We3H-3

Using a 3D-Printed Waveguide Filter with Ridge Resonators as a Dielectric Permittivity Sensor

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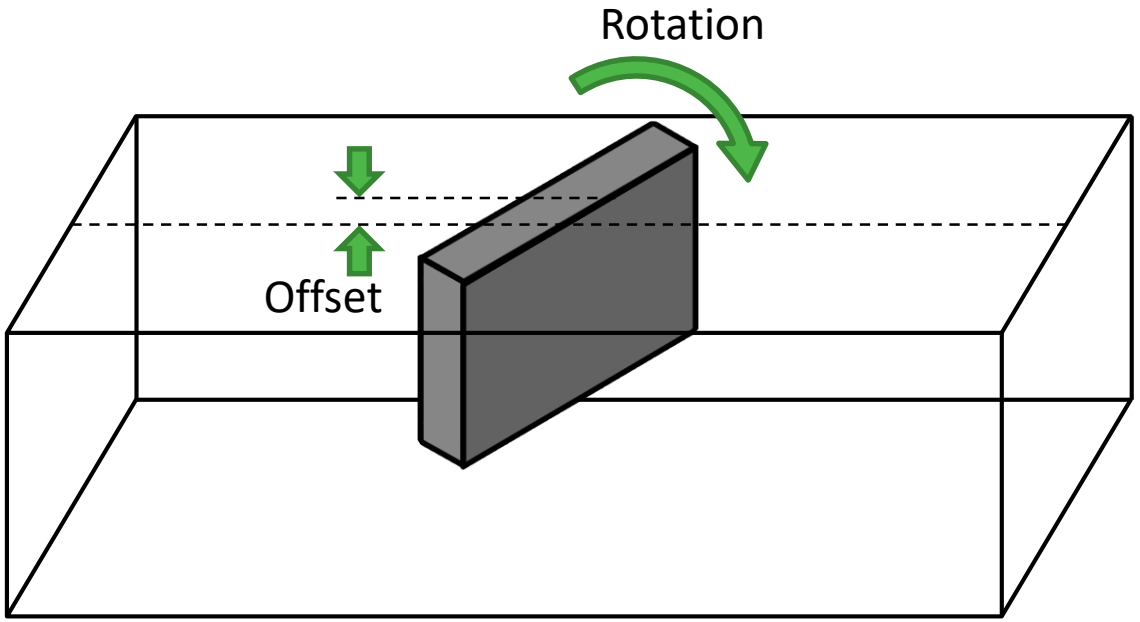
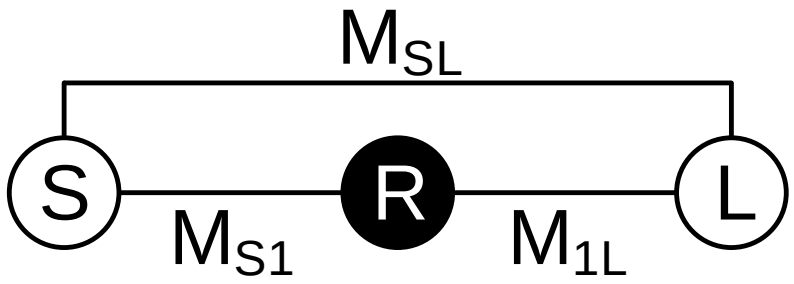
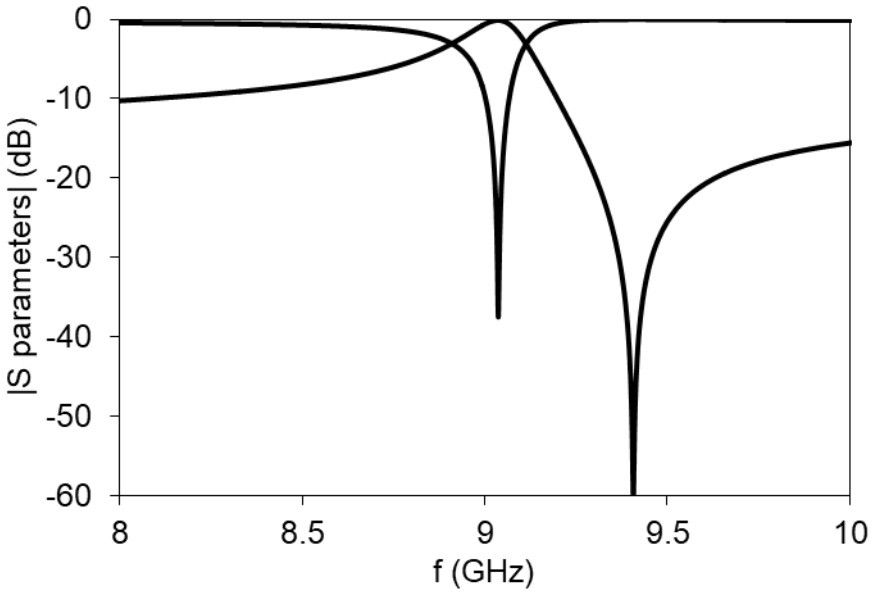
Outline

- Slanted ridge resonators
- Dielectric measurement principle
- Multiple slanted ridges
- Multiple slanted ridge dielectric sensor

