

Tu4B-3

An Extended Mason Model for Spurious-Mode Modeling of High Q FBAR Resonators

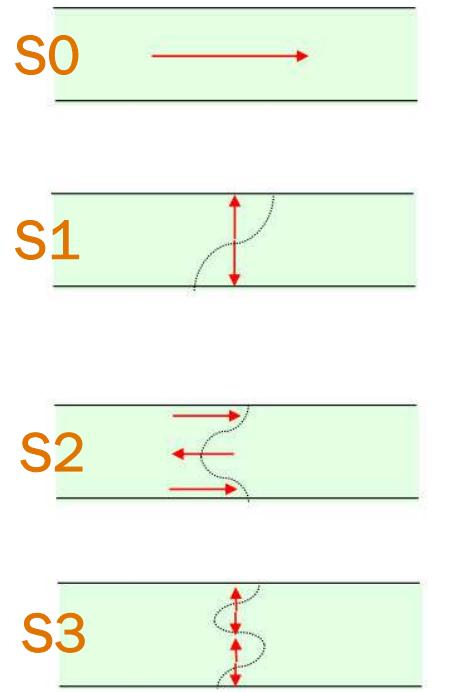
Jiashuai Wang¹, Xuan Zhang¹, Tao Yang¹

¹University of Electronic Science and Technology of China
(UESTC), Chengdu China

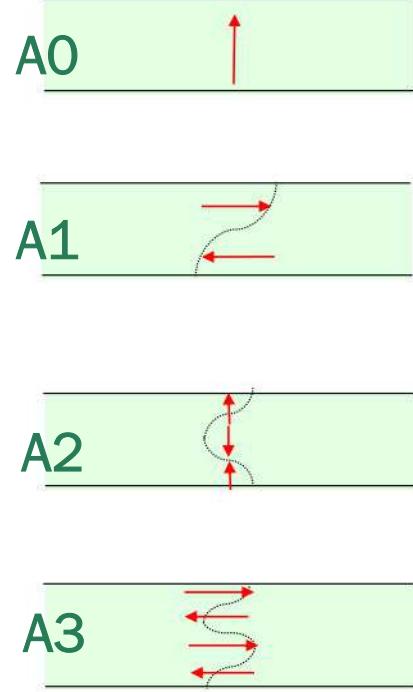
Outline of Presentation

- **Background and Motivation**
- **Proposed Extended Mason Model**
- **Experimental Verification**
- **Conclusion**

