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ORIGINAL PAPER

Investigation of Transmission Properties in One-Dimensional Quasi-periodic Superconducting Photonic Crystal

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Abstract
This paper explores the transmission characteristics of superconducting quasi-periodic photonic crystal structure arranged in Thue-Morse and double-period sequences. We mainly focused on the cutoff frequency of transmittance spectra. The study shows that the cutoff frequency can be appreciably tuned by generation number of sequence, thicknesses of constituent layers and operating temperature. Shifting behaviour of cutoff frequency is in contrast with periodic structure on varying superconductor thickness and temperature whereas it shows opposite trend on changing the dielectric layer thickness. It is also observed that different quasi-periodic structures show distinct values of cutoff frequency and different transmission properties. This features allow to tune the cutoff frequency or band gap in the whole infrared frequency region.

Keywords Cutoff frequency · Quasi-periodic · Superconductor

1 Introduction

Over the past several decades, artificial periodic layered nanostructures called photonic crystals (PCs) have attracted considerable attention [1, 2]. PCs are characterized by so-called photonic band gaps (PBGs) in which electromagnetic radiations of certain range of frequencies are forbidden. In the physical point of view, PBG is similar to electronic band gap in solids. The formation of PBG is due to Bragg scattering mechanism and localized resonance [3]. Engineering of PBG has opened up a new technique to control and manipulate the electromagnetic wave propagation, leading to novel applications in the field of photonics [4–12].

Recently, researchers has investigated PC composed of dispersive material to obtain tunable PBG such as metal [13], semiconductor [14], superconductor [15, 16], plasma [17] and liquid crystals [18]. Superconducting PC aroused a great deal of research interest due to negligible damping, lower dispersion and wide band width of superconductor compared with conventional materials like metals and dielectrics. Moreover, permittivity of superconductor can be tuned externally with temperature and magnetic field.

In addition to the periodic multilayer structures, certain quasi-periodic or quasi-regular structures have shown to exhibit many interesting optical properties. These structures are formed according to a simple deterministic generation rule. They possess the features of both periodic and disordered structure. These new classes of quasi-periodic structures were experimentally demonstrated by Shechtman et al. [19] in 1984. The most classic quasi-regular sequences are Fibonacci [20, 21], Thue-Morse (T-M) [22, 23], Cantor [24], Rudin-Shapiro [25], Pell [26] and double-period (D-P) [27]. Kohmoto et al. [28] investigated the quasi localization of photon in a multilayer arranged in Fibonnaci sequence. Based on transfer matrix method, Huang et al. [29] compared the light localization in random, Thue-Morse and Fibonacci sequence structure as the function of

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