Investigating the permittivity of SiC Substrate Integrated Waveguides at millimeter wavelengths

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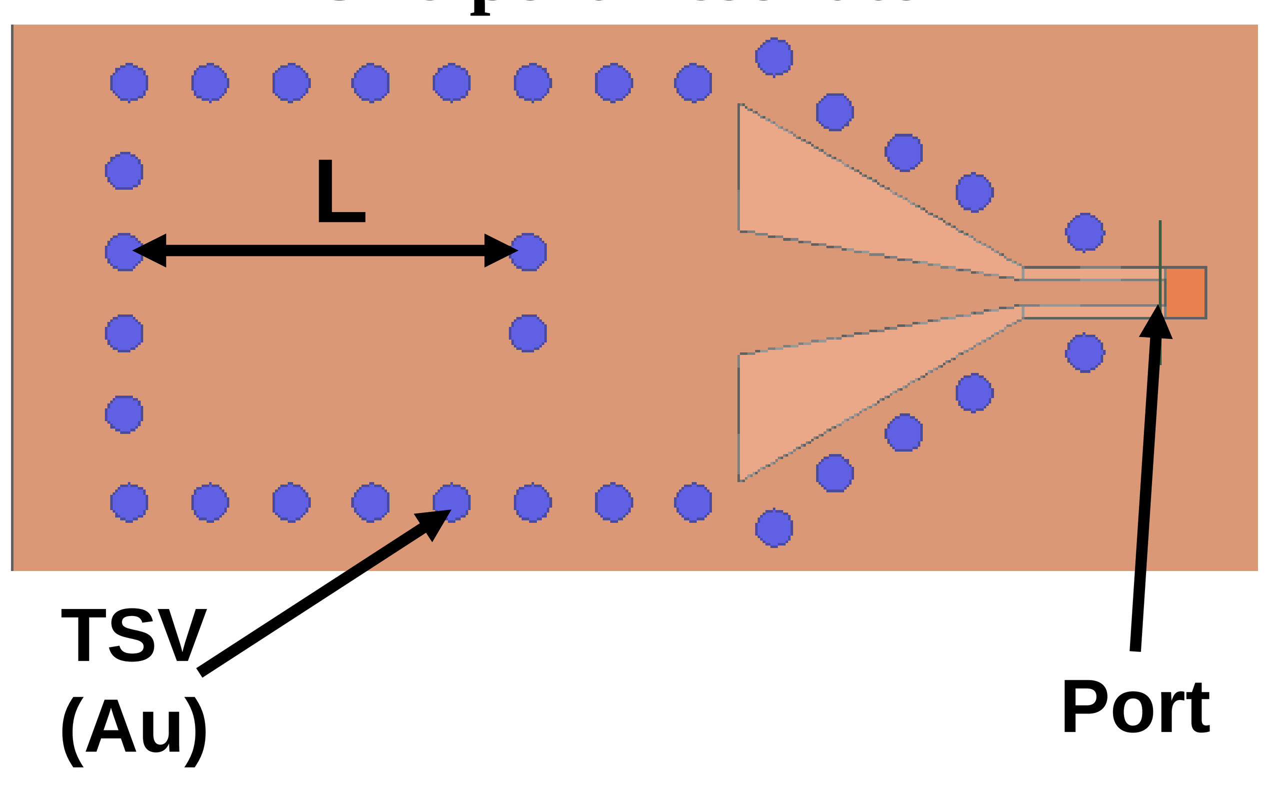
Introduction

- **Substrate Integrated Waveguides (SIWs)** allow us to integrate multiple circuit components onto the same chip [1]
- Their minimal crosstalk and high breakdown power will allow them to used in the **next generation of telecommunications (6G)**, which will run at mm-wavelengths (30-300 GHz)
- **SiC** is a promising material candidate based on its high permittivity, high breakdown voltage, and low loss tangent [1]
- There is a lack of reported data of the permittivity of SiC in this frequency range, prompting us to investigate

