WE3F-3

Hybrid Filter based on HMSIFW and SICL Technology with Wide-Stopband Suppression

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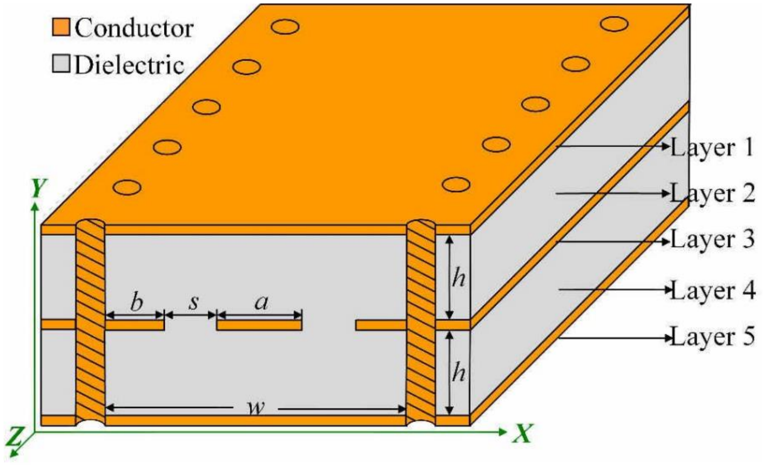
Table of Contents

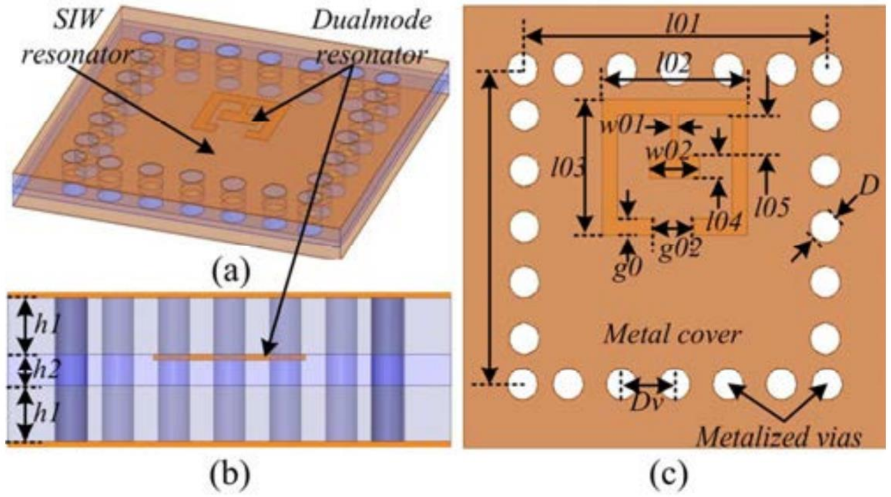
- ❑ Introduction & Motivation
- ❑ Filter Design & Working Principle
- ❑ Simulation & Measurement
- ❑ Comparison
- ❑ Conclusion

Index:
SIW: Substrate Integrated Waveguide
SICL: Substrate Integrated Coaxial Line
HMSIFW: Half Mode Substrate Integrated Folded Waveguide
TZ: Transmission zero

