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Introduction

Band-pass filter is the basic component in microwave/RF integrated circuit. It plays the extremely important role in communication systems such as wireless, radar and GPS navigation systems. This project develops a passive narrowband band-pass filter which works at X-band spectrum (8GHz-12GHz). The filter is fabricated on a 400 Åm thickness sapphire substrate with a 0.25Åm thickness BST thin film deposited using a large area pulsed laser deposition system. Compared with traditional microstrip filters, it has miniaturized dimensions and good frequency tunability. The filter is a grounded coplanar waveguide structure which has 2.4mm by 2.4mm dimension with center frequency at 10GHz, the bandwidth is 0.4GHz, the insertion loss is 1.7dB and the quality factor is 25.

Filter feature.

- Coplanar waveguide structure (CPW). Most of microwave filters in RFIC circuits are developed by microstrip structure. It means this structure has two conductor layers with dielectric material filled between them. CPW moves the ground metal from bottom layer to the first layer. For that reason, all conductors are on one layer of the substrate. This technique simplifies the fabrication process and reduces the cost significantly.
- Much smaller size than regular microstrip band-pass filter. At the same center frequency, the dimension of CPW hairpin resonator band-pass filter can be miniaturized to 5 times smaller than regular one. Such features are attractive for integrated microwave systems.
- BST material has strong tunability properties. The center frequency of this filter can be shifted under external electrical field. This significant property can make this filter works as multi-frequency filter to avoid multiple band-pass filters in one system.

Filter Design

- Build lumped element circuit
  Filter design is based on the analytic equation of chebyshev’s band-pass filter. According to the mathematical results, schematic circuit is built up by AWR software.
- Convert lumped element circuit to EM microstrip structure
  Transmission line theorem converts lumped element components to microstrip structure.
- Convert the microstrip structure to Coplanar Waveguide structure
  Move the ground conductor plane of microstrip up to the top plane (same layout as resonator).
- Extend the single layer CPW structure to double layer.
  Double layer structure creates huge shunt capacitance between top and bottom metal layers. External electric field can tune the capacitance that causes the shift of center frequency.

Further Steps

Device fabrication
- Device will be fabricated by MEMS technology
- 400 um thickness sapphire substrate is selected
- 0.25um thickness Barium Strontium Titanate (BST) thin film will be deposited on the sapphire substrate by Pulsed Laser Deposition system
- Metal fabrication uses the Electron-beam evaporation technic.

Device measurement
- Fabricated devices are on a 4 inches diameter wafer
- Device will be measurement on the probe station under microscope
- Test equipment is HP vector network analyzer
- DC bias probe will be used to add external electrical field
- 150um gap GSG probe will be used to measure the Scattering Parameters

Documentary
Detail explanation in thesis. Probably be published in journal or conference in the future.

Normal RF/microwave filters (a) Cavity filter with SMA connection (b) microstrip filter on substrate.

Microstrip band-pass filter prototype (a) top view (b) 3D view

Lumped element design (a) chebyshev’s band-pass filter (b) simulation result

E-field intensity at 10.2 GHz

Single layer CPW structure (a) top view (b) 3D view

Simulation output S21 parameter

Test equipment is HP vector network analyzer