Methods

- We fit simulated data to experimentally obtained data of the S_{11} parameter of one-port SIW resonators, fit is based on location or resonant peaks
- Simulations are done using the HFSS software
- Resonators of lengths 400, 500, and 600 μm were simulated
- ε_r is extracted based on the fitting parameters used in simulations
- Our adjustable parameters are TSV diameter and relative permittivity

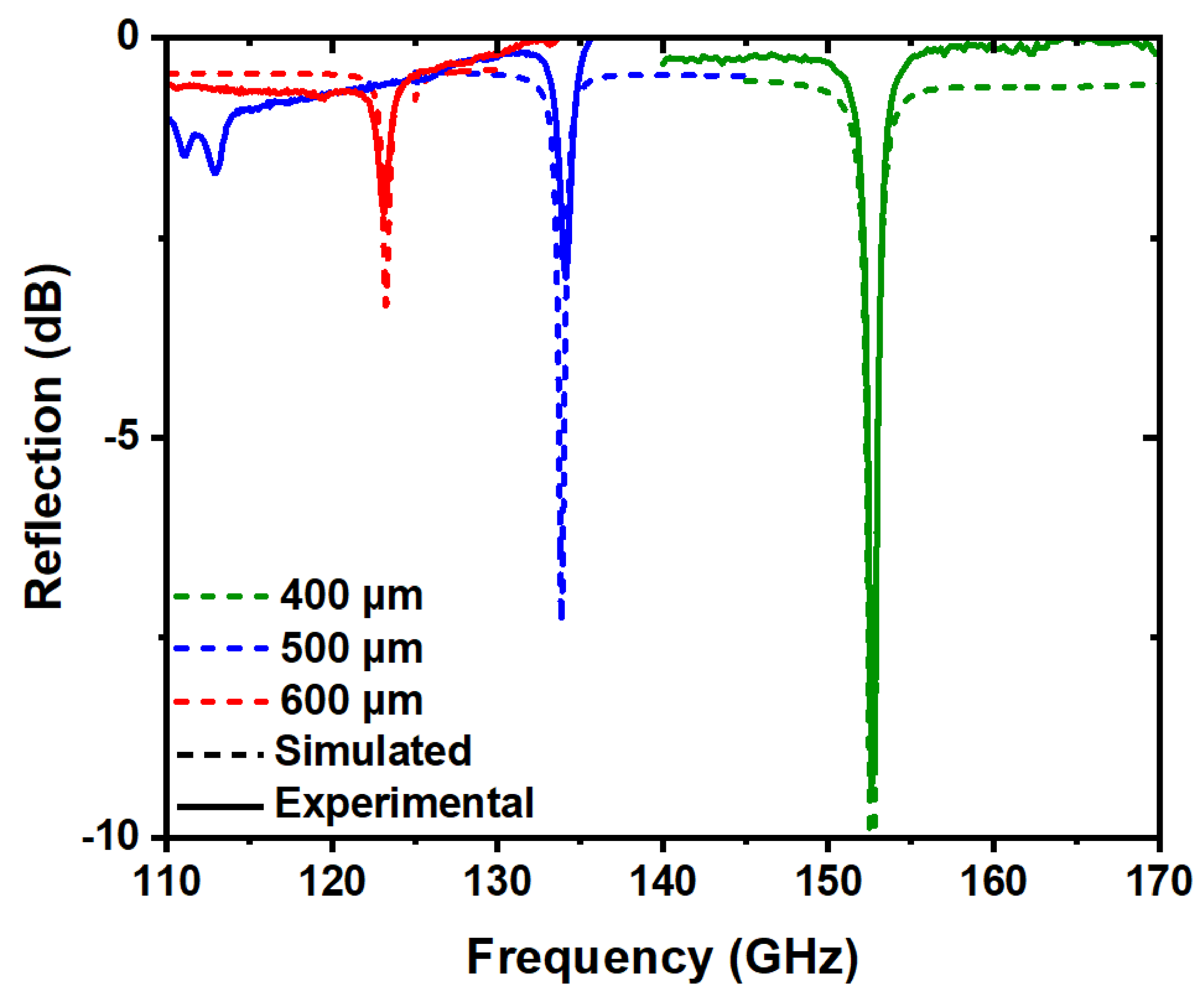
One-port Resonator

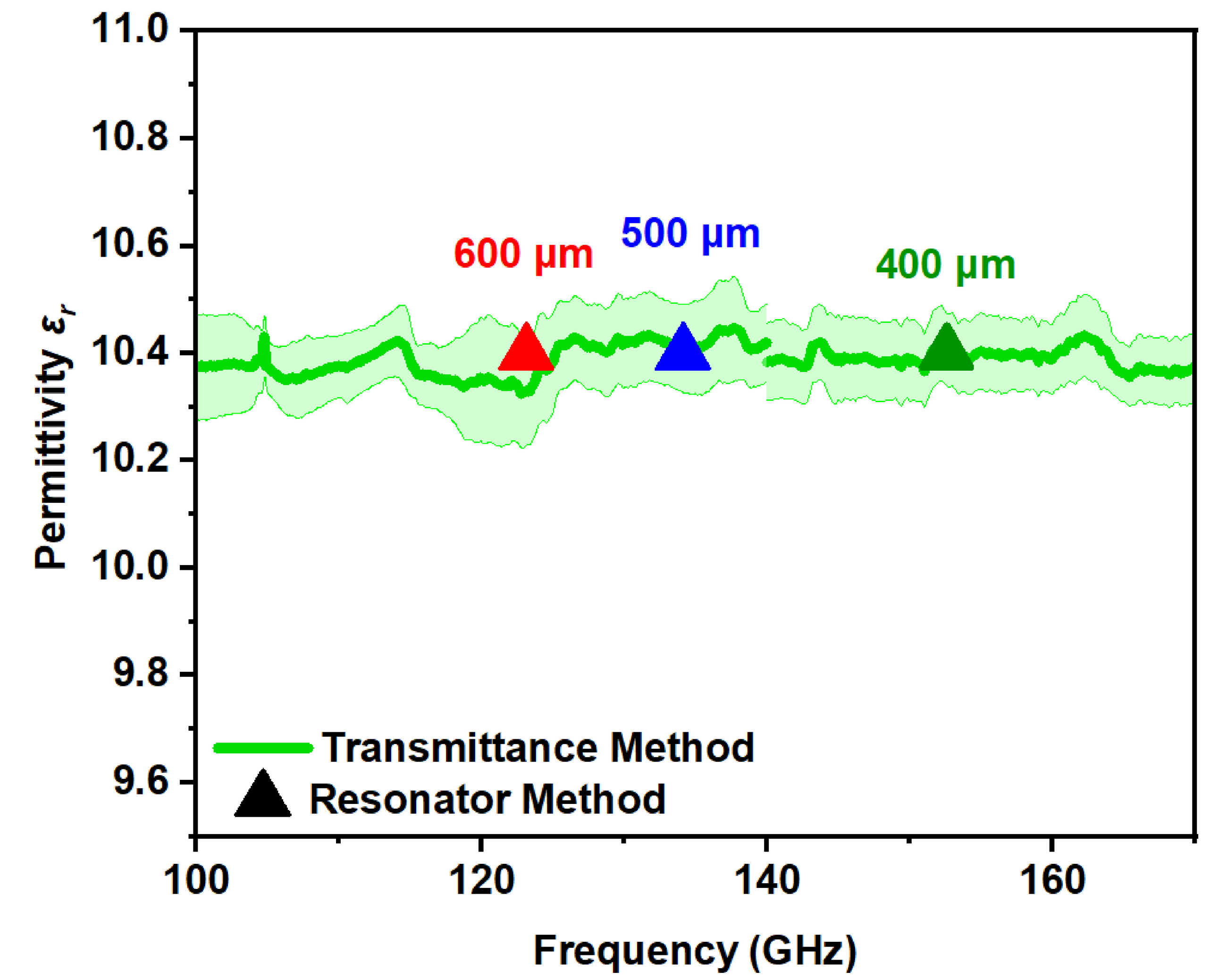


Results and Discussion

Extracting Permittivity

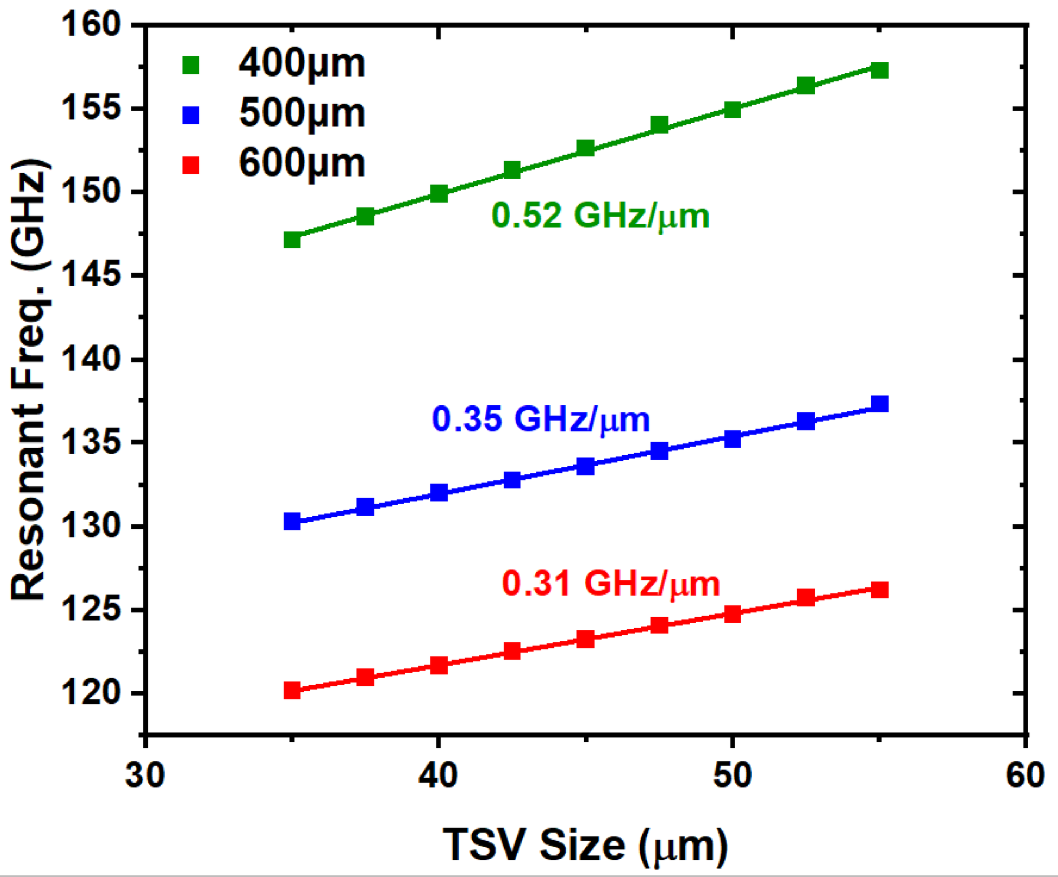
- Based on previous SEM imaging, we find the TSV size on our sample to be 45 μm
- Permittivity was then adjusted to find best match of resonant peak location
- Final fit gave <1% difference between experimental and simulated peak location
- We found a **permittivity of 10.4**
- Agrees with results obtained from previous transmission method measurements

