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Terahertz Radiation Generation via e-Beam Driven Photonic Band Gap Structures

The terahertz range from 100 GHz ~ 10 THz has long been an underutilized portion of the electromagnetic spectrum. It has been experiencing a renaissance in recent years, with broad interests from chemical and biological imaging, material science, telecommunication, semiconductor and superconductor research, etc. Nevertheless, the paucity of THz sources—especially strong THz sources—hinders both its use in commercial applications and nonlinear processes research. This paper will report a novel approach of THz photon generation explored at Stanford Linear Acceleration Center, by electron-beam wakefield radiation in dielectric photonic band gap (PBG) structures.

As an e-beam passes through a PBG structure via a defect wave channel in the lattice, electron energy radiates into waveguide modes that are supported along the defect channel in the band gap frequency range. These excited modes are highly confined along the channel due to the PBG cladding, and their energy can be efficiently coupled out of the beam line by deliberately designed microstructures in the PBG lattice. With a suitably designed lattice structure the defect modes are at THz range, and a pre-bunched electron beam will then radiate THz power when transiting the structure.

Several PBG structures including 2-dimensional photonic crystal glass fiber and 3-dimensional silicon woodpile structure have been studied. These PBG structures and coupler designs will be presented, together with far-field radiation calculations and e-beam driven simulation results to estimate the THz emission intensity and power spectrum. Potential fabrication methods for these THz PBG structures, including micromachining, lithography, or rapid prototyping will be investigated too. The Next Linear Collider Test Facility (NLCTA) and Facilities for Accelerator science and Experimental Test beams (FACET) at SLAC provides high quality, high energy sub-picosecond electron bunches that coherently radiate well within the THz frequency range. Initial experiments of THz generation will be carried out using their beam and test facilities.

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