Nonreciprocal frequency doubling of electromagnetic waves through double resonance and Bragg reflection in photonic crystals

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Abstract:

A computational study of the uni-directional second-harmonic generation in a one-dimensional dual photonic crystal structure made of GaAs, AlAs and SiO_2 with quadratic optical nonlinearity and material dispersion is presented. The computational approach uses a shooting method to solve nonlinear wave equations for coupled fundamental and second-harmonic fields and the invariant imbedding method to obtain the linear transmittance and group index spectra. The dual structure consists of two substructures, the left structure creating a strongly enhanced second-harmonic signal and the right structure blocking the fundamental frequency field by Bragg reflection while permitting the passage of the second-harmonic field. The left structure is built with an elementary cell consisting of four sublayers whose thicknesses are systematically varied. Doubly-resonant second harmonic generation with very high conversion efficiency is achieved for light propagating from left to right by choosing the geometrical parameters of the elementary cell optimally and controlling the band structure. A new mechanism to enhance second-harmonic generation by controlling the energy flow between the fundamental frequency and second-harmonic fields has also been found.

References:

1. S. Kim, K. Kim, F. Rotermund, and H. Lim, Opt. Express 17, 19075 (2009).