Flexible Metamaterial RF Filters Implemented through Micromachining LCP Substrates

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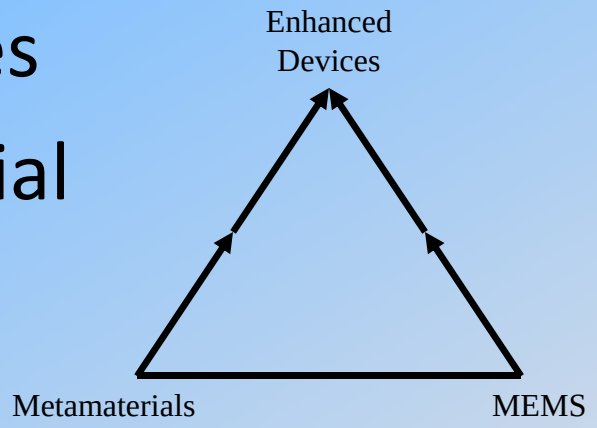
Overview

- Brief introduction to Metamaterials
- Common uses and Structures
- Metamaterial Simulations
- LCP Fabrication Processes
- Testing Procedure
- Results
- Future Work

Combined Technologies

- Smaller feature sizes
- More complex structures
- Ability to deposit material
- Use any substrate

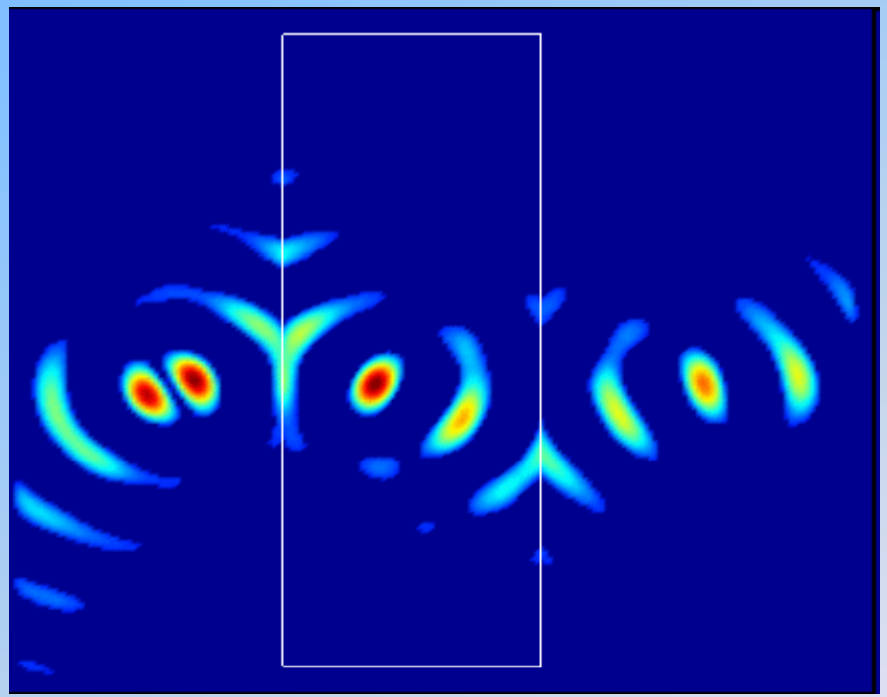


Definition

A Metamaterial is an arrangement of artificial structural elements, designed to achieve advantageous and unusual electromagnetic properties.

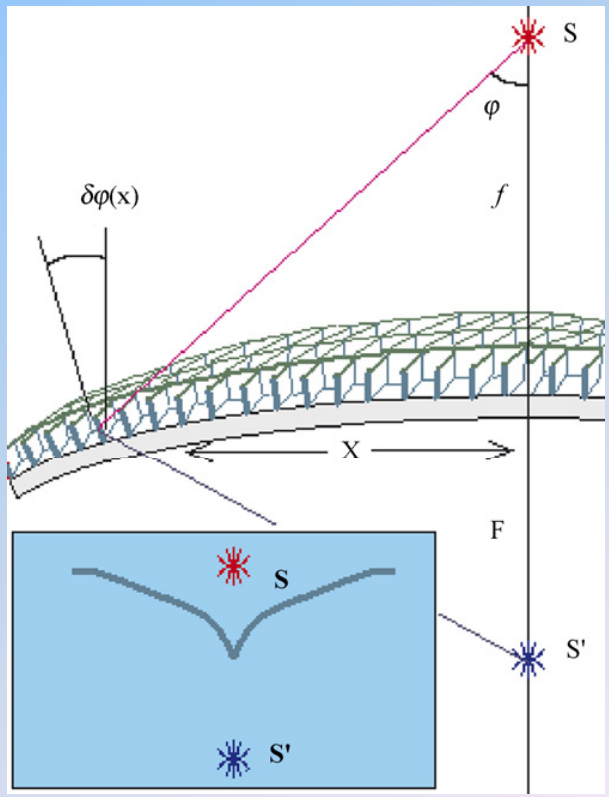
Introduction to Metamaterials

- Has negative index of refraction
- Double Negative materials a.k.a. Left handed
- Use of specially built structures
- Special structures use normal materials such as Rogers board, LCP, and Polyimides.