1. Introduction & Motivation



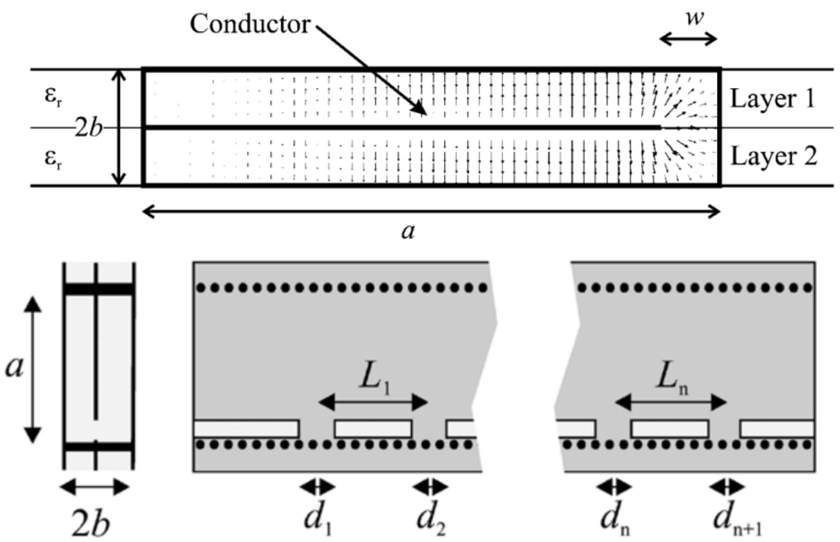
Traditional SICL structure



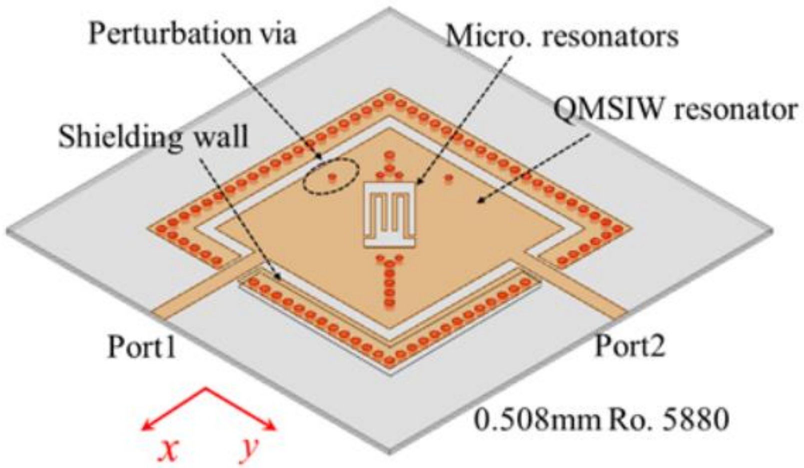
Hybrid SIW and SICL structure

[3] Zhaosheng He, Zhenhai Shao, Xiang Li and Mengkui Shen, "A dualband bandpass filter based on hybrid structure of substrate integrated waveguide and substrate integrated coaxial line," *2016 IEEE MTT-S Int. Microw. Symp.(IMS),* 2016, pp. 1-4.
[4] K. Ning, X. -C. Li and J. Mao, "A Compact Ridged Substrate Integrated Coaxial Line," 2020 *IEEE MTT-S Int. Microw. Symp.(IWS)*, 2020, pp. 1-3.

1. Introduction & Motivation



SIFW Filter



Hybrid QMSIW and Microstrip line

[6] N. Grigoropoulos, B. Sanz-Izquierdo and P. R. Young, "Substrate integrated folded waveguides (SIFW) and filters," *IEEE Microw. Wireless Compon. Lett*., vol. 15, no. 12, pp. 829-831, Dec. 2005.
[8] Y. Zheng, Y. Zhu, Z. Wang and Y. Dong, "Compact, Wide Stopband, Shielded Hybrid Filter Based on Quarter-Mode Substrate Integrated Waveguide and Microstrip Line Resonators," *IEEE Microw. Wireless Compon. Lett*., vol. 31, no. 3, pp. 245-248, March 2021.

