TH1E-4

A 6.4-GHz Spurious-Free Acoustic Filter based on Lithium Niobate S1-Mode Resonator

Xueyan Liu[1], Zhongbin Dai[1],
Zijia Su[1], and Chengjie Zuo[1,2]

[1]University of Science & Technology of China, Hefei, China

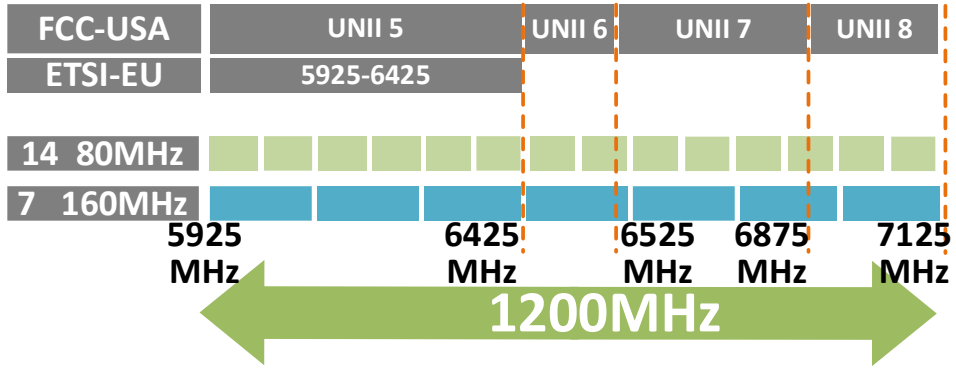
[2]YUNTA Technologies and ANUKI Technologies, Hefei, China

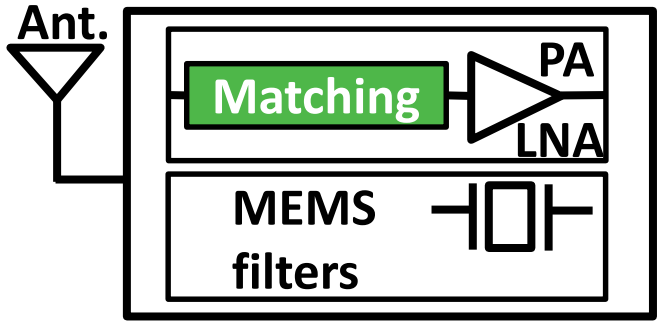
Outline of this Presentation

- ❑ Motivation & Challenges
- ❑ Spurious-free Resonator Design
  - ◆ Characteristic of S1 Mode
  - ◆ Impact of lateral parameters
  - ◆ Fabrication and Measurement
- ❑ Spurious-free Filter Design
- ❑ Conclusion and Outlook

Motivation & Chanllenges

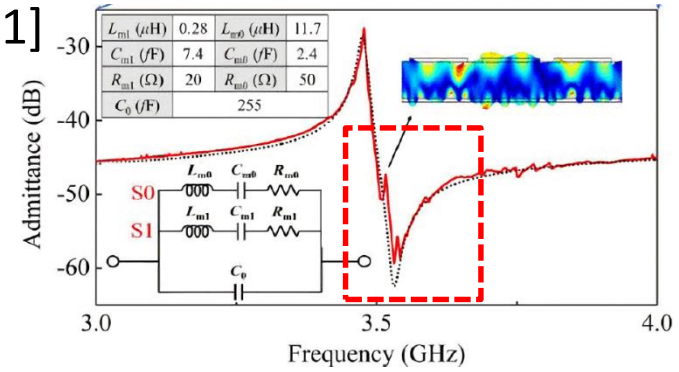
6G Channel Allocations



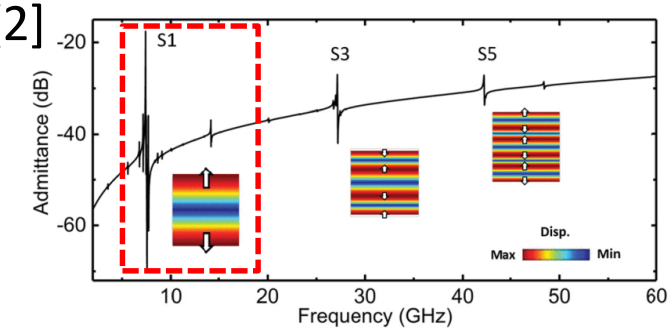


S1 Lamb Wave Mode Resonator

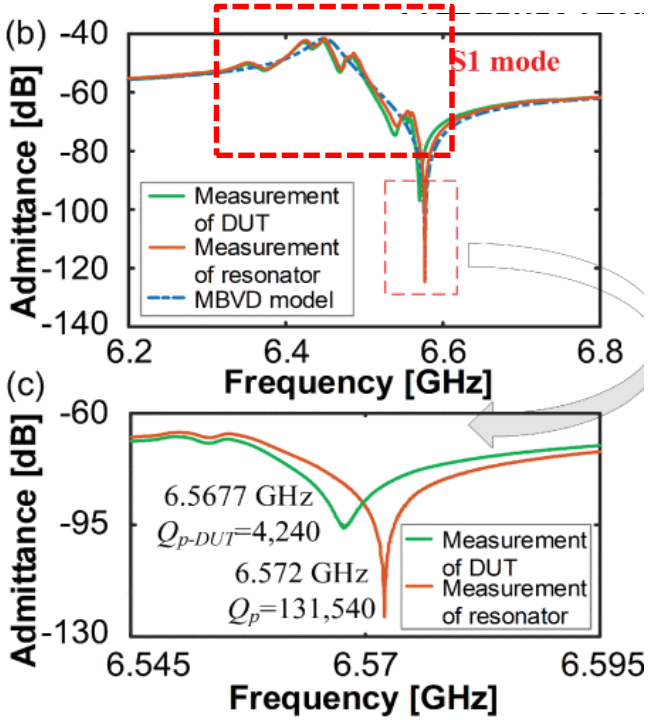
[1]



