Effects of Lattice Variations on Confinement in Photonic Crystal Microcavity using Green Tensor Method

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Electric field distribution in and around the 2D PC cavity was calculated for different lattice parameters using the Dyson formulation of the Green tensor. The results demonstrate the sensitive effects of structural variation of the photonic crystal on the effectiveness of field confinement in the cavity.

Summary

The Green’s tensor method is known to offer remarkable advantages over the other computational schemes in avoiding the tricky treatment of boundary condition for finite system or finite computational domain and in its adaptability in handling small and subtle perturbations in the system. As such, it provides a powerful scheme for the development of numerical tools for modeling, simulation and exploration of structural variation giving rise to novel functionalities for photonic device applications.

We report in this paper the results of applications of a numerical program developed for the application of Green tensor method to the study of a 2D photonic crystal with defect. The Green tensor for more realistic background characterized by \( \Delta \varepsilon(\mathbf{r}''') \) was calculated from the homogeneous background Green tensor according to the Dyson formulation below,

\[
\mathbf{G}(\mathbf{r}, \mathbf{r}') = \mathbf{G}^0(\mathbf{r}, \mathbf{r}') + \int_{\mathbf{r}''} d\mathbf{r}'' \mathbf{G}^0(\mathbf{r}, \mathbf{r}'') \cdot k_0^2 \Delta \varepsilon(\mathbf{r}''') \mathbf{G}(\mathbf{r}'', \mathbf{r}'). \tag{1}
\]

This allows the conversion of the implicit integral equation for finding the field solution into an explicit one as follows,

\[
\mathbf{E}(\mathbf{r}) = \mathbf{E}^0(\mathbf{r}) + \int_{\mathbf{r}''} d\mathbf{r}' \mathbf{G}(\mathbf{r}, \mathbf{r}'') \cdot k_0^2 \Delta \varepsilon(\mathbf{r}'') \mathbf{E}^0(\mathbf{r}''). \tag{2}
\]

The numerical calculation was implemented by a recursive scheme modified from a previously suggested one. This program was applied to the study of a 2D photonic crystal with a point defect structure was considered for its application as a microcavity for the TM wave. The electric field distribution in and around the cavity was calculated for different lattice parameters. The result demonstrated the sensitive effects of structural variation of the photonic crystal on the effectiveness of field confinement in the cavity.

References