Slanted ridge resonators

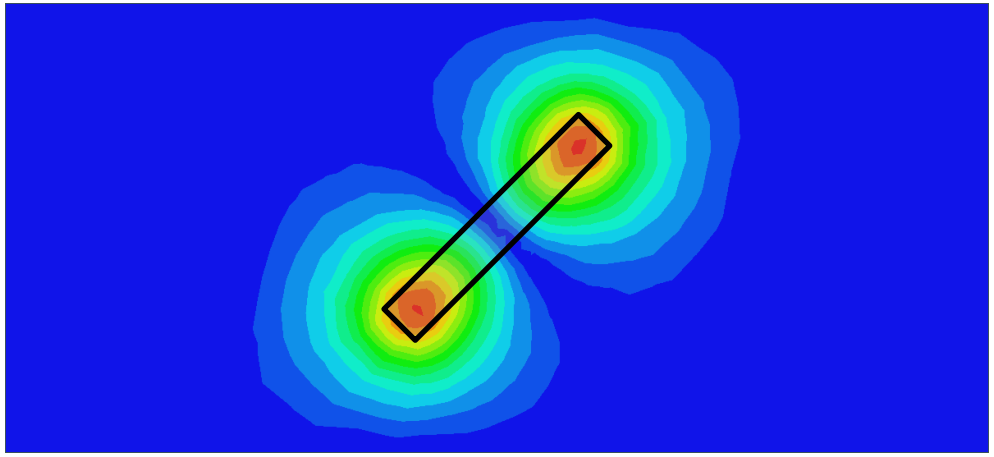




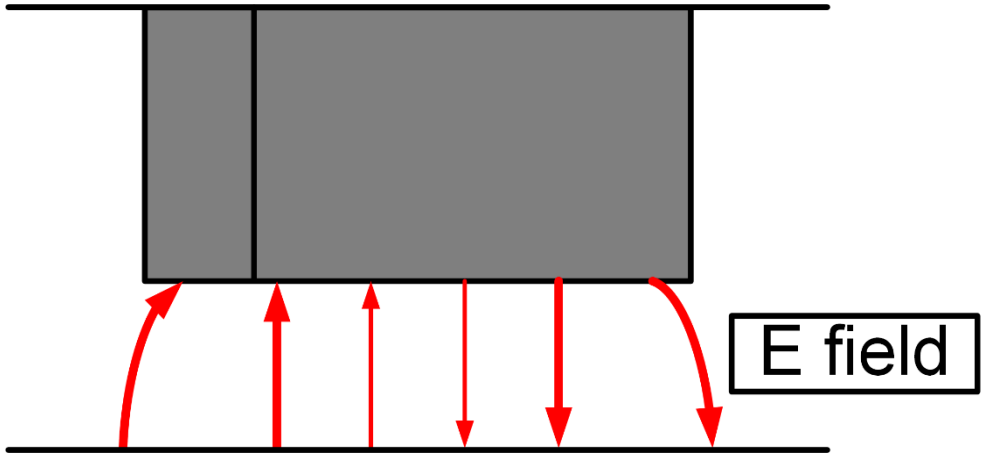


- Compact structure
- Doublet frequency response

Slanted ridge resonators



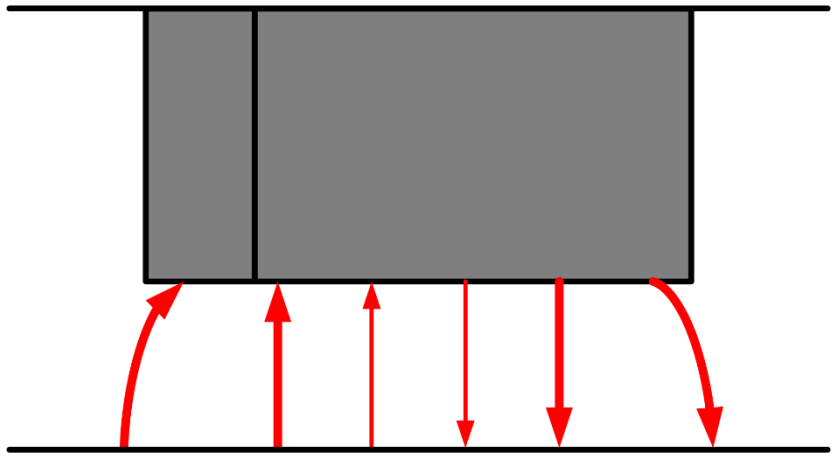
Top view

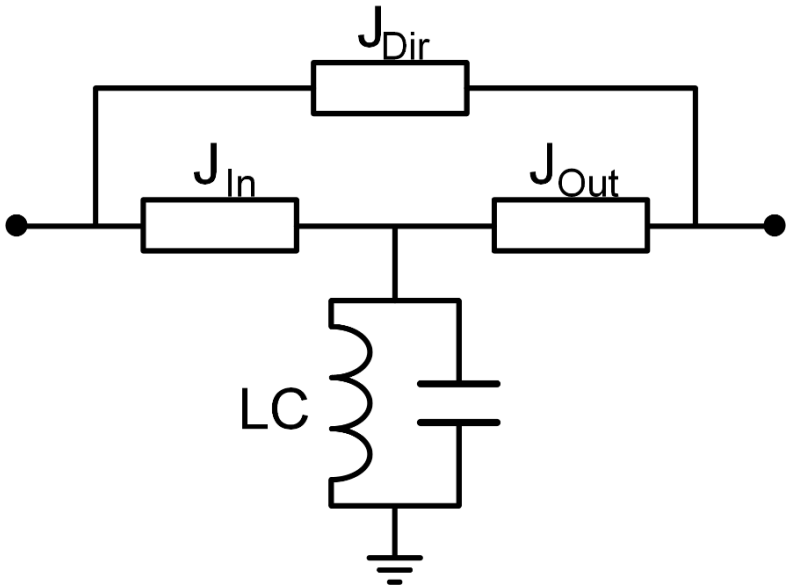


Side view

- Electric field distribution
- Strong vertical components below the ridge

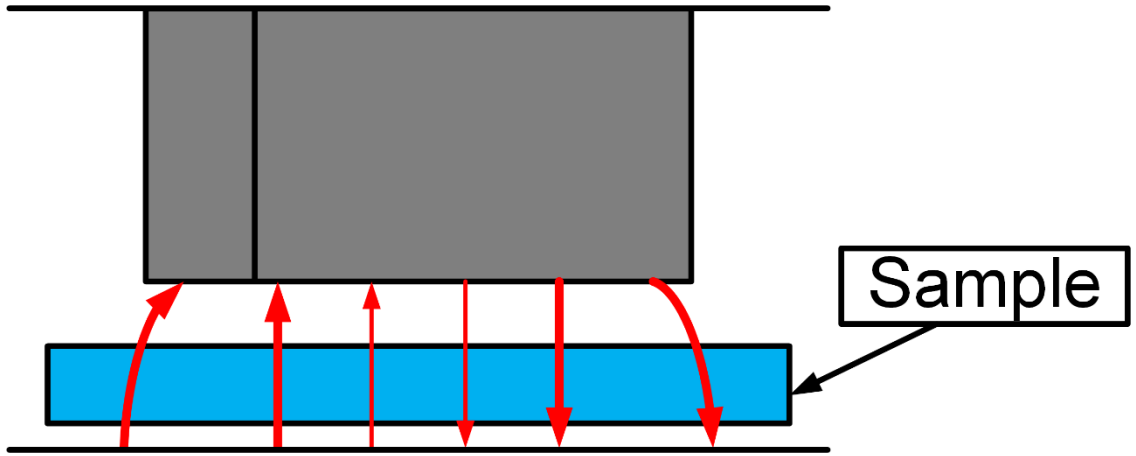
