



Dumanli, S., Paul, D. L., & Railton, C. J. (2010). LTCC or LCP, a comparison using cavity backed slot antennas with pin curtains at 60 GHz. 1 - 5.

[Link to publication record in Explore Bristol Research](#)
PDF-document

University of Bristol - Explore Bristol Research

General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available:
<http://www.bristol.ac.uk/pure/about/ebr-terms.html>

Take down policy

Explore Bristol Research is a digital archive and the intention is that deposited content should not be removed. However, if you believe that this version of the work breaches copyright law please contact open-access@bristol.ac.uk and include the following information in your message:

- Your contact details
- Bibliographic details for the item, including a URL
- An outline of the nature of the complaint

On receipt of your message the Open Access Team will immediately investigate your claim, make an initial judgement of the validity of the claim and, where appropriate, withdraw the item in question from public view.



LTCC or LCP

A COMPARISON USING CAVITY BACKED SLOT
ANTENNAS with PIN CURTAINS at 60 GHz

Sema Dumanli Oktar

University of Bristol in conjunction with Toshiba TRL



Outline

- Introduction
- Antenna Model
 - CBS antenna on LTCC
 - CBS antenna on LCP
 - Pin Curtains
- Simulations and Results
 - Return Loss and Radiation Pattern
 - Efficiency Calculations
- Conclusions



Introduction

- The 60 GHz band → 7 GHz unlicensed bandwidth
- Many materials used at microwave frequencies have unacceptably higher losses (more to consider, eg. substrate water absorption)
- Low temperature co-fired ceramic (LTCC) and liquid crystal polymer (LCP) → most popular !
- They both offer good electrical performance however LCP has lower cost

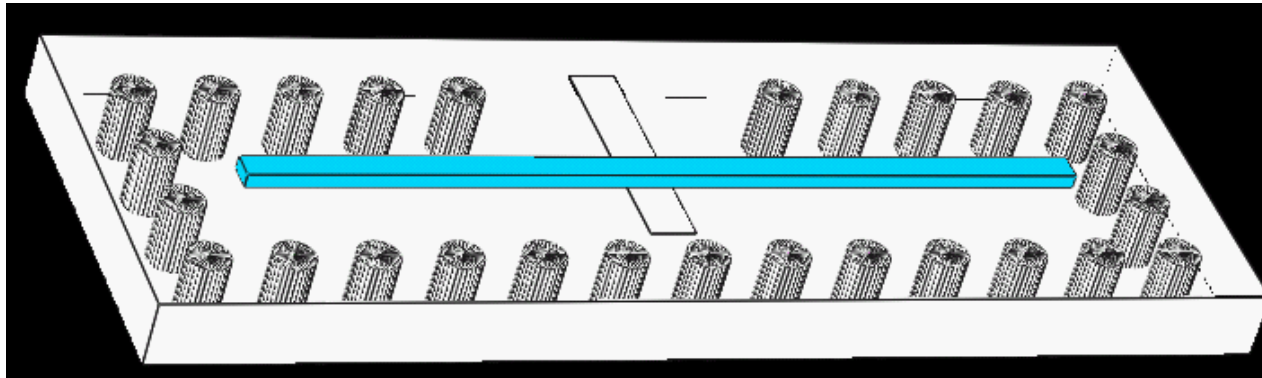


Outline

- Introduction
- **Antenna Model**
 - CBS antenna on LTCC
 - CBS antenna on LCP
 - Pin Curtains
- Simulations and Results
 - Return Loss and Radiation Pattern
 - Efficiency Calculations
- Conclusions



🔥 Antenna Model



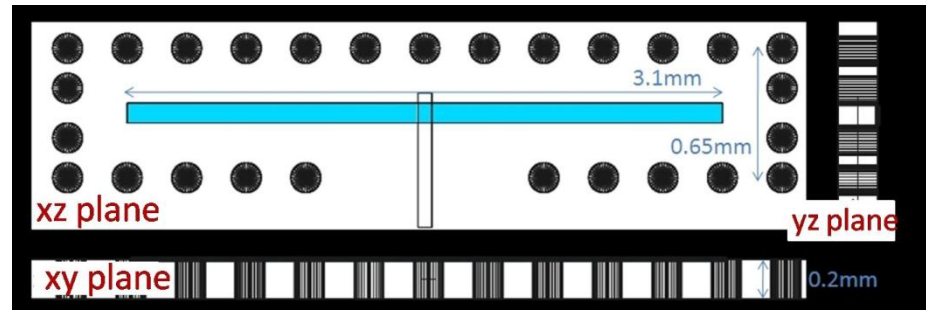
CBS

- 2 layers are needed for the strip.
- $t < \lambda g/4$ ($=538\mu\text{m}$) to suppress TE and TM modes on the strip.
- Lowest slot resonance by slot length.
- Cavity mode with the lowest resonant frequency is TE_{101} .

