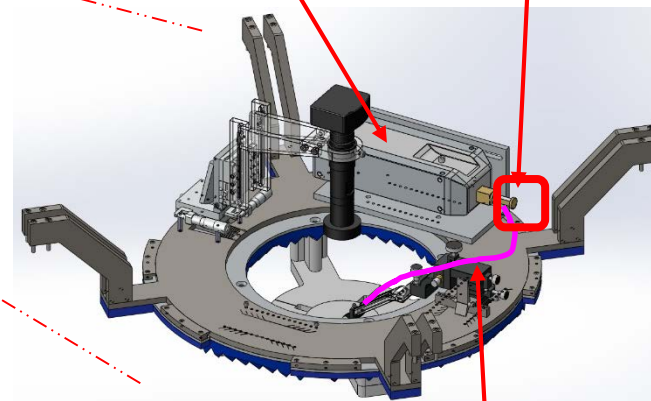


WR12天線(開口面)



- WR12轉1.0mm(Adapter)

- 待測端
接收天線路徑降頻器

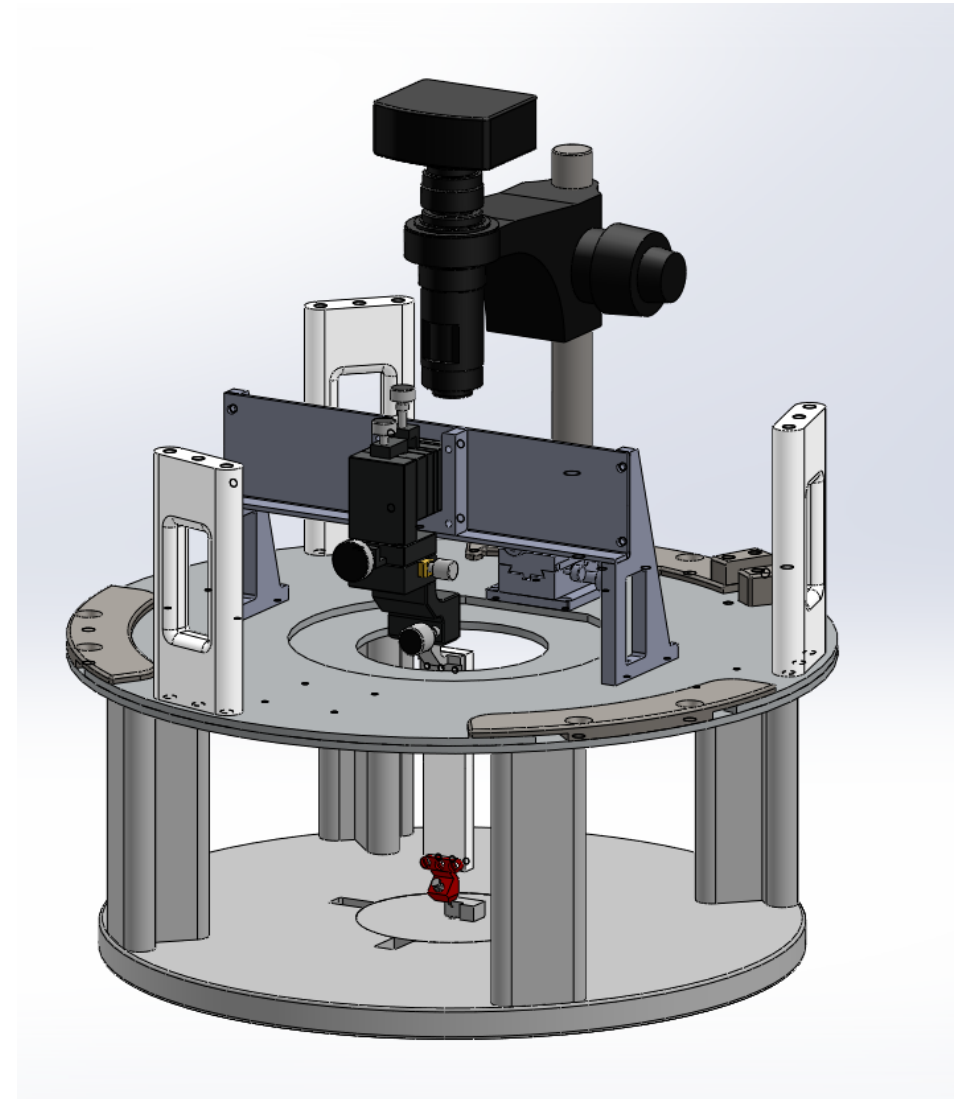
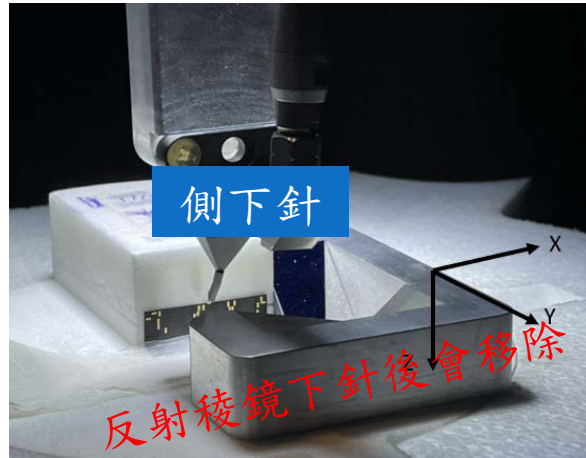
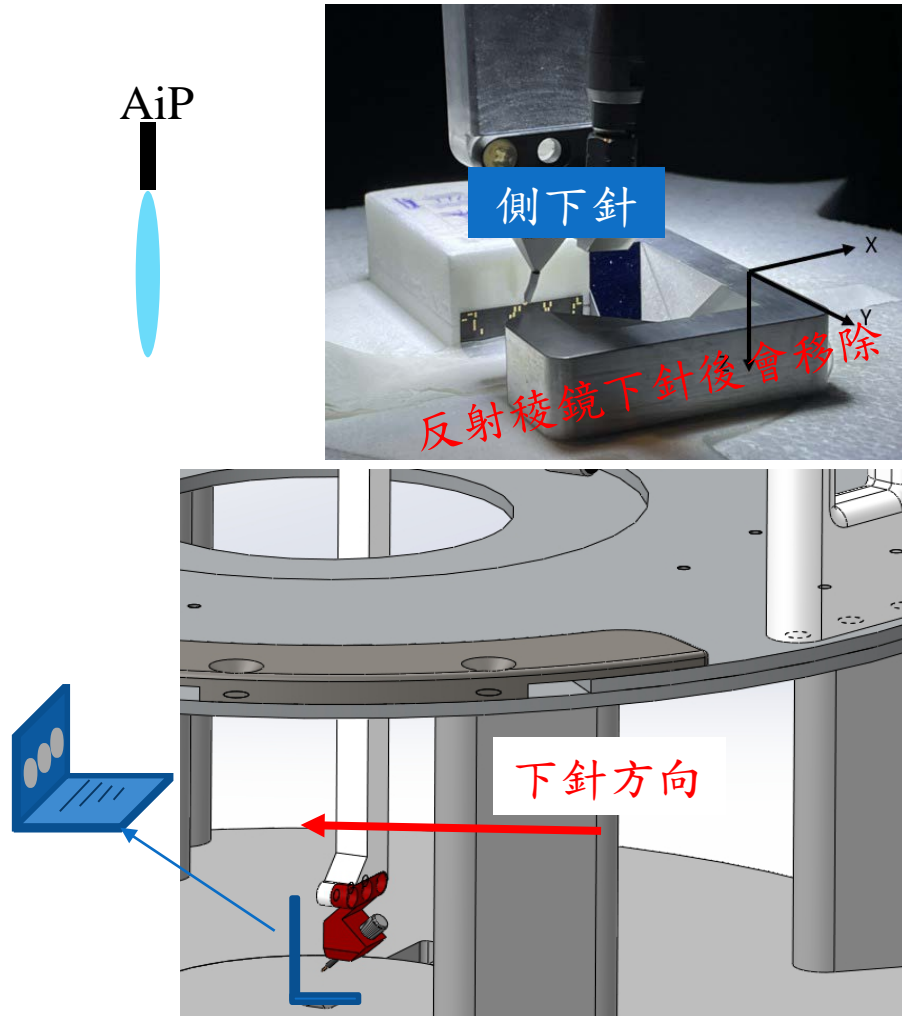