Dielectric measurement method

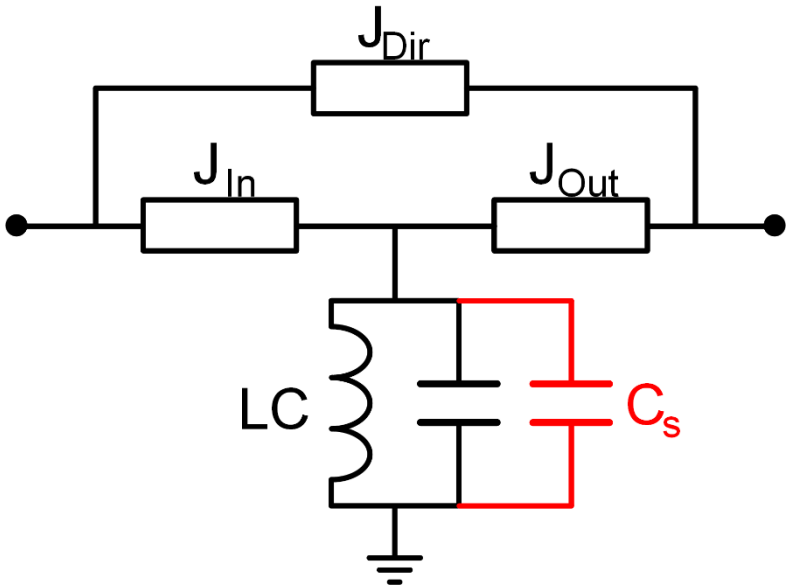




- Unperturbed state

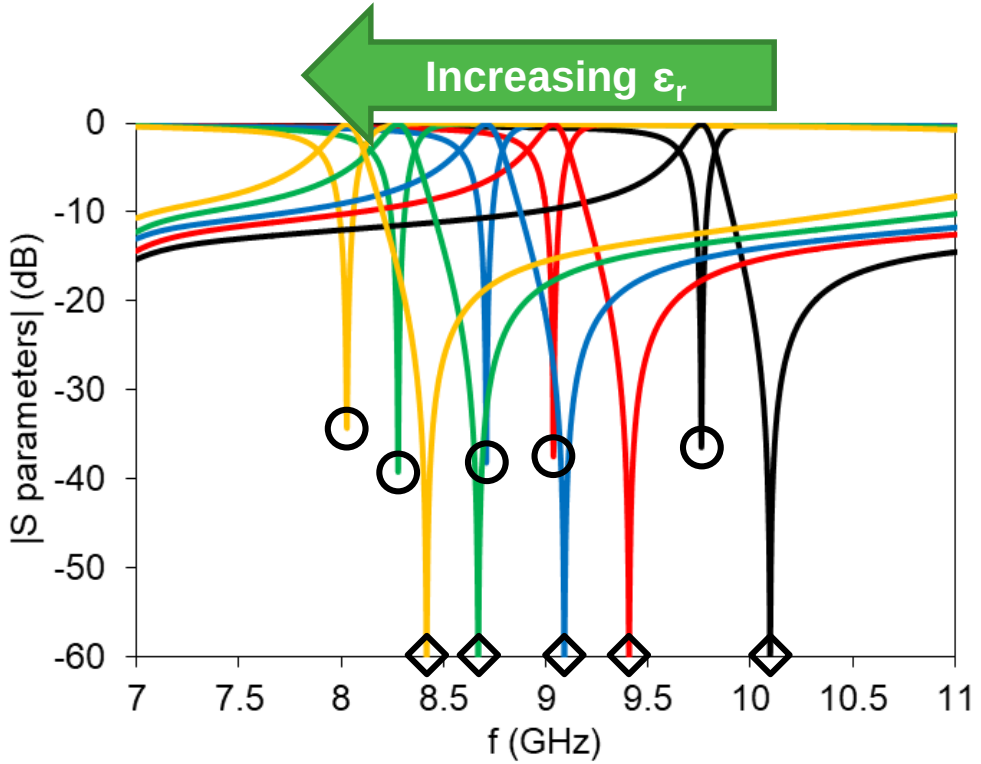
Dielectric measurement method





- Dielectric sample loading
- Shift in the resonance

Dielectric measurement method



Interpolating model

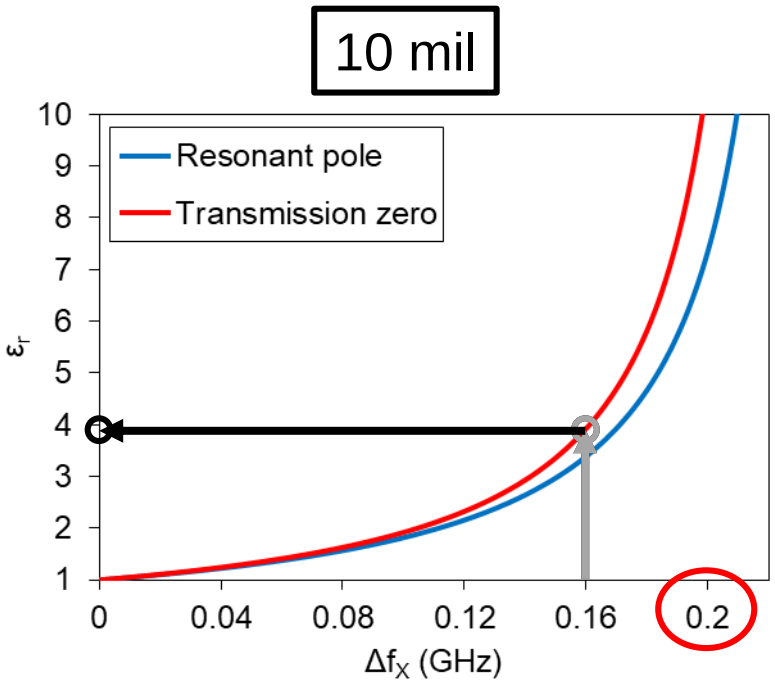
$$f_X(\varepsilon_r) = a \cdot (\varepsilon_r)^b + c$$