$$f_{nml} = \frac{c}{\sqrt{\epsilon_r}} \sqrt{\left(\frac{l}{2d}\right)^2 + \left(\frac{n}{2a}\right)^2 + \left(\frac{m}{2b}\right)^2}$$



🌟 Antenna Model

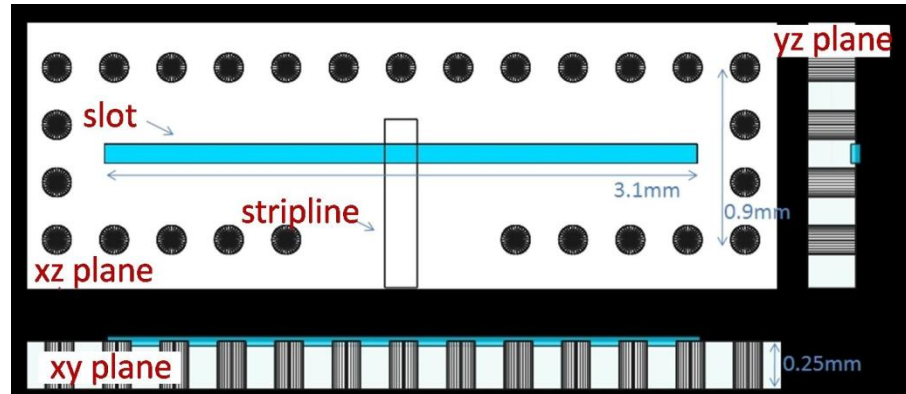


CBS antenna on LTCC

- $\epsilon_r = 5.4$ and $\tan\delta = 0.0015$
- Thickness (t) of LTCC layers ranges: 80 - 125 μm
- Cavity mode with the lowest resonant frequency is TE_{101} at approx. 109 GHz



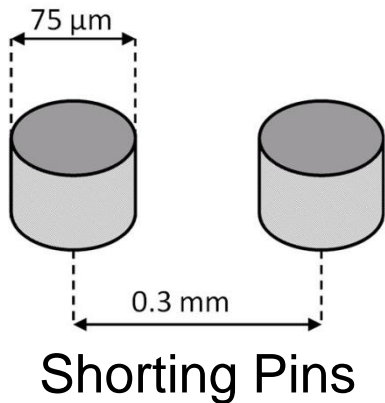
🌟 Antenna Model



CBS antenna on LCP

- The electrical properties of ULTRALAM 3850
- $\epsilon_r = 2.9$ and $\tan\delta = 0.0049$
- Substrate thickness is chosen as 250 μm .
- Cavity mode occurs at 100 GHz

🔥 Antenna Model



- Manufacturing repeatability
- Integration with other SIW structures

- The dimensions of the pins -> not critical in terms of antenna performance but watch the leakage!
- Design restrictions due to the manufacturing capabilities.
- Via diameter, via pitch, line or slot width (since the sizes get smaller at 60 GHz.)