- 1.0mm cable

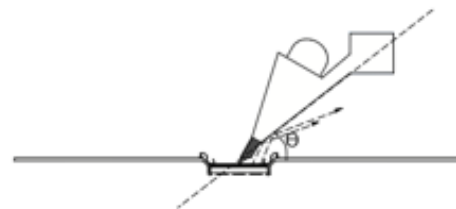
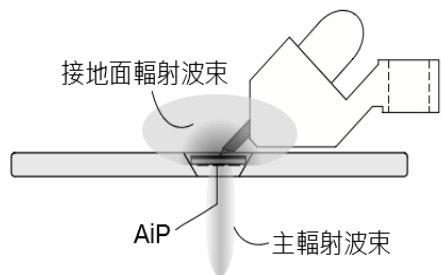


- WR12 Feed Horn

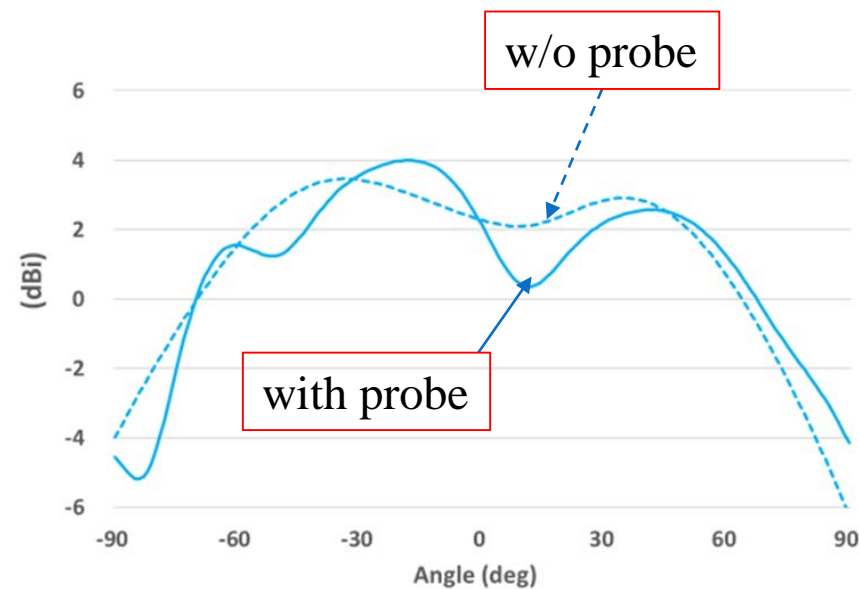
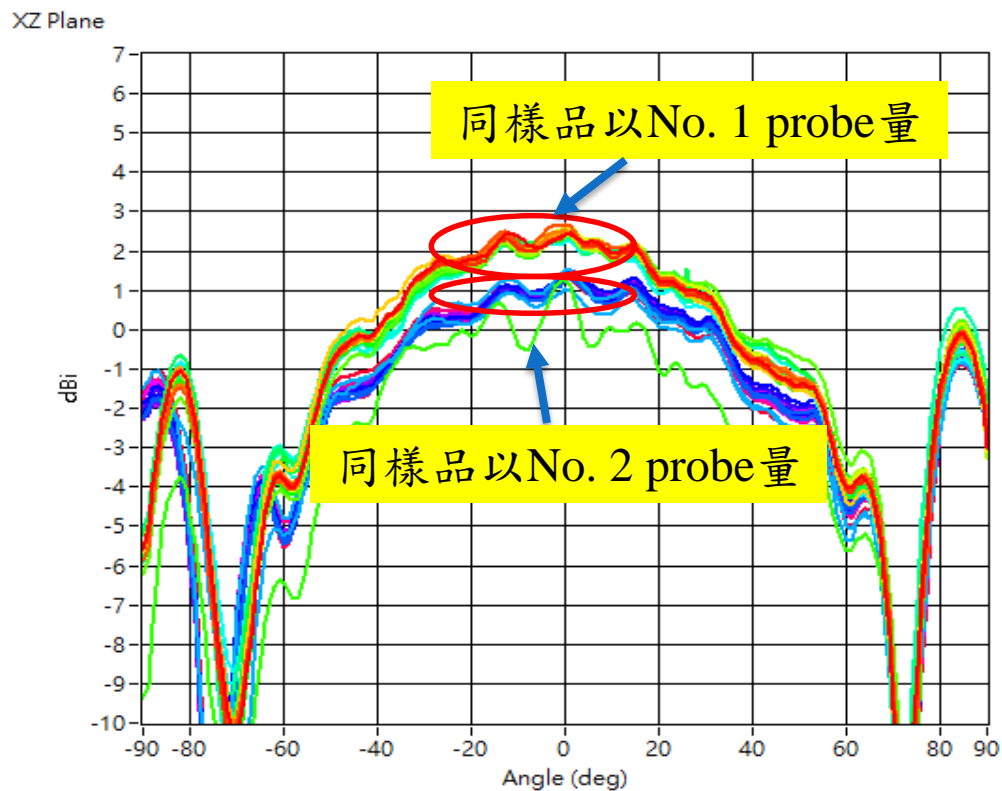
Probing OTA使用-治具設計



