Review article

Holography

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**1. Introduction**

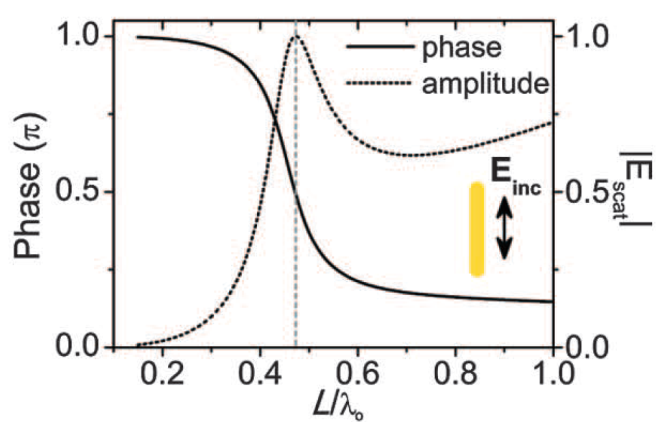
Holography is a technic to make a hologram, which is a Three-dimensional (3D) image and invented in 1948 by Denis Gabor [1]. Holography can be made by manipulating amplitude and phase. To manipulate them, we use Spatial light modulators (SLM). Recent SLM’s pixel sizes are a few micro meters. They are smaller than visible light’s wavelength, so they can’t represent all information for Three-dimensional (3D) information thus noise and viewing angle problems appear. Metamaterial[2-4], is a sub-wavelength scale material and can manipulate amplitude and phase [9-14]. This review focuses on plasmonic, dielectric and active metasurfaces for holography.

**2. manipulate phase and amplitude**

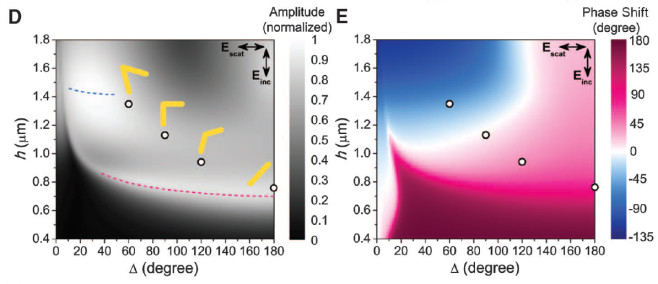
2.1 plasmonic metasurface

A surface plasmons(SPs) is a collective oscillation of electrons. It can propagate along the boundary between metal and dielectric and then it is called as a surface plasmon polaritons(SPPs). It is a highly localized electromagnetic fields, so they can manipulate photons on subwavelength scale [5-8]. Using Plasmonic antenna [9,15-18] can be made. When incident electromagnetic wave impinges antenna, it suffer phase and amplitude changes. Fig 1 is calculated by analytically solving Hallen’s integral equations for linear antenna with length L and radius a = L/50. when small antenna (L/<<1) the charges in the antenna instantaneously follows the incident filed, where is the accumulated charges at one end of the antenna. The emitted light, which is proportion to the acceleration of the charges [20] is . Clearly, incident and scattered light have phase difference. At resonance (L/, the incident field in in phase with the current at the center of the antenna and . Clearly phase difference. When antenna length is same with wavelength (L/, antenna impedance is primarily inductive, .

Clearly, both waves are in phase.[9] As you can see fig. 1, plasmonic antenna can only make phase delay. For full control of phase, we need 2 phase coverage, so use the polarization. Also, amplitude must be same, so adding freedoms to antenna is essential. Yu [9] made V shape antenna with same amplitude and /4 phase difference each antenna. Fig 2 show that freedom at length (h) and degree (△) of antenna make same amplitude but different phase.



**Fig. 1** calculated phase and amplitude of scattered field with length L and radius a = L/50. [9]



**Fig. 2** changing amplitude and phase by different degree(△) and length(h). [9]

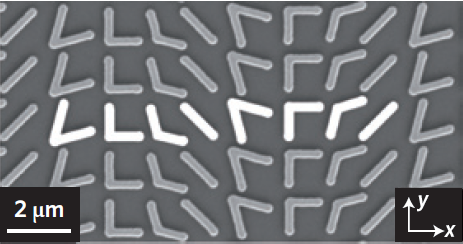
Using linearly polarized light and mirror structure, 8 metasurfaces, which are equal amplitude and incremental phase of are made. Fig. 3 shows the metasurfaces. By the fig. 4, the generalized laws of reflection and refraction can be derived and if metasurfaces are set along y axis the 3D generalized laws of reflection and refraction is [11]

Generalized law

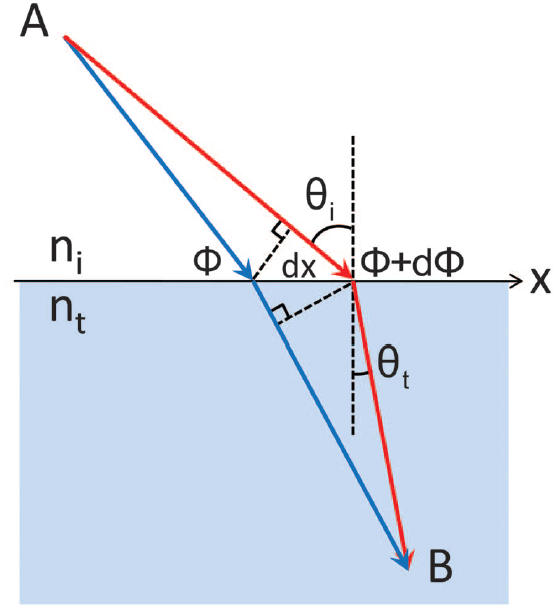
cos( of refraction

Generalized law

cos( of reflection



**Fig. 3** metasurfaces which are equal amplitude and incremental phase of [11]



**Fig. 4** metasurfaces are set between the two media with same amplitude but incremental phase along x.[9]

[9] metasurface uses metal, so it makes absorption loss. So, nowadays metasurface researches focus on dielectric metasurfaces.

2.2 Pancharatnam-Berry phase

Geometric phase, Pancharatnam-Berry phase or most commonly Berry phase is a phase difference acquired over the course of a cycle. In other words, right circular polarized (RCP) and left circular polarized(LCP) waves suffer different phase delay. Polarizer for jones matrix is [19]

When incident circularly polarized wave transmit polarizer, transmitted light is

=

=exp(

Clearly, RCP and LCP have a phase difference 2 [13] is berry phase metasurface for holography. they used poly-si and made x shaped metasurfaces.

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