Common Uses

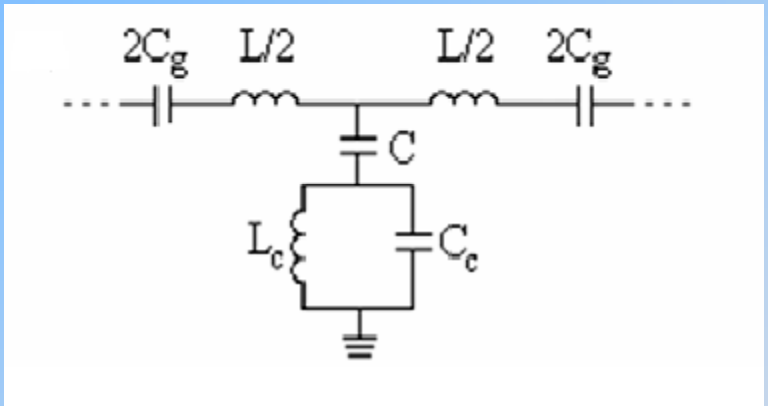
- Mirrors and lenses
- Transmission Lines Filters
- Invisibility cloaks



CSRR Structure

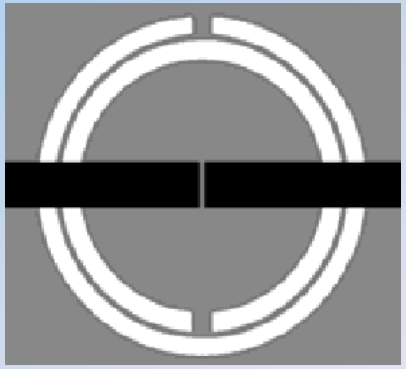
Lumped Element Representation

- Cg = Gap Capacitance
- Lc and Cc represent the resonator as a tank circuit
- L and C relate to the line per unit length



