

TH1E-3

A 20.4-GHz Lithium Niobate A3-Mode Resonator with High Electromechanical Coupling of 6.95%

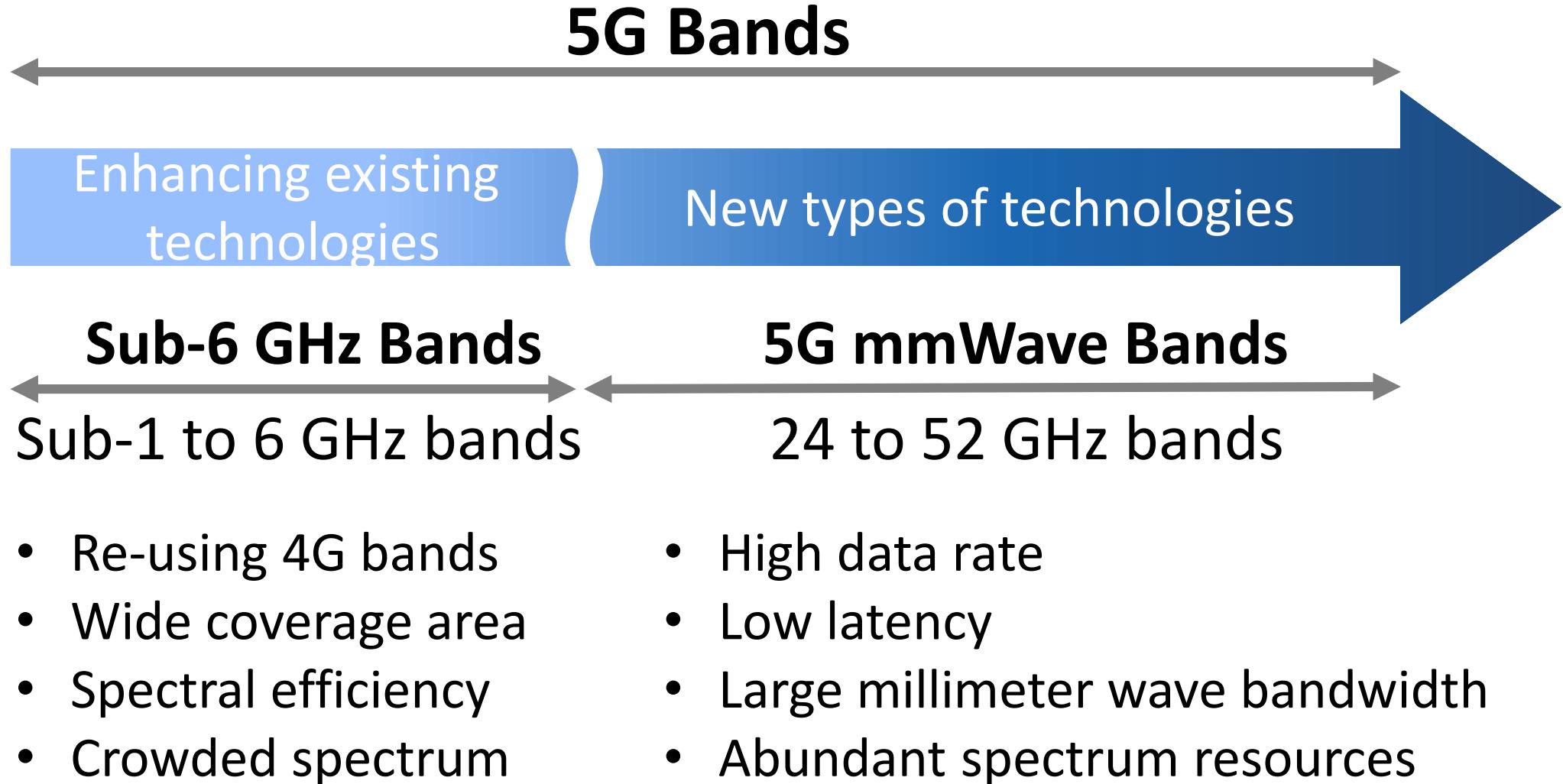
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- **Introduction and Motivation**
- **Challenges in State-of-the-Art**
- **A3-Mode Resonator Design and Simulation**
- **Fabrication and Measurement**
- **Conclusions**