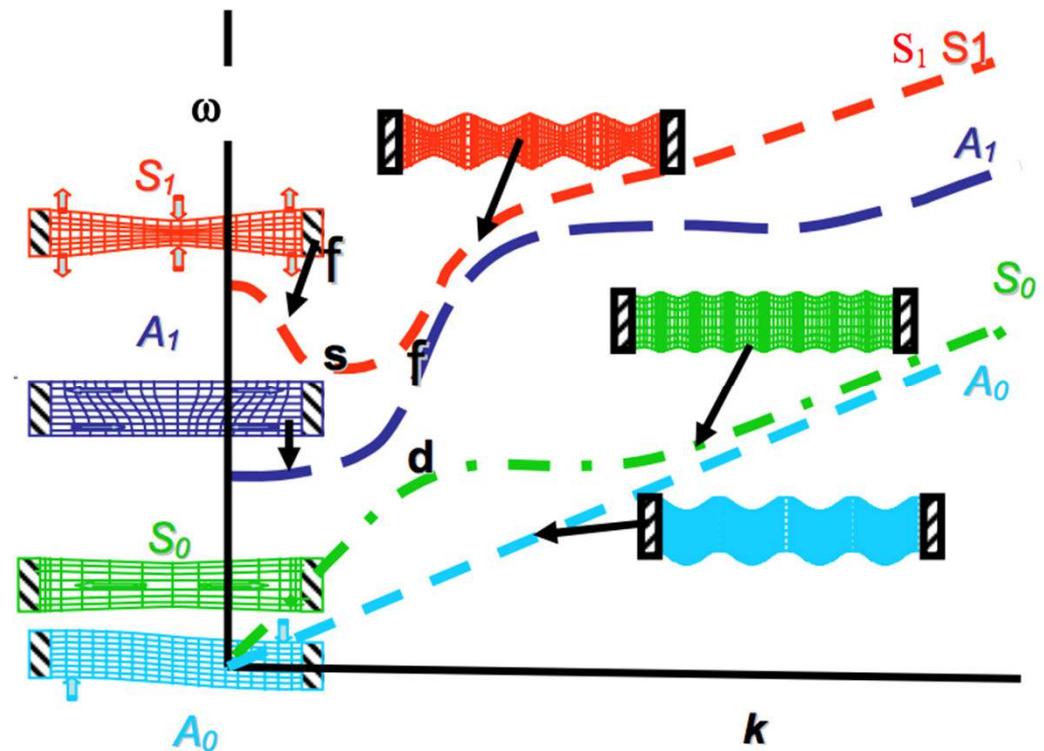
Dispersion Curve of FBAR



Symmetric wave



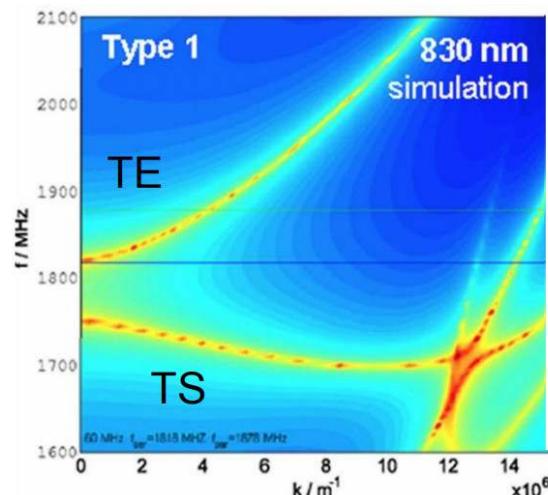
Antisymmetric wave



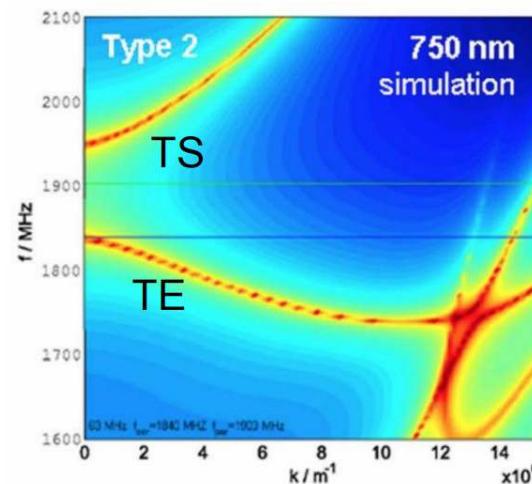
Background and Motivation

- Dispersion Curve of BAW

SMR-BAW



AIN FBAR

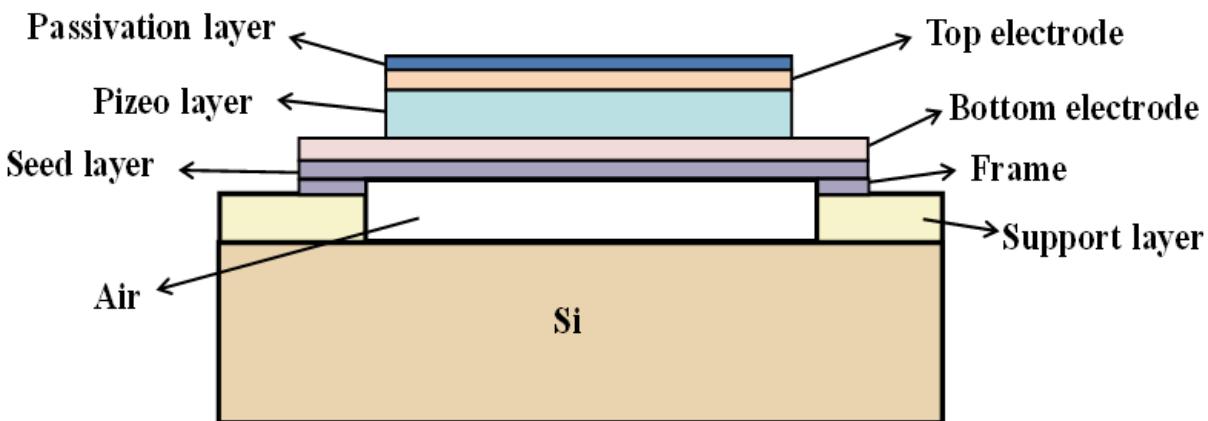


- Type I Dispersion
- The higher order modes occur between F_s and F_p

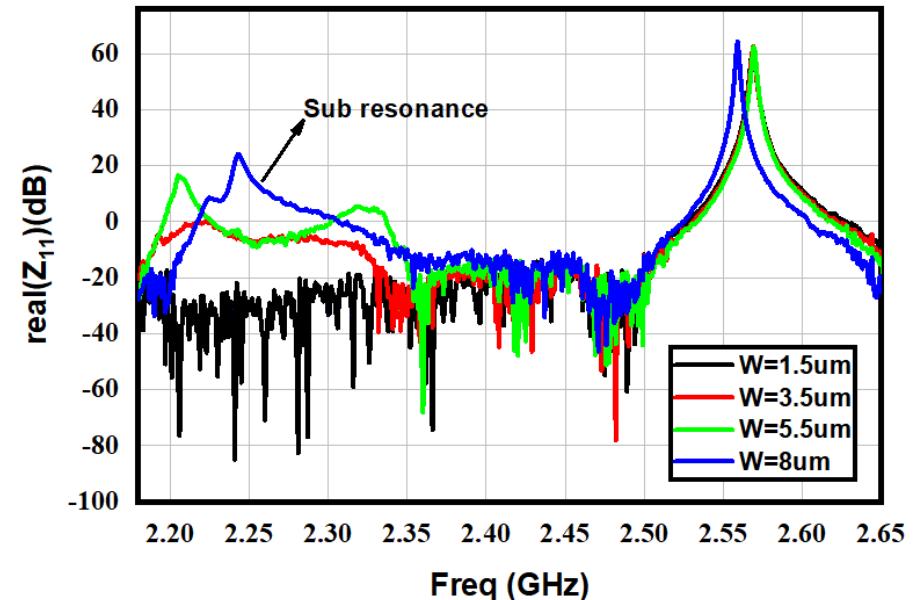
- Type II Dispersion
- The higher order modes occur below F_s