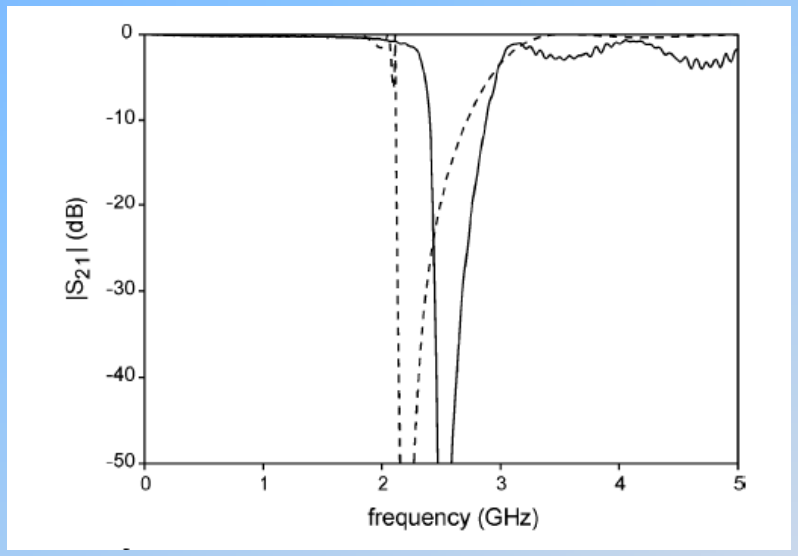
Physical Layout

- Gray = ground plane
- White = etch off ground plane
- Black = metal on surface

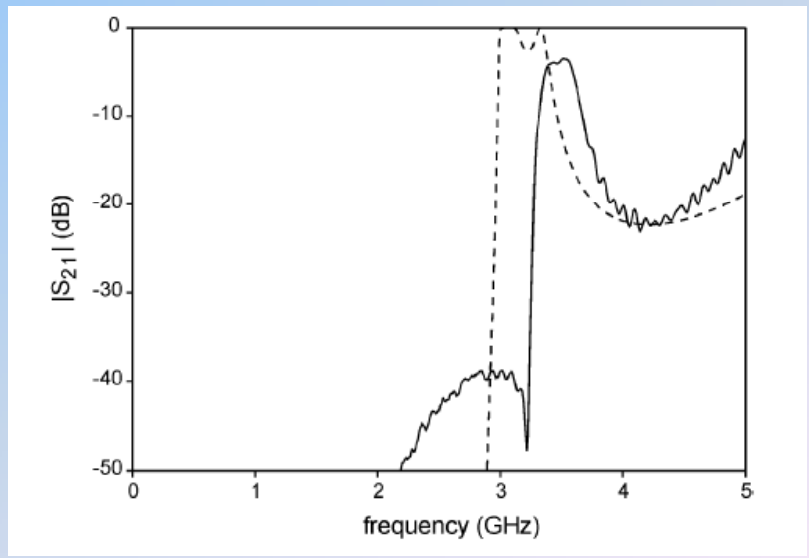


CSRR Gap Capacitance Effect

No Gap – Band Stop

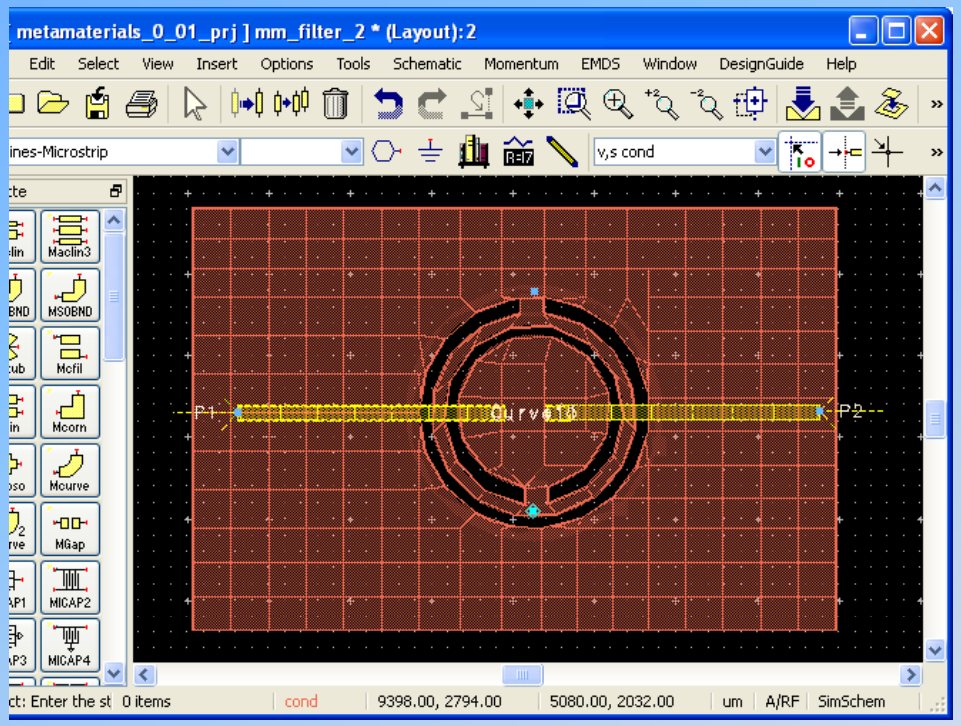


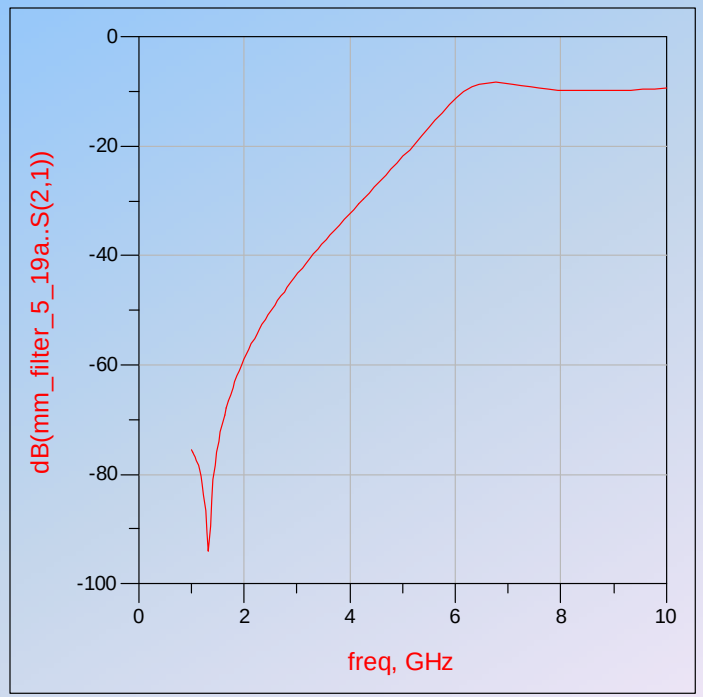
Gap – Band Pass



Metamaterial Simulations

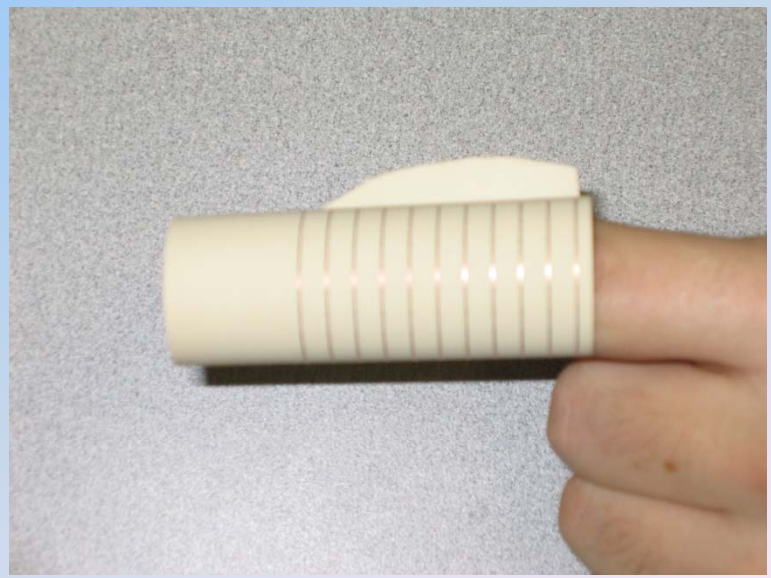
- ADS Momentum uses method of moments
- CSRR arrays were constructed in ADS layout
- Ran through frequencies and calculated S-parameters





Why LCP as a Substrate?