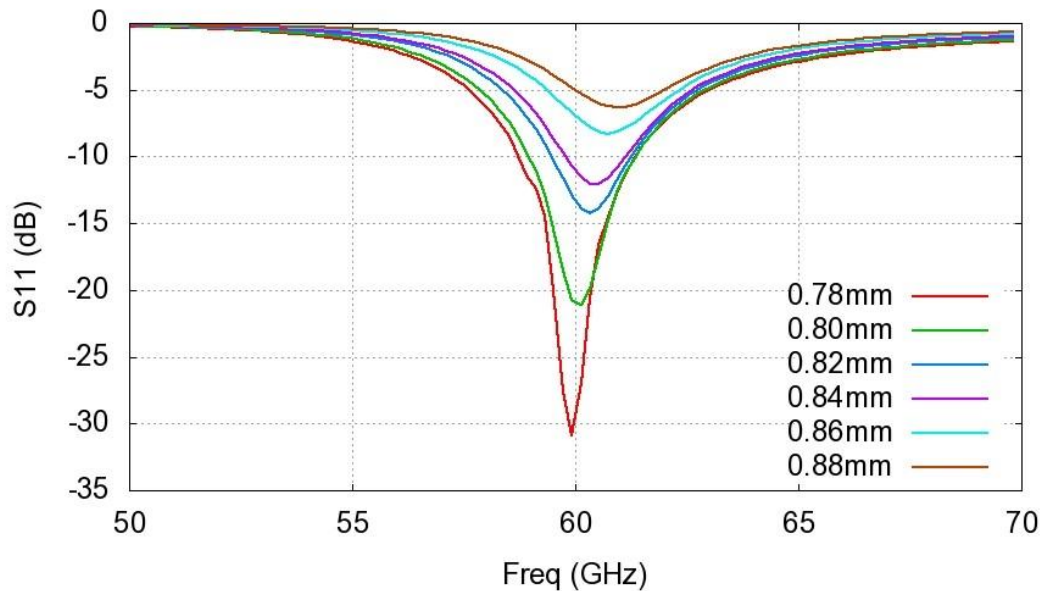


Outline

- Introduction
- Antenna Model
 - CBS antenna on LTCC
 - CBS antenna on LCP
 - Pin Curtains
- **Simulations and Results**
 - Return Loss and Radiation Pattern
 - Efficiency Calculations
- Conclusions



🔥 Simulations and Results

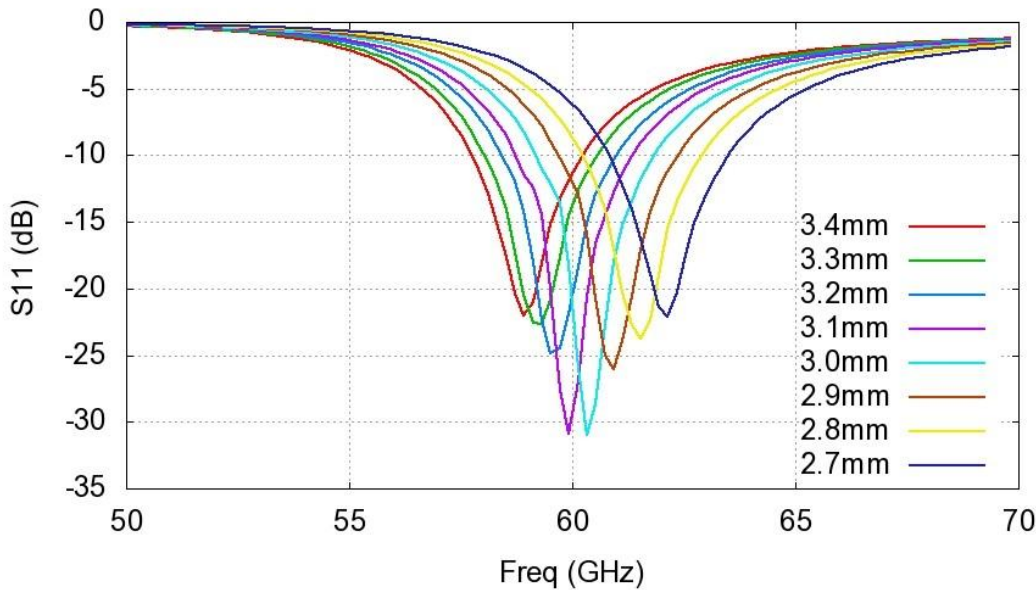


Tuning of CBS antenna on LCP, feed line lengths from 0.78 to 0.88 mm

- The feed line length -> optimized for best return loss (for each antenna).
- The tuning of S_{11} is shown in the figure.



