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High frequency tunable LC devices with ferroelectric /ferromagnetic thin film heterostructure

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Recently, there has been some progress in developing tunable microwave filters and phase shifters utilizing layered ferroelectric-ferromagnetic structure [1]-[2]. In this heterostructure, if C and L of a microwave device can be simultaneously changed, the resonance frequency $f_r(=1/2\pi\sqrt{LC})$ and phase velocity $v_p(=1/\sqrt{LC})$ determined by the LC product are very large while maintaining the transmission line characteristic impedance Z_0, resulting in the reduced insertion loss generated between the device and transmission line.

In this work, heterostructure tunable LC devices utilizing ferroelectric BST($(Ba,Sr)TiO_3$) and ferromagnetic LSMO($(La,Sr)MnO_3$) thin films were developed. The tunable LC devices were composed of either MIM-type or interdigital-type ferroelectric C and spiral-type ferromagnetic L. LSMO films were prepared by chemical solution deposition (CSD). La acetate hydrate, Sr acetate, Mn acetate tetrahydrate were dissolved and refluxed in acetic acid. The mixed solution was dropped on SiO_2/Si substrate, spun-off at 3000rpm for 30 seconds and dried at 350℃ for 5 minutes on a hot plate. The dried films were crystallized by annealing at 800℃ for 1 h in RTA furnace. BST thin films were also fabricated by CSD. The BST solution was supplied by High Purity Chemicals(BST-06-P). The BST thin films were annealed at 700~800℃ for 1 h for crystallization. Ferromagnetic properties of LSMO thin films and dielectric properties of BST thin films were measured using VSM and Impedance Analyser, respectively.

A heterostructure tunable device which was composed of MIM-type ferroelectric C and spiral-type ferromagnetic L was designed and the electrical characteristics were simulated using a Maxwell three-dimension field simulator. The new tunable device with the heterostructure were fabricated as the following order: ferromagnetic LSMO thin films were deposited on SiO_2/Si substrate and platinum was deposited as a diffusion barrier and ferroelectric BST thin films were deposited and spiral-type metal(Pt/Ti) was patterned using lift-off process. The heterostructure tunable device showed large C-V tunability, 58% and also L-V tunability, 11.5% in voltage ranges of -10V to +10V.

References

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