1. Introduction & Motivation

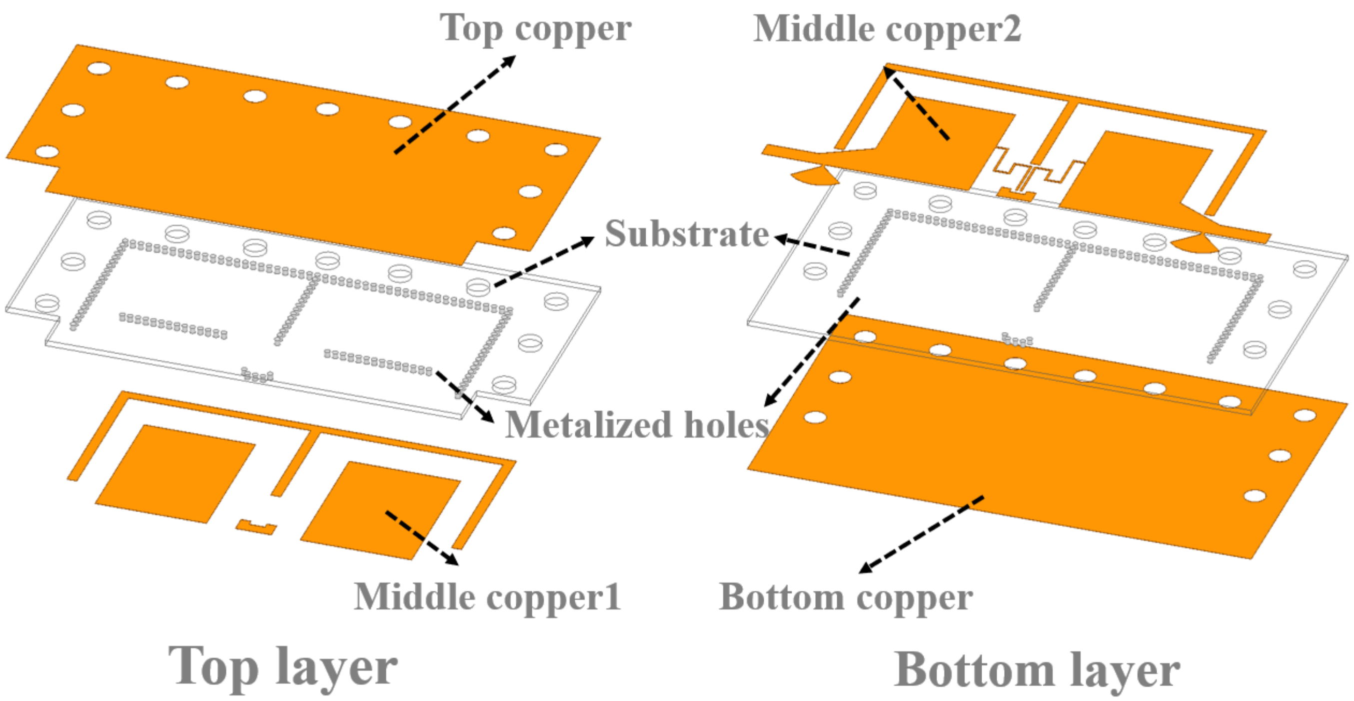
Motivation:

- Compact size, low cost, good selectivity.
- Wide-Stopband Suppression.
- Easy fabrication hybrid HMSIFW and SICL structure.

Approach:

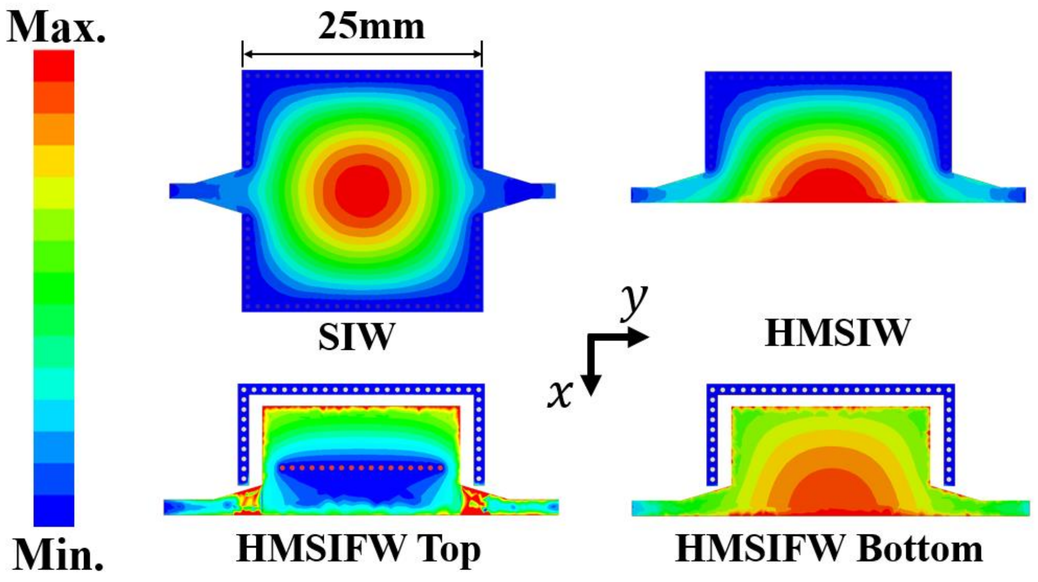
- Hybrid structure based on HMSIFW and SICL.
- Design with HMSIFW cavities and SICL structure.
- Higher mode is suppressed by coupling-null structure.