[2]



[3]

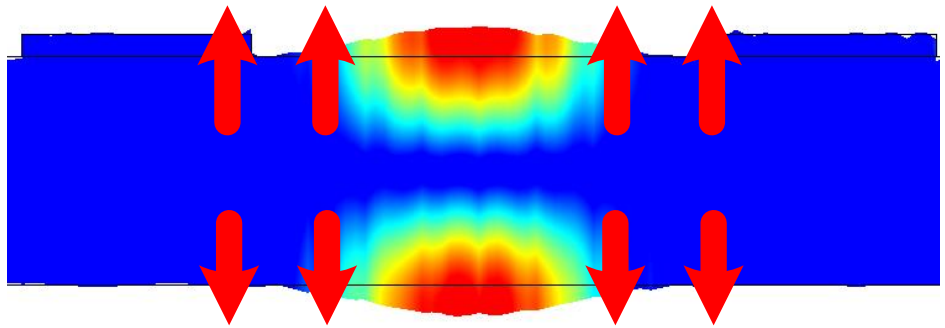


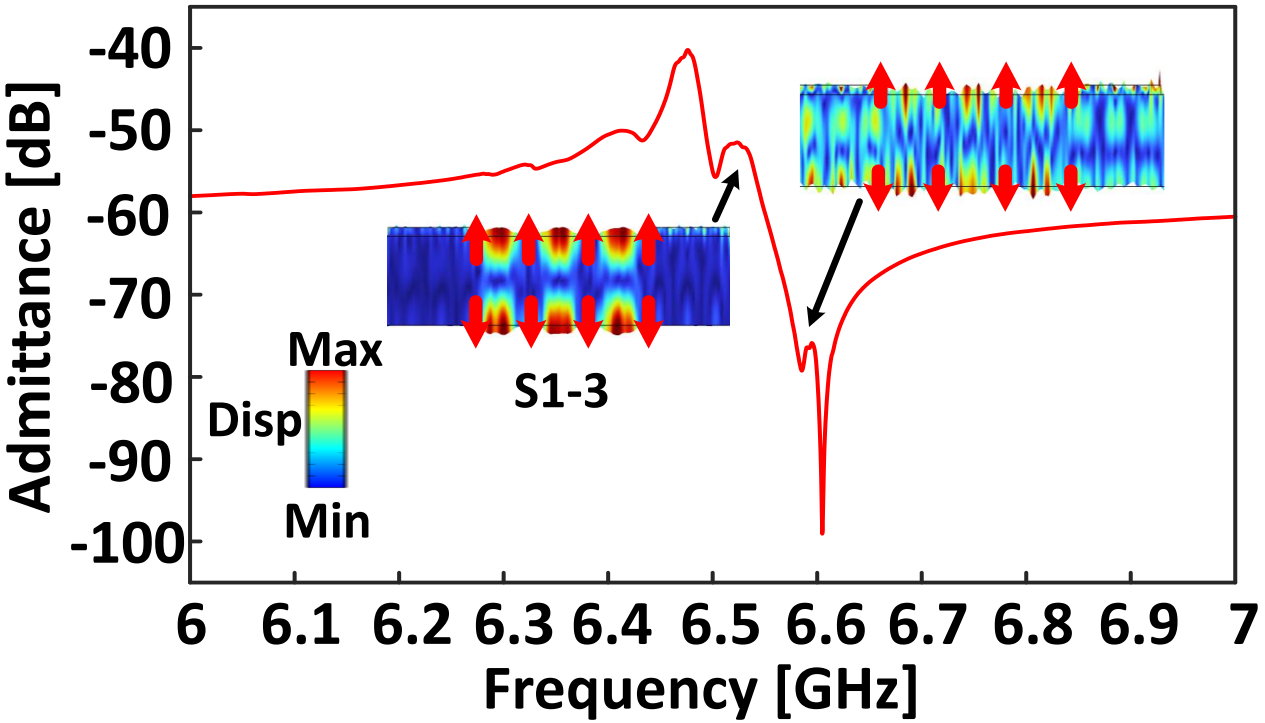
- **High frequency**
- **Low Loss & Sharp roll-off**

- **High acoustic velocity, but parasitic modes**
- **Breakthrough of Q_p over 100,000**

[1] [A. Gao, et al., IUS, 2017] [2] [Y. Yang, et al., TMTT, 2020] [3] [Z. Dai, et al., Electron Device Lett., 2022]

