Calculation of confinement losses in photonic crystal fibers by use of a source-model technique

Amit Hochman and Yehuda Leviatan*

Department of Electrical Engineering, Technion—Israel Institute of Technology, Haifa 32000, Israel

Received April 13, 2004; accepted July 3, 2004; revised manuscript received August 20, 2004

We extend our previous work on photonic-crystal fibers (PCFs) using the source-model technique to include leaky modes of fibers having a finite-sized photonic bandgap crystal (PBC) cladding. We concentrate on a hollow-core PCF and calculate the confinement losses by means of two different methods. The first method is more general but also more computationally expensive; we use sources that have a complex propagation constant and seek a transverse resonance in the complex plane. The second method, applicable only to modes with small confinement losses, uses sources with a real propagation constant to approximate leaky modes that have a propagation constant that is close to the real axis. We then apply Poynting's theorem to calculate the attenuation constant in a manner akin to the perturbation methods used to calculate the losses in finite-conductivity metal waveguides. This first approximation can be improved through iterative application of the algorithm, i.e., by use of sources with the attenuation constant found in the first approximation. The two methods are shown to be in good agreement with each other and with previously published results for solid-core PCFs. Numerical results show that, for the hollow-core PCF analyzed, many layers of PBC cladding are needed to attain confinement losses that are acceptable for telecommunications.

OCIS codes: 000.4430, 060.2270, 060.2310, 060.2400, 230.7370, 230.3990.