Introduction & Motivation



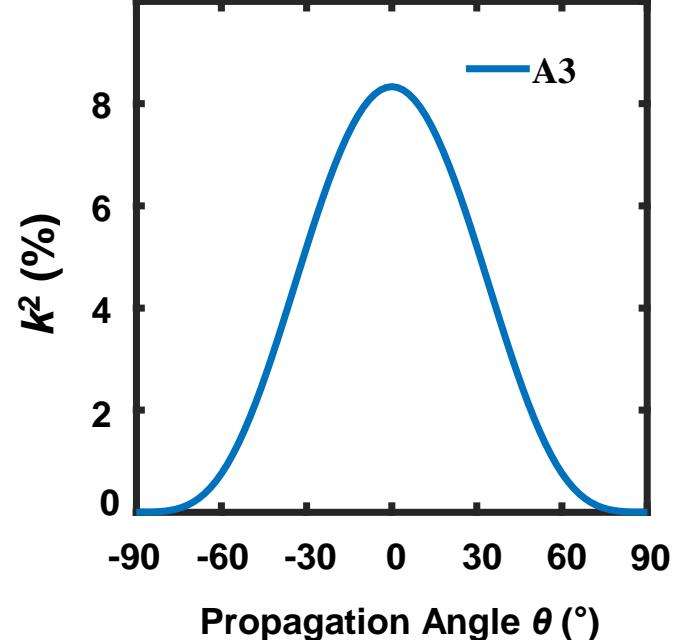
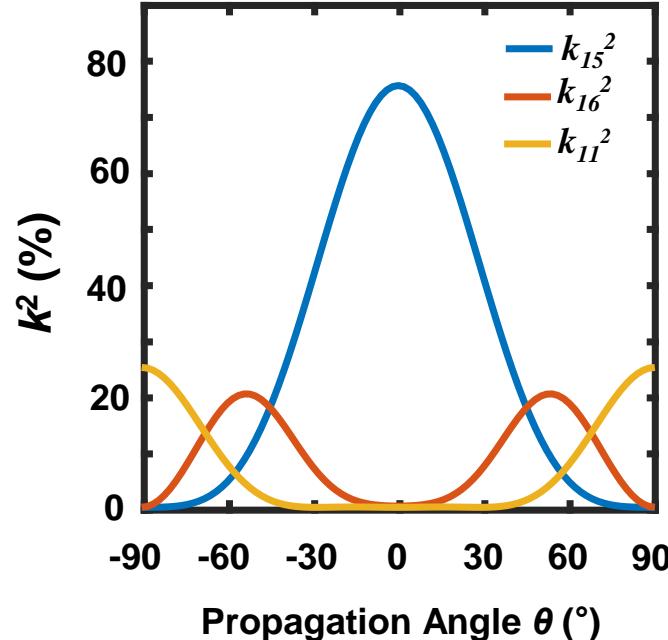
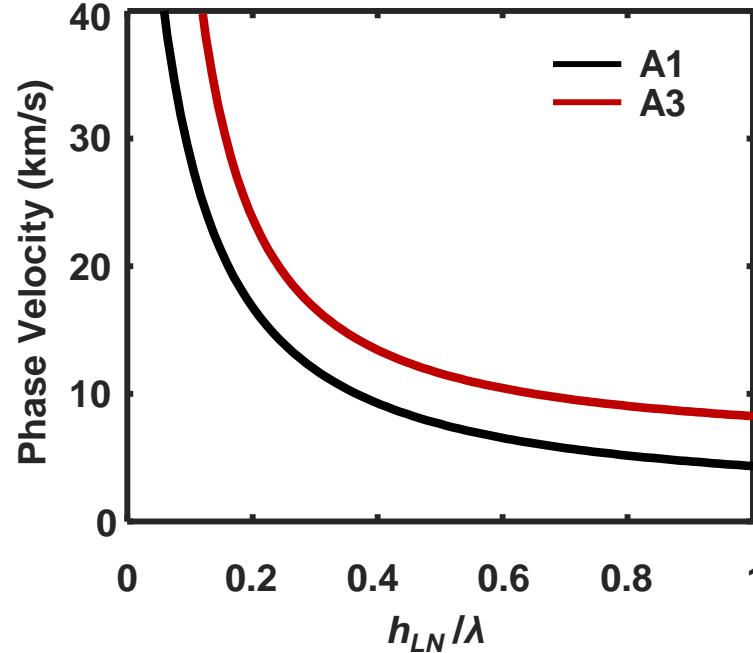
Challenges