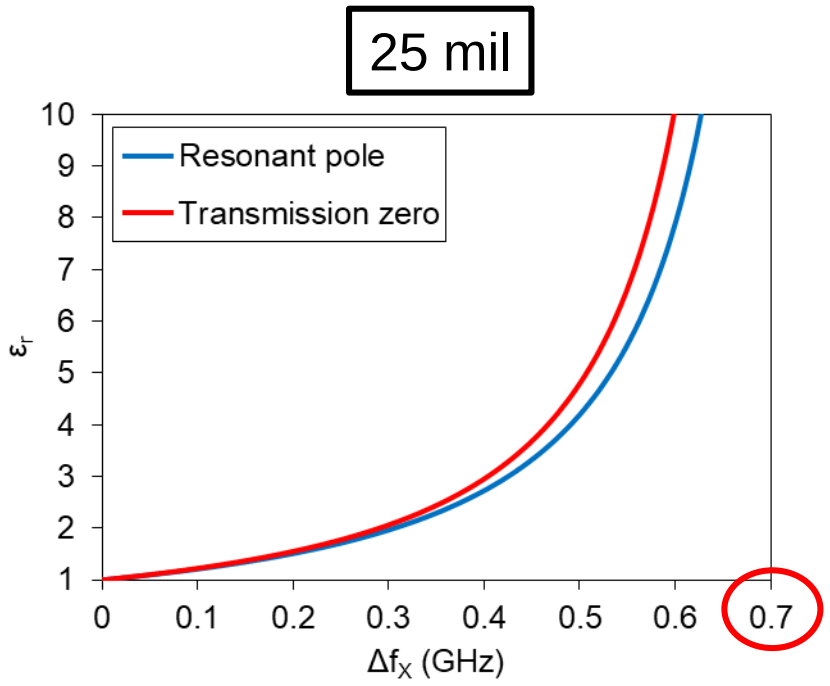
Inverse model

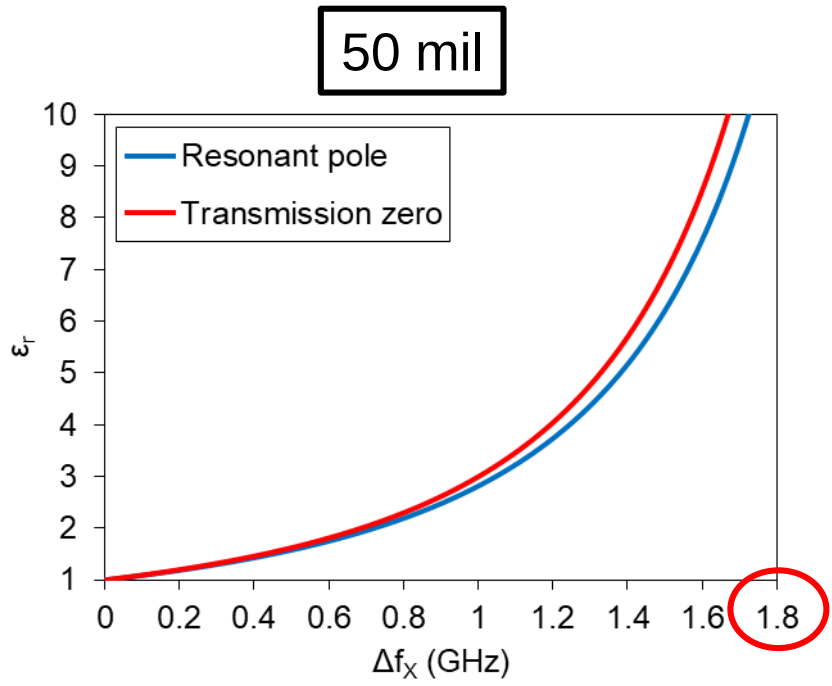
$$\varepsilon_r(f_X) = \left(\frac{f_X - c}{a}\right)^{\frac{1}{b}}$$