Background and Motivation

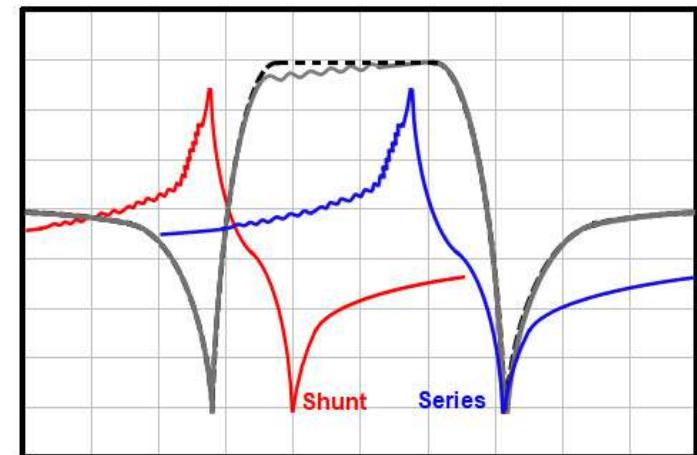
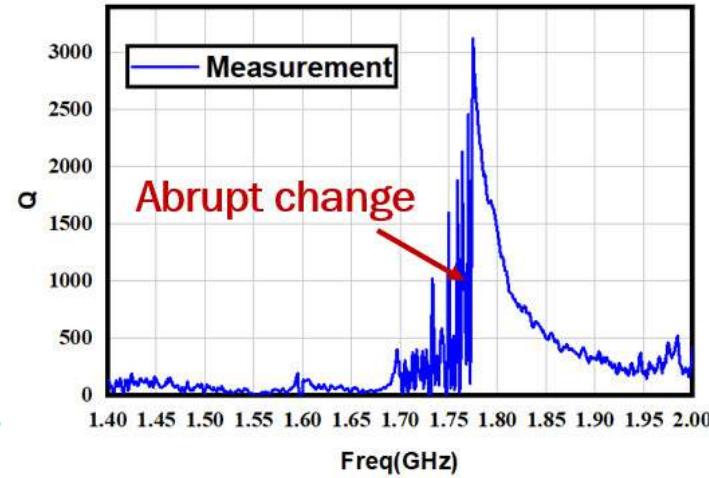
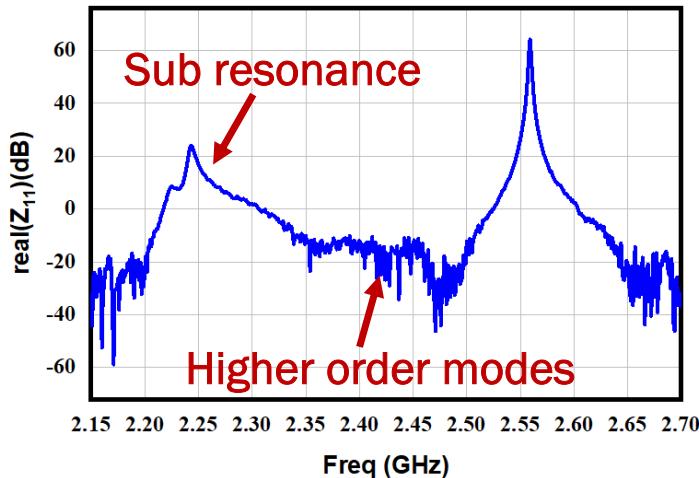
- Frame introduces sub resonance



High Q FBAR with Frame



Background and Motivation



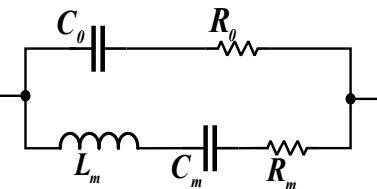
Motivation

- Higher order modes below F_s
- The sub resonance introduced by frame
- Abrupt change of Q factor near F_s

