Planar Slotline Isolator Based on Semiconductor Magnetoplasma

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Most nonreciprocal microwave devices use ferrite materials which are biased with a DC magnetic field. The maximum saturation magnetization of conventional ferrites has set an upper bound on the use of these materials at the millimeter and sub-millimeter wavelengths. The availability of spectrum in the 60 - 70 GHz range as well as the infrared region has increased the demand for improved performance of devices and systems. Fortunately, advancements in semiconductor material technology provide alternative materials for nonreciprocal devices. High mobility semiconductors that can be used as anisotropic solid-state plasmas when exposed to a DC magnetic bias are now available. In fact, magnetoplasmas have been reported in the design of nonreciprocal microwave devices, e.g. isolators and circulators, at room and liquid nitrogen temperatures.

For practical applications, it is convenient not to have to cool the device. One solution is to use thin film magnetoplasma slabs (μm). Thin films still allow us to excite the appropriate non-reciprocal EM modes while the losses are minimized. In our proposed work, we are utilizing the field displacement effect that is accompanied with the transversely magnetized thin films to design planar slotline isolator. To the best of our knowledge, this is done for the first time with thin film magnetoplasma for planar structures. The structure contains two n-type InSb high-mobility semiconductor layers, substrate and superstrate, sandwiching the slot structure to attain maximum field displacement. The power is observed to be strongly concentrating toward one of the slot edges, where some loss (resistance card) can be added in order to provide the nonreciprocal power attenuation. Other planar structures, e.g. microstrips, were also attempted but with no satisfactory performance in terms of field displacement. Based on a general Finite Element (FEM) code, 2-D eigenvalue modal analyses as well as 3-D realization model are provided to illustrate the phenomena and study the performance. The behavior of the proposed device has been investigated over many frequency values at room temperature. The proposed isolator shows good performance in terms of the forward-to-backward power attenuation ratio. Note that this structure will later be used to design a three-port circulator.