🔥 Simulations and Results

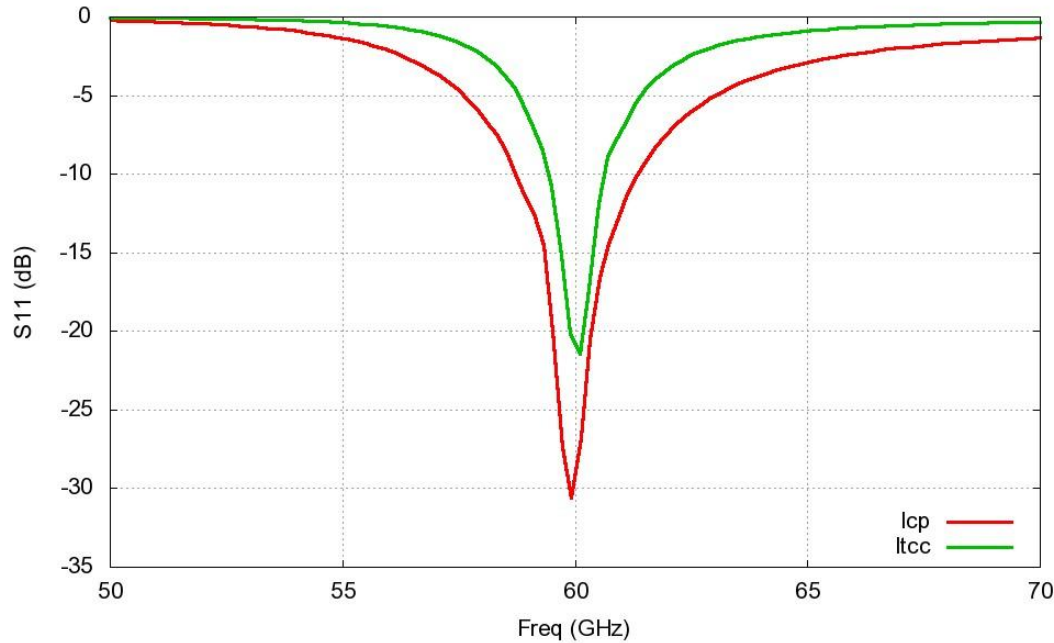


Tuning of CBS antenna on LCP, slot length from 3.4 to 2.7 mm

- The slot lengths are optimized -> 60 GHz.
- Figure shows the response of the LCP antenna to different slot lengths.



🔥 Simulations and Results

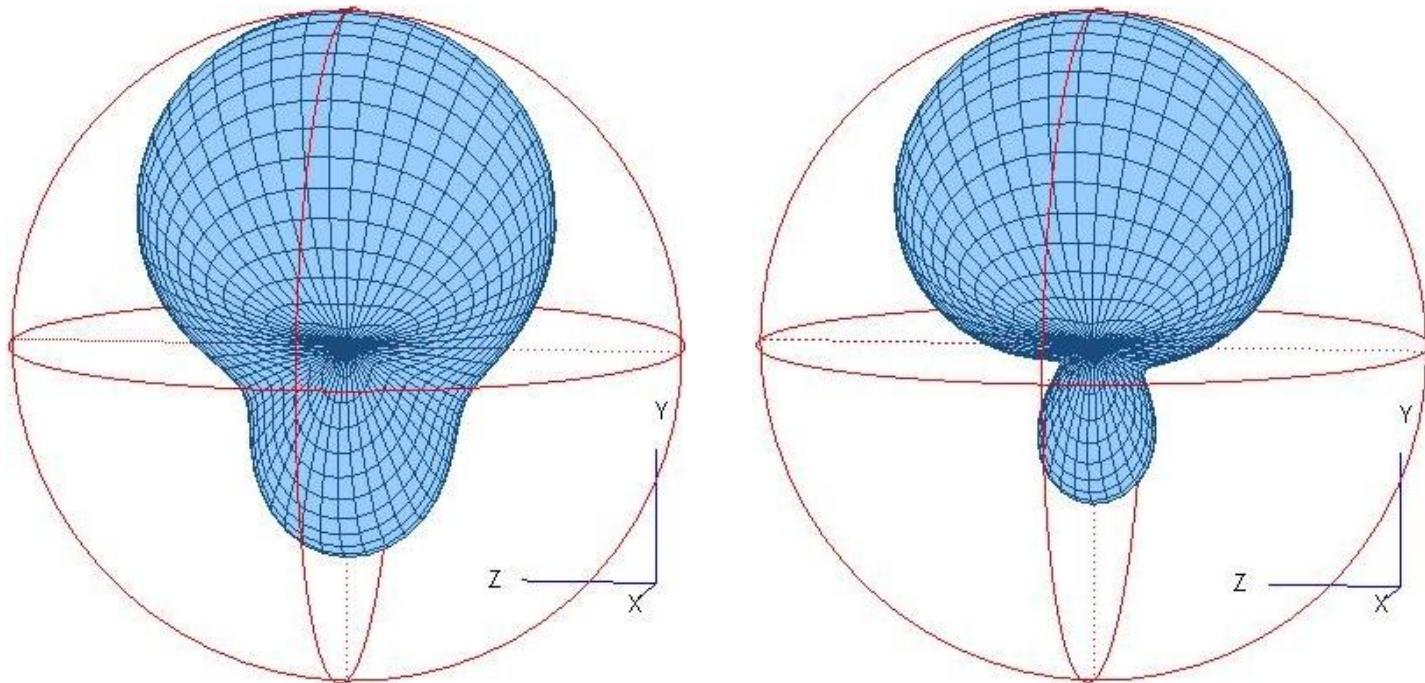


Frequency response of the CBS antennas

- 22 dB for LTCC and 31 dB for LCP at 60 GHz.
- CBS on LCP has a larger bandwidth -> the thickness of the substrate.



