Design of high-bandwidth one- and two-dimensional photonic bandgap dielectric structures at grazing incidence of light

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Received 5 February 2008; revised 19 June 2008; accepted 5 September 2008; posted 8 September 2008 (Doc. ID 92494); published 7 October 2008

We propose one-dimensional photonic bandgap (PB) dielectric structures to be used at grazing incidence in order to obtain an extended bandgap exhibiting considerably reduced reflection loss and dispersion compared to similar structures used at a normal incidence of light. The well-known quarter-wave condition is applied for the design in this specific case, resulting in resonance-free reflection bands without drops in reflection versus wavelength function and a monotonous variation of the group delay dispersion versus wavelength function, which are important issues in femtosecond pulse laser applications. Based on these results we extend our studies to two-dimensional PB structures and provide guidelines to the design of leaking mode-free hollow-core Bragg PB fibers providing anomalous dispersion over most of the bandgap.

OCIS codes: 310.4165, 060.2280, 230.1480, 320.7080.

1. Introduction

Multilayer (ML) structures designed on the basis of the Bragg condition are extensively used as high reflectors for neutrons and electromagnetic waves. While such mirrors are usually designed for normal incidence for most of the electromagnetic spectrum, for neutrons and x rays they are designed to be used at grazing incidence for the following reason. The refractive index difference between the alternating layers in these wavelength regions is relatively low, and it can be shown that high reflectance in a meaningful bandwidth can only be obtained at a high value of angle of incidence [1]. Typically MLs are composed of Ni/Ti and Mo/Si, and they are used at an 85°–90° angle of incidence (1°–5° and <1°, according to their conventional notations) for neutrons and x-rays, respectively.

A technique to further increase the bandwidth of grazing incidence neutron and x ray mirrors is "chirping", i.e., properly varying the Bragg period of the ML structure [2]. This method has also been successfully applied in the design of ultrabroadband dielectric mirrors—used at normal incidence—for broadly tunable and ultrashort pulse femtosecond systems [3,4].

Interestingly, grazing incidence quarter-wave dielectric mirrors have not been applied in the construction of laser resonators yet, despite the fact that the bandwidth of such mirrors is considerably higher than for normal incidence ones (this refers to *S*-polarized light only). The use of grazing incidence dielectric mirrors instead of ultrabroadband chirped mirrors could be desirable in some applications for the following reasons: (i) grazing incidence dielectric mirrors require a much lower number of layers than chirped mirrors to reach the same reflectivity (this might be advantageous in the near-IR regime, where the physical thickness of the layers is relatively high); (ii) periodic grazing

0003-6935/08/295330-07$15.00/0