Characteristics of S1 Mode

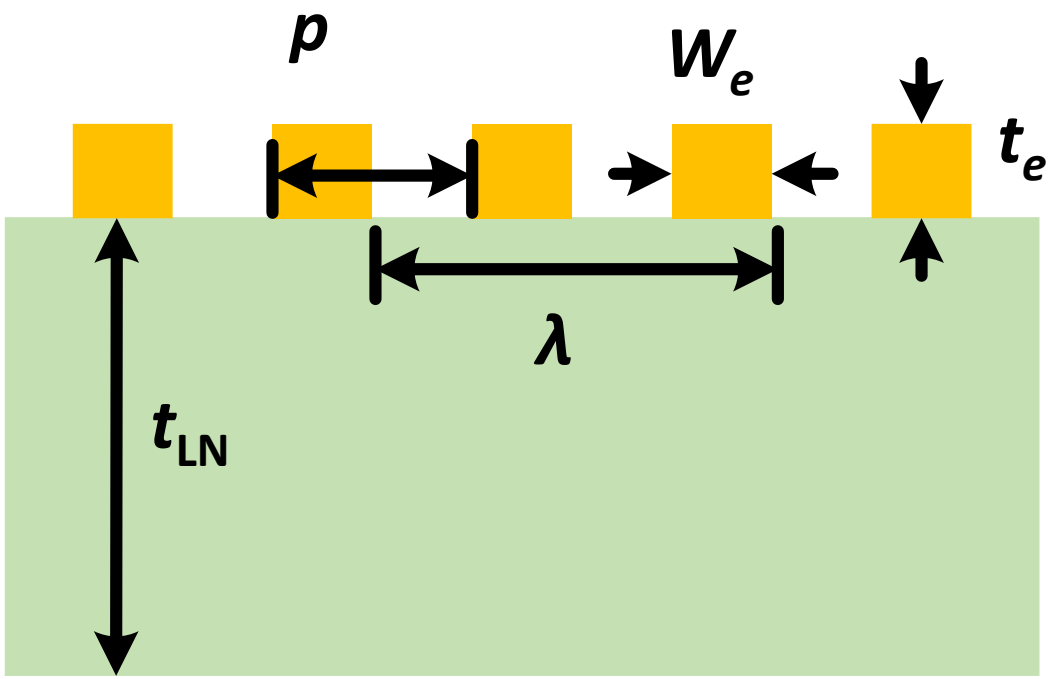


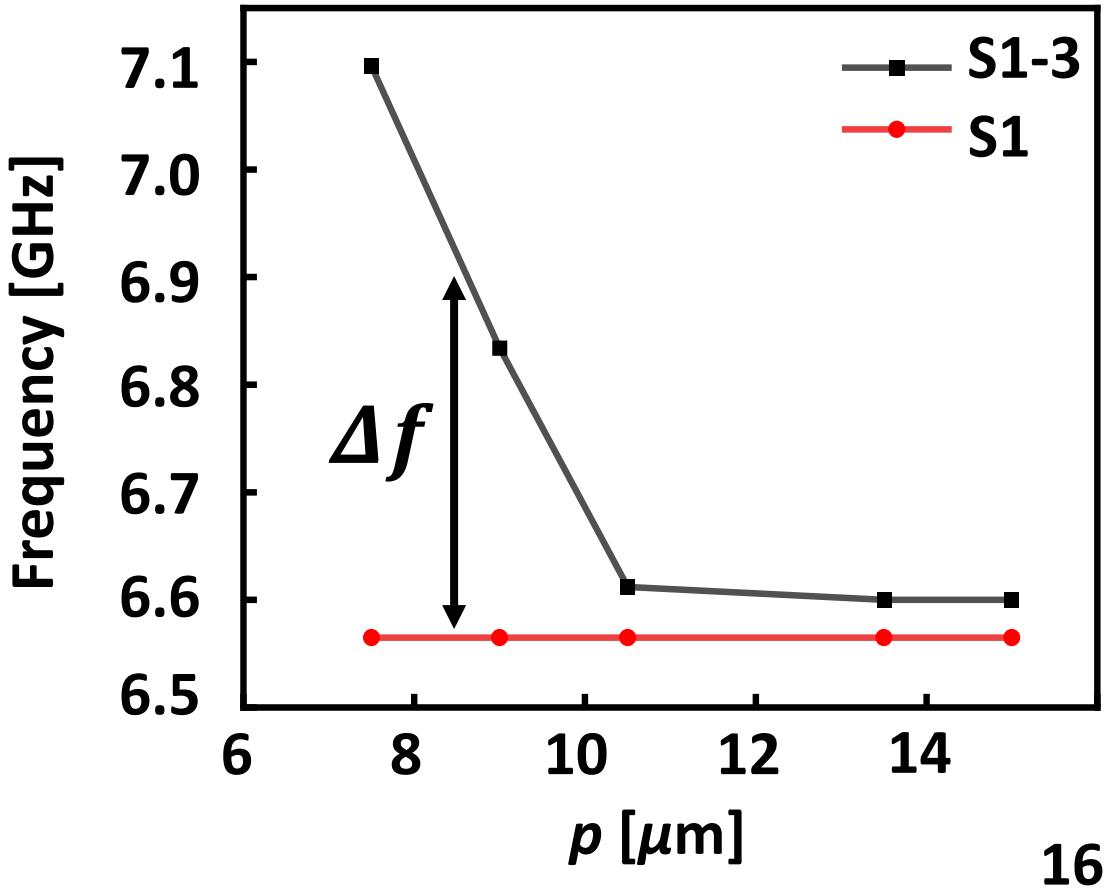


- **Displacement of S1 Mode**
  - Thickness defined

- **Spurious Modes:**
  - S1-3 & higher-order modes
  - Inhomogeneous electric filed