🔥 Simulations and Results



3D Radiation Patterns of the CBS antennas : LTCC, and LCP



Simulations and Results

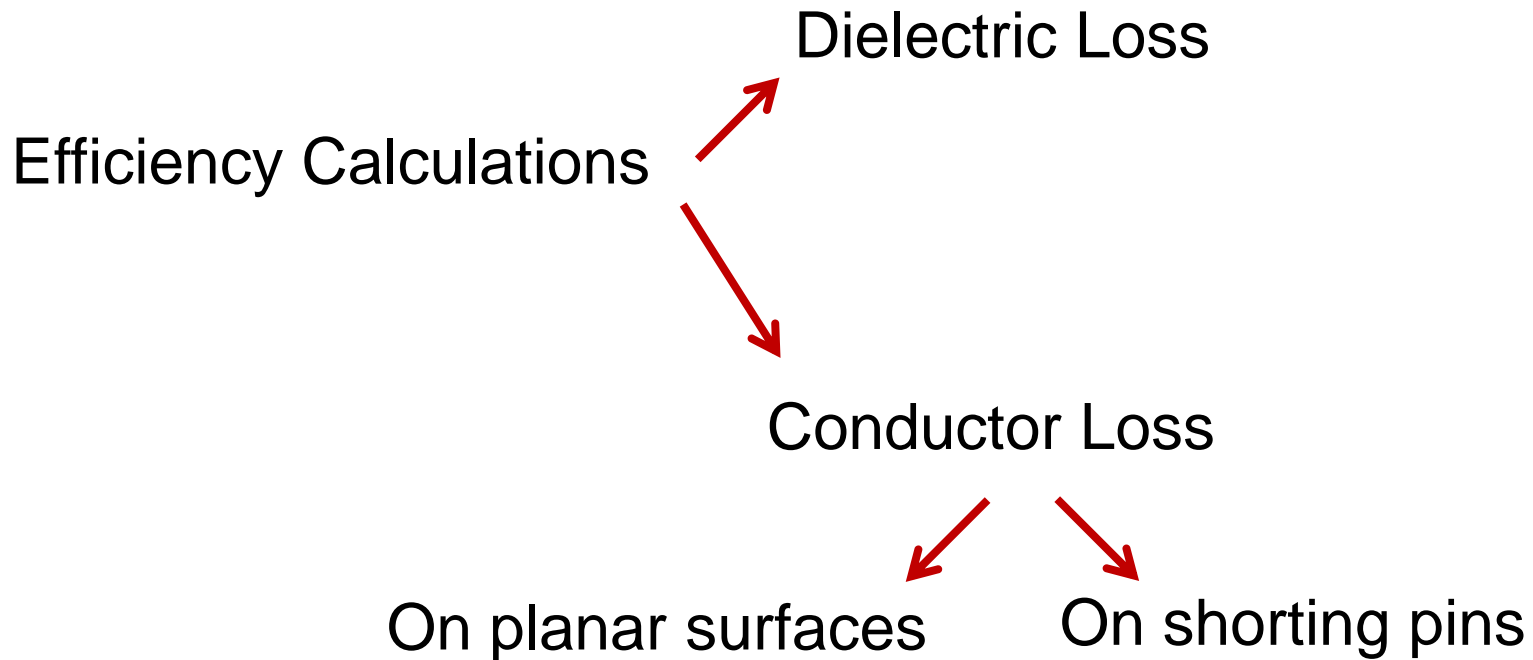
RADIATION CHARACTERISTICS OF THE CBS ANTENNAS

