Compact planar terahertz waveguides with lower propagation loss based on spoof surface

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***Abstract*—Although subwavelength plasmonic devices can be implemented based on planar spoof surface plasmons (SPs), they still suffer from a little high propagation loss, especially at terahertz (THz) region. Here the dispersions and propagation characteristics of spoof SPs on the planar waveguides constructed by rectangular grooves, meander grooves, and dumb-bell grooves have been investigated at THz frequencies. The proposed waveguides can achieve lower propagation loss. More compact devices can be designed based on the proposed waveguides.**

I. INTRODUCTION

Metal surfaces drilled with periodic arrays of subwavelength grooves or holes can support a kind of surface electromagnetic (EM) mode called spoof SPs which behave like SPs [1]. These structured metal surfaces formed by periodical textures are called plasmonic metamaterial [2]. Such metamaterials address the challenge of routing EM waves on subwavelength scale in THz frequencies [3]. Various structured surfaces with different geometries have been proposed to achieve tight confinements of spoof SPs. Recently, conformal SPs (CSPs) on ultrathin corrugated metallic strips have been reported [4], paving the way of developing versatile surface plasmonic integrated devices or circuits at lower frequencies bands, especially at THz region. It has been shown that CSPs waveguides can find broad applications in plasmonic devices and high-speed circuits [5-6]. But the proposed plasmonic devices before still suffer from a little high propagation loss at low frequency; here we proposed two kinds of compact THz waveguides with lower propagation loss, we believe that more compact devices can be designed based on the proposed waveguides.

II. RESULTS

Most of the proposed CSPs waveguides are constructed by periodic array of rectangle grooves as illustrated in the picture *i* of Fig. 1 (a). In this paper, we have investigated two kinds of spoof plasmonic waveguides corrugated with meander grooves and dumb-bell grooves, as shown in the picture *ii* and *iii* of Fig. 1 (a). Their dispersions characteristics are calculated and shown in Fig. 1 (b). We can see that the dispersion curves of the waveguides based on dumb-bell/meander grooves are lower than that of the waveguide with rectangle grooves when they have same width *w*, which means both waveguides can achieve stronger confinement of CSPs. Fig. 1(c) is the current distributions of the those three kinds of plasmonic waveguide when L = 480 μm (along the red arrows). Fig. 1 (b) also show the dispersions when they have same current path L = 480 μm, from which we can see that their dispersion curves are very closed to each other which means their dispersion relations may relate to current of the waveguide. We have compared the propagation loss of the conventional plasmonic waveguide with rectangle grooves and the waveguide with meander/dumb-bell grooves whose dispersion curves are very close. The normalized propagation lengths (L/λ) of the CSPs on the three kinds of waveguides are plotted in Fig. 1 (d). It can be seen that the propagation length is nearly 16 wavelengths at the transmission band from 0.2 THz to 0.4 THz for the meander/dumb-bell grooves, while it is only 8 wavelengths or so for the conventional waveguide at the transmission band.

Compared with the waveguides with rectangle grooves, the proposed waveguides not only can achieve much lower propagation loss, but also are more compact. More compact devices in THz region can be designed, including compact broadband slow wave system, ultra-wide band filter and 4-way wavelength splitter.

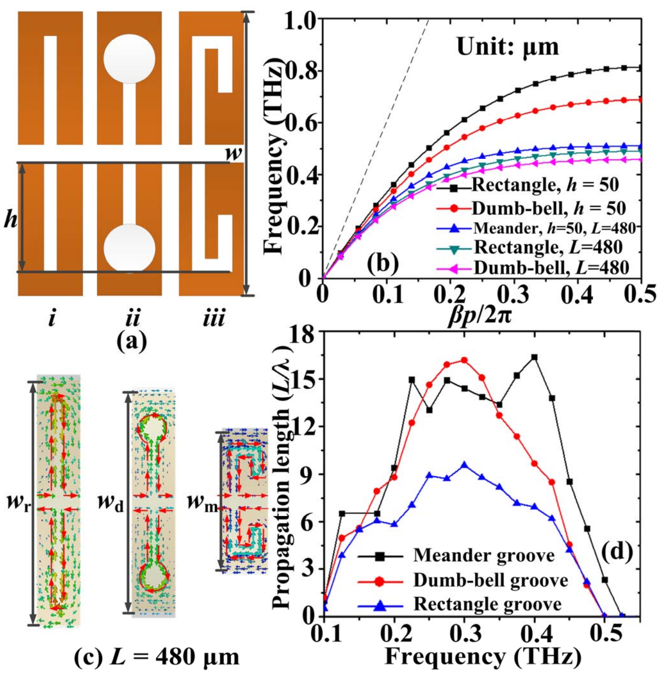

Fig.1. (a) The unit cell structure of those three kinds of waveguide, *i*: Rectangle groove; *ii*: Dumb-bell groove; *iii*: Meander groove; (b) Dispersion lines of three kinds of plasmonic waveguides with the same maximum groove height h = 50 μm and with the same current path length L = 480 μm; (c) Current distributions of those three kinds of waveguides; (d) Normalized propagation length of CSPs on the three kinds of waveguides.

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