- Model for frequency shift of resonant pole or transmission zero

Dielectric measurement method

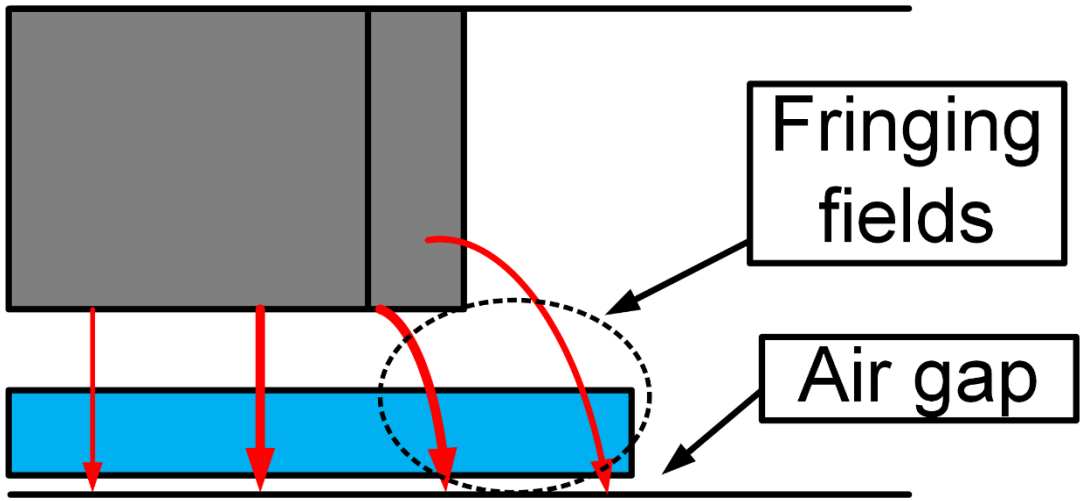


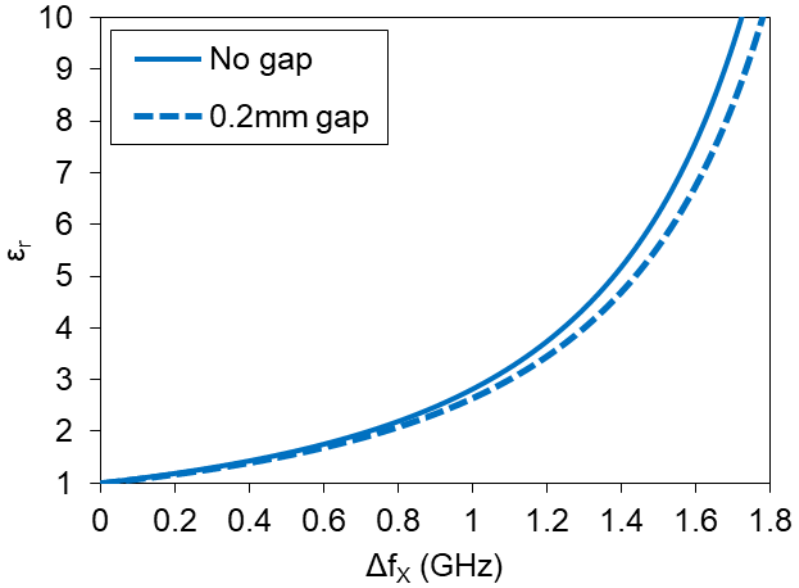




- Different sample thicknesses have different sensitivity
- A model can be made for each situation

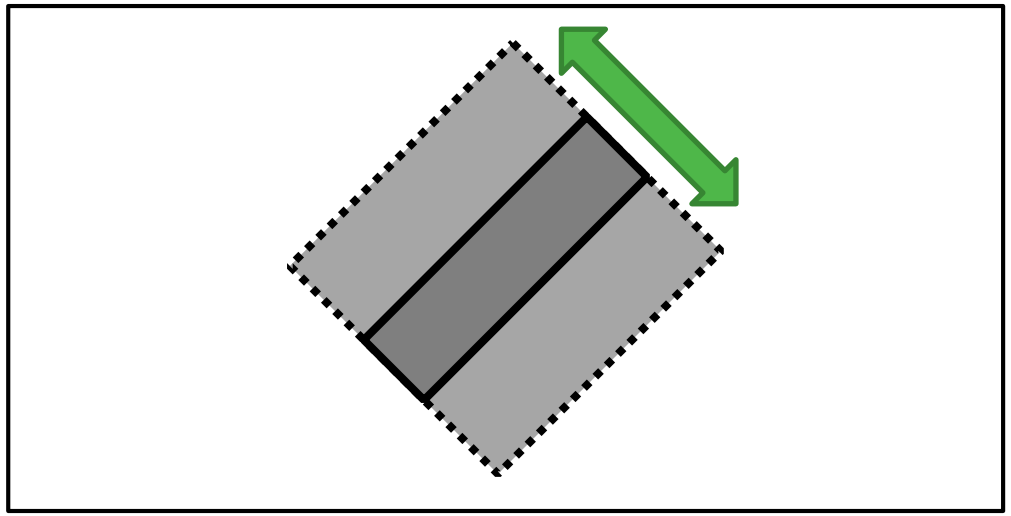
Dielectric measurement method

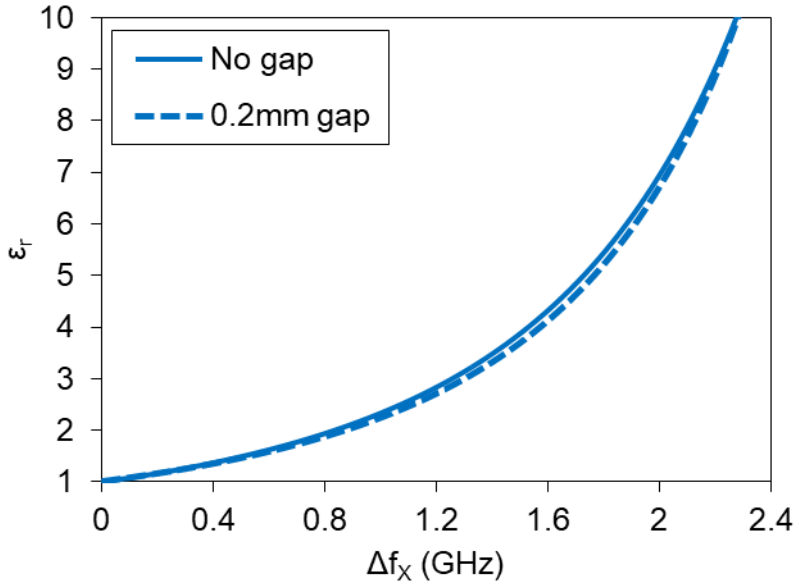


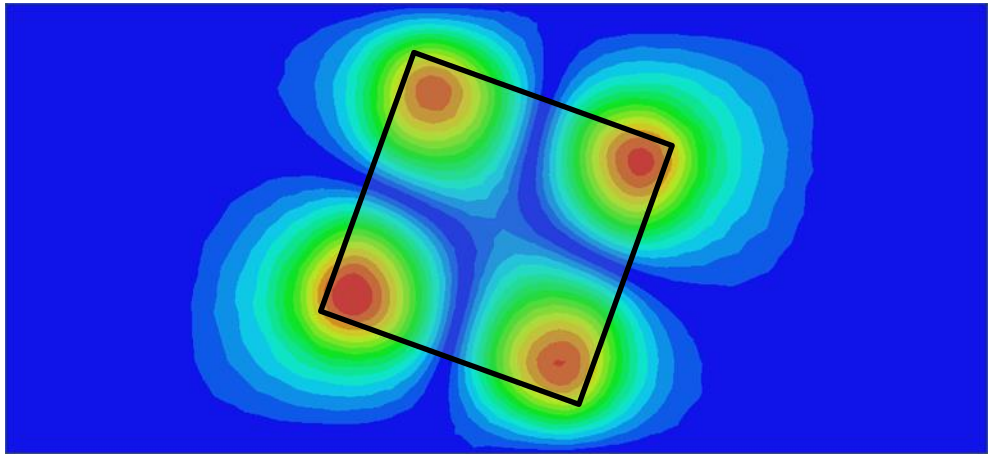


- Fringing fields shape makes the setup sensitive to positioning errors
- Air gap below the sample