Probing OTA 使用經驗分享-Probe選擇

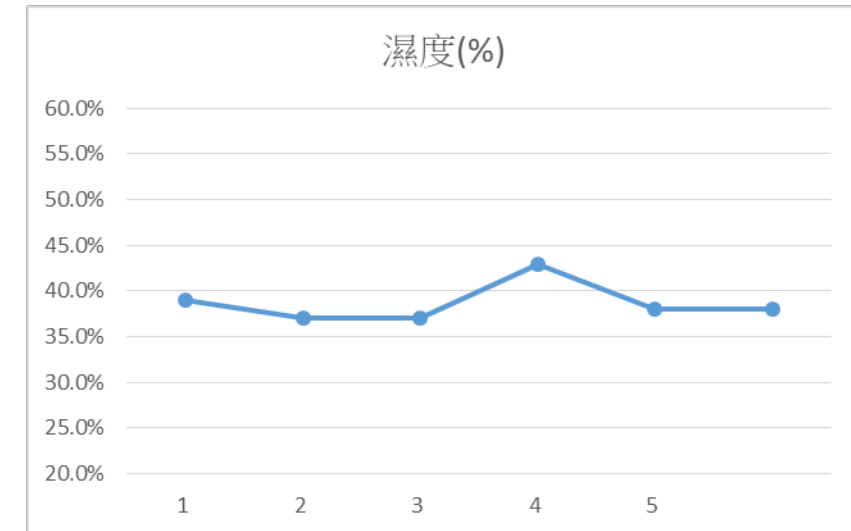
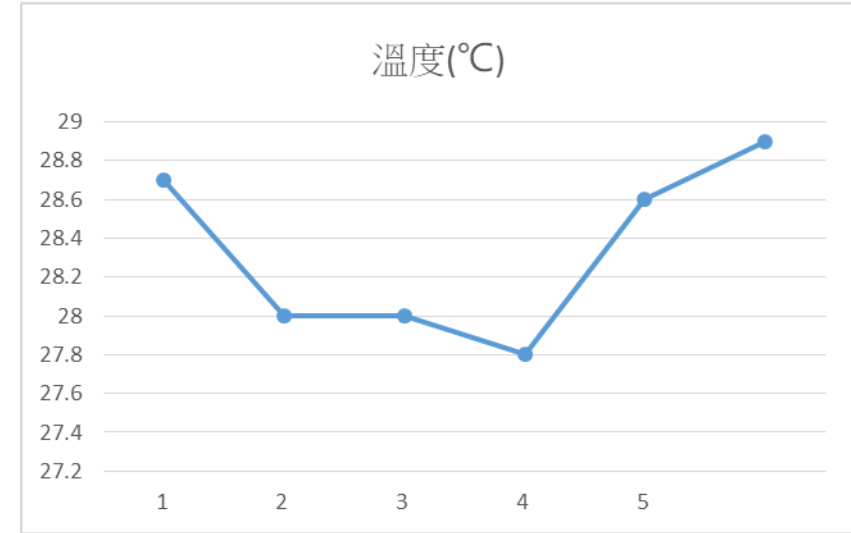
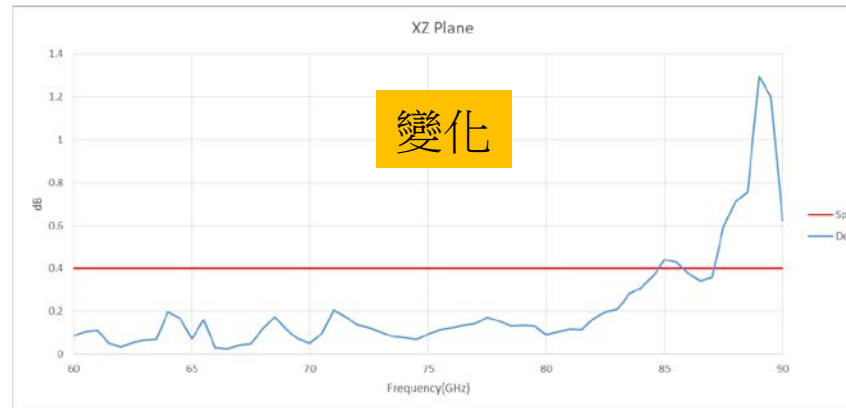
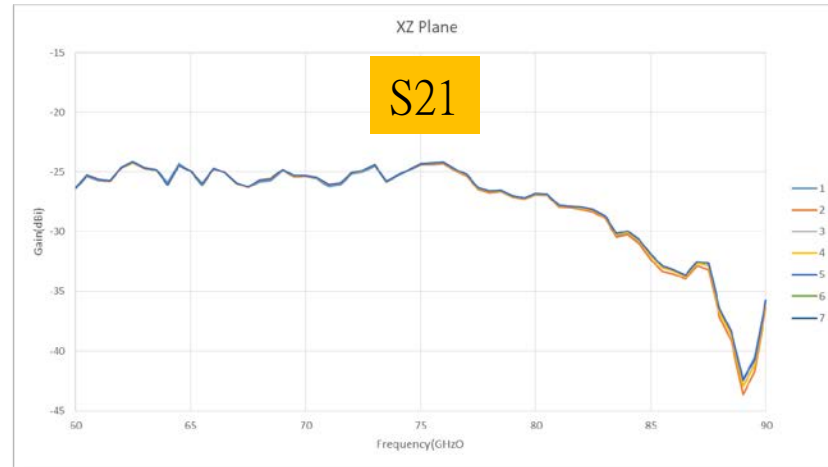
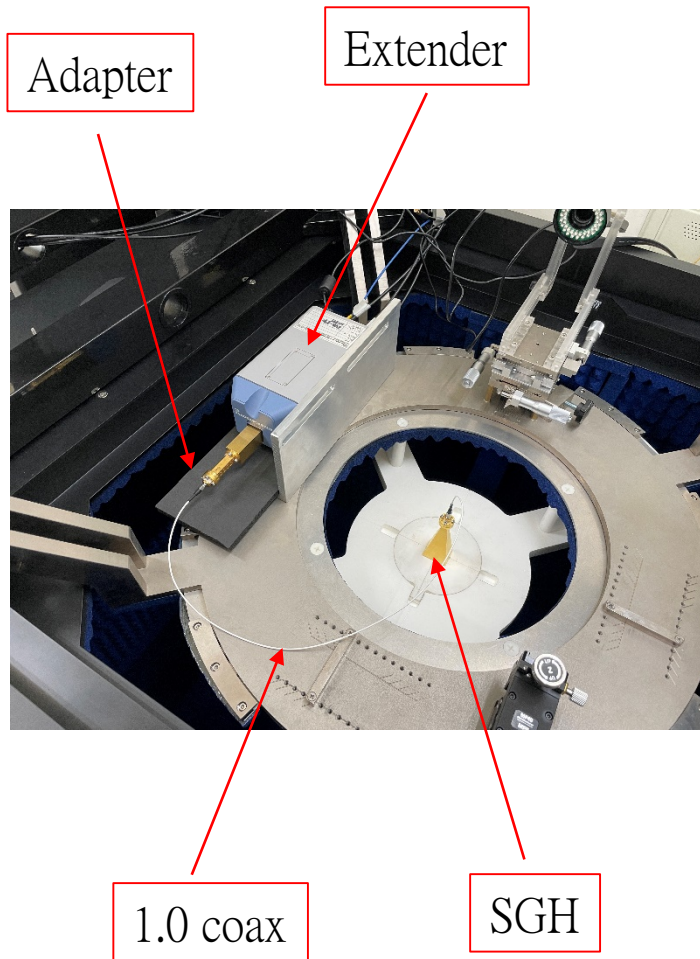


