Domain-Decomposition Spectral-Element-Boundary-Integral Method With Periodic Layered Medium Green's Function

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Numerical simulation plays a substantial role in the nano-scale applications such as extreme ultraviolet lithography (EUVL), transformation optics and plasmonic metamaterials. These problems are generally multiscale because of the complicated fine structures and the large background substrate, which is difficult for the traditional methods like FEM and FDTD. To effectively solve such problems, hybrid methods are recommended.

Previously, spectral-element-boundary-integral (SEBI) method proved to be a promising hybrid method for such problems. Inside the computational domain, spectral element method was used to solve the vector Holmholtz equation. On the boundaries, Bloch boundary condition was applied to truncate the periodic structure, and boundary integral method using electrical-field-integral-equation (EFIE) was used to truncate the layered medium background. However, the mesh size, as well as the order of basis function need to be the same across the whole computational domain.

In this work, we decompose the SEM domain and its BI surface, and use Riemann solver to couple them. The SEM domain is surrounded by the BI surface domain. Between the SEM domain and the BI domain, nonconformal mesh is allowed. Larger elements and higher order basis function can be used in the SEM domain to obtain high accuracy with low PPW, while small elements and first order basis function can be used in BI domain to allow the accelaration by FFT. This reduces the computational cost and makes it easier and more flexible to solve large problems in reality.

Cases with periodic structures and layered medium background will be presented. The accuracy of our method will be validated by commercial softwares. Convergence tests will prove the robustness of our method and the advantages over traditional methods. Computational cost will be compared between our method and the previous SEBI method.