

# Lossless high-index contrast Distributed Bragg Reflector

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**Abstract:** A new approach for achieving nearly lossless high-index contrast planar Distributed Bragg Reflector structures is proposed. It provides means of eliminating diffraction losses, without compromising device performance.

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Distributed Bragg Reflectors (DBR) are widely used for photonic devices. Applications include VCSELs, filtering and Wavelength Division Multiplexing (WDM) [1,2]. The performance of DBRs (e.g., bandwidth and reflectivity) improves with the index contrast of the materials. However, losses also increase, as a consequence of light diffraction in the low-index regions. Conventional solutions for reducing losses are usually either reduction of index contrast or an excessive shortening of the low-index region [3,4], both leading to a decrease in device performance.

A schematic 2D description of the new class of DBR is shown in Fig. 1 for a 4-period structure. The structure is embedded in a medium with index  $n_L$  and consists of a sectioned waveguide with high index of refraction  $n_H$ . It is periodic in  $\lambda_0/2$ , with each of the sections separated by  $l_L$ . Losses are reduced through the insertion of a high index, narrow wire, hereafter called *wire-lens*, in the low-index region. The *wire-lens* width ( $w_L$ ) of index  $n_H$  is much smaller than the waveguide width ( $w_H$ ). In Fig. 1 we show the electric field distribution for a Si structure ( $n_H = 3.48$ ) surrounded by air ( $n_L = 1$ ), with  $\lambda_0 = 1.55 \mu\text{m}$ ,  $w_H = 500 \text{ nm}$ ,  $w_L = 50 \text{ nm}$  and  $l_L = 100 \text{ nm}$ . We calculate the effective indices and find that  $n_{H,\text{eff}} = 3.27$  and  $n_{L,\text{eff}} = 1.45$  in the high and low index regions, respectively. Simulations are performed employing the finite-difference time-domain (FDTD) method (FullWAVE<sup>TM</sup> 2.0), for the TE-mode.

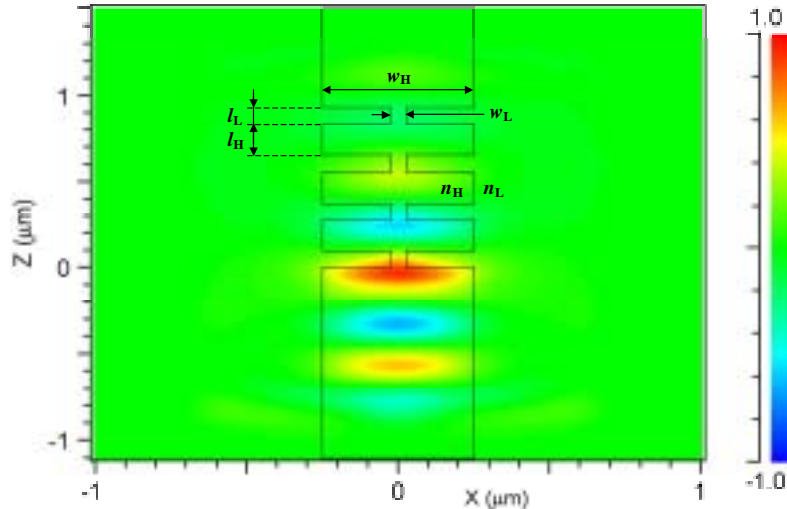


Fig. 1. 2D 4-period DBR with a wire-lens structure together with the electric field distribution for TE-mode. Light is launched next to the first interface (at  $z = 0$ ) in the  $z > 0$  direction

Fig. 2 shows the dependence of losses and reflectivity on the *wire-lens* width for an 8-period structure.  $w_L$  is varied from 0 to  $w_H$ .  $l_L$  is kept constant ( $l_L = 100 \text{ nm}$ ) while  $l_H$  is varied as necessary in order to satisfy the condition:  $2[n_{H,\text{eff}} l_H + n_{L,\text{eff}} l_L] = \lambda_0 = 1.55 \mu\text{m}$ .

When  $w_L = 0$  (no bridge), the losses are about 1.6% due to the diffraction of light in the air regions. When  $w_L \sim 225 \text{ nm}$ , losses increase to almost 5%. When  $w_L = 50 \text{ nm}$ , losses are *practically eliminated* (below 0.04%) while reflectivity remains approximately 100%. This is mainly due to the index profile change at the interface between air and Si, leading to strong alterations of the mode profile.

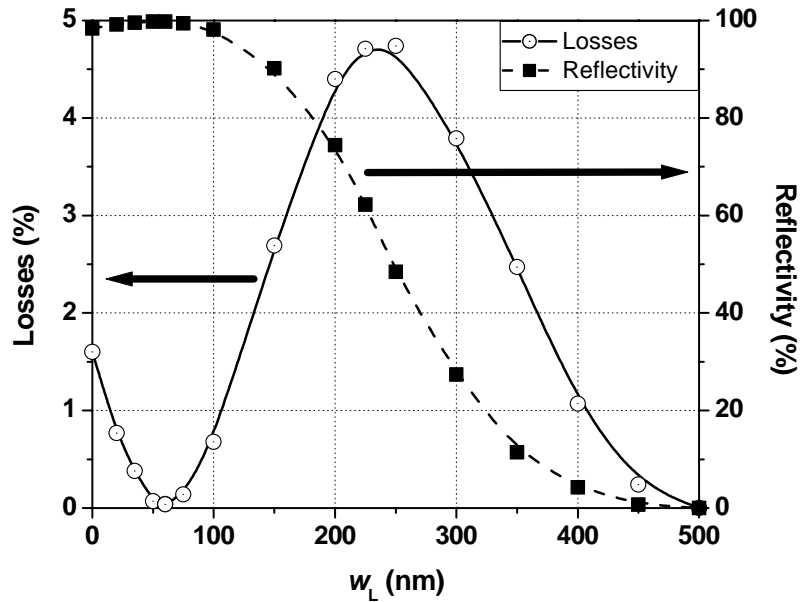


Fig. 2. Dependence of losses and reflectivity on the wire-lens width for a 8-period DBR structure.

In conclusion we show that lossless high index contrast structures *can* be achieved without affecting device performance. This approach can be extended to 3D and to more elaborate photonic structures. It will open the door to a new class of lossless photonic devices for applications in planar all-optical circuits.

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