- ✓ balun設計
- ✓ Pitch及型式選擇
- ✓ 頻率限制
- ✓ 型狀選擇
- ✓ 探針機構強度選擇

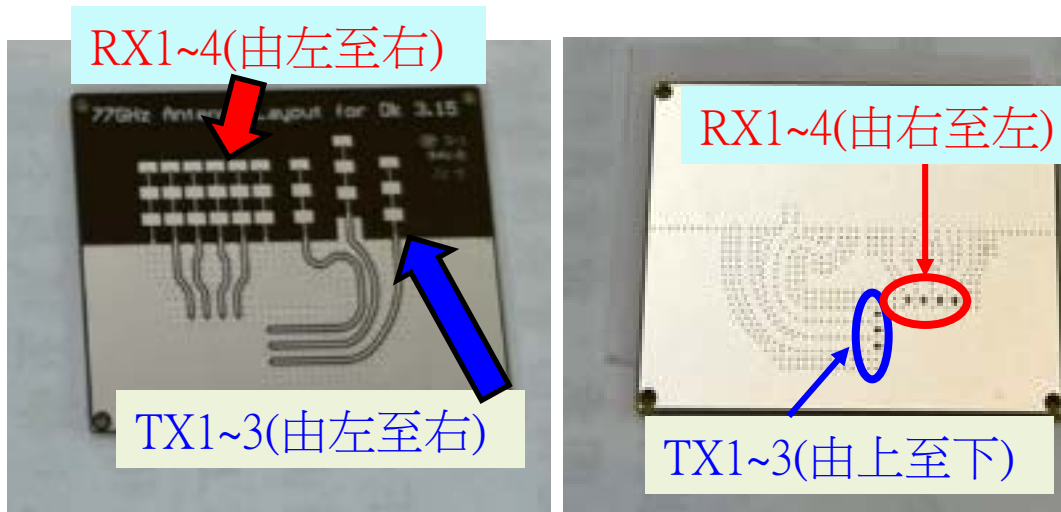
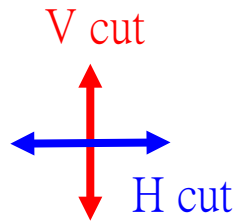


