REFLECTION BEAM ISOLATOR
FOR SUBMILLIMETER WAVELENGTHS

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Abstract

Magnetoplasma reflection beam isolators for submillimeter wave use are discussed. The basic configuration used is that of the Kerr transverse magneto-optical effect. Theoretical and experimental data at 337 μm using InSb as a plasma medium are given.

Introduction

The purpose of this paper is to discuss magnetoplasma reflection beam isolators for use at submillimeter wavelengths. The basic geometry chosen has the plane of polarization of em waves in the plane of incidence, and the direction of propagation is perpendicular to a dc magnetic field which is parallel to the surface of the magnetoplasma (Kerr transverse magneto-optical effect, as shown in Fig. 1).

General Discussion

Various studies of this basic geometry have been made. Barber and Crombie[1] have calculated the reflection coefficient from a sharply bounded ionosphere and found that the reflection coefficient for em waves propagating from west to east was numerically greater compared to east-west propagation. A physical explanation of the non-reciprocity, expanding the ideas of Davies,[2] is based on changes in the elliptical electron orbits in the plane of incidence. Non-reciprocal reflection of em waves incident on a solid state magnetoplasma at 94 GHz was studied by Seaman,[3] but no choice of parameters was found which gave a very large ratio of forward to reverse reflection coefficient along with low forward loss, as required for an efficient isolator.

One significant difference between the ionospheric case and a solid state magnetoplasma is the presence in the latter of the large lattice permittivity (K_L = 12 to 18 for many semiconductors). Two different structures using the same basic relations of incident electric field, surface plane and magnetic field were considered to improve efficiency: 1) free space replaced by a medium of high dielectric constant, and 2) the surface plane covered with a relatively thin dielectric. This latter geometry seemed promising in performance and is the one analyzed here in some detail. Theoretical results for the various structures will be presented as well as some experimental results at 337 μm.

Calculation of Reflection Coefficient

The reflection coefficient R is derived for the interface between free space and a dielectric coated magnetoplasma as shown in Fig. 1 using a transmission line impedance method. If the plasma is lossless, there will be a change of phase but no change in the magnitude of R upon reversal of direction of propagation. However, with loss in the magnetoplasma, the reflection coefficient R is found to be non-reciprocal.

Experimental Results

Experiments were performed at 337 μm using n-type InSb as the plasma. The dielectric layer was a high density polyethylene film. The block diagram of the experimental apparatus for the measurement of the far-infrared non-reciprocal reflection is shown in Fig. 2.

The theoretical and experimental reflection loss from the interface between free space and dielectric coated InSb at 284°K are shown in Fig. 3 for the dc magnetic field of 15 kG as a function of incident angle, and in Fig. 4 at a fixed angle of 65° as a function of dc magnetic field. The general shapes of the curves for the theoretical and experimental results agree fairly well except at large incident angles. Errors are accounted for by the experimental system used.

Conclusion

The theoretical and experimental investigations in this paper were performed to develop a reflection beam isolator for submillimeter wavelengths using non-reciprocal reflection of em waves incident on a semiconductor. At wavelength of 337 μm the experiments demonstrated 4.1 db isolation with 2 db insertion loss, whereas the theory predicts 16 db isolation with an insertion loss of less than 1 db. Narrowed beam angle should improve experimental performance.

References

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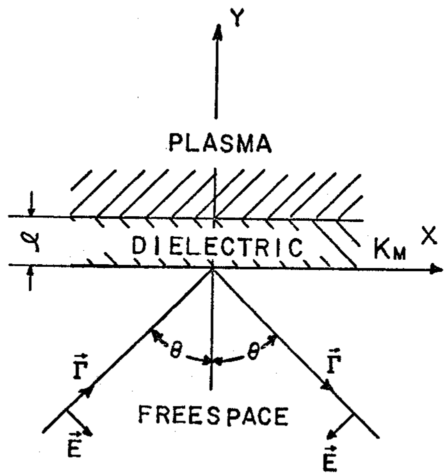