Dielectric measurement method

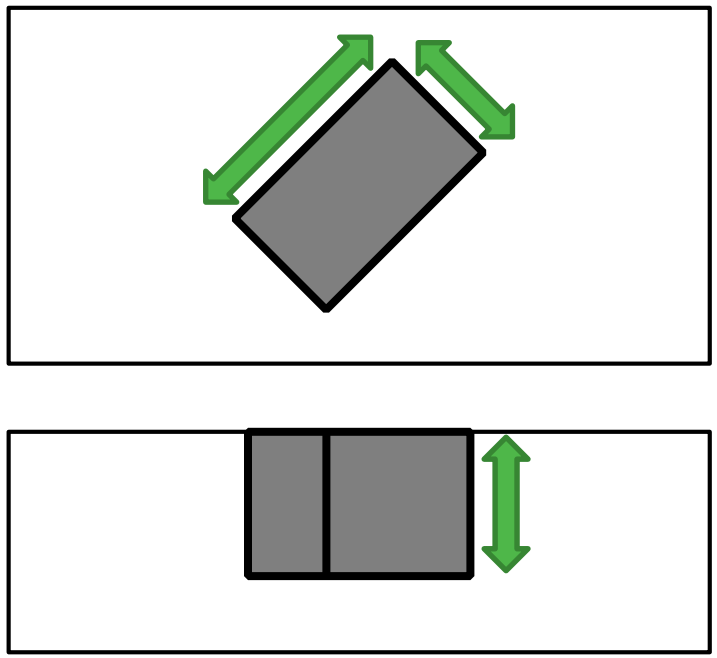


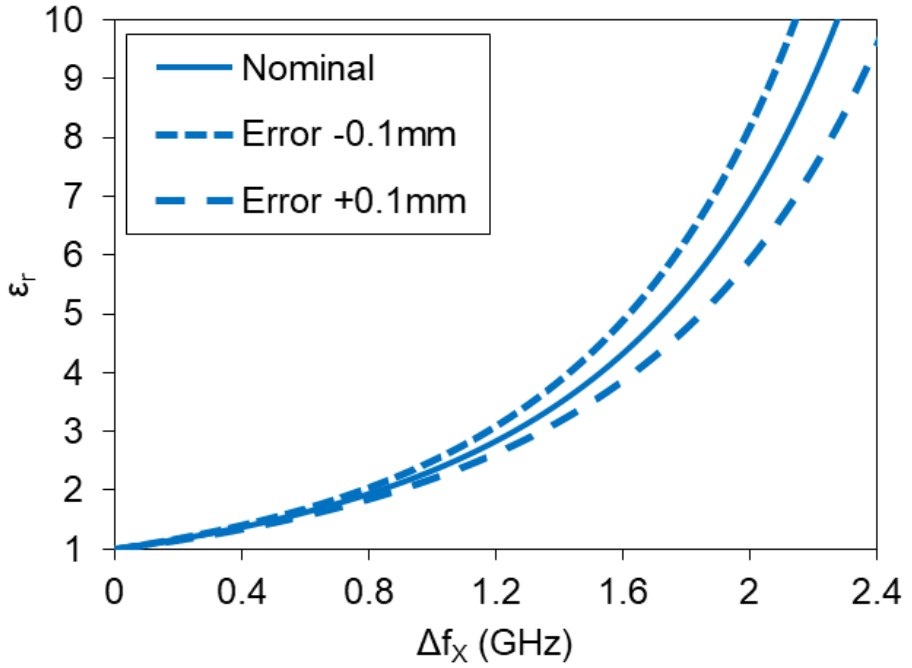




- Effect mitigated by increasing capacitive load
- Thicker iris with high order mode

