THz wakefield in dielectric PBG structure driven by electron bunches

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***Abstract*—The wakefield effects driven by a relativistic electron bunch train in dielectric PBG structure are presented here. The energy of electron beam can be modulated by self-wake or laser modulation. The excited narrow-band THz wakefield is confined in the defect of 2-D dielectric structure when bunches travel through the PBG structure. And the other spectrum signals are freely radiated through the PBG structure.**

I. INTRODUCTION

THE density of relativistic electron beam can be modulated at THz spectrum by two lasers with different frequencies has been reported recently [1]. These microbunch trains can be used for driving high power coherent Cherenkov radiation in dielectric-line waveguide and Smith-Purcell radiation in periodic structures [2].

The narrow-band THz wakefield can be achieved by driven bunch according to the spectrum analysis if the electron bunch density has Gaussian- like profile [3]. But the real modulated electron beam covers a broad spectrum. As the bunched trains travel along the vacuum channel in a dielectric line, the coherent Cherenkov radiation wakefield will be excited in the structure, containing lots of modes. PBG provide an efficient and flexible technology to design structures by simply introducing linear defects within the periodic lattice. The peculiar structures can be used to alleviate unwanted modes by utilizing the band gap effects of PBG. Most previous work about THz coherent radiation focused on dielectric or periodic structures which are enveloped by metal. But the breakdown and loss are always severe problems to metal at THz spectrum. A 2D dielectric PBG triangular lattice with a vacuum line defect driven by microbunch trains is considered here. According to the simulating results, although the bunched beam contains harmonic components, the most energy of excited wakefield with narrow band is confined within the tunnel defect. And the unwanted modes are radiated through the 2D periodic lattice.

II. RESULTS

The 2D dielectric PBG triangular lattice with air hole which has a vacuum defect as a tunnel for electron bunches is considered here. The major design parameters of the lattice are presented in table 1. Fig. 1 shows the band diagram of the designed 2D triangular lattice where a complete PBG is observed for TE polarized bandgap which is found around the 3THz frequency within the lattice. Here the lattice length is long enough. The TM polarized components excited by high aspect ratio sheet bunches are negligible here.

Table 1. Lattice design parameters.

Parameters	Values
Air hole radius(r)	12um
Lattice constant(a)	30um
Lattice length(d)	200um
Beam tunnel gap(h)	56um

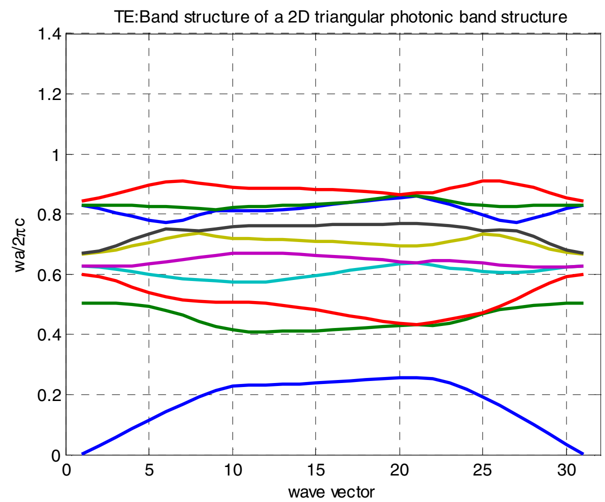

Fig. 1. Band diagram of the defect state localized within the TE lattice.

The CST Particle Studio PIC solver is used for simulation of the interaction between the dielectric PBGs and electron bunches. Seven Gaussian-like density relativistic bunches with rectangular cross-section are used to excite the wakefield within the PBG structure. The spectrum of electron bunches have multiple harmonics, shown as Fig. 2. The first peak of spectrum is around 3THz, which is designed to be locating in the band gap of the PBG structure. There are some unwanted modes with small energy which will transfer through the lattice. The most energy of wakefield with narrow-band is confined within the vacuum tunnel as shown in Fig.3. Fig.4 is the spectrum of wakefield in the tunnel driven by the bunched trains. The generated wakefield benefited from the high spectral purity that PBGs naturally possess.

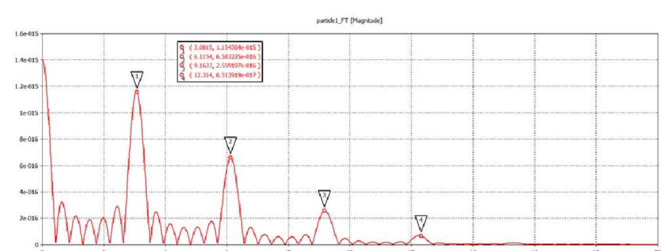

Fig. 2. The spectrum profile of bunched trains.

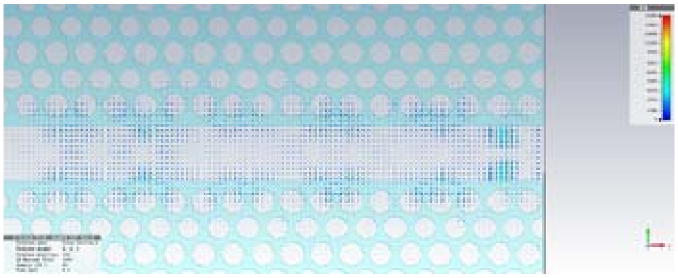

Fig. 3. The electric field distribution in 2D dielectric PBGs driven by bunched trains.

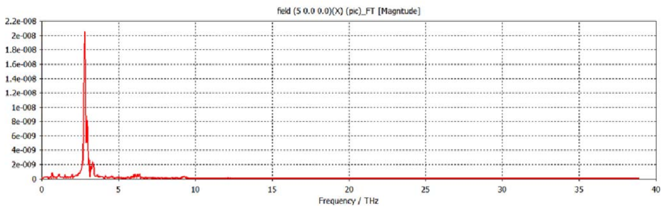

Fig. 4. The spectrum of wakefield driven by the bunched trains within the 2D dielectric PBGs.

III. SUMMARY

The wakefield effects excited by bunched trains traversing through 2D dielectric PBGs have been simulated by CST PS software. Proper PBG parameters can be used to guarantee the fundamental mode be excited and the unwanted modes being radiated outside through PBGs.

ACKNOWLEDGMENT

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