- Good RF properties up to 90 GHz
- Flexible
- Micromachinable
- Impervious to moisture

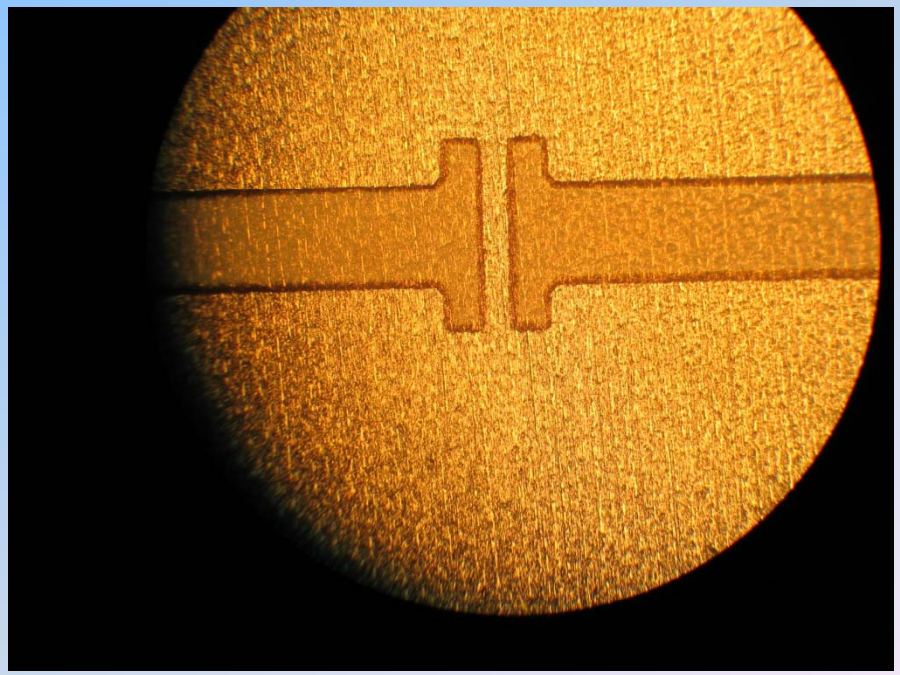


LCP Fabrication Overview

- Place mask on Liquid Crystal Polymer (LCP) with photolithography process
- Copper etching techniques
- LCP etching techniques

Photolithography Process

- Inspect and clean wafer with HCl bath
- Add HMDS to promote adhesion
- Spin on photoresist
- Expose wafer
- Develop wafer