	CBS on LTCC	CBS on LCP
Directivity	5.7dB	6.4dB
Cross Pol Level	17%	14%

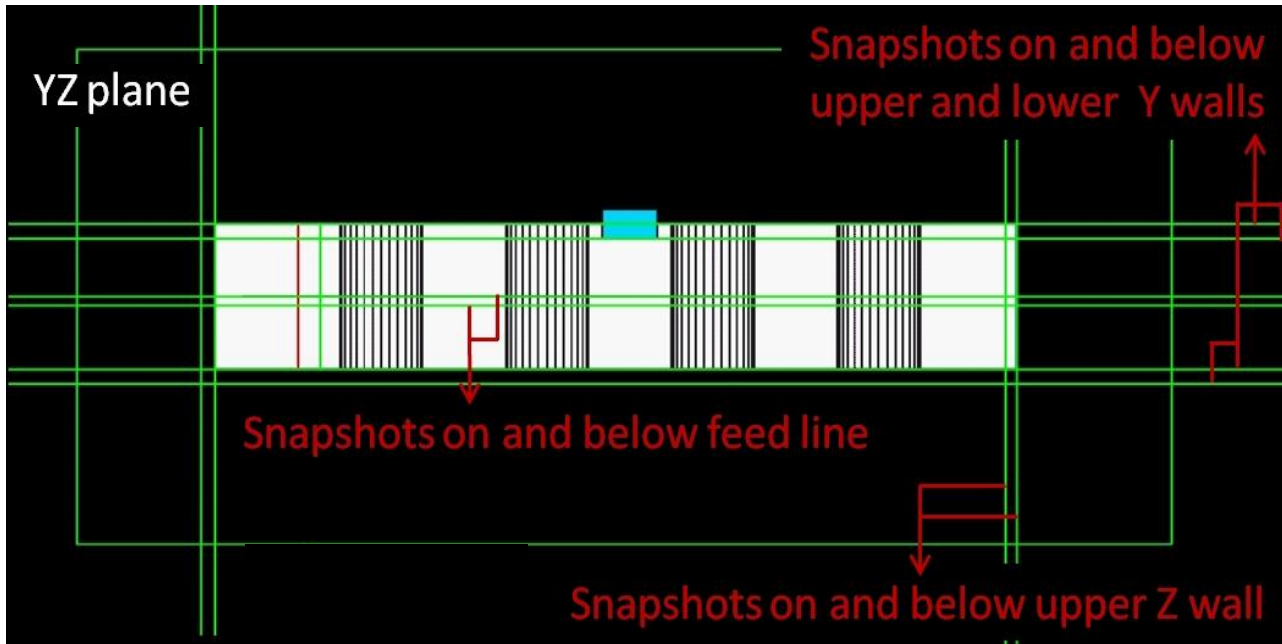
- LTCC has more back radiation.
- Main lobes are directed at an angle of $\theta = 90^\circ$; $\varphi = 90^\circ$ for both.
- Directivity and polarisation purity : LCP has a better performance



Simulations and Results



🔥 Simulations and Results



$$\overline{J}_s = \hat{n} \times \overline{H} = \overline{H}_t$$

&

$$R_s = \sqrt{\frac{w \cdot \mu}{2 \cdot \sigma}}$$



$$|\overline{J}_s|^2 \times R_s \times \text{unitarea}$$

Conductivity of copper is taken as $5.813 \times 10^7 \text{ Sm}^{-1}$, and the surface resistivity is calculated to be 0.064 at 60 GHz

