This work was written as part of one of the author's official duties as an Employee of the United States Government and is therefore a work of the United States Government. In accordance with 17 U.S.C. 105, no copyright protection is available for such works under U.S. Law. Access to this work was provided by the University of Maryland, Baltimore County (UMBC) ScholarWorks@UMBC digital repository on the Maryland Shared Open Access (MD-SOAR) platform.

Please provide feedback

Please support the ScholarWorks@UMBC repository by emailing scholarworks-group@umbc.edu and telling us what having access to this work means to you and why it’s important to you. Thank you.
THz generation in one dimensional photonic crystal structures

Nadia Mattiucci
Time Domain Corporation, Cummings Research Park, 7097 Old Madison Pike, Huntsville, AL 35806
Università “Roma 3”, Dipartimento di Fisica “E. Amaldi”, Via Della Vasca Navale,84, I-00146 Rome, Italy
Weapons Sciences Directorate, AMSMI-RD-WS-ST, Research, Development and Engineering Center, U.S. Army Aviation and Missile Command, Huntsville, AL 35806

Giuseppe D’Aguanno
Time Domain Corporation, Cummings Research Park, 7097 Old Madison Pike, Huntsville, AL 35806
Weapons Sciences Directorate, AMSMI-RD-WS-ST, Research, Development and Engineering Center, U.S. Army Aviation and Missile Command, Huntsville, AL 35806
INFM,DipartimentoEnergetica,LaSapienza,UniversityofRome,ViaA.Scarpa14,00161Rome,Italy

Michael Scalora and Mark J. Bloemer
Weapons Sciences Directorate, AMSMI-RD-WS-ST, Research, Development and Engineering Center, U.S. Army Aviation and Missile Command, Huntsville, AL 35806

Neset Akozbek
Time Domain Corporation, Cummings Research Park, 7097 Old Madison Pike, Huntsville, AL 35806
Weapons Sciences Directorate, AMSMI-RD-WS-ST, Research, Development and Engineering Center, U.S. Army Aviation and Missile Command, Huntsville, AL 35806

J.W. Haus
Electro-Optics Program, University of Daytona, Daytona, Ohio, 45469-0245 USA

Abstract: We propose a device based on a one-dimensional photonic band gap structure that is optimized for the generation of coherent, THz radiation tunable up to 10 THz.

©2003 Optical Society of America

OCIS codes: (190.2620) Frequency conversion; (999.9999) Photonic Band Gap Materials;
Recently great attention has been devoted to the problem of the generation of coherent THz radiation [1]. In this work we study a $\chi^{(2)}$-doped photonic crystal that is able to generate coherent THz radiation in a region that ranges up to $\sim 10$ THz. The THz radiation comes out from a difference-frequency generation (DFG) process, where two, nearly-degenerate optical pumps of frequencies $\omega_1$ and $\omega_2$ generate $\omega_3=\omega_2-\omega_1$, which falls in the THz range. In order to have an efficient device two condition should be satisfied: (i) the two pumps should be tuned near the band edge, preferably inside the same transmission resonance peak, in order to take advantage of the enhancement of the nonlinear process due to high field localization, slow group velocities, and field overlap [2]; (ii) the $\chi^{(2)}$ photonic crystal should allow only the DFG process and inhibit all other second-order processes, such as sum-frequency (SF) and second harmonic (SH) generation. SF and SH processes can be inhibited by designing a structure having a large band gap centered around the SH frequency, as shown in figure 1.

For the structure that satisfies these conditions, in the undepleted pump regime, THz total conversion efficiency ($\eta=\eta^{(+)}+\eta^{(-)}$) is calculated using the Green function approach, as:

$$\eta = \frac{8\pi^2}{\epsilon_0 c} \left( d^{(2)} \right)^2 \left[ \frac{I_1 I_2}{I_1+I_2} \right] \left[ F_1 + F_2 \right] z \left[ \Phi^{(+)}_1 \Phi^{(-)}_2 \right],$$

where $F_{1/2} = \frac{1}{L^2} \int_{0}^{L} \left[ \Phi^{(+)}_1 \Phi^{(-)}_2 \right] dz$.

$I_1$ and $I_2$ are the intensities of the input pumps, $d^{(2)}$ is the nonlinear coupling coefficient, $f(z)$ is the nonlinear grating, $\Phi^{(+/-)}_i$ are the linear, right-to-left and left-to-right field modes inside the structure [2]. In figure 2 we plot the predicted THz conversion efficiency as a function of the relative intensity of two collinear input pumps, at normal incidence. We note that the frequency of the outgoing THz radiation can be tuned by varying the frequency and the angular incidence of at least one of the pumps.

Reference: