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Sheng Wang, MingSen Guo, Wei Liu, Zheng You Liu, and Xing-Zhong Zhao

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Properties of microstrip filter with elliptic-fractal pattern

Sheng Wang and MingSen Guo
Department of Physics, Wuhan University, Wuhan 430072, China; Key Laboratory of Acoustic and Photonic Materials and Devices of Ministry of Education, Wuhan University, Wuhan 430072, China; Department of Applied Physics, The Hong Kong Polytechnic University, Hunghom, Kowloon, Hong Kong, China; and Materials Research Centre, The Hong Kong Polytechnic University, Hunghom, Kowloon, Hong Kong, China

Wei Liu, Zheng You Liu, and Xing-Zhong Zhao[a)]
Department of Physics, Wuhan University, Wuhan 430072, China and Key Laboratory of Acoustic and Photonic Materials and Devices of Ministry of Education, Wuhan University, Wuhan 430072, China

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We described the properties of microstrip band gap filter with elliptic-fractal pattern from 40 Hz to 20 GHz. It used the characteristic of the fractal and elliptic pattern to improve the performance of microstrip band gap filter. The center frequencies of gaps of the filter were about 5.5 and 15 GHz, and the band stop bandwidth of the filter can be increased by increasing the numbers of the cell of elliptic-fractal pattern. To verify the characteristic of dual-mode band gap filter, we simulated the above microstrip filter with the finite differential time-domain method. The simulation results were in good agreement with the experimental results. © *2007 American Institute of Physics.* [DOI: 10.1063/1.2757135]

Due to the fact that several different modes in an elliptic disk resonator were harmonically related for appropriate choice of eccentricity,[1–3] the elliptic disk microstrip resonator is promising for various practical applications in microwave communication. In signal processing, the band gap filter is such device that passes most unaltered frequencies, but attenuated those in a specific range to very low levels. Recently, required by the modern communication, dual-mode frequency operating mode and even multiple frequency operating modes are becoming more popular.[4] An H-shape fractal pattern was developed to exhibit the property of multiple gaps and passbands from 40 Hz to 20 GHz.[5–8] It had been studied that the microstrip filter with "H-shaped" fractal pattern can selectively reflect the EM wave and control the center frequency of band gap by varying the length of the fractal structure. In this article, we studied, through experiments and finite difference time-domain (FDTD) simulations, that a microstrip filter with elliptic-fractal pattern can reflect the certain frequency EM wave and increase the bandwidth of gaps along with the increase of the number of cells of elliptic-fractal pattern. Therefore, a microstrip filter with elliptic-fractal pattern can function as dual gap filter and be utilized in the microwave communication.

The schematic diagram and cross section of the microstrip band gap filter with elliptic-fractal pattern were shown in Fig. 1. The microstrip band gap filter was implemented with the elliptic-fractal pattern patches. The major axis and the minor axis of the main elliptic pattern were 3 and 0.5 mm, respectively. According to the fractal theory, the major axis of the adjunctive was half of the main elliptic patch; the midpoint of the major axis of the adjunctive was connected to the ends of the major axis of the main elliptic patch; the major axis and the minor axis of the second level elliptic pattern were 1.5 and 0.5 mm, respectively. The cell of elliptic-fractal patches consists of the two elliptic-fractal patches. The distance between the two cells is 6 mm. The cell of elliptic fractal patches was also mirrored with the microstrip line.

The microstrip structures were fabricated on an FR-4 substrate by printed circuit board method. (Fig. 2) The thickness and dielectric constant of the substrate were 1.4 mm and 4.5, respectively. The thicknesses of ground and microstrip line were both 0.1 mm. The width of the microstrip line was about 2.5 mm, and the impedance of the microstrip line was 50 Ω. Two 50 Ω SMA connectors were connected directly to the antipodal positions of the microstrip to excite the microstrip filter and to detect the output. Transmission and reflection characteristics of the microstrip filter were measured by an Anritsu 37269C vector network analyzer. The response characteristics were simulated by the FDTD method. In the simulation, the background material of the microstrip filter was air; the boundary conditions of the microstrip band gap filter were free space except the ground plane, which was assumed that the electrical field was zero. The excited signal was the normal Gaussian signal and the frequency range was from 0 to 20 GHz.

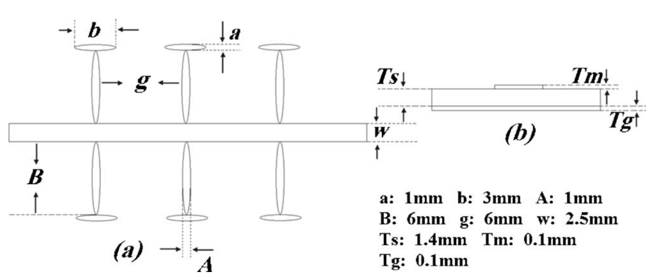

FIG. 1. (a) The schematic diagram of microstrip filter with elliptic-fractal pattern. (b) The cross section of microstrip filter with elliptic-fractal pattern.

[a)]Author to whom correspondence should be addressed; electronic mail: xzzhao@whu.edu.cn

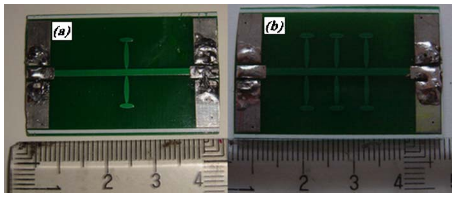

FIG. 2. (Color online) (a) The photograph of the microstrip with one elliptic-fractal pattern. (b) The photograph of the microstrip with one elliptic-fractal pattern.

Figure 3(b) showed the measurement results of the microstrip filter with one elliptic-fractal pattern. It is shown that the center frequencies of gaps were about 5 and 15 GHz, and the minimum −3 dB bandwidth of gaps was about 2 GHz at 5.5 GHz. Comparing, Fig. 3(a) to Fig. 3(b), it showed that the measurement data agreed well with the simulation data. There was an interesting phenomenon that the bandwidth of gaps increased with the increase of number of the cell of elliptic-fractal pattern. Figure 4 showed the transmission characteristics of the microstrip filter with different numbers of the cells. It is shown that the bandwidth of the gaps increased with the number of the cells increased. To verify the simulation results, the microstrip filters with different numbers of the cells were fabricated to measure. In Fig. 5, the S21 and S11 characteristics of the microstrip filter with one cell of elliptic-fractal pattern showed that there were two gaps from 40 Hz to 20 GHz, and the center frequencies of gaps were 5 and 15 GHz, respectively. Simulations were in good agreement with the measurement, and it showed that

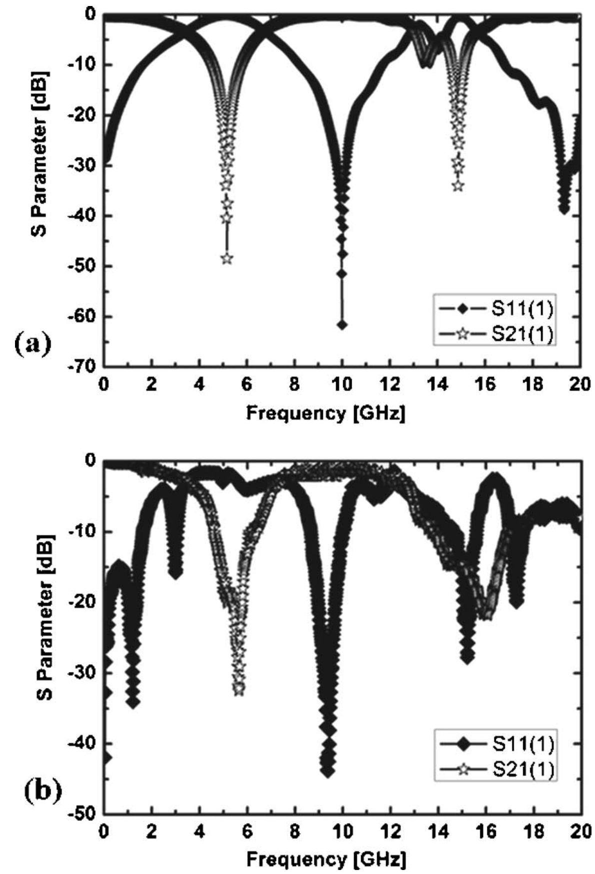

FIG. 3. (a) The simulation of microstrip filter with three elliptic-fractal patterns. (b) The measurement of microstrip filter with one elliptic-fractal pattern.