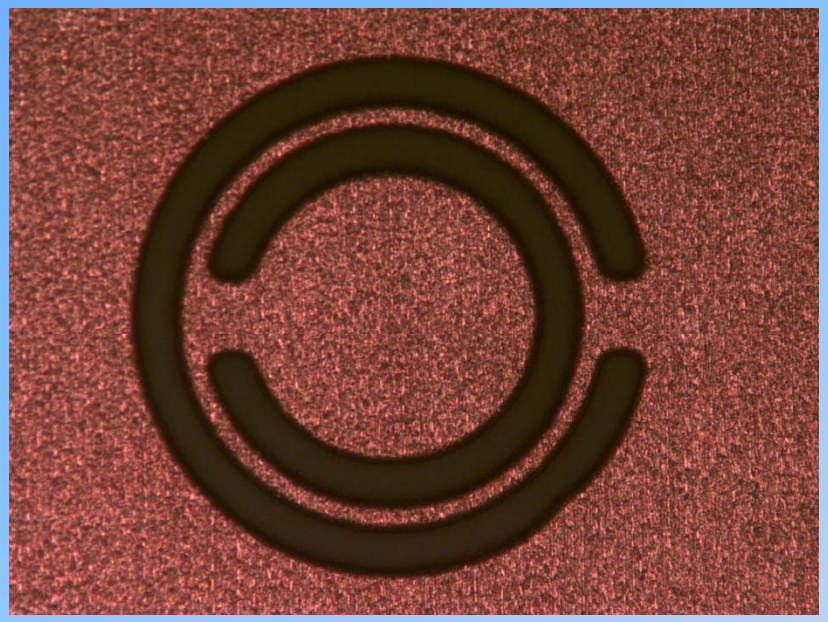


Copper Etching

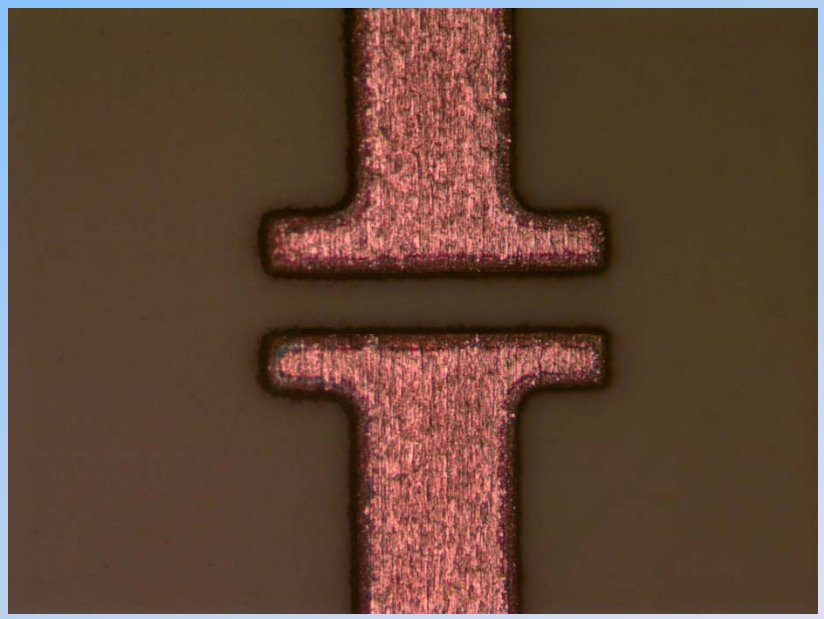
- Before etching, cover opposite side with tape or photoresist since LCP comes double clad with copper
- Wet etching is isotropic which is accounted for with photolithography mask
- Slower wet etching causes less variance across the wafer

Copper Etching Continued

Over etched CSRR



etched transmission gap



LCP Etching

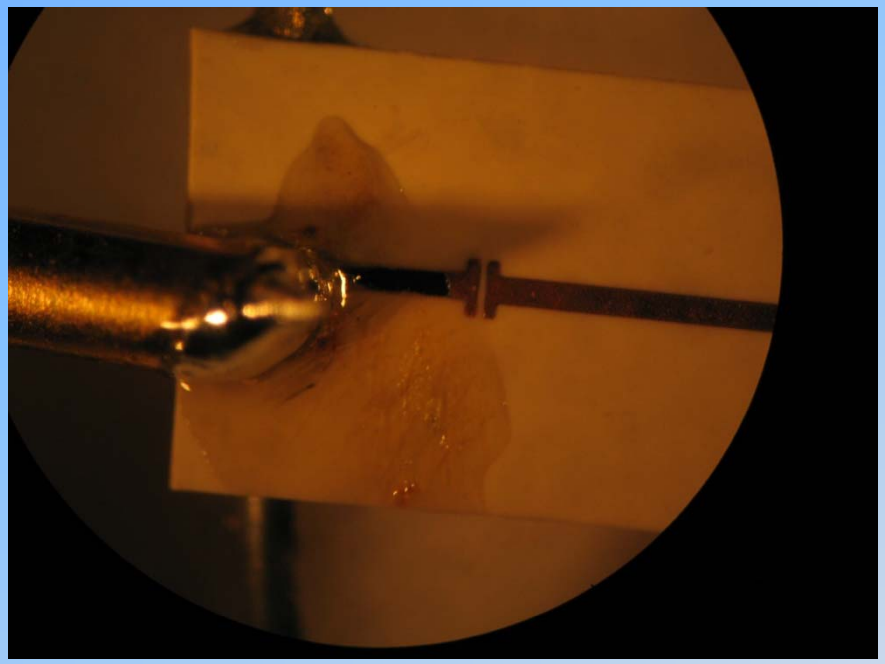
- After copper has been fully removed where desired, E-beam Al onto wafer
- Add mask using photolithography process
- Etch Al mask with highly select etchant
- Use 0_2 chemistry RIE to remove LCP followed by Al mask removal

Testing Procedure Setup

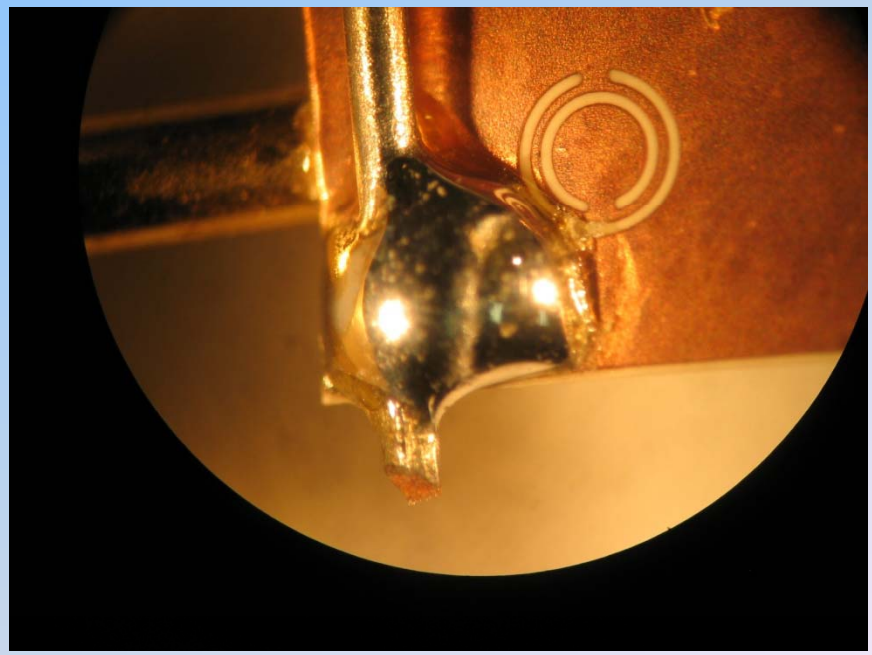
- Since the T-lines were impedance matched to 50Ω, sma connectors could be soldered on
- Provide extra T-line on masks to help with soldering and providing more surface area between LCP and Cu.
- Add tape to LCP and sma connector to provide structural support