**SAW****FBAR****LWR****This work**

-  Piezoelectric materials
-  Metal
-  Silicon oxide
-  Poly/ α -silicon
-  Silicon

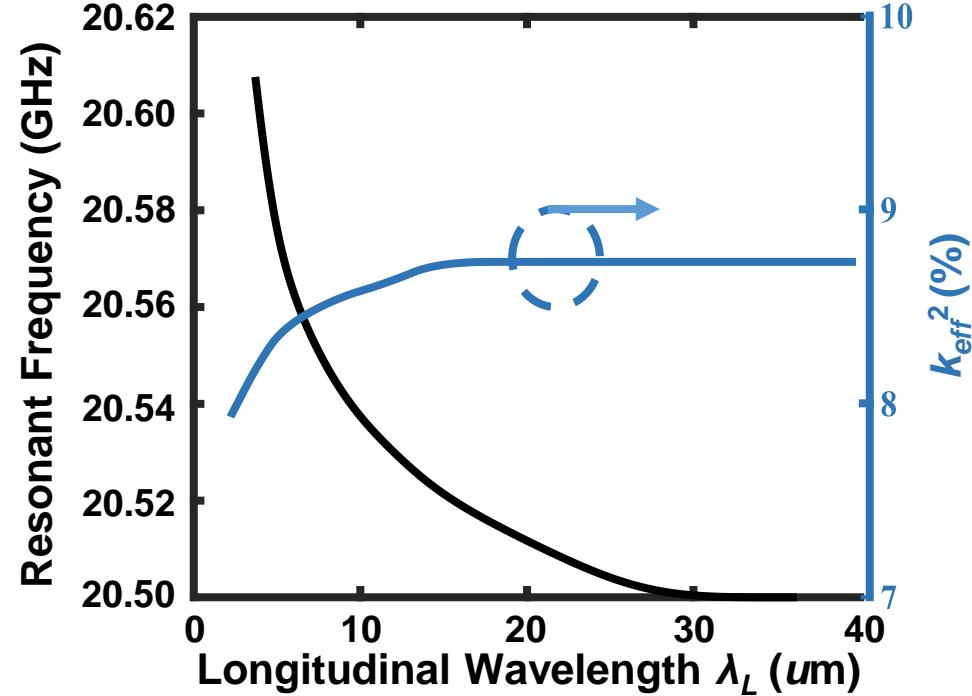
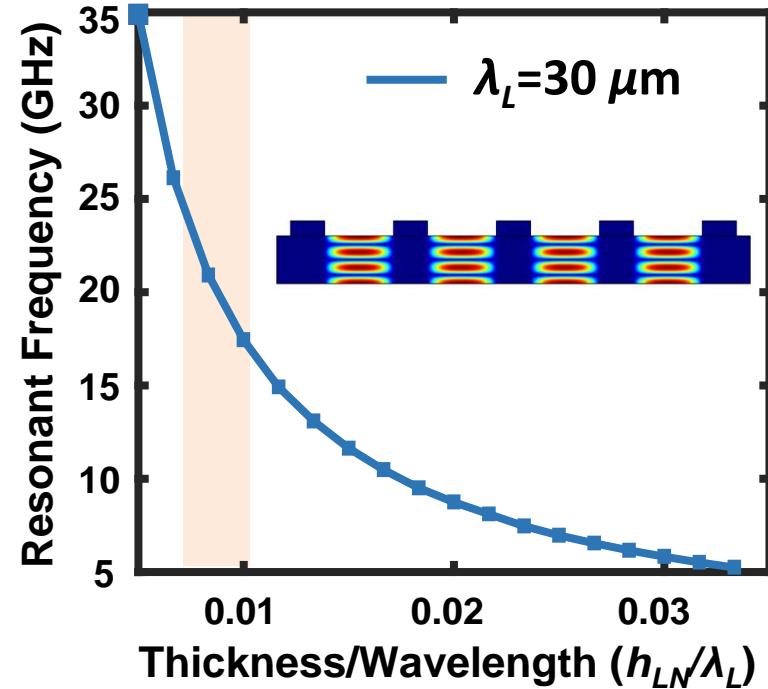
- **High frequency**
- **High k^2**
- **High Q and low loss**
- **Ultra-thin film with high quality**