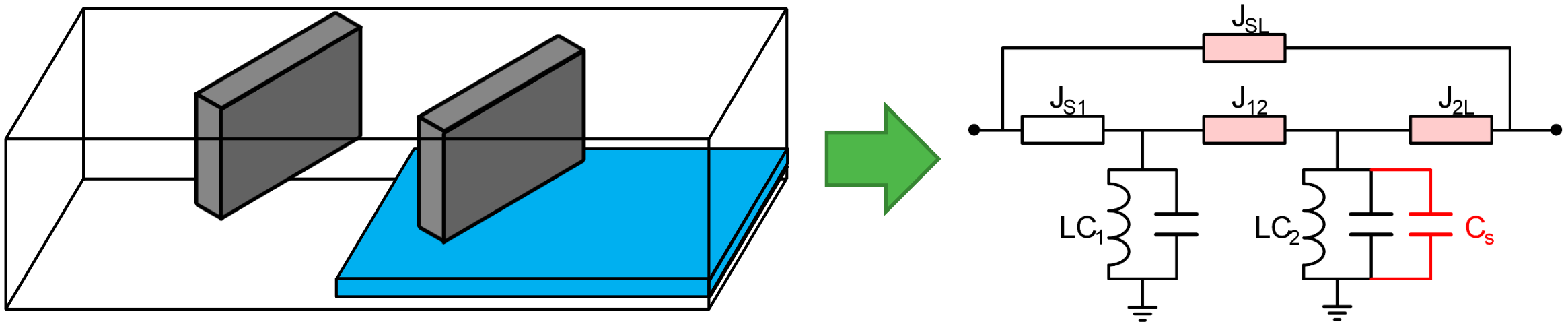
Dielectric measurement method





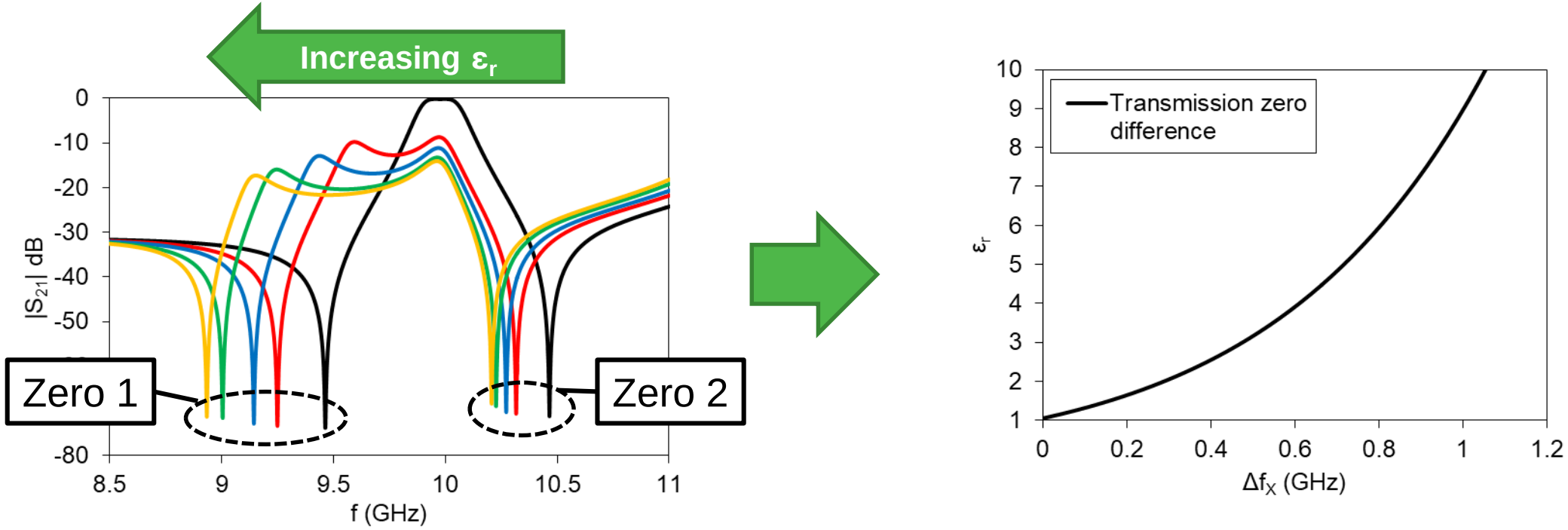
- Fabrication imperfections lead to uncertainties
- Important with low cost fabrication methods (additive manufacturing)

Multiple ridge dielectric sensor



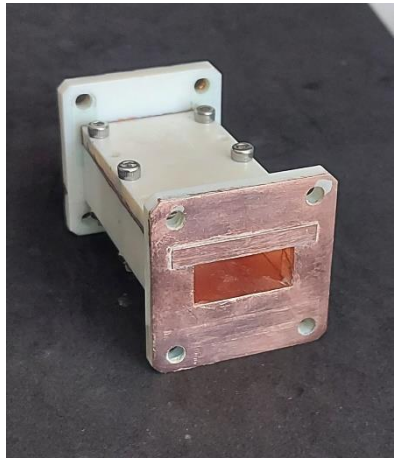
- Sample placed under one of the irises
- Other resonator is mostly unloaded

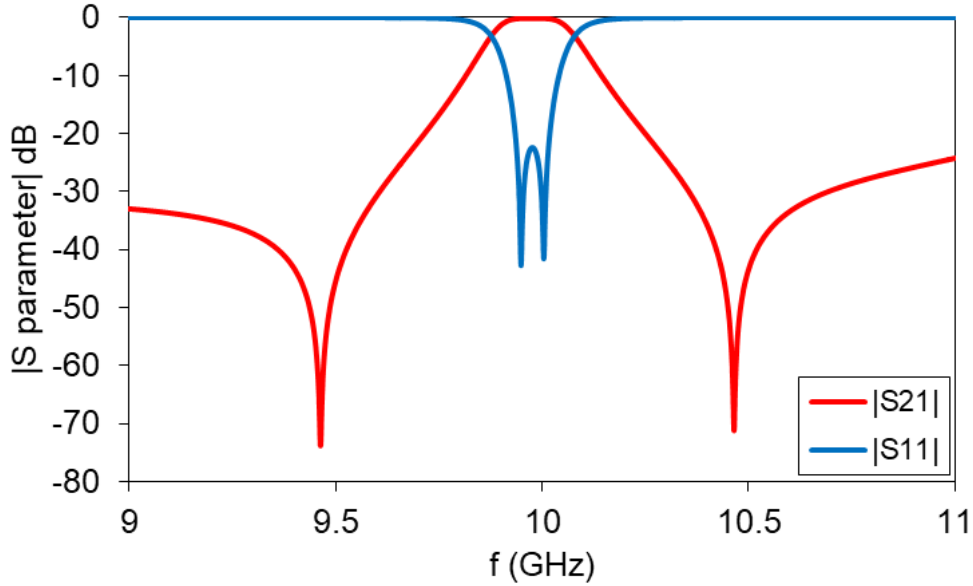
Multiple ridge dielectric sensor



- Dielectric loading strongly shifts lower frequency zero
- Upper frequency zero less affected
- $\Delta f = f_{z2} - f_{z1}$