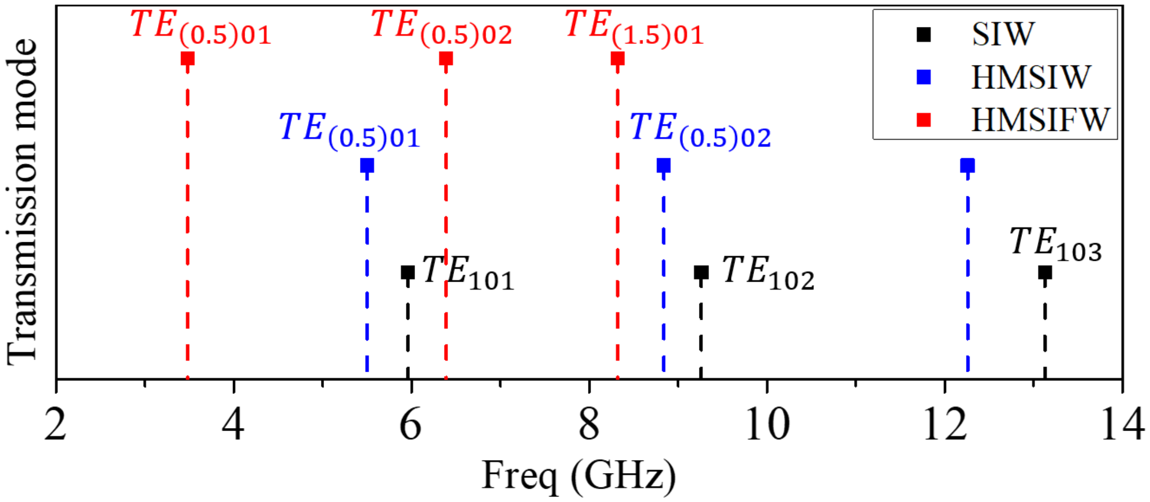
2. Filter Design & Working Principle



- $35.4mm \times 20.2mm$ $(0.472\lambda_0 \times 0.27\lambda_0)$.
- $TE_{(0.5)01}$ mode HMSIFW cavities.
- TE_{101} mode is suppressed by coupling-null structure.
- Two Tzs are generated by cross-coupling.

2. Filter Design & Working Principle





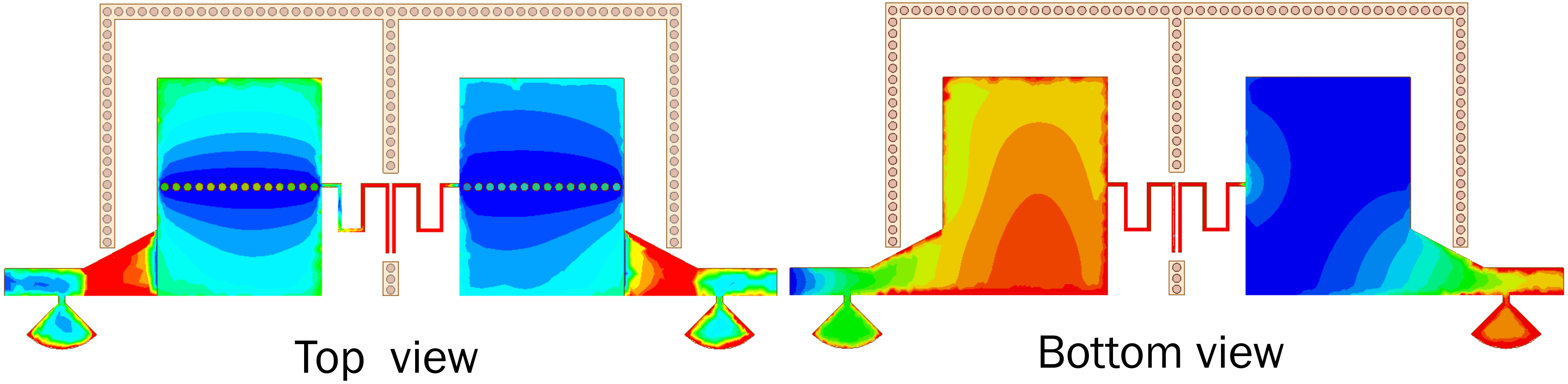
Resonance frequency of the HMSIFW cavity:

$$f_{TE_{m0n}} = \frac{c}{2\sqrt{u_r \varepsilon_r}} \sqrt{\left(\frac{m}{w_{\text{eff}}}\right)^2 + \left(\frac{n}{l_{\text{eff}}}\right)^2}$$

Compared with SIW cavities:

