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Improvement of Surface Plasmon Polariton Propagation Length in Magneto-optic Waveguide by Optical Gain Medium

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ABSTRACT— In this paper, we have analyzed four layer surface plasmon polariton (SPP) slab waveguides with optical gain medium and the magneto-optic (MO) layer in a transversal configuration that the applied magnetic field is parallel to the interfaces and normal to the wave propagation direction. Metal-Insulator-insulator-Metal (MIIM) configuration with dielectric ferromagnetic layer and optical gain dielectric is analyzed. We have shown that the SPP waves in this anisotropic waveguide exhibit nonreciprocity with respect to their direction of propagation. Because of the utilizing of optical gain medium, the loss of waveguide is compensated and the propagation length of SPP modes increases. Because of the long propagation length and nonreciprocity, this configuration with high confinement could be used to design elements, such as isolators and modulators in photonic integrated circuits (PICs).

KEYWORDS: Magneto-optic effects, Anisotropic plasmonic slab waveguides, Surface plasmon polaritons, Optical gain medium, Metal–insulator–metal waveguides.

I. INTRODUCTION

The surface plasmon waves propagate at the interface of a metal and dielectric and decay exponentially at both sides of the interface. Therefore, thin films of noble metals and dielectrics can be used as waveguides for the SPP propagation [1]. The diffraction limit of the light has been overcome by utilizing surface plasmon polaritons (SPPs). The possibility of the reduction of the dimensions of the conventional optical components to nanooptic scales has been provided by the plasmonic structures. Nanoscale modification of the layers and application of magneto-optic (MO) effects can lead to desirable components to control the propagation properties of the SPP, the same as those of the conventional optical devices, such as switches, modulators, isolators, and circulators [2]-[3]. Insulator-metal-insulator (IMI) waveguide with different orientations of the magnetization and more concentration on transversal configuration has been analyzed by Sepúlveda *et al.* [3], and the application of the MO effects of surface