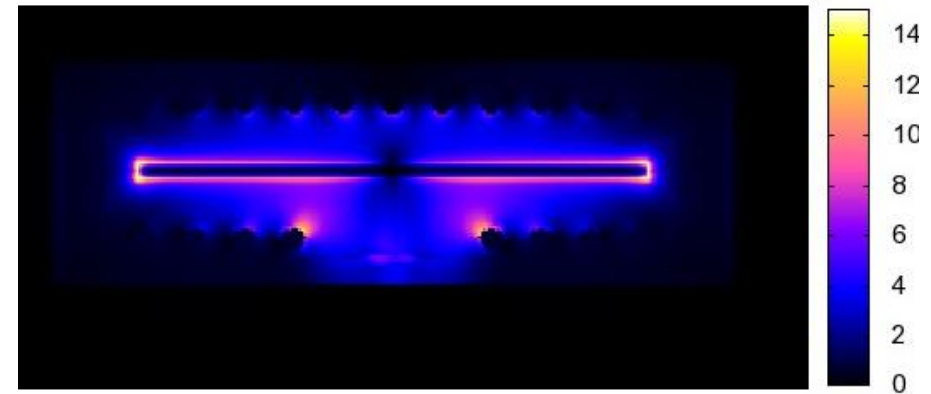


🔥 Simulations and Results

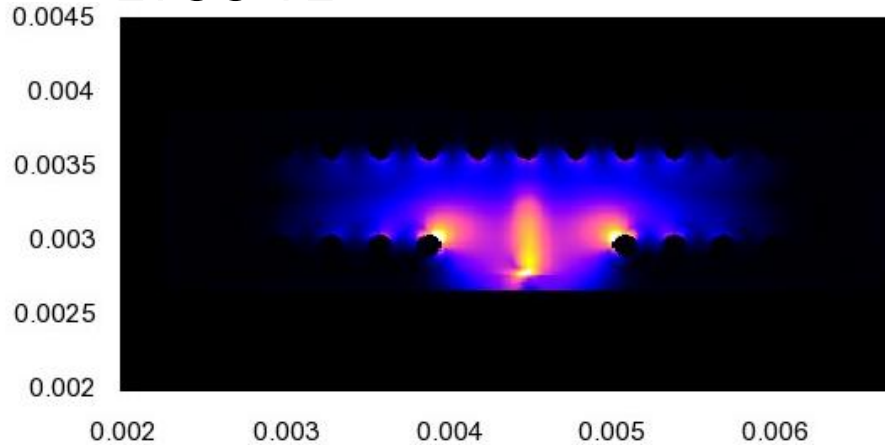
LCP YL



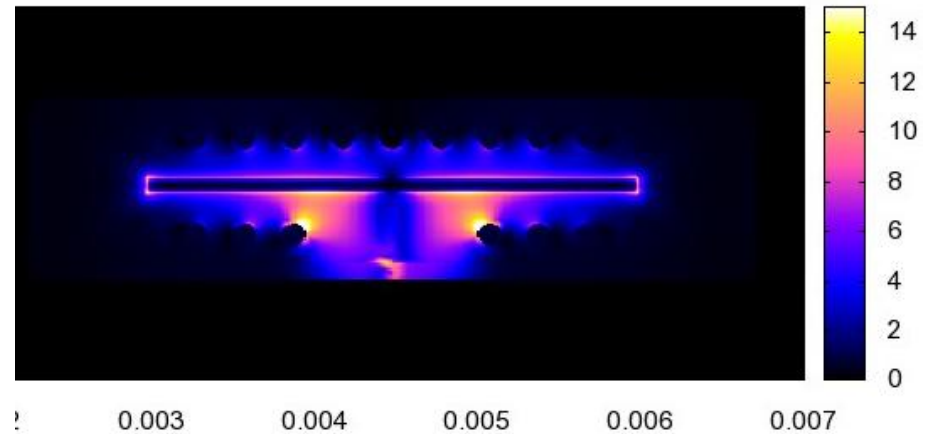
LCP YU



LTCC YL



LTCC YU



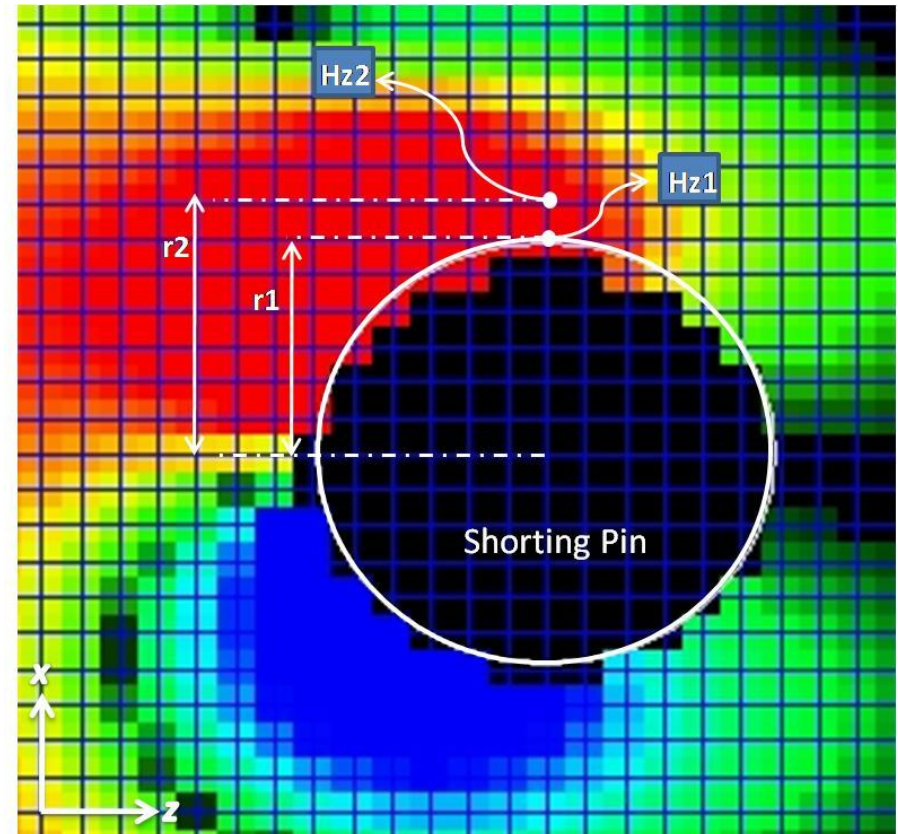
🔥 Simulations and Results

$$J_y = |\overline{H_{z1}} - \overline{H_{z2}}|$$



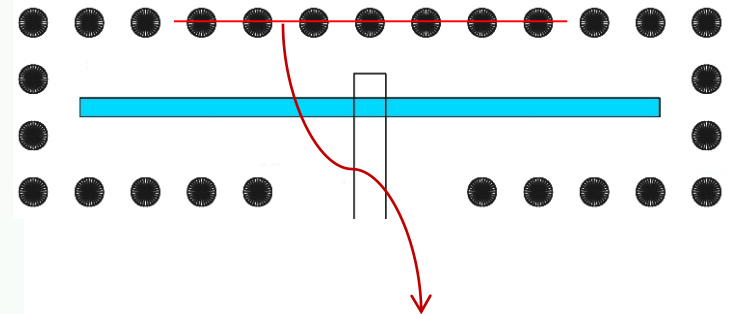
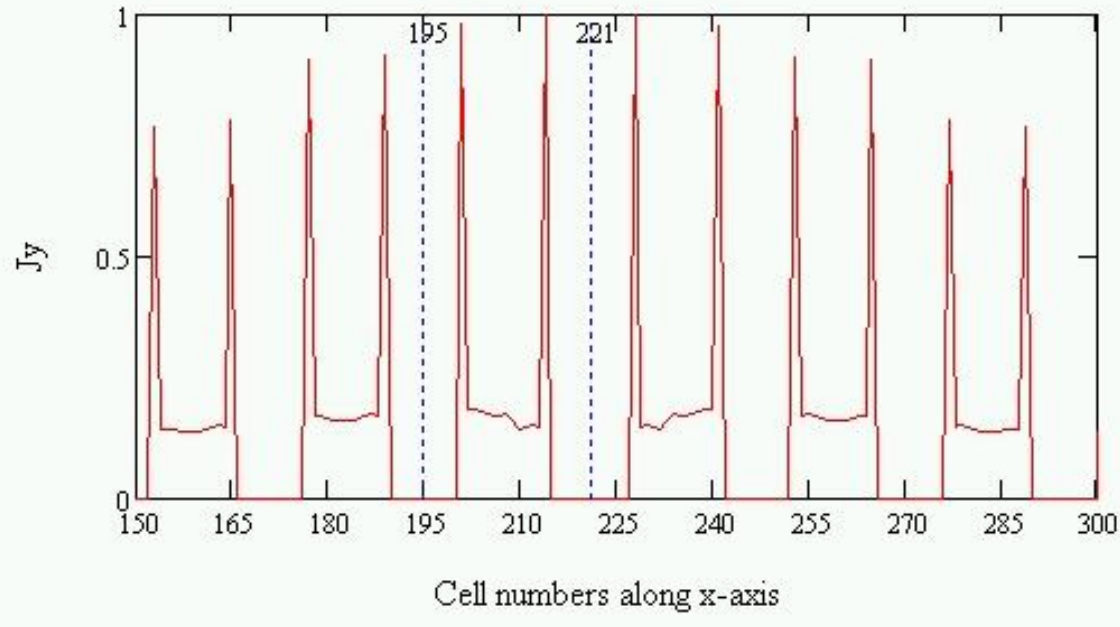
$$(2\pi \cdot r_2 \cdot J_y)^2 \times R_s \frac{L}{\pi(2 \cdot r_1 - \delta_s)}$$

- H_{z2} and H_{z1} are subtracted from each other to find J_y .



- Flow from the outer surface of the pins with a skin depth of $2.695 \times 10^{-7} \text{m}$.

Simulations and Results



Current along the red line,
CBS antenna on LCP

- The pins located at cell numbers $x = 123, 147, 171, 195, 221, 247, 271, 295, 319$
- The current goes down to zero towards the centre of the pin

Simulations and Results

CONDUCTOR LOSSES NORMALIZED TO THE POWER RADIATED IN
LOSSLESS CASE

	CBS on LTCC	CBS on LCP
Feed Line	0.032	0.008
X Wall	0.072	0.016
Y Wall	0.066	0.020
Z Wall	0.040	0.014
Pin Curtains	0.009	0.002

$$\eta_m = 1 - \Gamma^2$$



$$Efficiency = \eta_m \cdot \eta_\Omega$$

- The final efficiency values = **65% for LTCC**
84% for LCP.
- η_m = mismatch efficiency & η_Ω = conductor and dielectric losses.
- Mismatch efficiencies = 0.92 for LTCC
0.94 for LCP



Outline

- Introduction
- Antenna Model
 - CBS antenna on LTCC
 - CBS antenna on LCP
 - Pin Curtains
- Simulations and Results
 - Return Loss and Radiation Pattern
 - Efficiency Calculations
- **Conclusions**



Conclusions

- Two 60 GHz slot antennas are designed which are backed by cavities on LCP and LTCC.
- The performance of the antennas are compared to demonstrate the effect of the dielectric material by keeping the other factors as constant as possible.
- It is shown that LCP offers better performance in terms of efficiency and radiation purity as well as having lower cost.





LTCC or LCP

A COMPARISON USING CAVITY BACKED SLOT
ANTENNAS with PIN CURTAINS at 60 GHz

Sema Dumanli Oktar

University of Bristol in conjunction with Toshiba TRL