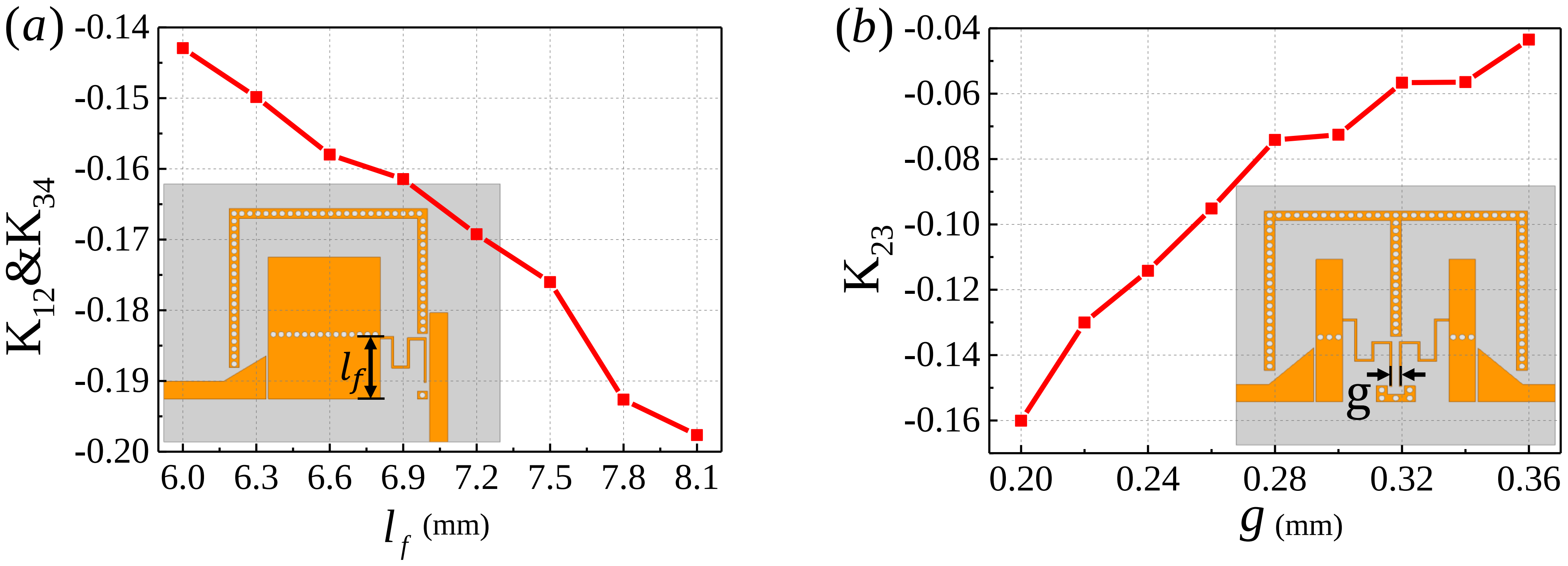
1. HMSIW: familiar f_0, half reduced size.
2. HMSIFW: much lower f_0, half reduced size.

2. Filter Design & Working Principle



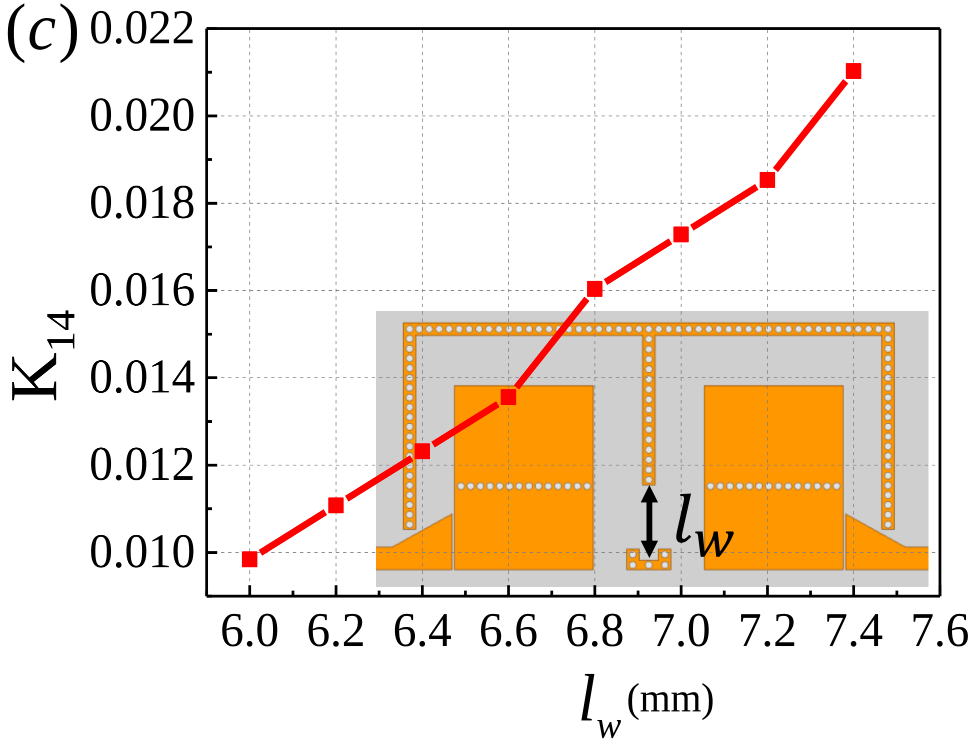
- Electric field distributions of HMSIFW cavities ($TE_{(0.5)01}$ mode)
- Electrical Coupling :HMSIFW-SICL , SICL-SICL
- Magnetic Coupling :HMSIFW-HMSIFW(cross-coupling)