A3-Mode Lamb Wave



- High phase velocity v_p up to 40 km/s
- High k^2 at high frequencies
- Spurious-free modes design

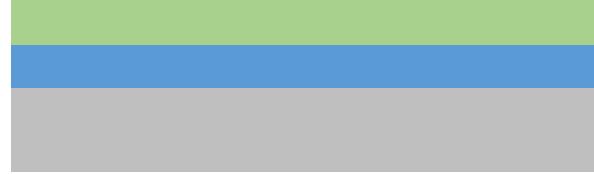
Resonator Design



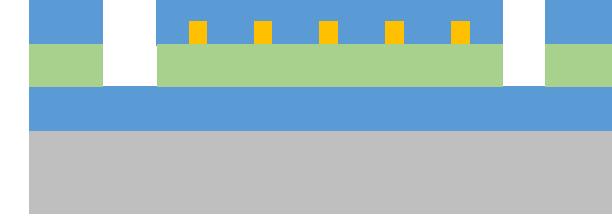
- $h_{LN}/\lambda_L < 0.01$ for 20 GHz above design
- f_s exhibits weak dependency on wavelength

Fabrication

1. Start with POI substrate



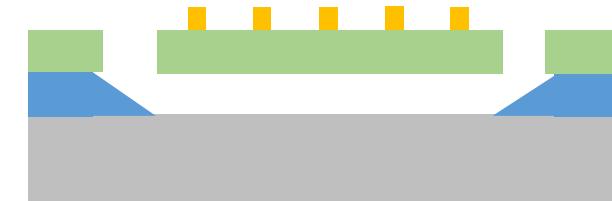
4. ICP for LiNbO₃ etching



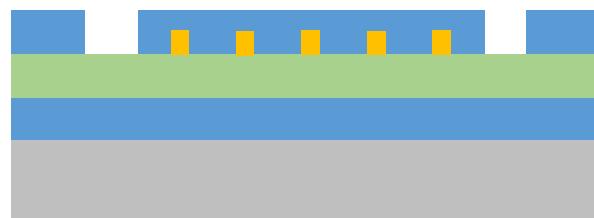
2. Top electrodes deposition



5. Resonator release using BOE



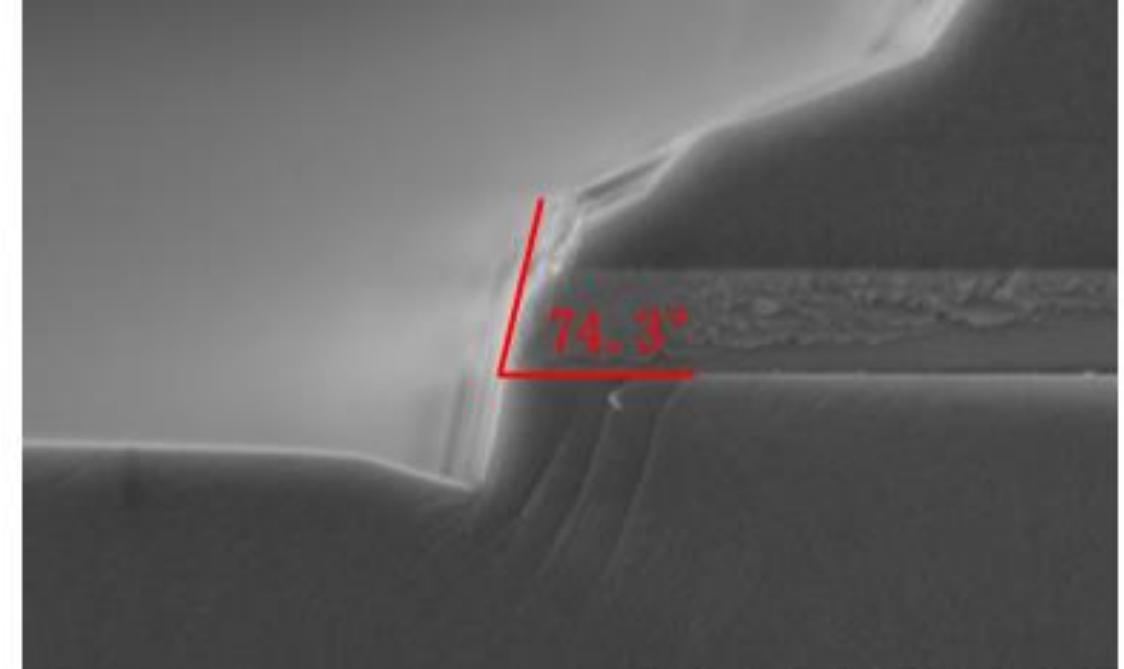
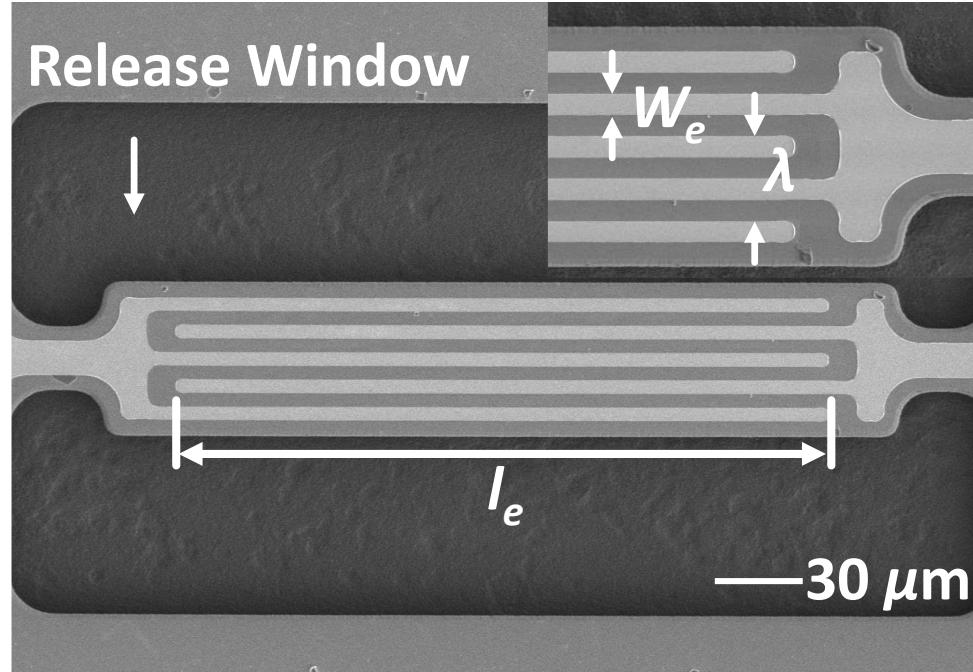
3. Definition of etch mask