T-line Setup

T-line with small Soldering area



Ground plane with small soldering area

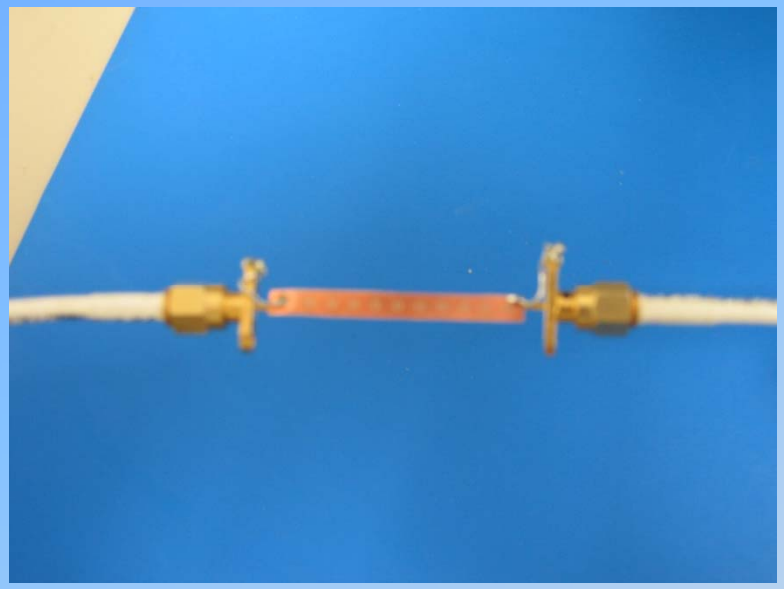


Testing T-lines

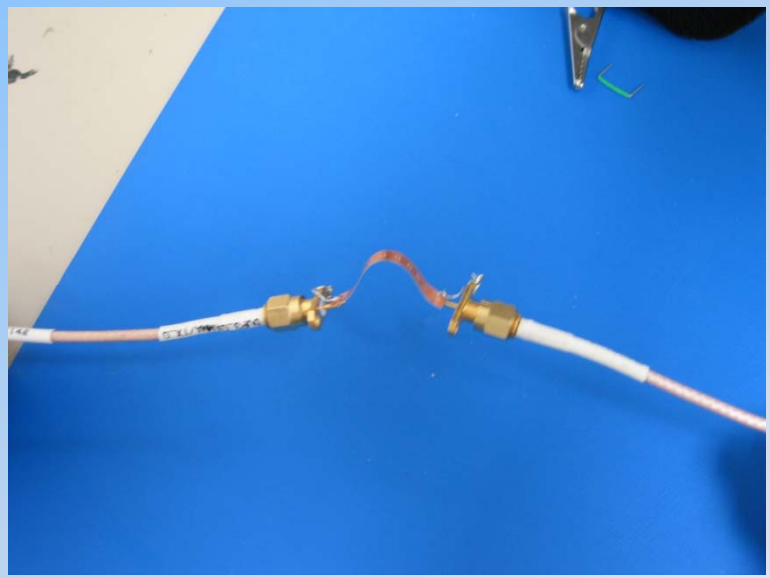
- Calibrate Network Analyzer
- Keep hands away from LCP and connectors during data capture
- Elevate LCP into the air to avoid affecting fringing capacitance

