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Optimum design of periodic microstructures for minimal dispersive effects in wave propagation

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Abstract

It is well known that dispersion (i.e. spreading of the wave profile) [1] is a higher order effect on wave propagation in periodic inhomogeneous media. In fact, the homogenized wave equation can be corrected by a higher derivative term as can be shown by the method of asymptotic expansions in mathematical homogenization theory [2]. This effect is important for engineering applications (like photonics waveguide), because periodic size of the microstructures is finite in all engineering applications. This research work presents level set based-structural optimization methods [3, 4] for periodic microstructures having specified homogenized material properties and minimizing the dispersive effect. First, the homogenization theory in wave propagation problem is briefly discussed and the dispersive tensor is formulated using the Bloch wave decomposition. Next, the optimization problem is formulated to minimize the dispersive effect using level setbased boundary expression in the microstructures. The optimization algorithm is constructed using the Finite Element Method to calculate the homogenized tensor and the dispersive tensor and to update the level set function. Several numerical examples are shown to confirm the validity of the proposed optimization method.

References

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