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Transmission properties of metal photonic crystal films in visible light and microwave

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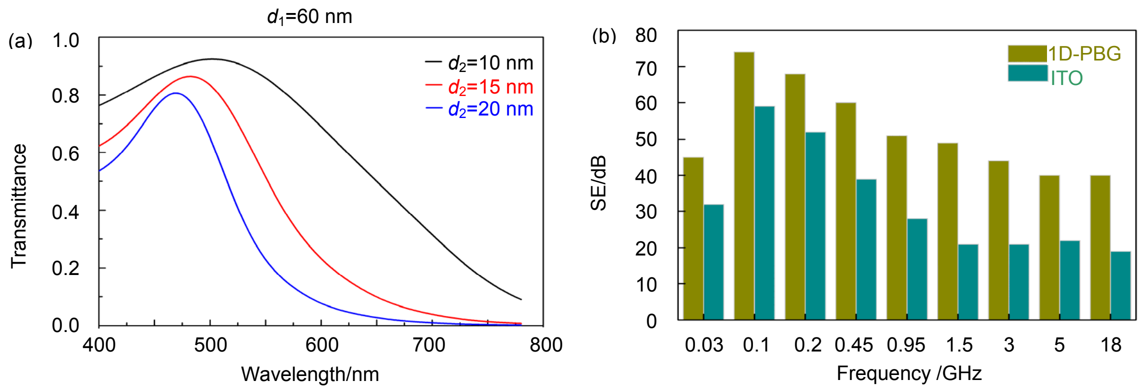

(a) Optical transmission spectra for samples with different thickness of Ag films and a fixed 60 nm ITO films. (b) Electromagnetic shielding effectiveness for samples with structure of (ITO(60 nm)Ag (22 nm))^3 ITO (60 nm) and ITO films with a thickness of 300 nm.

Abstract: The one-dimensional metallic photonic crystal film is an anisotropic metamaterial with an equivalent and uniform metal-medium multilayered structure. Compared with single-layer metal film, the one-dimensional metal photonic crystal film has a higher degree of freedom in terms of chromatic dispersion regulation and control. With the existing of surface plasmon polariton (SPP), directional transmission of evanescent waves can be achieved. This paper designed a one-dimensional metallic photonic crystal film, which was made of ITO and Ag layers. The thickness of each Ag films is less than 2 times the penetration depth of SPP. According to the effective medium theory of metallic photonic crystal, it is found that the equivalent dielectric constant of metallic photonic crystal structure in visible region can be greater than 0 by structural adjustment and its equivalent dielectric constant can be negative in microwave region. This makes metallic photonic crystal in visible region have higher transmitting performance due to the SPP coupling effect, as shown in Fig.(a). In infrared and microwave bands, due to the band gap, metallic photonic crystal shows good reflectivity (shielding effectiveness) in Fig.(b). Based on the effective medium theory, both FDTD and experimental results showed that, in metallic photonic crystal, lower metal component ratio corresponds to greater cutoff wavelength and center wavelength in visible light, wider transmission frequency band, and lower electromagnetic shielding effectiveness in microwave band. Results in this paper agreed with the SPP mode coupling theory, by which active design of transmission performance in visible light and electromagnetic shielding effectiveness in microwave band for metallic photonic crystal is possible. Additionally, the research shows that thinner metallic film layer corresponds to stronger SPP coupling effect and transmittance of visible light. When the metallic film thickness is less than the penetration depth of SPP, visible light transmission in wide frequency band can be achieved due to the smaller distance between the spacing of modes. Furthermore, when the pairs of metallic photonic crystal are 3.5, a good forbidden band can be well formed. With further increase of its pairs, no increase can be seen in the shielding performance of the metallic photonic crystal film. In conclusion, metallic photonic crystal film can be used to realize efficient transmission of visible light, and it also supports the active design of center wavelength, cutoff wavelength and bandwidth for the transmission of visible light. Thus, by adopting the metallic photonic crystal film, light and visual electromagnetic shielding materials with thin films can be created. This unique feature makes the metallic photonic crystal have wide application prospects in the field of visible electromagnetic shielding.

Keywords: metallic photonic crystal film; surface plasmon; visible light transmittance; electromagnetic shielding effectiveness

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