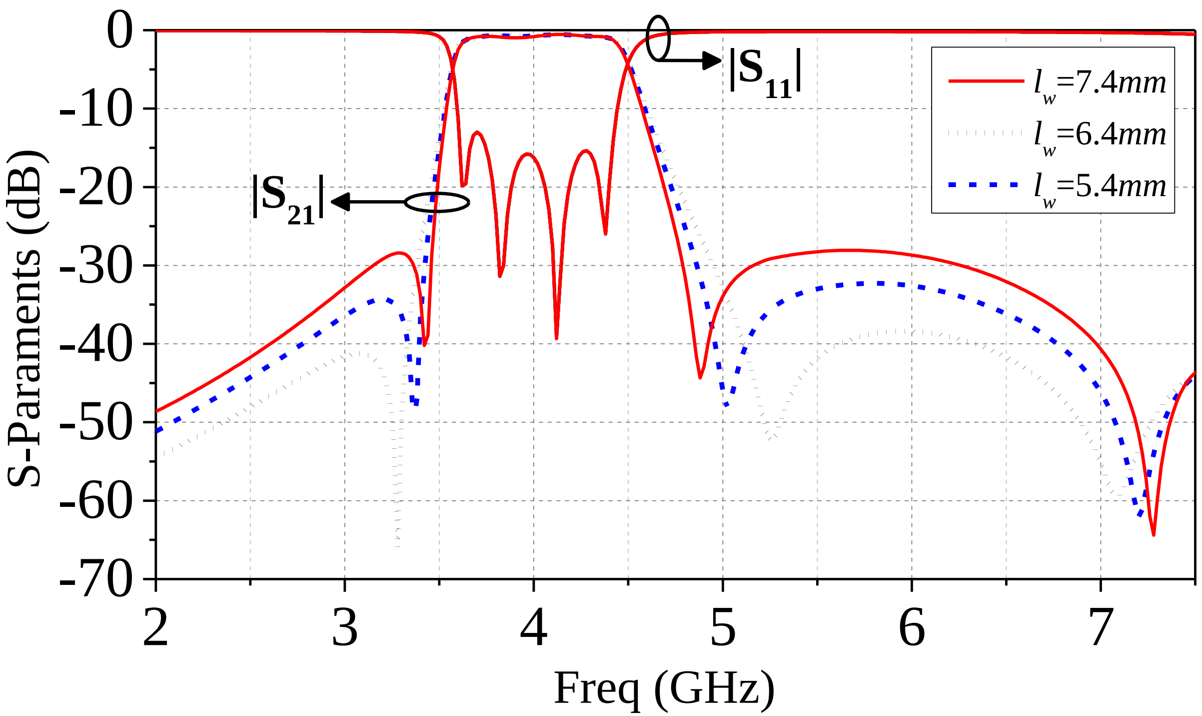
2. Filter Design & Working Principle



- Coupling curves are extracted from weak coupling structures.
- Coupling coefficient can be controlled by l_f, g, l_w.
- Two TZs are generated by cross-coupling.