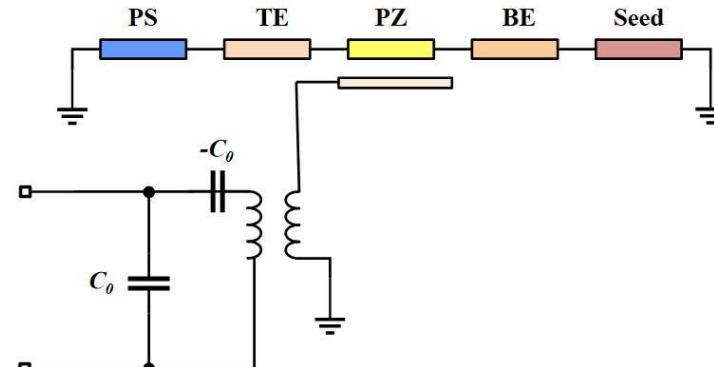
Deterioration of insertion loss

Deterioration of insertion loss

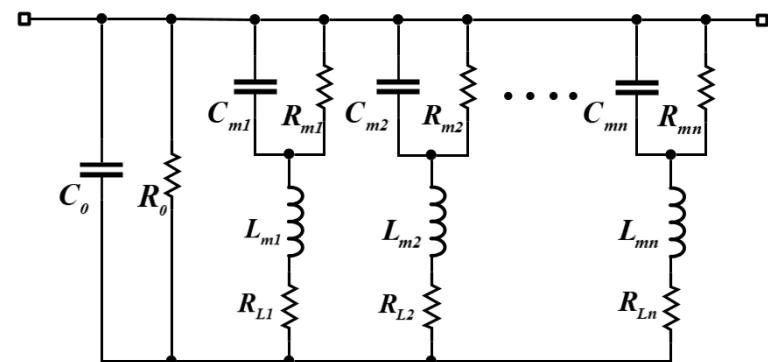
Background and Motivation



MBVD model



Mason model



EBVD model

Main Mode Only

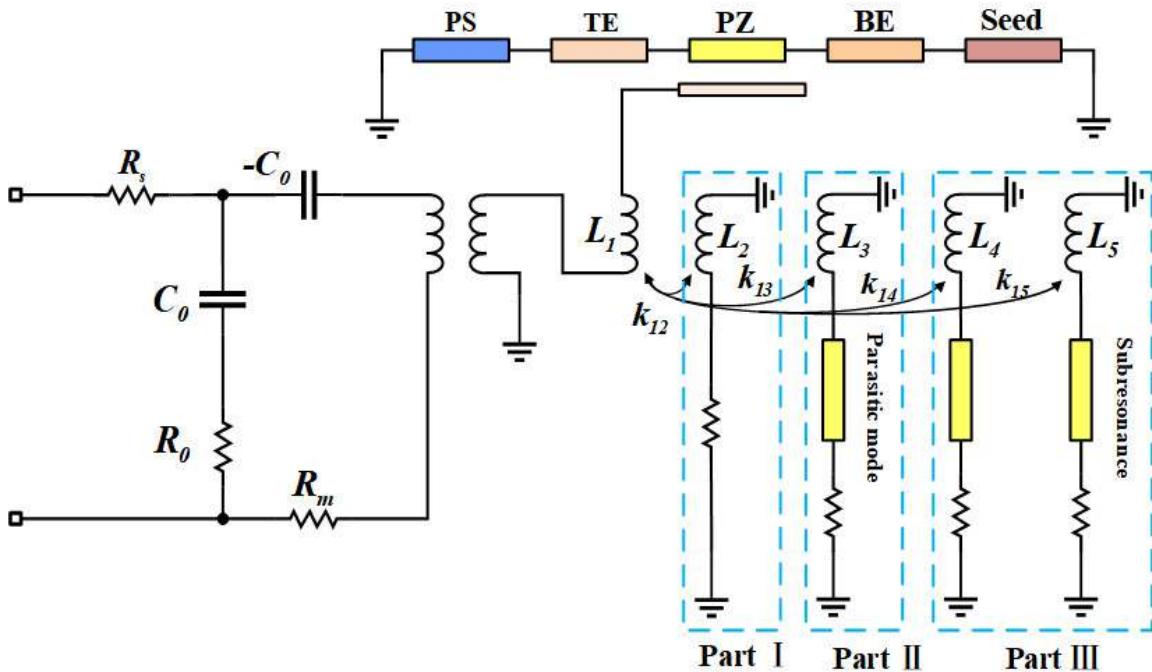
Complex Architecture

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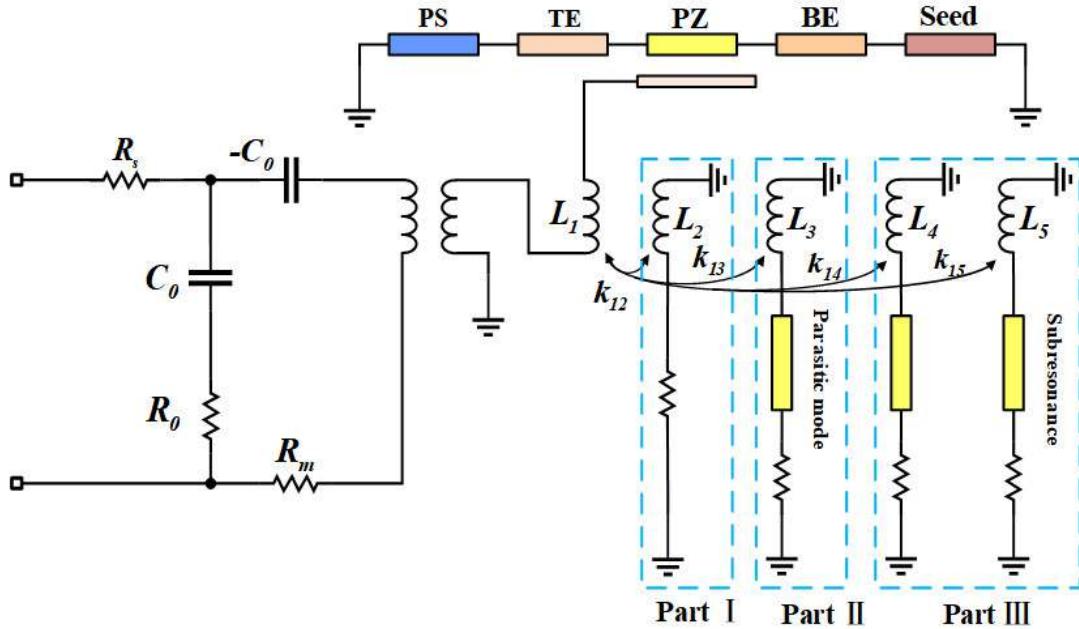
Proposed Extended Mason Model

- Adding three partial couplings
- Realized by mutual inductance



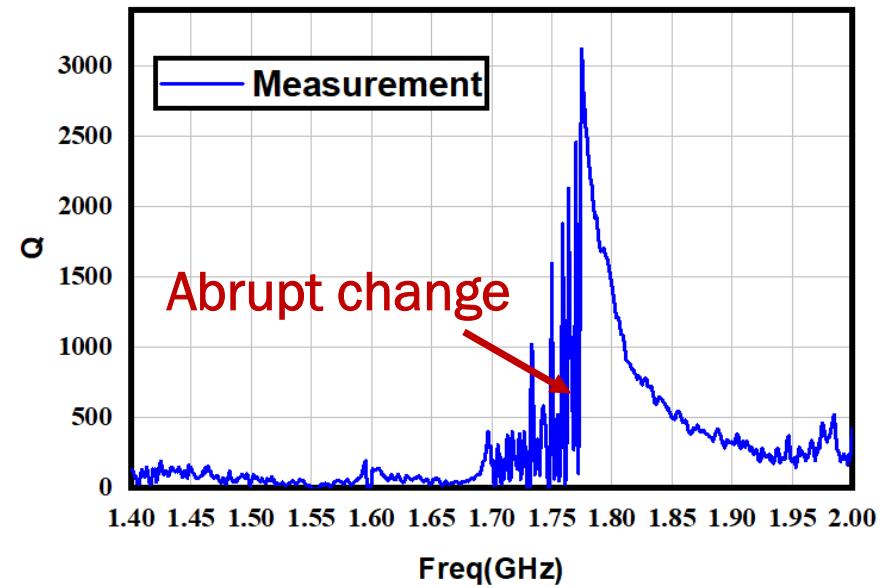
- Part I : Abrupt change of Q factor
- Part II: Higher order modes
- Part III: Sub resonance