Testing T-lines Continued

Elevated flat test

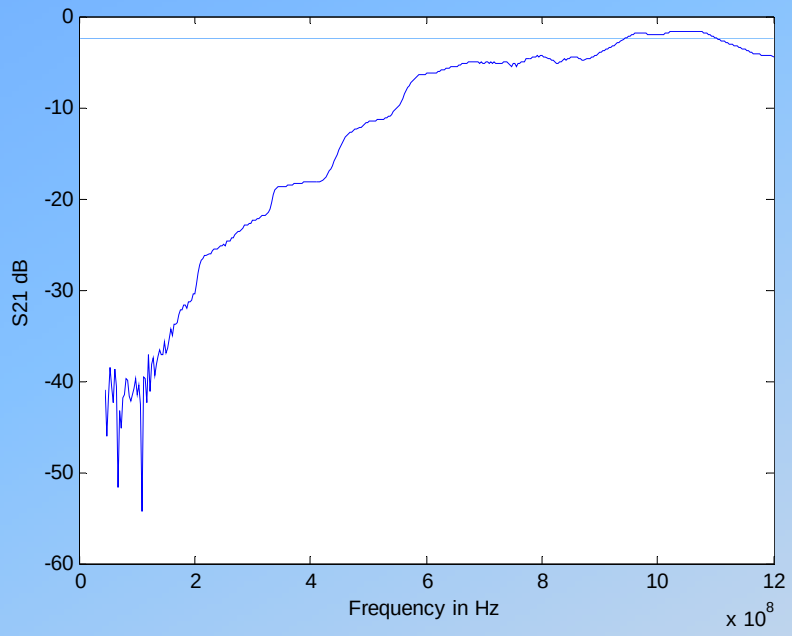


Elevated curve test

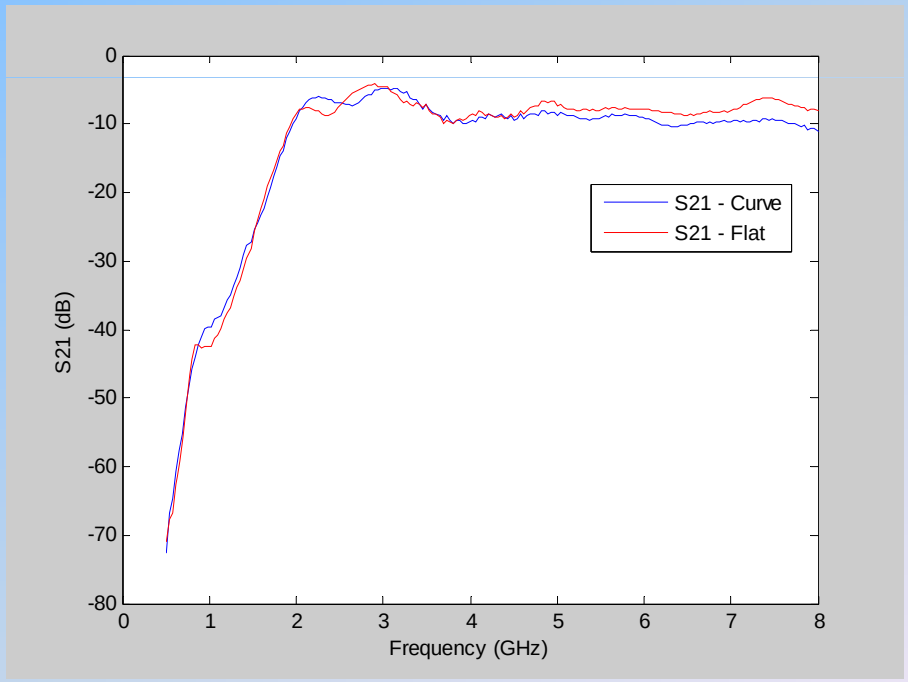


Results

Single CSRR Cell



Multi CSRR Array

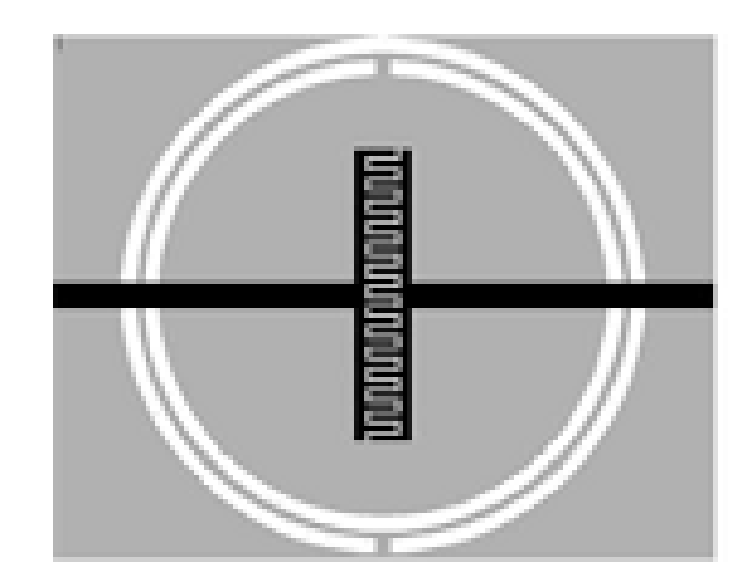


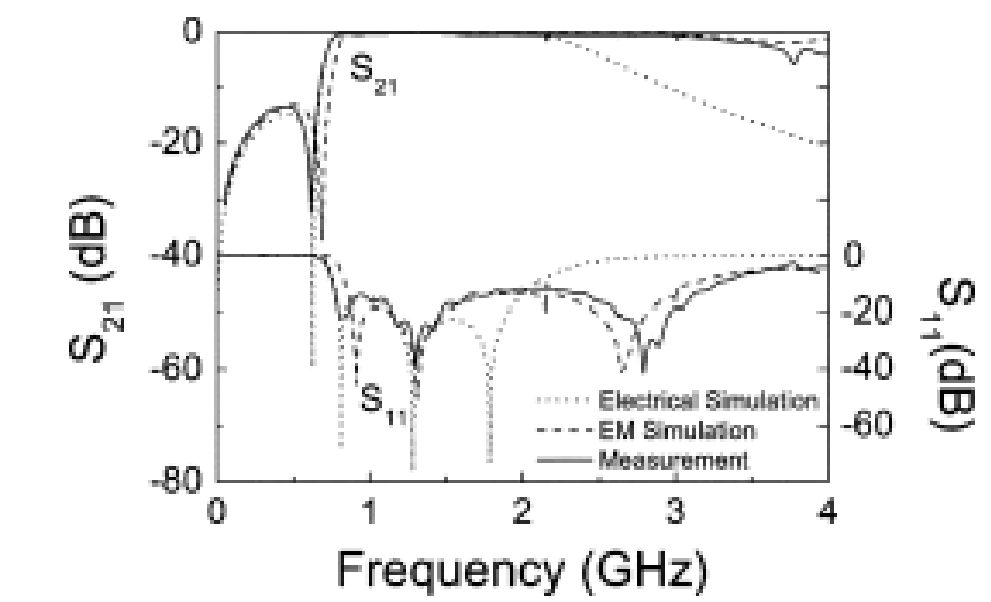
Future Work

- Ability to mount LCP to a desired object with either manually drilled or LCP etched holes.
- Develop a flexible 3-D cloak with LCP (currently done with polyimides)
- Deposit dielectrics

UWB Metamaterial Filter

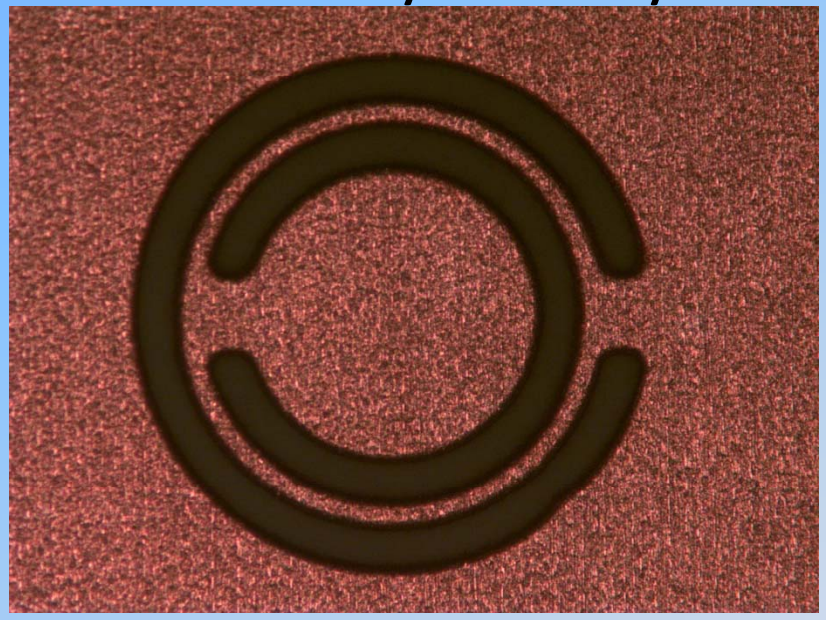