Impact of Pitch

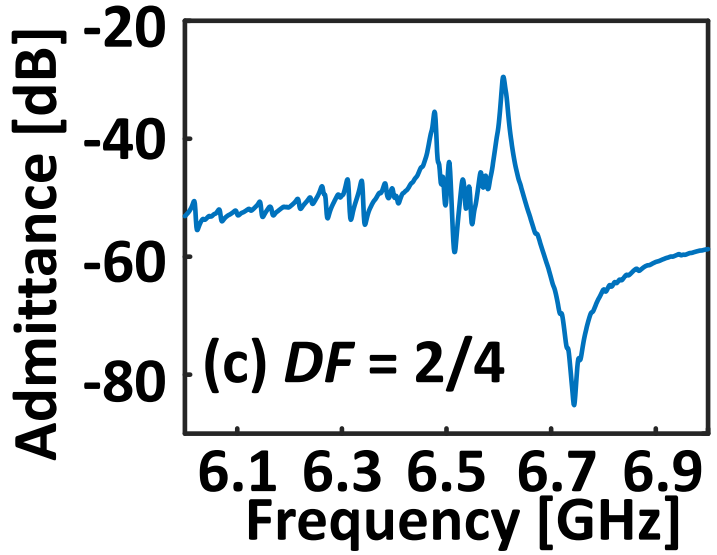


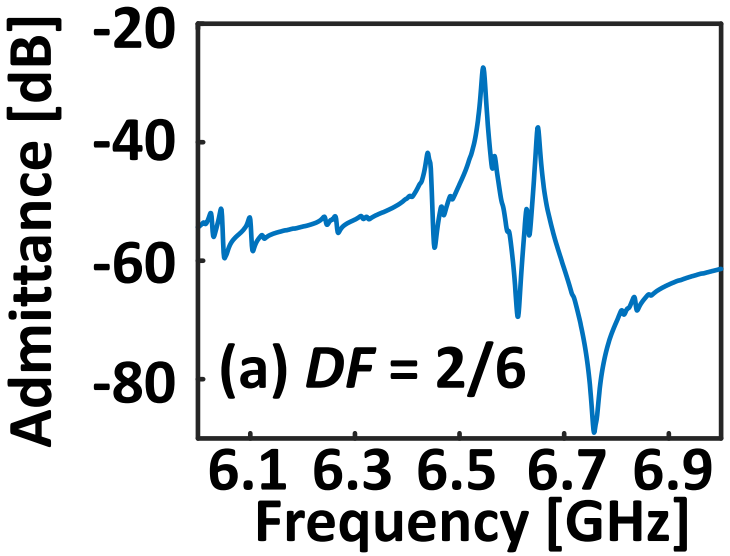


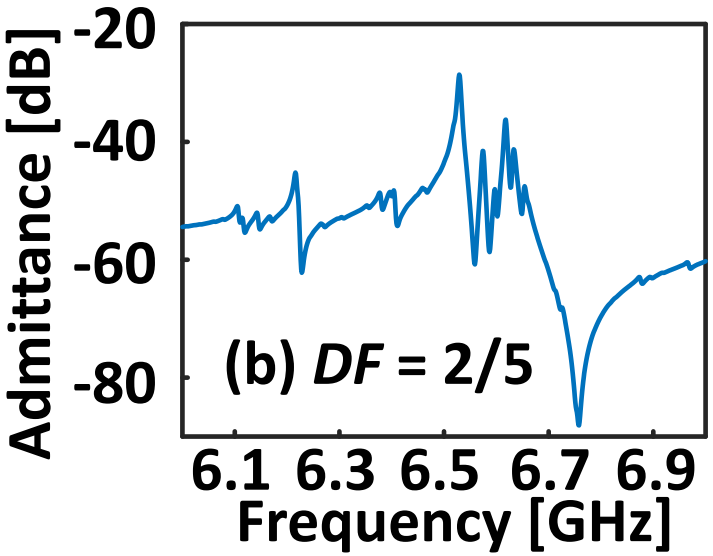
Pitch increases, Δf decreases

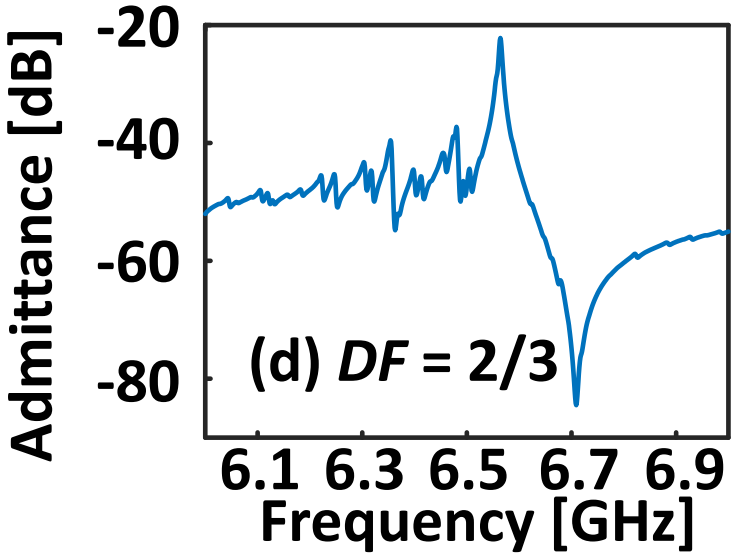
Impact of Duty Factor

- Duty Factor (*DF*)
  - $DF = \frac{W_e}{p}$
  - *DF* increases, spurious modes drift away