Proposed Extended Mason Model



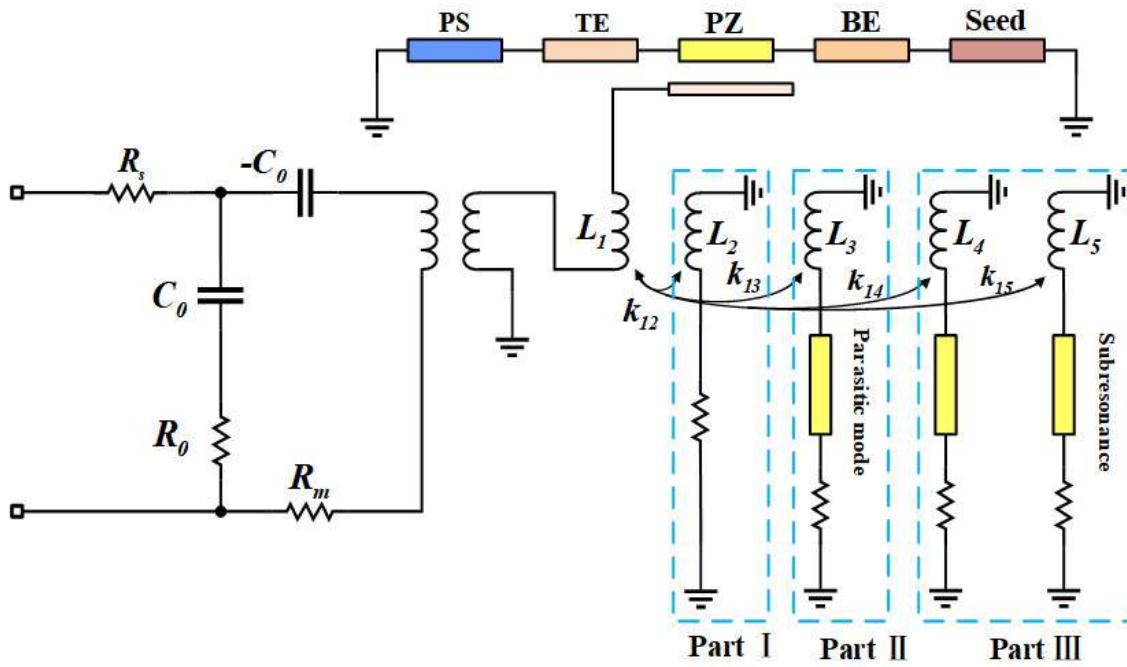
- $L_1 = L_2 = 0\text{nH}$
- T determines the slope of the steep decline of Q value

■ Part I : Abrupt change of Q factor



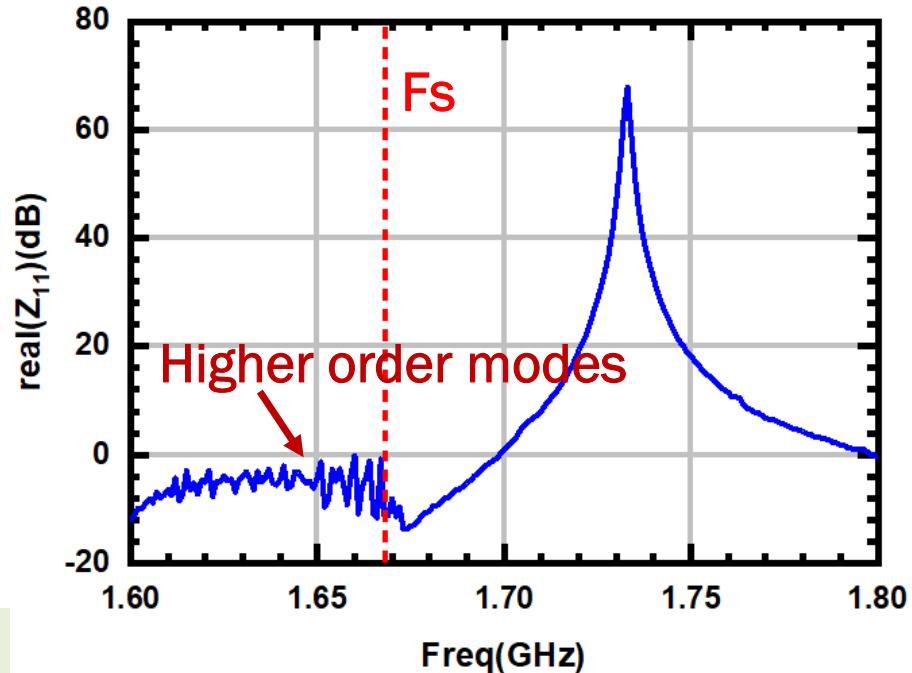
$$k_{12} = m_1 \times \arctan(T \times (1 - freq/f_s))$$

Proposed Extended Mason Model

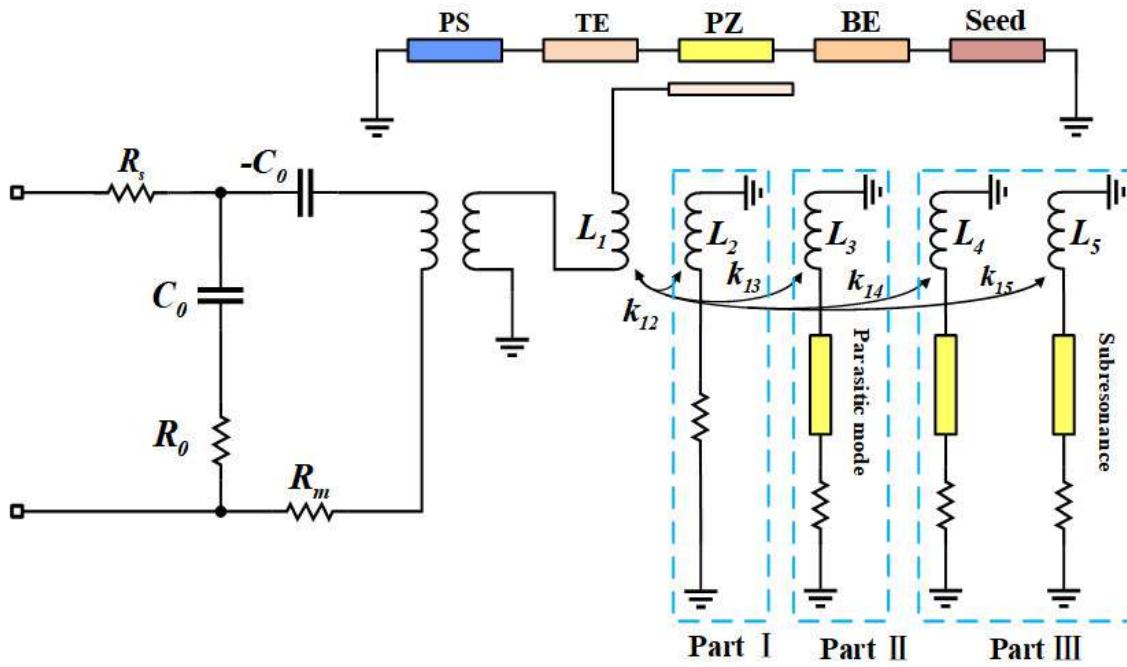


- Higher order modes occur in the frequency range 80-100MHz below F_s
- Ideal microstrip affects higher order modes