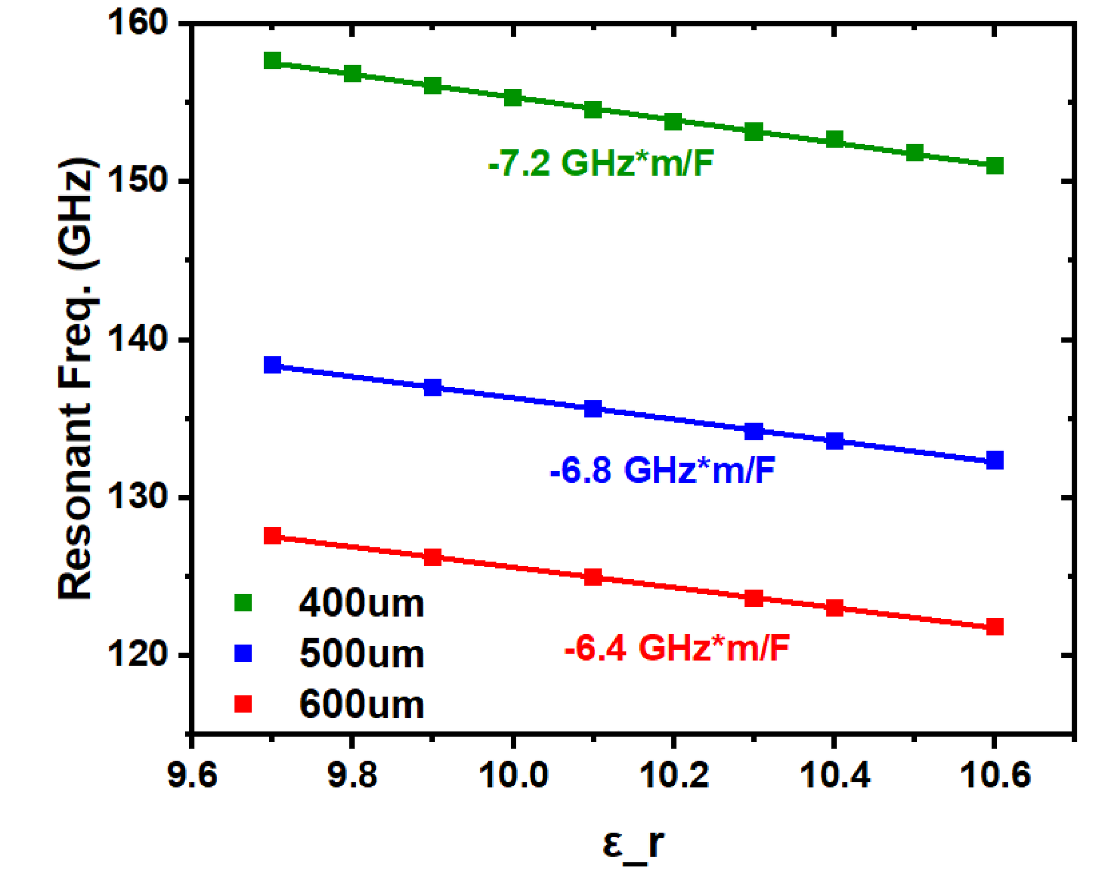




Sensitivity Analysis

- Performed sensitivity analysis of change in resonant peak location w.r.t. permittivity and TSV size
- Found that sensitivity for the parameter's trends with resonator size, **larger resonators are less sensitive**, and **smaller resonators are more sensitive**





Conclusions & Future Work

Conclusions

- Based on the resonator method, **SiC's permittivity is 10.4** at 123, 134, and 154 GHz
- This has good agreement with results from transmittance method
- The 600 μm resonator is the least sensitive, and the 400 μm resonator is the most sensitive to changes in permittivity and TSV diameter

Future work

- Quantitatively find the Q-factor of simulations and experimental data, and fit the simulations to experimental data to find the imaginary part of permittivity
- Eventually apply similar methods to Si SIWs to get data of permittivity of Si in mm-wavelength frequencies

Acknowledgements

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References

[1] M. J. Asadi et al., "SiC Substrate-Integrated Waveguides for High-Power Monolithic Integrated Circuits Above 110 GHz," 2021 IEEE MTT-S International Microwave Symposium (IMS), 2021, pp. 669-672, doi: 10.1109/IMS19712.2021.9574845.