Multiple ridge dielectric sensor

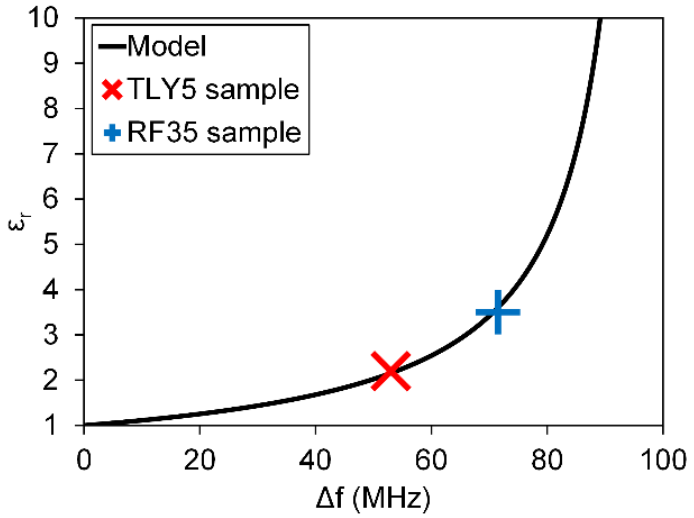




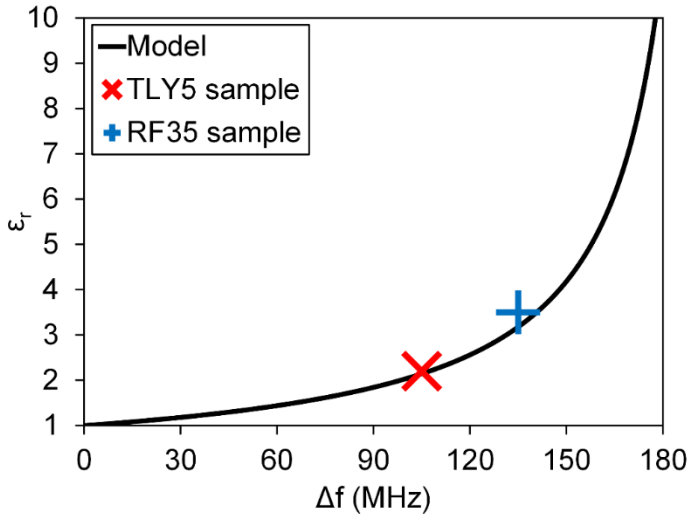
- Test measurements done on a previously designed filter [1]
- Two transmission zeroes
- [1] F. Romano, N. Delmonte, C. Tomassoni, L. Perregrini, and M. Bozzi, "*3D-Printed Compact Waveguide Filters Based on Slanted Ridge Resonators*," IMS 2022, Denver, CO, USA, 19-24 June 2022

Multiple ridge dielectric sensor

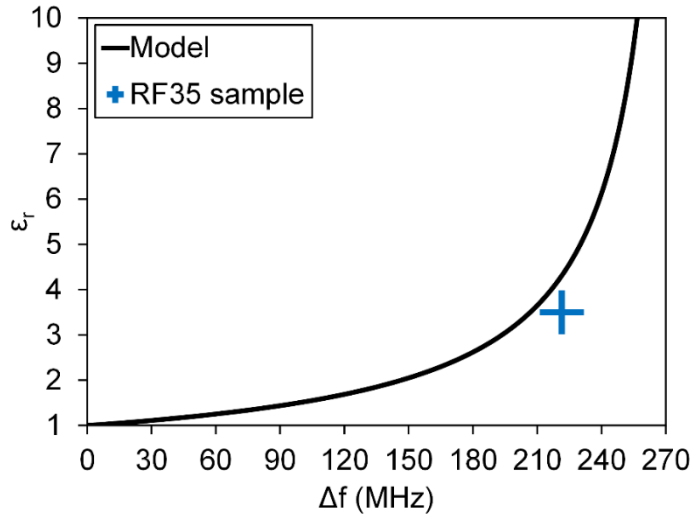
10 mil



20 mil

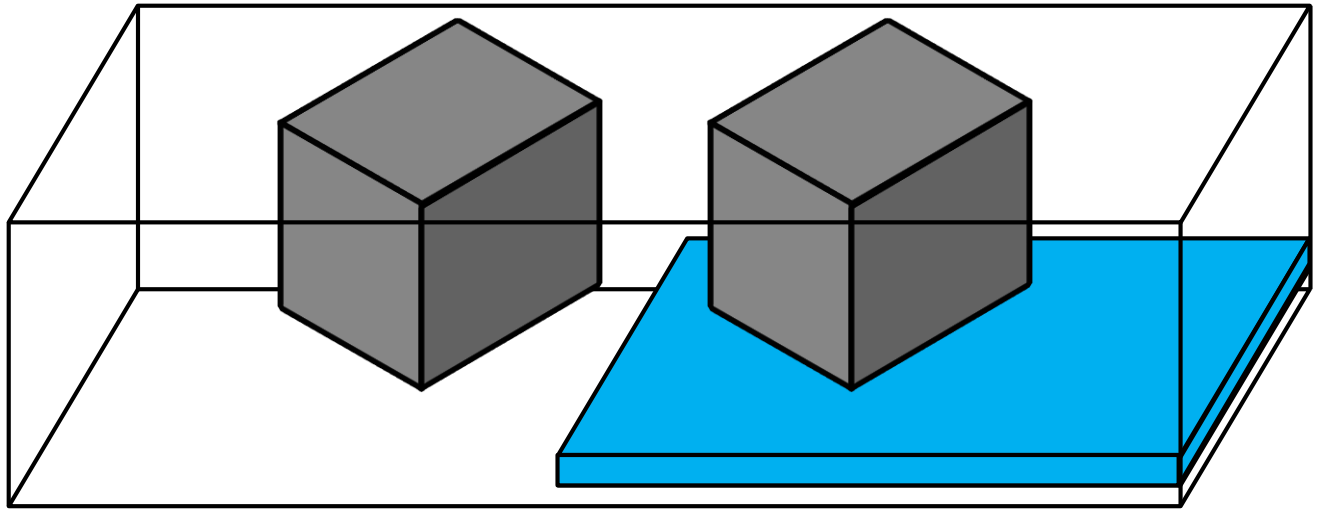


30 mil



Dielectric material	Nominal ε_r	Sample thickness	Retrieved ε_r	Error
TLY5	2.2	10 mil	2.16	-2%
		20 mil	2.14	-2.6%
RF35	3.5	10 mil	3.6	+3%
		20 mil	3.18	-9.2%
		30 mil	3.73	+6.5%

Multiple ridge dielectric sensor



- Multiple thick irises to improve sensitivity vs air gap

Conclusion

- Compact slanted ridge structures for dielectric sensing
- Ridge dimension optimization improve resilience vs sample position error
- Multiple ridges allow for differential measurement