Fabrication and Measurement

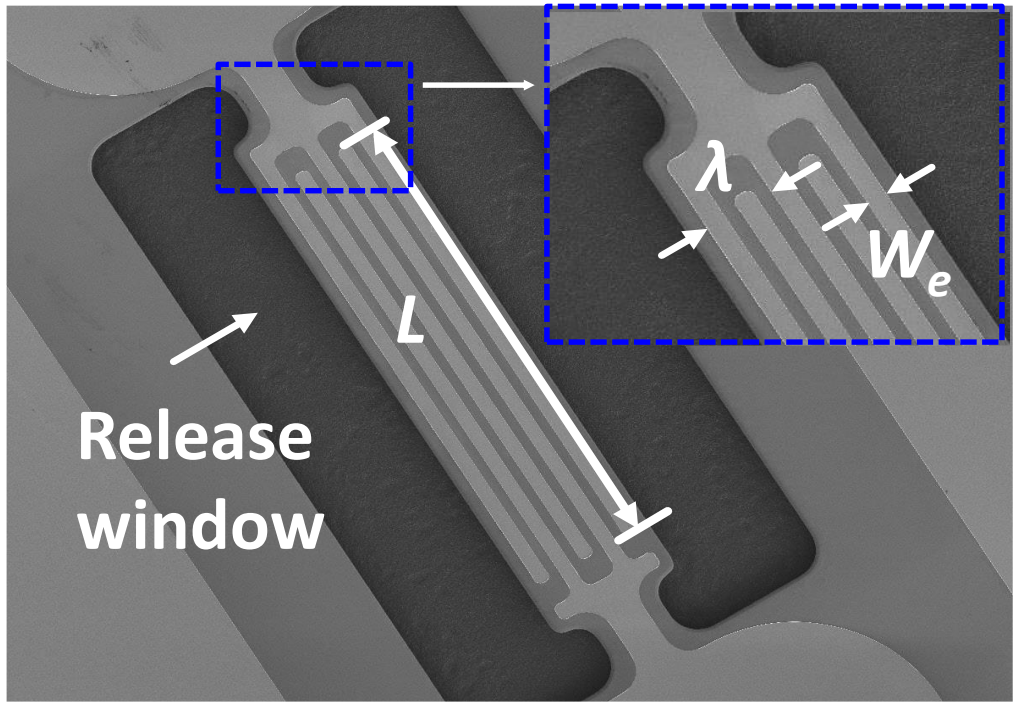
1. Top electrodes lift-off

2. Definition of etch mask

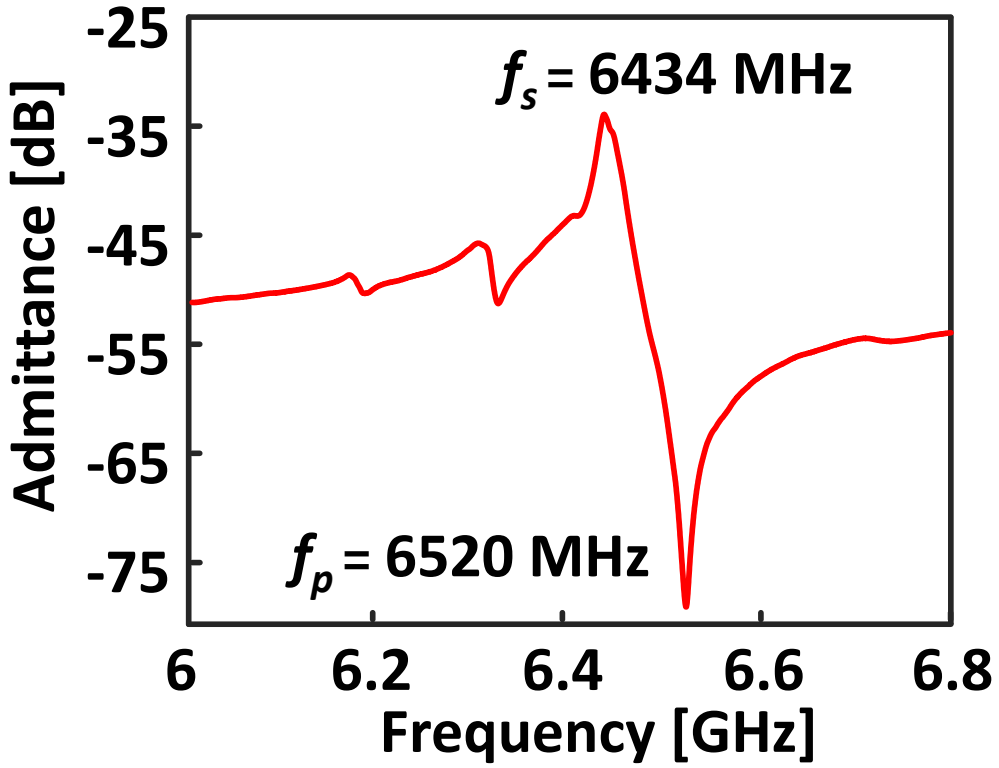
3. ICP for $LiNbO_3$ etching

4. Device release using BOE

Fabrication and Measurement

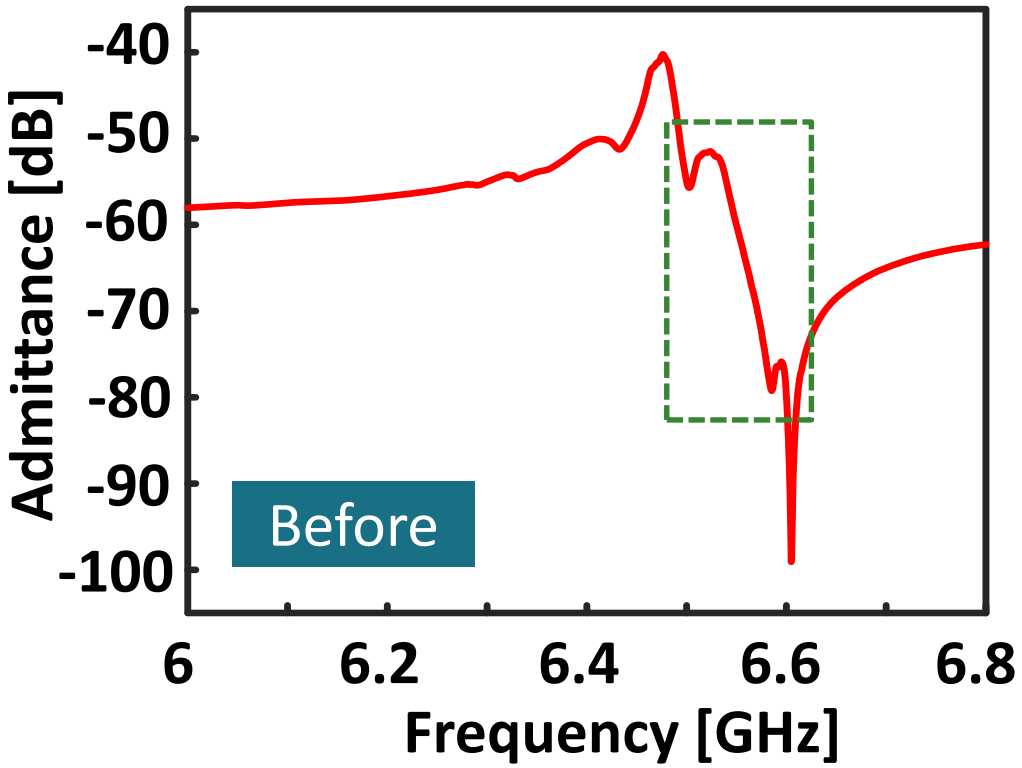


(a) SEM graph of the fabricated resonator with its geometry labeled

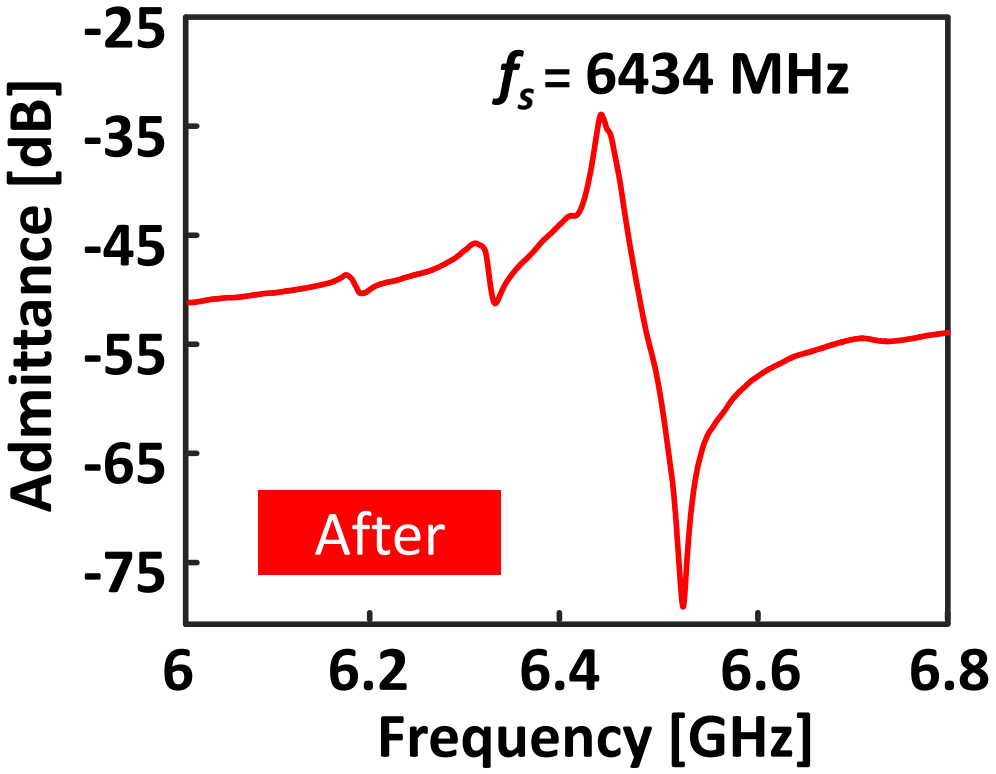