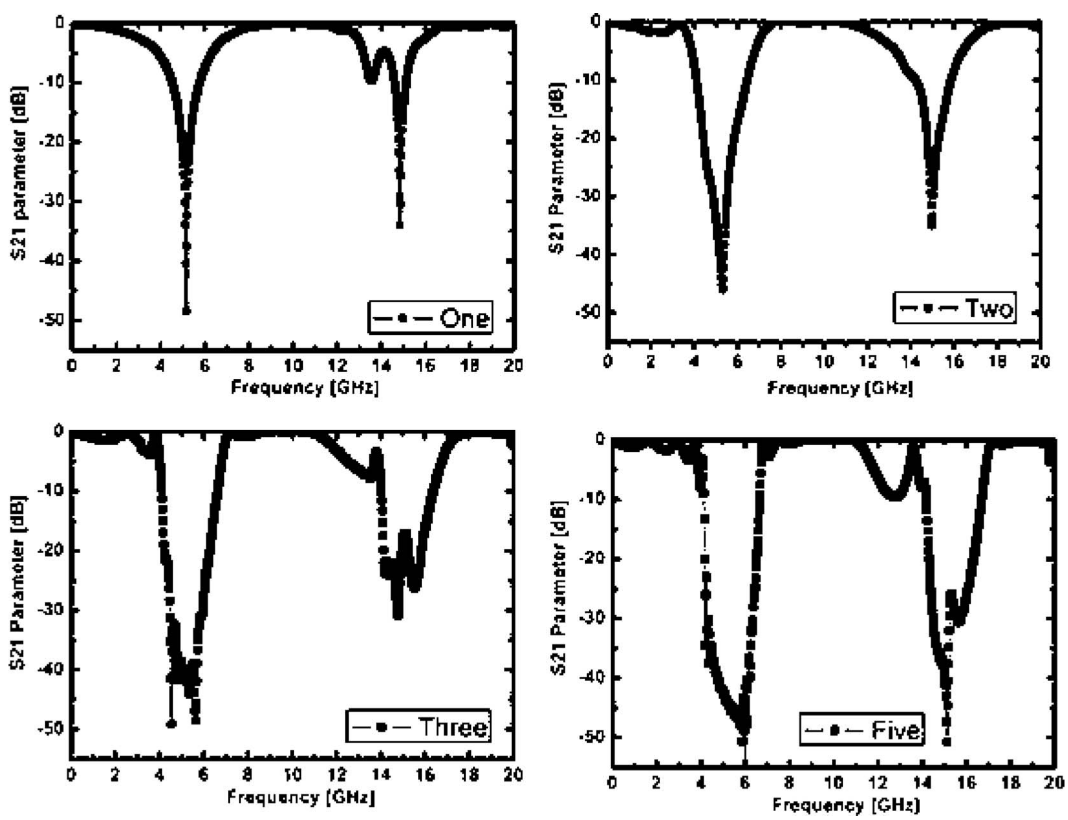

FIG. 4. The simulation of microstrip filter with different numbers of cells of elliptic-fractal pattern.

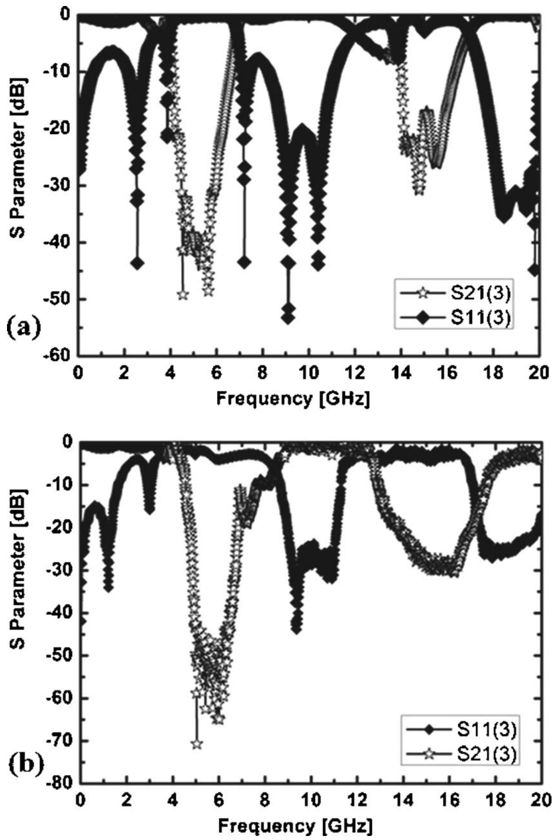

FIG. 5. (a) The simulation of microstrip filter with three elliptic-fractal patterns. (b) The measurement of microstrip filter with three elliptic-fractal patterns.

the microstrip filter had dual band stop. The center frequency of the gaps did not change with the number of the cells increased, but the minimum bandwidth of the gaps arrived at 4 GHz at 5.5 GHz.

In conclusion, through the results of experiment and simulation, the influence of fractal elliptic pattern on the transmission characteristics of microstrip filter by changing the number of the units was studied, and it was observed that the fractal elliptic pattern units can effectively increase the bandwidth of the band stop. Therefore, a microstrip filter with elliptic pattern can function as multiple gap filter and be utilized in the microwave communication.

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