- Needs increased gap capacitance
- Traditionally uses interdigitated teeth to achieve necessary capacitance

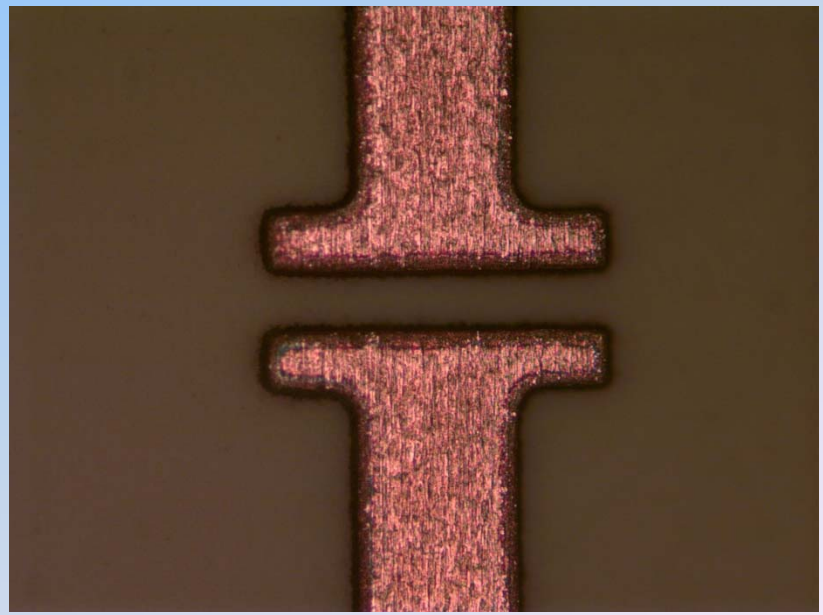




Polyimide Deposition

- Deposit Polyimide inside gaps to increase Єr
- C = Єr * Єo * A / d
- Capacitance increases
- Can ideally use any dielectric





Conclusions

- LCP has been shown to be a viable substrate for metamaterial designs.
- Combined with MEMS fabrication processes, flexibility in substrate selection, feature size, and thin film deposition can be utilized.

Thanks