Slow Wave Structure integrated with Ferro-electric and Ferro-magnetic thin film for Compact and Multiband Passive Components

Modern Communications system is following a common trend to increase the operational frequency and degree of integration. It also requires the devices to work at multiband frequencies. But high performance RF passive components which take 70% of the total board area are a big challenge towards this technological advancement. Slow wave elements are promising structures to design compact RF and mm-Wave passive components. This thesis reports ferromagnetic and ferroelectric thin film enabled compact slow wave structures workable at multiple frequencies.

Initially, a comparative study on different types of coplanar wave-guide (CPW) slow wave structures (SWS) has been demonstrated at 60GHz. Slow wave structures with various shapes have been investigated. SWSs have been further optimized by changing signal conductor shape, ground conductor shape and pitch of the sections. Novel techniques i.e. the use of the defected ground structure and the different signal conductor length has been implemented to achieve higher slow wave effect with comparable loss. Our results show that over 43.47% and 37.54% reduction in length is reported in the expense of only 0.27dB and 0.102dB insertion loss respectively, which can end up with 68% and 61% area reduction for the design of a branch line coupler.

Then, Permalloy (Py), a ferro-magnetic thin film is patterned in sub-micrometer range on top of the SWS for the first time to increase the slow wave effect as well as to tune the inductance value. The use of ferromagnetic thin film is restricted at very low frequency by ferro-magnetic resonance as the inductance falls below zero beyond that. The patterning of Py has allowed our operation until 6.3GHz and 3.2GHz by introducing shape anisotropy. In addition to the reduction in size, the center frequency is tuned in a frequency range 10% with the application of DC current which applies the magnetic field along the hard axis of magnetization.

Lead Zirconium Titanate (PZT), a ferro-electric material is grown by standard sol gel method on top of the section which is responsible for capacitance value. The inter digit capacitor type structure along with PZT thin film showed capacitance value increment by 36%. An electric field in between signal and ground changed the capacitance which in turn shifted the center frequency by 15%. Finally, a novel approach is implemented by integrating the ferromagnetic and the ferroelectric thin films simultaneously to achieve higher slow wave effect and wider tuning range with a small variation in impedance. The size of the final structure has been reduced from 14.86mm to 3.98mm while the center frequency was tuned by 25% at 2GHz.

At last the thin films have been applied at various RF passive components. The nano patterned Permalloy thin film is utilized to suppress the electromagnetic noise of the system. The suppression frequency was tuned by external current. A comprehensive study has been performed on tunable meander line inductor for high inductance density at 4-5GHz frequency. The ferromagnetic and the ferroelectric thin film has also been applied to tune the center frequency of a band pass filter.