Part II: Higher order modes

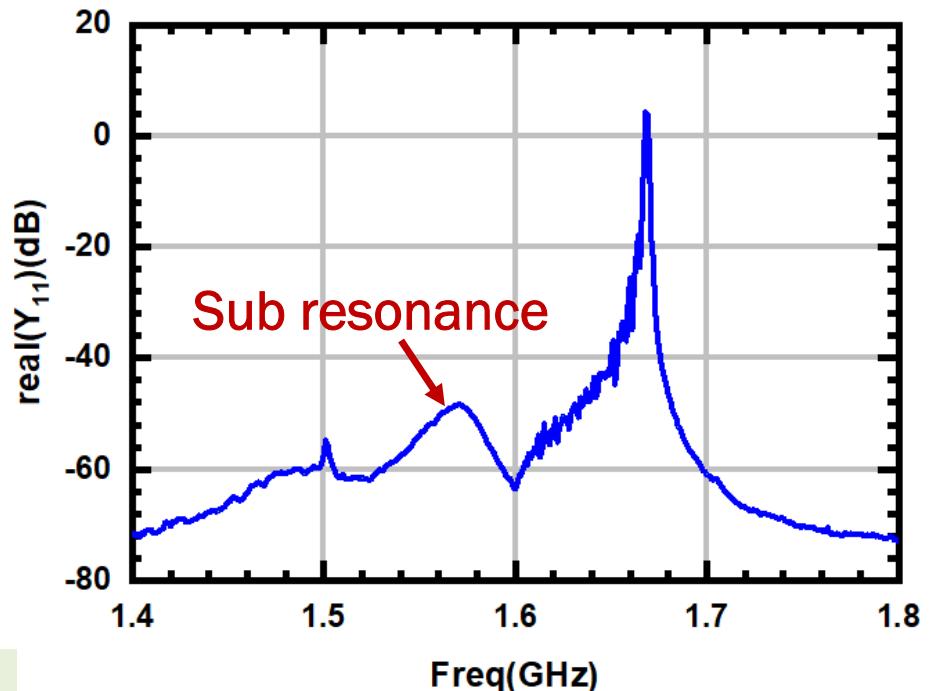


Proposed Extended Mason Model



- $L_1 = L_4 = L_5 = 0\text{nH}$
- Ideal microstrip affects sub resonance

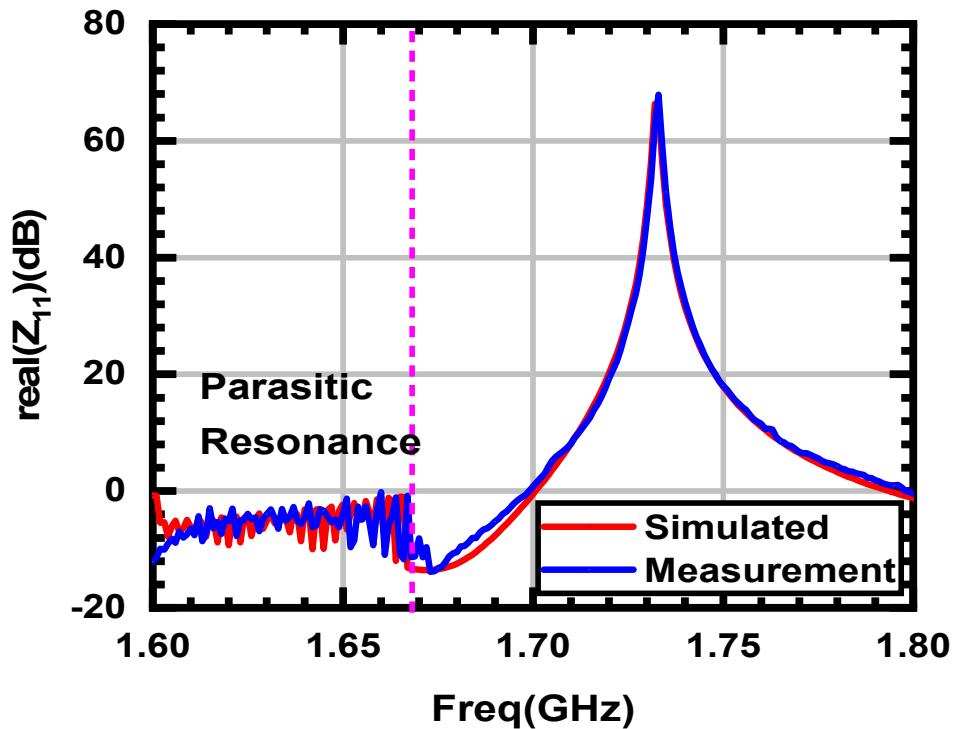
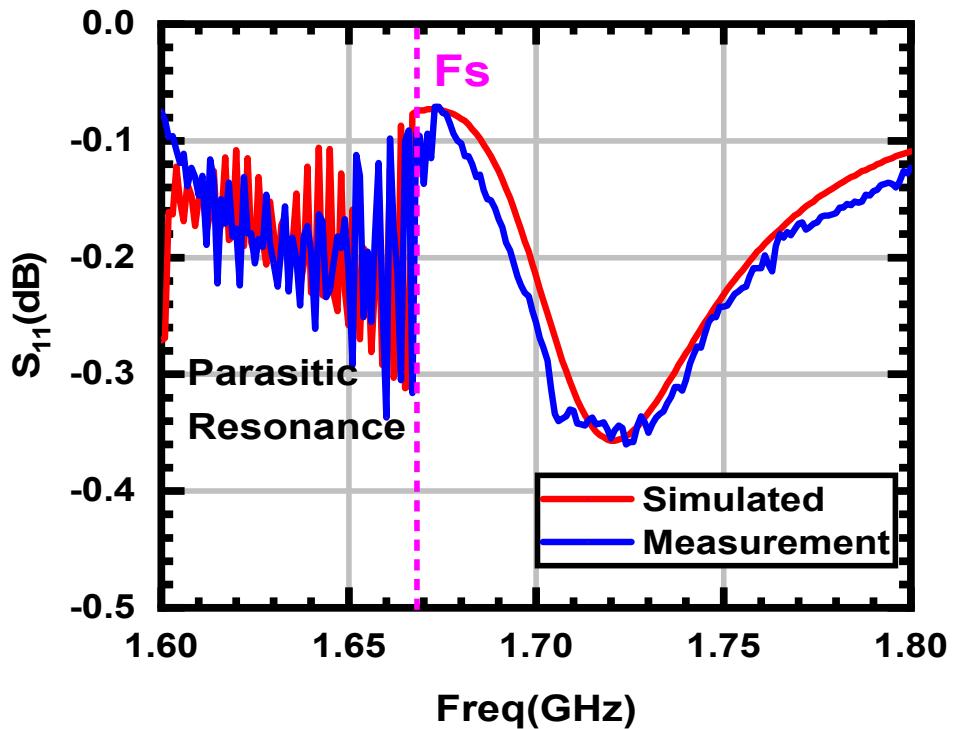
Part III: Sub resonance