2. Filter Design & Working Principle





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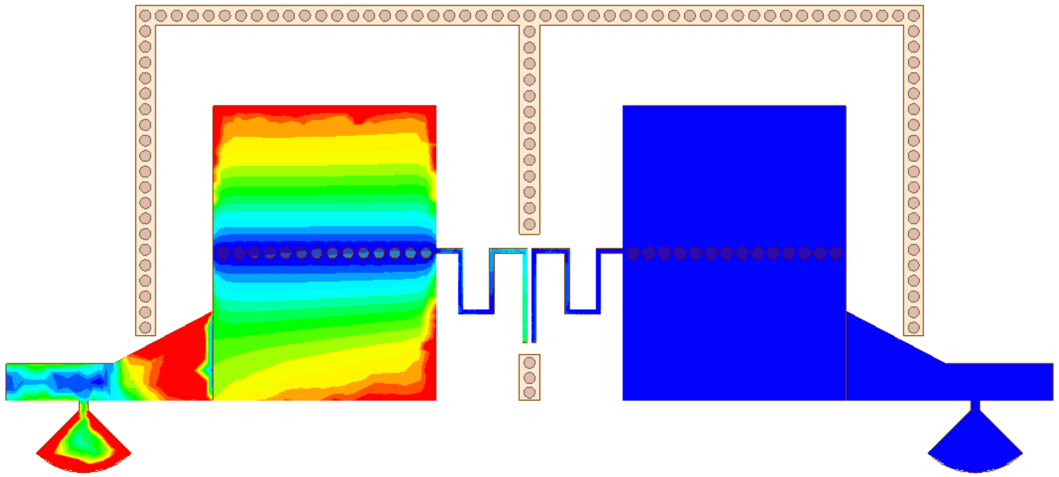
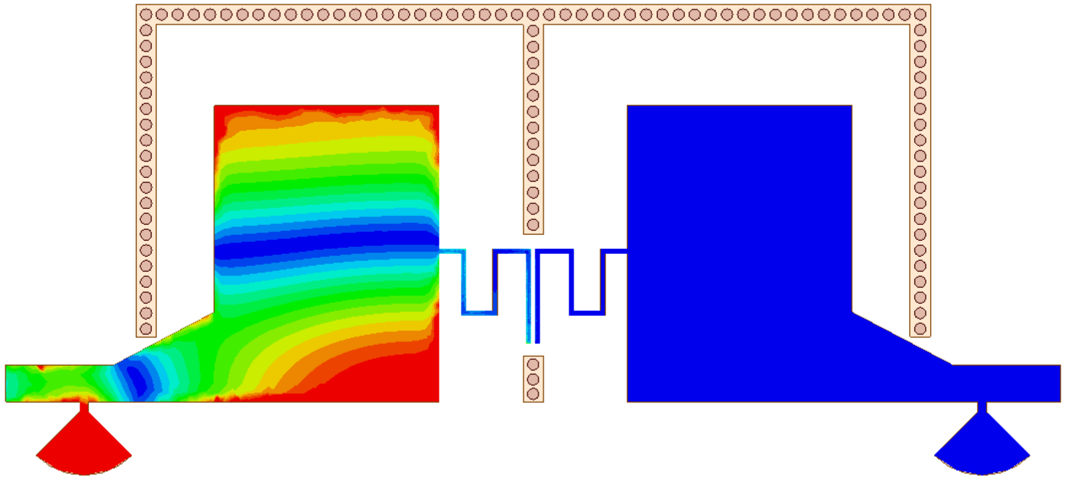