w/o probe分析感謝高科大研究提供

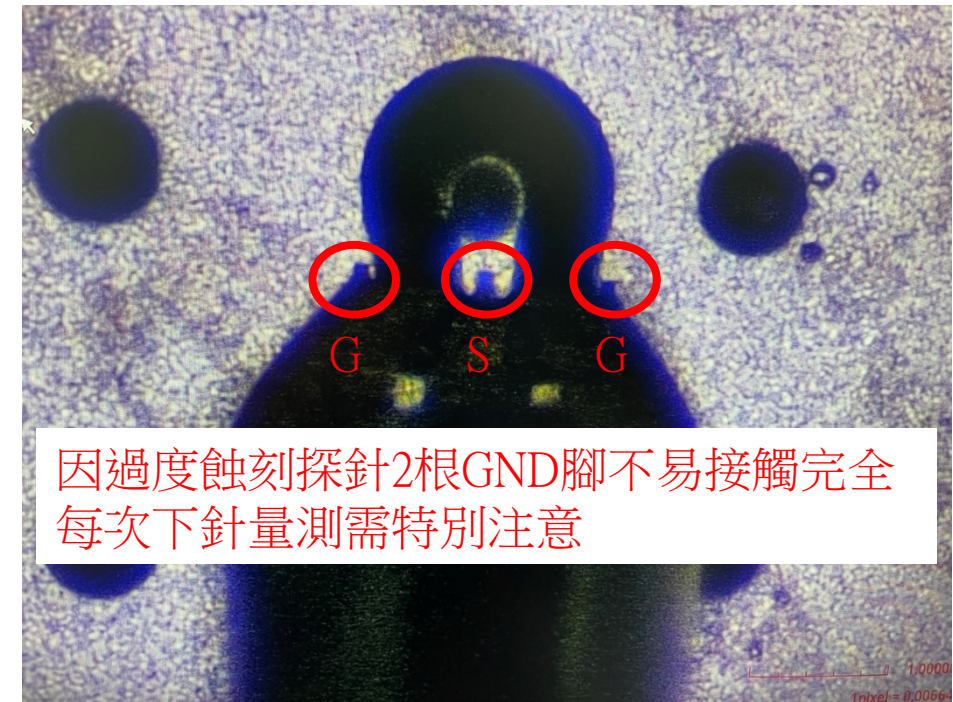
OTA系統穩定性



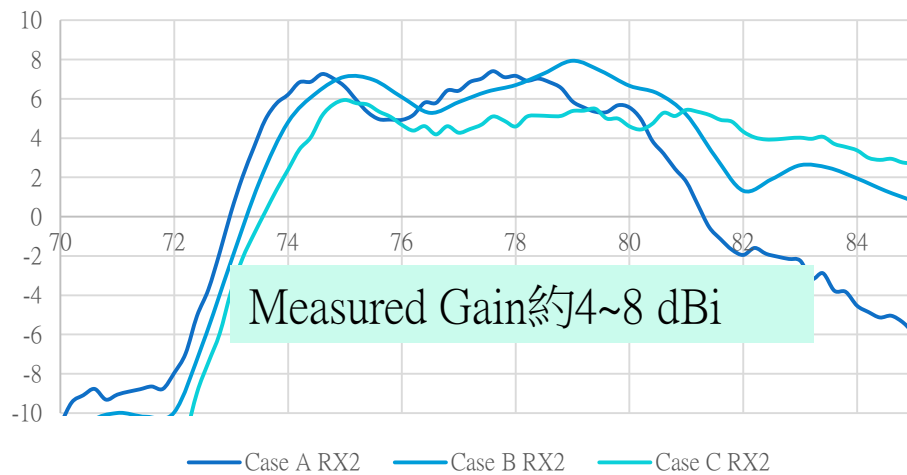
AUT介紹



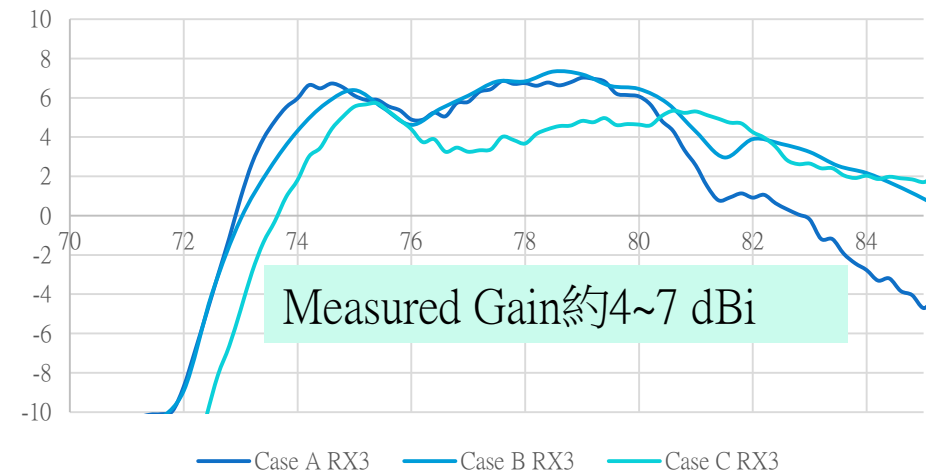
PCB size: 35x28 mm



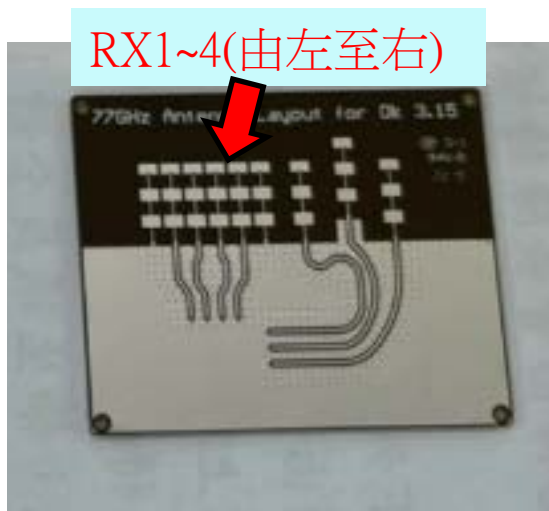
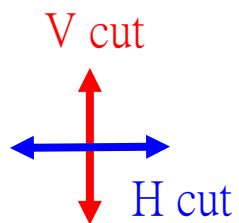
H cut Measured Gain (dBi) (test port: RX2)



H cut Measured Gain (dBi) (test port: RX3)



