Spoof surface plasmons dispersion and modes of a lamellar grating for Terahertz applications

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This abstract presents a complete study of dispersion and mode distribution of spoof surface plasmons (SSPs) in planar metal gratings. The subject under investigation is intended for Terahertz wave generation. Because of its characteristics of near field localization of this plasmonic wave and collective resonance effects of electrons in metals, SSPs in this textured metal surface has attracted enormous interest such as potential applications in plasmonic metamaterials (F. J. García-Vidal. et al., *J. Opt. A: Pure Appl. Opt*, **7**, 2005, S97-S101). There are many novel phenomena steam from surface plasmons, such as enhanced total reflection (G. A. Plotz. et al., *J. Opt. Soc. Am.*, **69**, 1979, pp.419-422), extraordinary optical transmission (T. W. Ebbesen. et al., *Nature*, **391**, 1998, pp. 667-669), enhanced Raman spectroscopy (P. L. Stiles. et al., *Ann. Rev. Chem.* **1**, 2008, pp. 601-626), superradiant Terahertz Smith-Purcell radiation (Y. M. Shin. et al., *Appl. Phys. Lett*. **90**, 2007, pp. 031502), etc.

The structure parameters of plasmonic gratings contain depth h, lattice period d, groove width a, the distance from cover metal to groove bottom b ,grating side width w ($a = 15\mu m$, $a/d = 0.5, b/d = 3, h/d = 2.2, w/d = 10$). The SSPs dispersion diagram obtained by analytic theory is presented in Fig. 1(a). Where black solid line, which lies within light line, is two-dimensional SSPs lowest mode and the axial electrical field distribution is given in top left corner of Fig. 1(b) with designation I . From this field contour we can clearly see that plasmonic wave is strongly limited in narrow space of grating surface. Other canonical dispersion modes with labels from II to VI are the first several three-dimensional (3-D) SSPs symmetric and anti- symmetric mode both distribute in phase space alternately. From 3-D SSPs dispersion diagram, there are two discrete modes which are separated by light line. The transverse electric field distribution in Fig. 1(b) from II to VI , two distinct modes of symmetric or anti-symmetric mode can also be observed. We deduce that one is surface-wave mode which lies within light line and the other mode which is far away from grating surface is fast-wave mode. Investigations on Terahertz SSPs dispersion and mode distribution pave the way for more practical applications based on this plasmonic grating, such as enhanced SSPs-free-electron interaction vacuum sources, noval plasmonic waveguide and circuitry, super-resolution imaging and sensing.etc. in the near future.

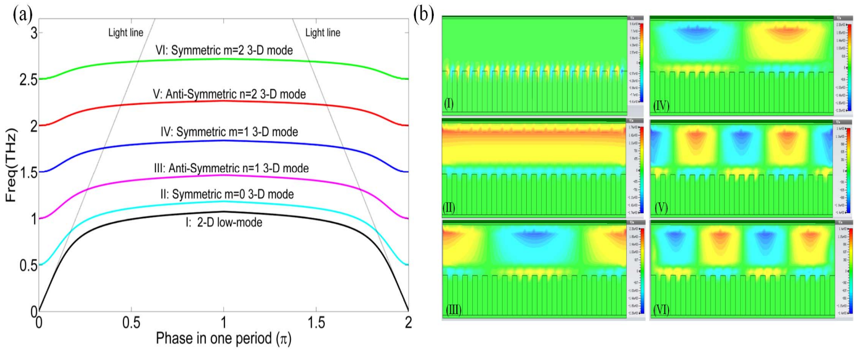

Fig.1 (a) The two-dimensional SSPs lowest dispersion mode and other five canonical three-dimensional SSPs mode of a lamellar grating. (b) corresponding axial and transverse electronic field distribution in Fig. 1(a). Parameters are set as: $a = 15\mu m, a/d = 0.5, b/d = 3, h/d = 2.2, w/d = 10$.