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**Barium-Strontium-Titanate (BST) Varactor-tuned Spiral Band-stop Filter for Microwave Applications**

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**I. Objective**  
To design a varactor-tuned Bandstop Filter in X band using spiral structured inductors. The considered spiral-structured tunable inductors of different spiral lengths \(l\), gap widths \(g\), and number of turns \(n\) for integration into BSFs are designed and fabricated.

**II. Device Structure**  
Sapphire is used as the substrate. Bottom metal layer is patterned as spiral inductors. Barium Strontium Titanate (BST) is deposited using Pulse Laser Deposition (PLD) and used as the tunable dielectric material for varactor application. Top metal is patterned as GSG Coplanar Waveguide (CPW) transmission line.

**III. Tuning of Resonance Frequency**  
The resonance frequency is determined by the effective capacitance of the varactor and shunt inductance of the spiral inductor. The effective varactor capacitance is determined by the overlap area of the narrow region of the center signal line in top metal layer and the spiral shorting line in bottom metallic layer, while the inductance is determined by the geometry of the spiral shunt line (Fig. 1).

**IV. Performance**  
![Effective capacitance of the Varactor Area](image)

\[
C(V) = \frac{\varepsilon_0 \varepsilon_r A}{d}
\]

- \(C(V)\): DC dependent effective capacitance of the varactor.  
- \(A\): Overlapping area between two metal layers.  
- \(d\): Thickness of the ferroelectric dielectric material (BST).

**V. Simulation Results**  
![Simulation Results](image)

1. The fabricated BSF can reach 20.52 dB rejection at 0V dc bias with a Q-factors of 140.  
2. The fundamental frequency can be tuned from 10.83GHz to 12.96GHz as the dc bias increases to 4V.  
3. The varactor capacitance at 0V is 0.922pF and 0.562pF therefore the capacitance tunability is about 2:1.

**VI. Equivalent Schematic Model**  
![Equivalent Schematic Model](image)

- \(C(V)\): Equivalent shunt capacitance of the varactor which can be tuned by application of a DC voltage.  
- \(R(V)\): Equivalent shunt resistance of the varactor.  
- \(R_s\): Parasitic series resistance of the shunt conductor in the bottom metal layer.  
- \(L_s\): Parasitic series inductance of the shunt conductor in the bottom metal layer.  
- \(L_i\): Equivalent spiral line inductance.  
- \(R_i\): Equivalent spiral line resistance.  
- \(C_i\): Equivalent spiral line capacitance.

**VII. Conclusion**  
1. The fabricated BSF can reach 20.52dB rejection at 0V dc bias with a Q-factor of 140.  
2. The fundamental frequency can be tuned from 10.83GHz to 12.96GHz as the dc bias increases to 4V.  
3. The varactor capacitance at 0V is 0.922pF and 0.562pF therefore the capacitance tunability is about 2:1.