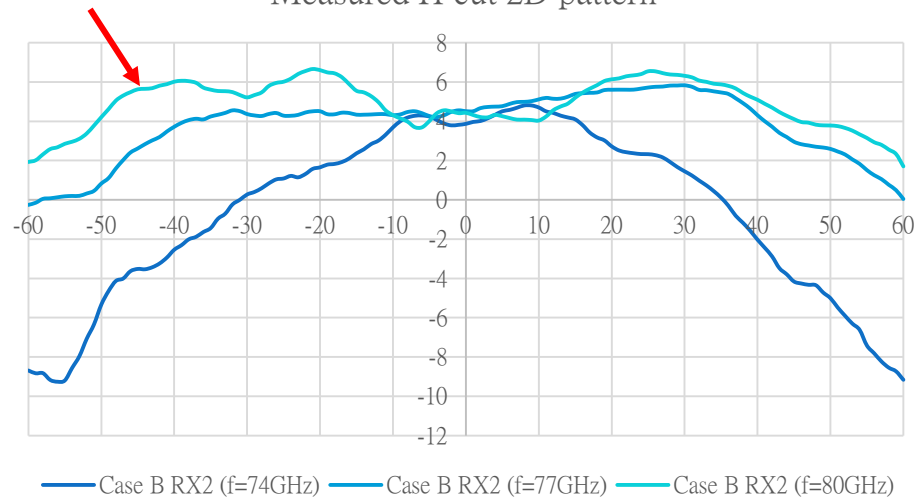
量測結果 - Radiation Pattern



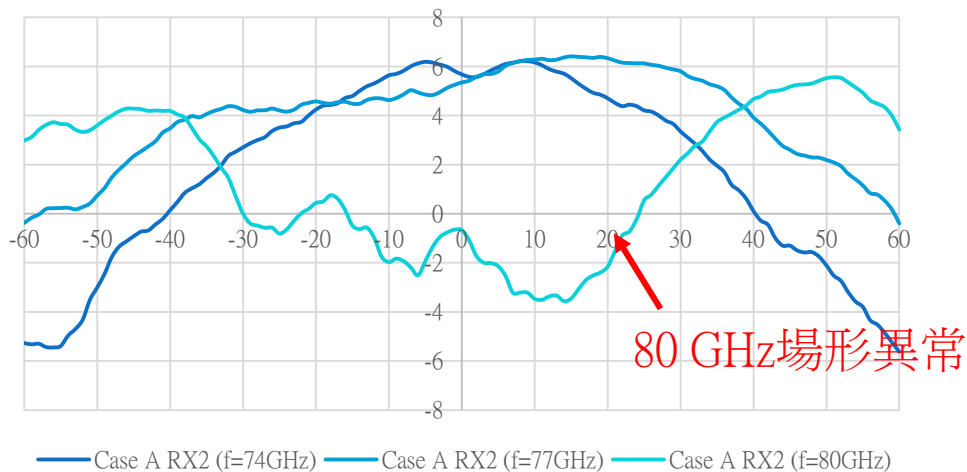
Simulated H cut HPBW: 65~70 deg.

