Effect of anisotropy on nonlinear surface plasmon polaritons in anisotropic/metal/nonlinear slab waveguides

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Abstract. The nonlinear surface plasmon polariton (SPP) supported by a linear/metal-nonlinear slab waveguide was studied analytically. The dispersion conditions were obtained from fundamental Maxwell's equations to determine the propagation characteristics of the nonlinear SPPs supported by the waveguide. The mode profile of the nonlinear mode was studied to analyze the physics behind the observed propagation characteristics. After studying propagation characteristics of the mode, the linear layer was replaced with a layer containing a uniaxial material. The effect of optical anisotropy of the layer on the dispersion characteristics of the nonlinear SPPs was investigated to understand the possible tunability of the mode. It has been observed that the propagation characteristics of modes supported by the waveguide can be tuned with the help of an anisotropic medium. The guiding structure could find application in the tunable components in all-optical integrated chips. © *2016 Society of Photo-Optical Instrumentation Engineers (SPIE)* [DOI: 10.1117/1.JNP.10.036020]

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1 Introduction

The essential requirement of optoelectronics integrated circuits is the development of optical waveguides with subwavelength confinement. More and more investigations are reported over the past decade in an effort to introduce the surface plasmon-based circuits to merge photonics and electronics in nanoscale.[1–4] Surface plasmon polariton (SPP) waveguides can provide subwavelength confinement through the coupling of electromagnetic waves to electron oscillations at the metallic surfaces.[5] In recent times, many nanoscale structures such as strips, slots, coplanar strips, and wedges have been proposed to design SPP waveguides with subwavelength mode confinement and low loss.[6–8] Recently, the focus of the research has been moved to the possibility of tunable nanoscale optical waveguides.[1,5] Apart from externally tunable devices, the self tunable waveguide devices have recently been proposed to improve efficiency.[9–12]

Nonlinear optical properties have an important role in optical circuits because of various control functionalities required in all-optical integrated circuits.[13–15] But optical nonlinearities are weak as they are governed by photon–photon interactions enabled by materials and hence require high-input field intensity to observe the nonlinear effects. Recently, the advantage of obtaining significant field enhancements in plasmonic devices due to the increased density of electromagnetic states near the metal surface for the frequency range of surface plasmon excitations has been utilized to enhance the effective nonlinearity of nonlinear materials placed near the metal surface.[16] If the SPPs can be used as a signal carrier, these nonlinear effects can bring various controlling possibilities in all-optical integrated circuits as minute changes in the refractive index of the nonlinear material alter surface plasmon propagation along the interface.

In recent years, the dispersion characteristics of nonlinear SPPs in metal-dielectric slab waveguides containing a nonlinear dielectric medium have been reported providing additional

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