(b) Results of the spurious-free resonator: Q_s = 313; Q_p = 989

Fabrication and Measurement

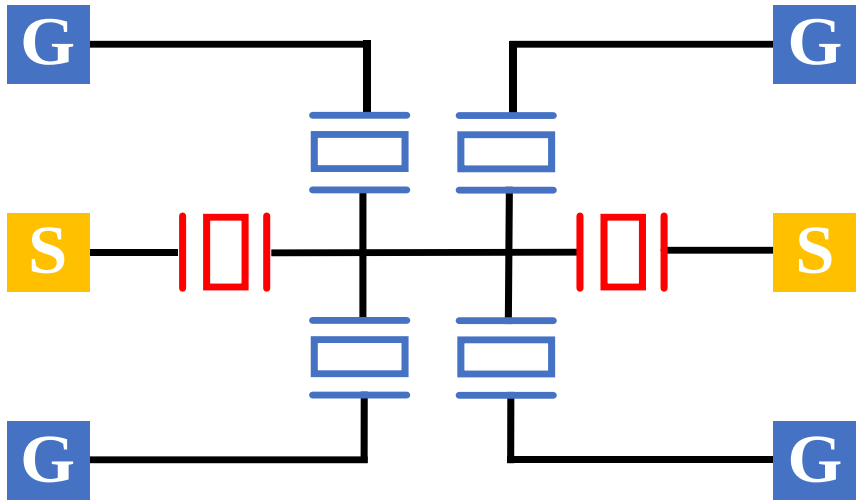


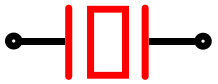
Q_s = 279
Q_p = 5504



Q_s = 313
Q_p = 989

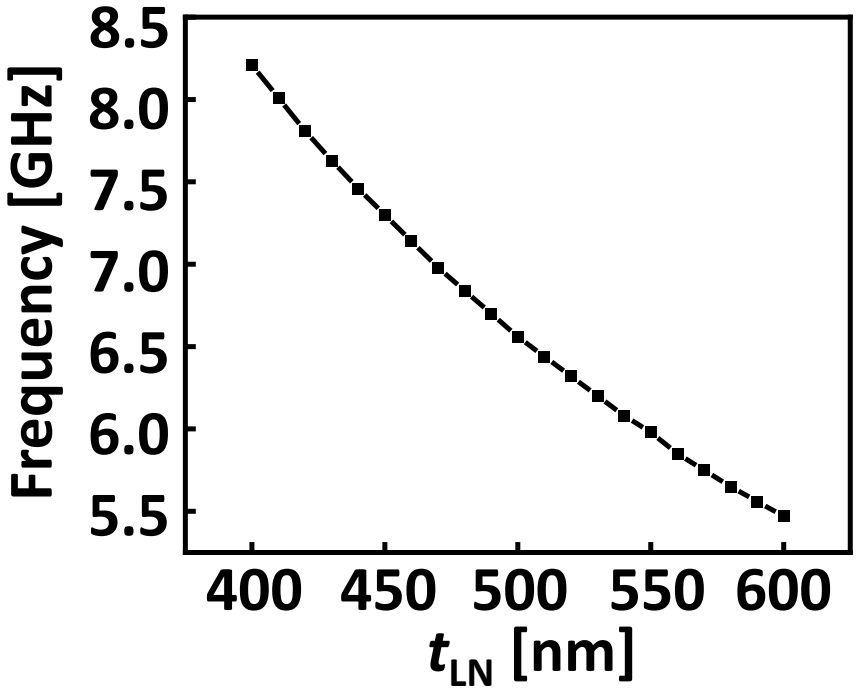
Spurious-free Filter Design





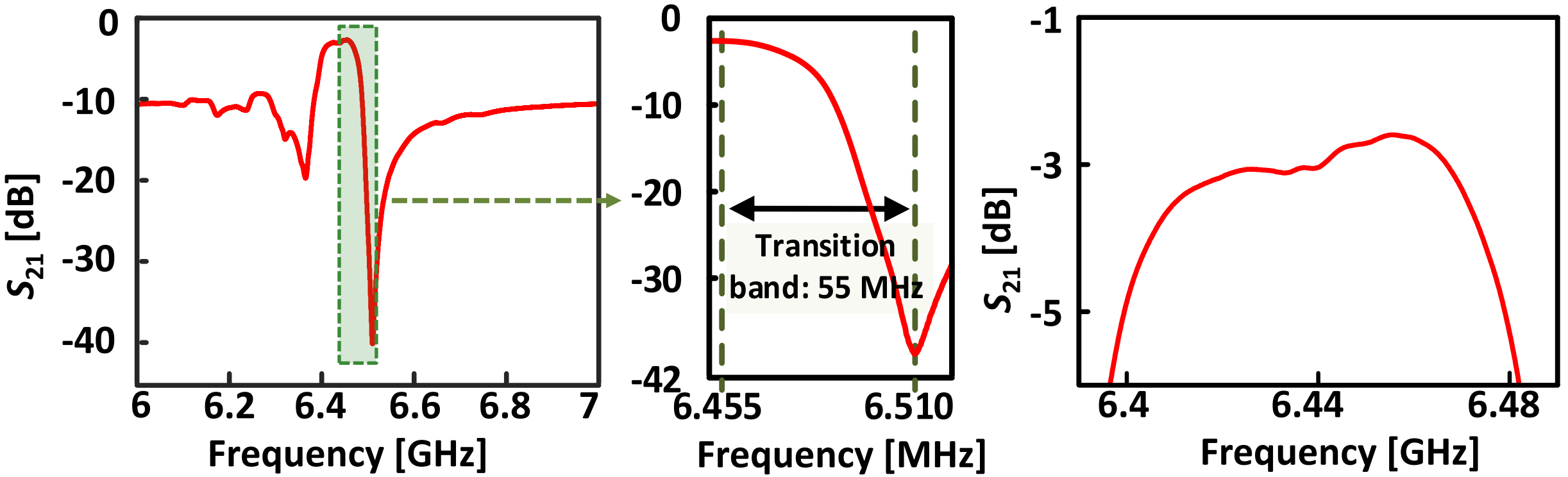
Series Resonator

Parallel Resonator



- **Ladder-topology filter**
  - Series resonators are realized by regional thinning