Outline of Presentation

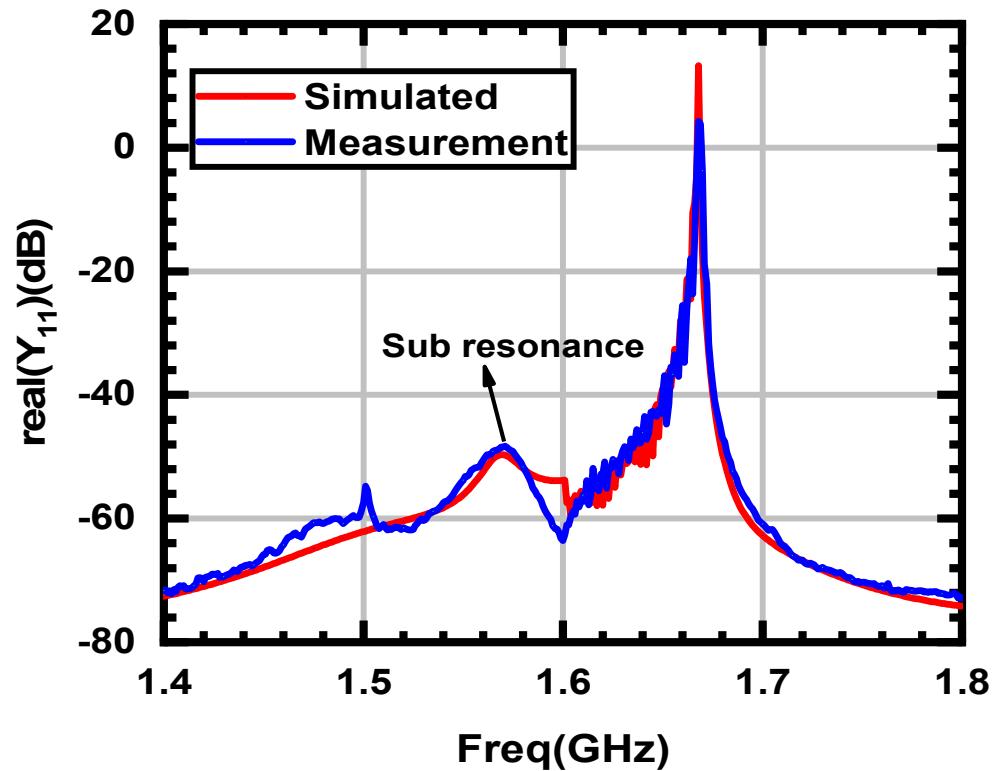
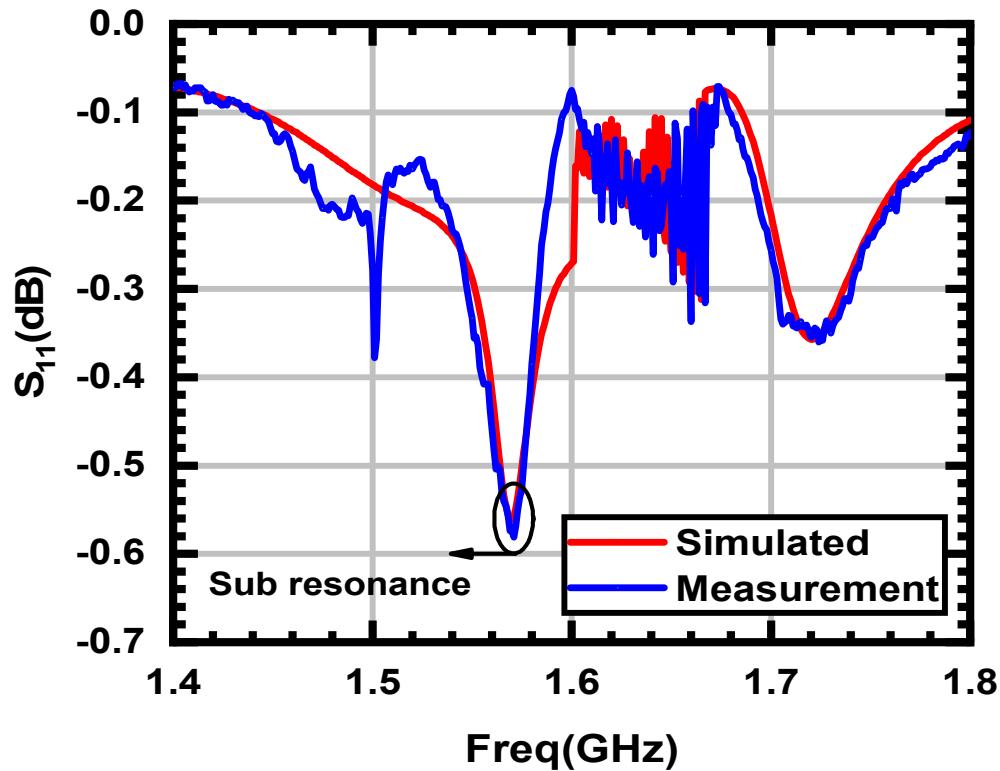
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Experimental Verification