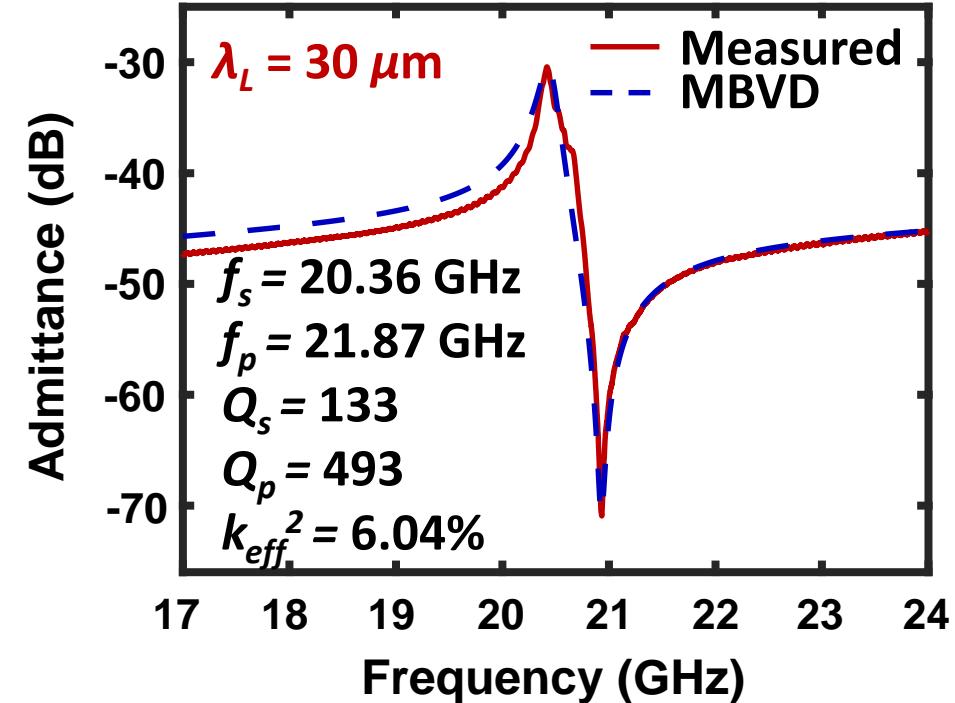
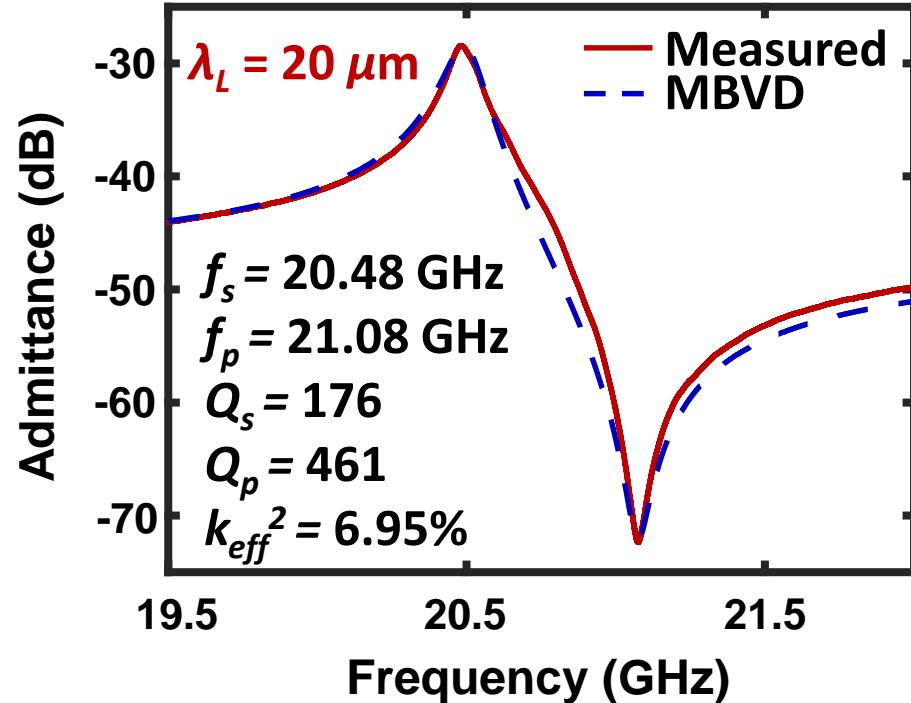
 LiNbO₃  SiO₂

 Au  Si

Fabrication



- LiNbO₃ etching profile over 74°



- At 20 GHz, Q is close to 500, $k_{eff}^2 > 6\%$ and FoM ($Q \cdot k_{eff}^2$) > 30, the highest value among reported for super high frequency operation
- Spurious-free characteristics in wide band

Compared to Reported Resonators

Reference	f_s (GHz)	Q	k^2 (%)	FoM ($Q \cdot k^2$)	Platform
Hara 2010	24	283	6.0	17	thin-film AlN
Schaffer 2022	33	110	1.7	2	thin-film AlN
Yang 2020	13	214	3.8	8	LiNbO_3 on Si
Yang 2020	21.6	242	1.2	3	LiNbO_3 on Si
This work	20.4	461	6.95	32	$\text{LiNbO}_3\text{-SiO}_2$ on poly-Si/Si
	20.3	193	6.04	30	$\text{LiNbO}_3\text{-SiO}_2$ on poly-Si/Si

Conclusion

- A3-Mode lamb waves in 128° Y-cut LiNbO₃ possess **high phase velocity**
- Improving device performance by design and process optimization
- The A3-mode resonator implemented demonstrates Q_p **close to 500**, $k_{eff}^2 > 6\%$ and **FoM > 30** at 20 GHz
- Realizing High Q_p of A3-mode due to introduction of poly-silicon

**Thanks for your attention!
Question?**