Fabrication and Measurement



- IL = 2.6 dB, BW is around 80 MHz
- Transition band of 55 MHz, S_{21} drops from 2.6 dB to 40 dB

Conclusion

- This work designed and fabricated a 6.4-GHz spurious-free resonator & filter based on X-cut LN film.
- By designing the electrode pitch and DF of IDTs, in-band spurious modes are suppressed.
- The implemented resonator has a high *Q* close to 1,000, and the filter based on it has a low insertion loss of 2.6 dB, a sharp roll-off of 55 MHz.
- In further optimization, adding passive devices to design a hybrid filter could enable a larger BW.

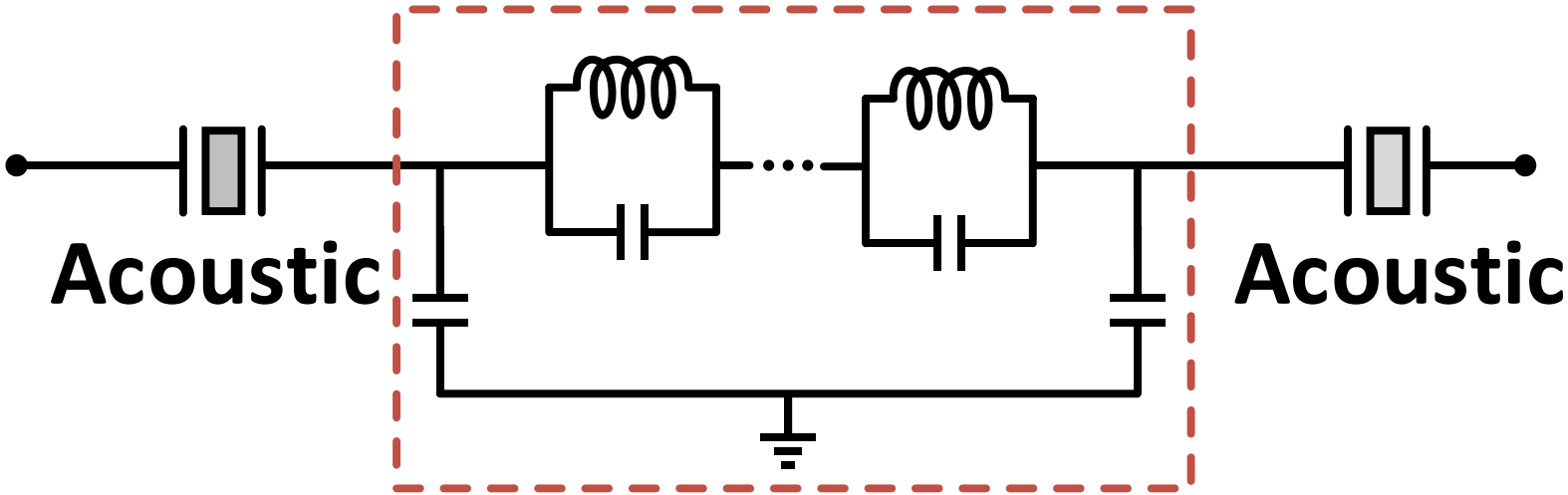
Thanks for your attention!

Further discussion is welcome at:

xueyanliu@mail.ustc.edu.cn

Further optimization

Lumped *LC* component



Passive devices → Enlarge bandwidth

\+

Acoustic components → Sharp roll-off

★ Promising solution