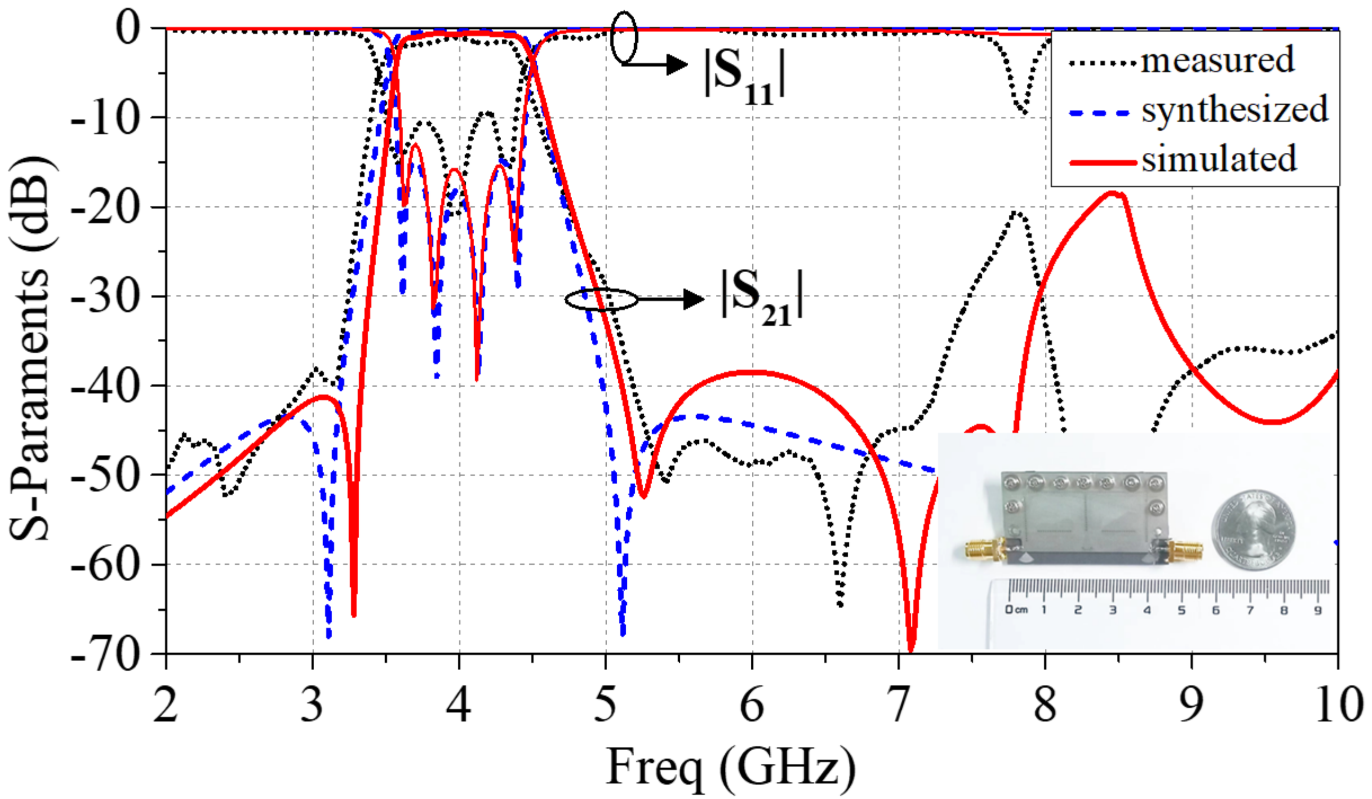
Top view



Bottom view

- Electric field distributions of HMSIFW cavities. (TE_{101} mode)
- TE_{101} is a higher order mode should be suppressed.
- Wide stopband is achieved by coupling-null structure.

3. Simulation & Measurement



- ElectricSubstrate: Rogers RT/Duriod 5880 ,0.508mm, ε_r=2.2, *tan D*=0.001.
- Measured minimal insertion loss: 1.0dB.
- Measured 3-dB bandwidth: 3.59 to 4.48 GHz (centre frequency:4.04GHz).

4. Comparison

Reference	[7]	[9]	[10]	[11]	This work
f_0(GHz)	10.11	13.2	27	10.04	4
IL (dB)	1.22	1.5	2	1.5	1.07
FBW (%)	11.7	4.5	7.5	4.68	23
Size ($\lambda_0{}^2$)	0.54 × 0.93	0.40 × 0.40	2.39 × 0.75	0.48 × 1.1	0.472 × 0.27
Stopband Rejection	>20dB@2.9f_0	>20dB@2.3f_0	>20dB@1.5f_0	>20dB@1.9f_0	>20dB@2.5f_0
Order	4	2	4	2	4
Technology	Hybrid	SIW	SIW	SIW	Hybrid

- The filter can achieve a wide stopband and lower cost while maintaining a compact size

5. Conclusion

- Novel hybrid filter based on HMSIFW and SICL structure is proposed.
- TZs are generated by cross coupling to improve the selectivity of filter.
- Coupling-null structure are designed to suppress the transmission of higher mode.
- Compact size, low cost, good selectivity and wide stopband.

Thanks for listening!

Questions ?

Further discussion is welcome at:
ydong@uestc.edu.cn