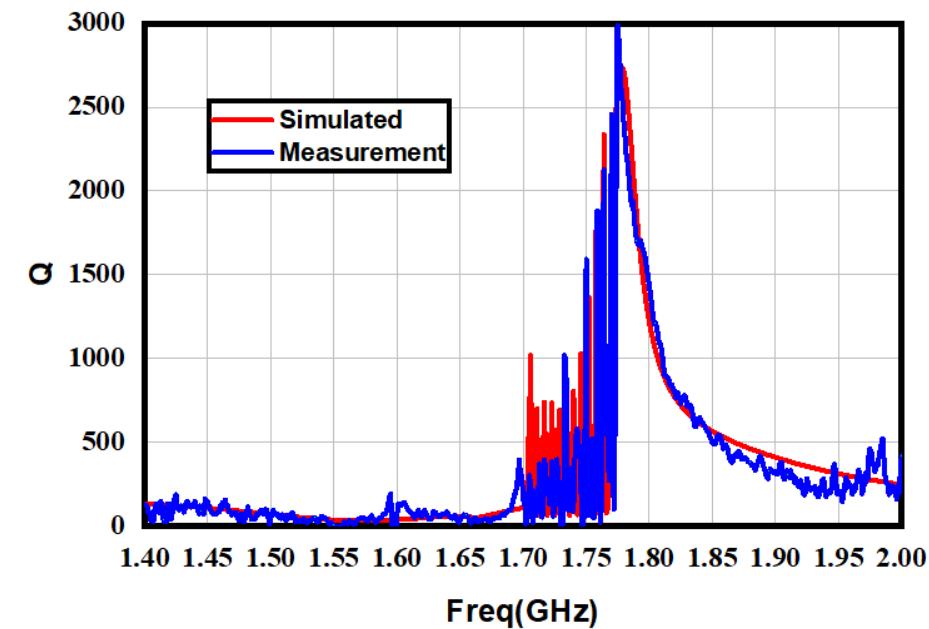
50 Ω FBAR resonator

Experimental Verification

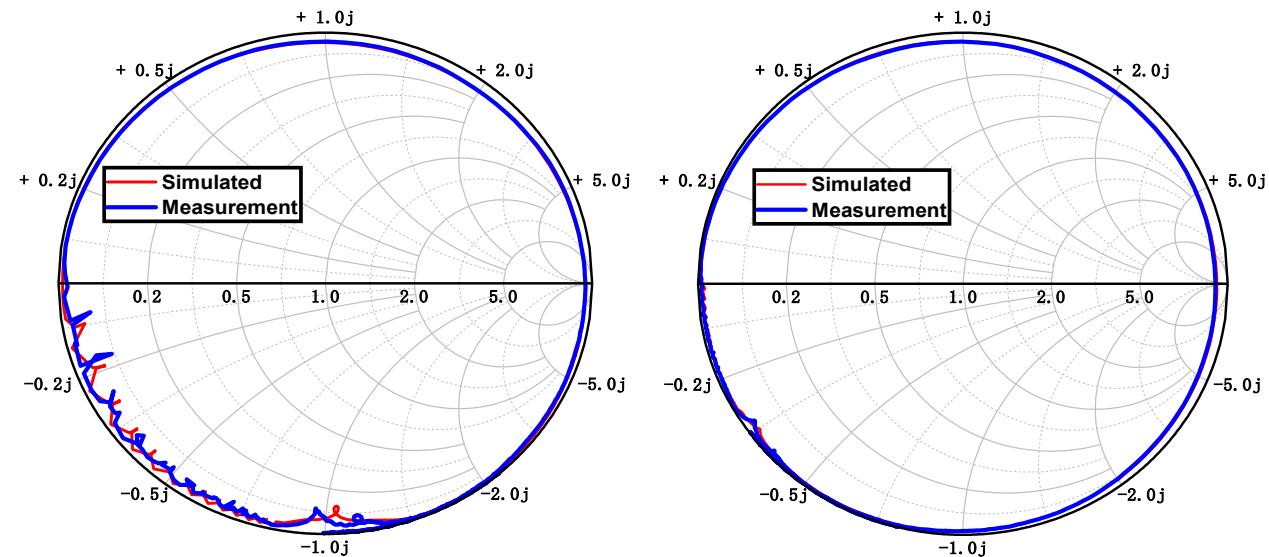


50 Ω FBAR resonator

Experimental Verification



50 Ω FBAR resonator



25 Ω & 100 Ω FBAR resonator

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Conclusion

- An Extended Mason Model was proposed for High Q FBAR Resonators
- Proposed model can simulate the higher order modes and the sub resonances arising from the frame structure, and the abrupt change of the Q factor near f_s can be well fitted
- This model is applicable to FBAR resonators with different structures , different stacks and different impedance

Thanks for your attention!
Questions?