80 GHz場形異常

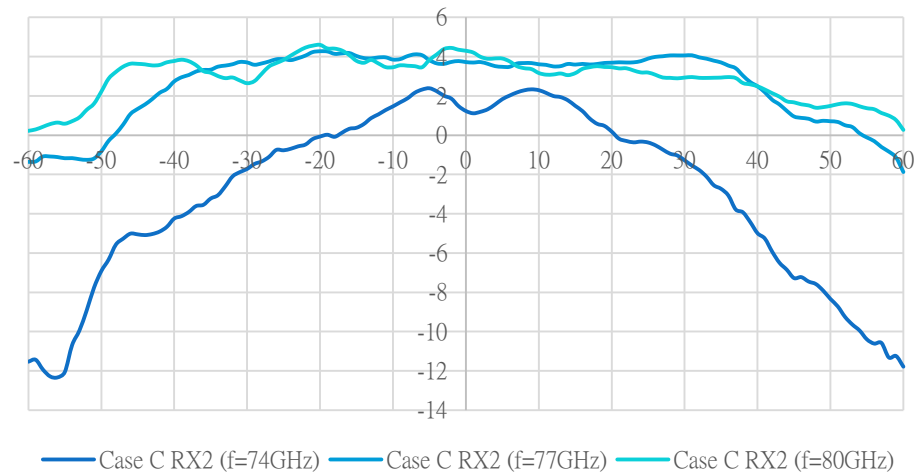
Measured H cut 2D pattern



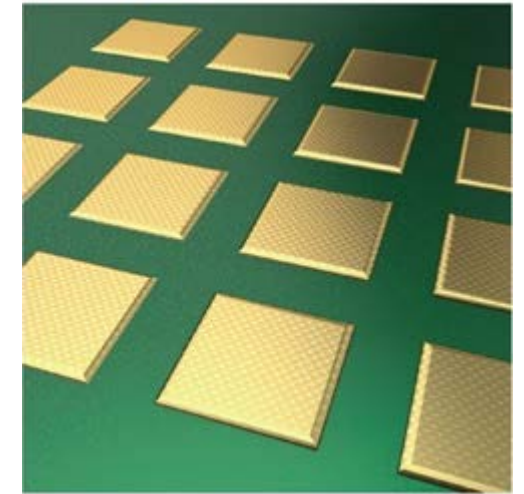
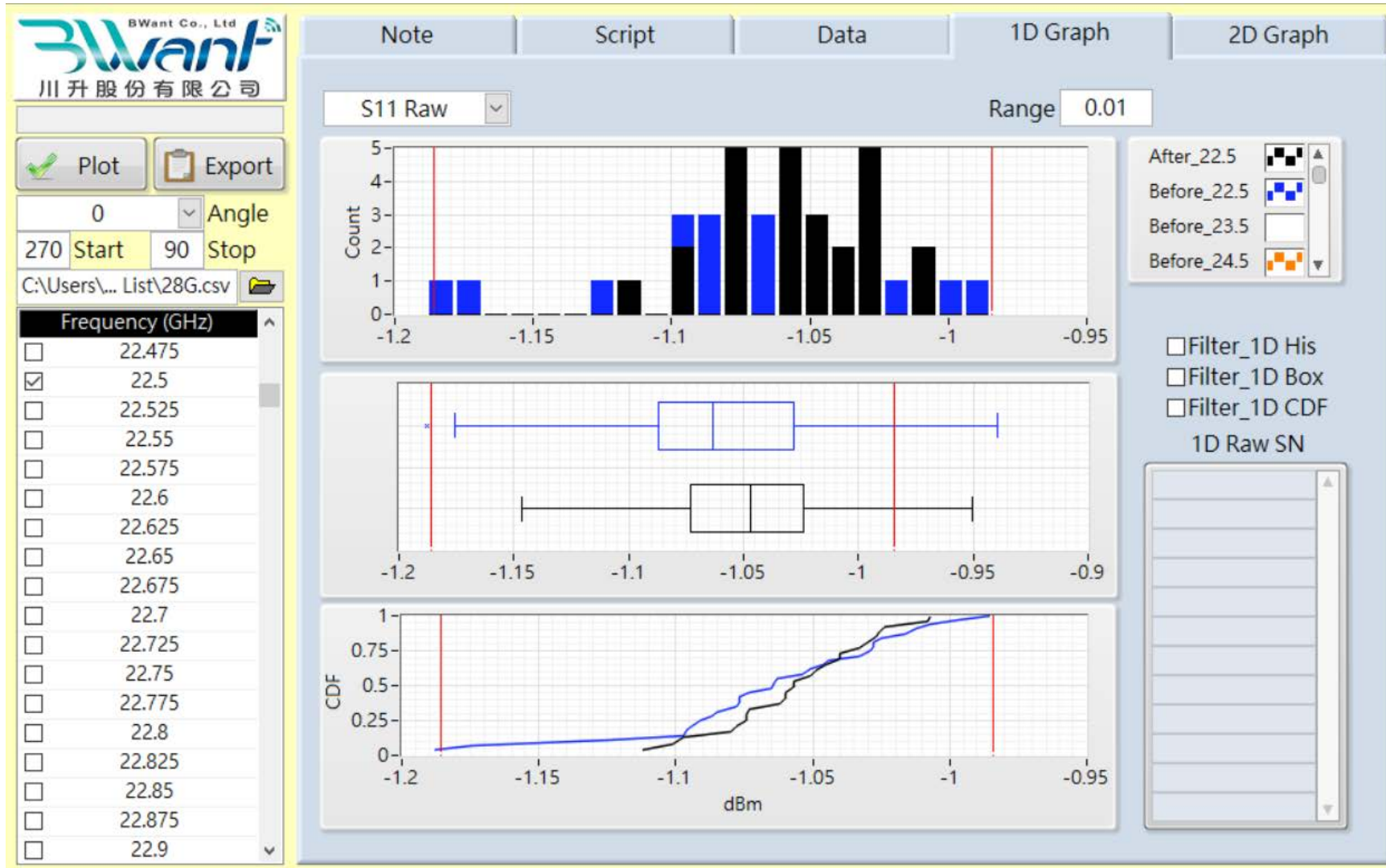
Measured H cut 2D pattern



Measured H cut 2D pattern



天線與BFIC組合分析-大數據



+ 溫度/濕度



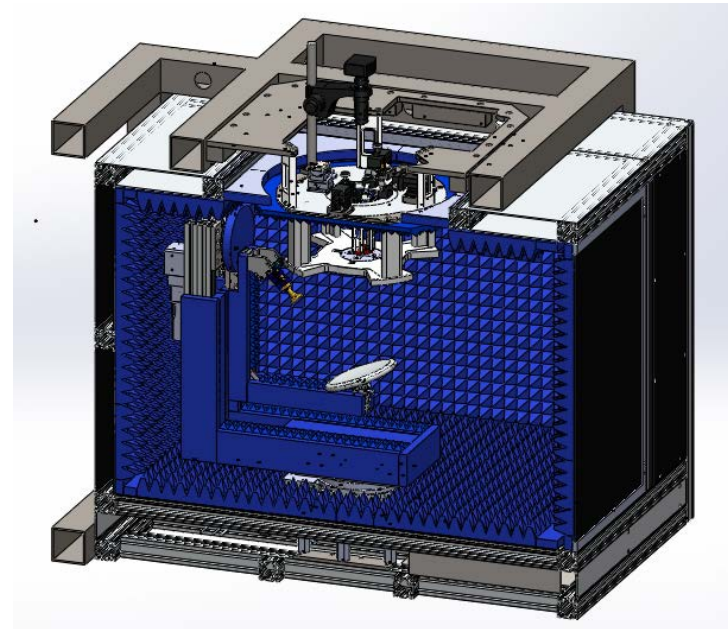
圖片來源www.analog.com

大綱

- 天線系統量測新挑戰 – Why Probing OTA
- Probing OTA 實例分享
 - 1) 文獻分享
 - 2) Sub THz 設計介紹– MW5e
 - 3) 量測結果
- 結論

結論

- ✓ 適用於輻射元件，以及連接輻射元件的通訊模組
- ✓ 結合升降頻、波導及高頻同軸等微波元件
- ✓ 省時方便，S參數 & 輻射性能一站式量測
- ✓ 適用於AiP及相控陣列天線
- ✓ Probing-OTA設計重點：
 - ① 治具材質及結構
 - ② 防震
 - ③ Probe選擇
 - ④ 顯微鏡焦距及倍數





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