FIG. 1 Orientations of Field Vector $\vec{E}$, Propagation Vector $\vec{\Gamma}$ and dc Magnetic Field $\vec{B}$

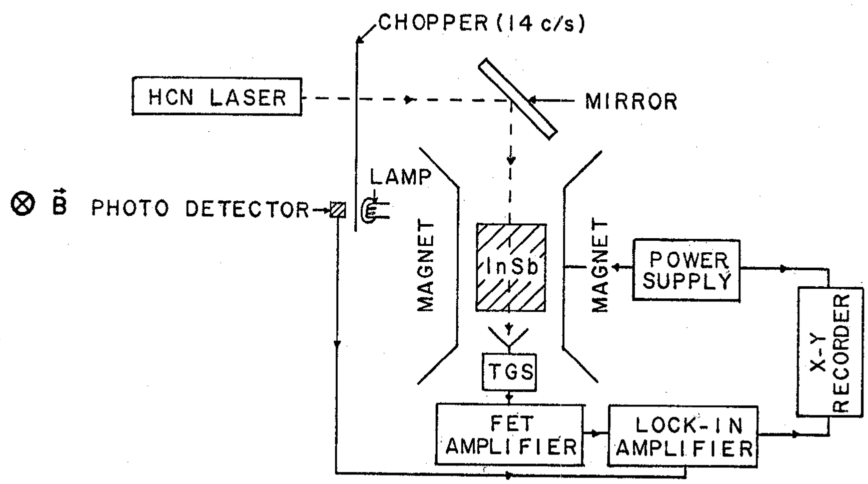

FIG. 2 Block Diagram for IR Experimental Set-up

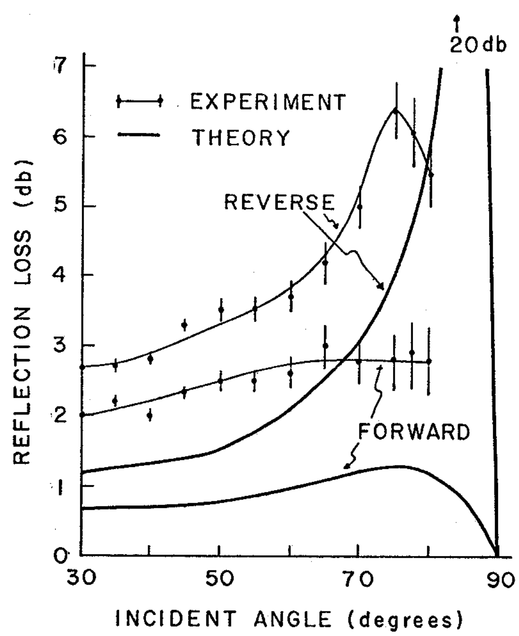

FIG. 3 Theoretical and Experimental Reflection Loss of InSb at 337 μm as a Function of Incident Angle

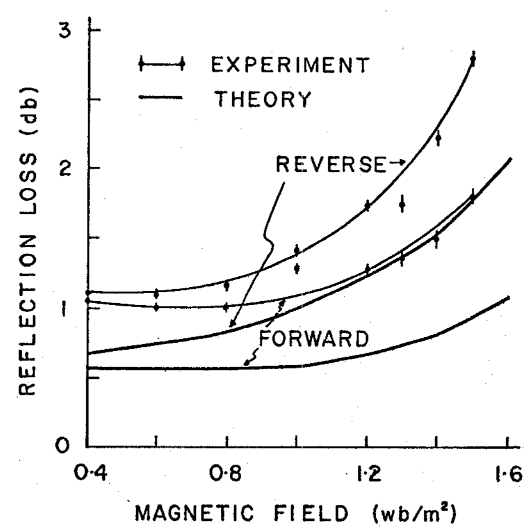

FIG. 4 Theoretical and Experimental Reflection Loss for InSb at 337 μm as a Function of Magnetic Field