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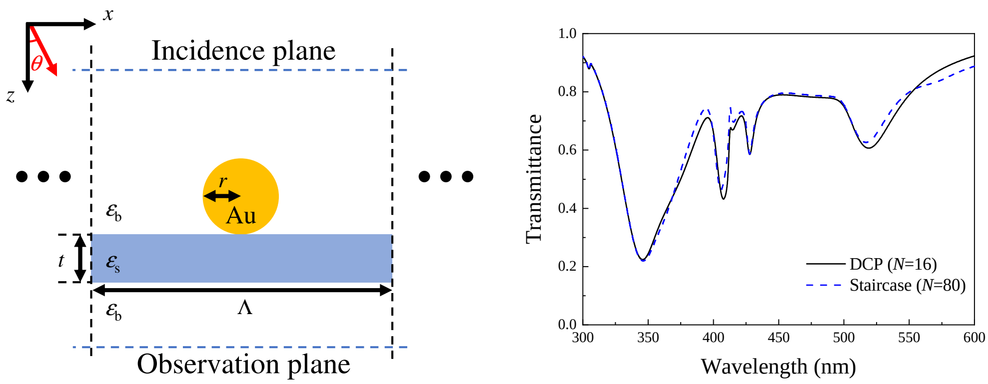
# Application of the DCP-FDTD Method to the Analysis at Oblique Incidence

Jun Shibayama(1), Tetsuya Iwamoto(1), Junji Yamauchi(1), and Hisamatsu Nakano(1)
(1) Hosei University, Tokyo 184-8584, Japan

Recently, much attention has been paid to investigating plasmonic devices, in which noble metal components are used to excite surface plasmon plaritons. It is known that metal at optical frequencies should be treated as a dispersive medium. For the analysis of dispersive media with the finite-difference time-domain (FDTD) method, we require the frequency-dependent formulation using dispersion models such as the Drude and Drude-Lorentz (DL) ones.

It should be noted that plasmonic devices involve metal circular rods or spheres, particularly for the sensor applications. For the analysis of these devices using the traditional FDTD method, the curved metal surface should be modeled with the staircase approximation. Unfortunately, this gives rise to a localization of spurious fields on the bumps of the surface. To alleviate this problem, the dispersive contour-pass (DCP) technique has been developed for arbitrarily-shaped metal surfaces using the Z-transform-based FDTD method [1]. We have also applied the DCP technique to the simple frequency-dependent FDTD method based on the trapezoidal recursive convolution (TRC) scheme for the Drude [2] and DL [3] models. Note that the application of the above mentioned DCP techniques has been limited to the analysis at normal incidence.

We here extend the DCP-FDTD method to the analysis of the DL model at oblique incidence. Although not shown in this article, we formulate the FDTD equations based on the TRC technique with the field-transformation scheme. Fig. 1(a) shows the configuration to be analyzed, in which only the single unit cell is illustrated for a periodic array of gold rods on a dielectric substrate. The parameters are as follows: $r = 40$ nm, $\Lambda = 350$ nm and $t = 200$ nm. The permittivity of Au is expressed with the DL model and those of $\varepsilon_s$ and $\varepsilon_b$ are set to be $1.5^2$ and 1, respectively. Fig. 1(b) shows the transmittance as a function of wavelength for $\theta = 10°$, in which $N$ means the number of sampling points in the rod diameter, i.e., $\Delta = 2r/N$. It is found that the DCP technique with course meshes ($N = 16$) provides the comparable result obtained from the traditional staircase approximation with fine meshes ($N = 80$). In this case, the computation time is reduced to less than 1% of the staircase counterpart.




(a) (b)

**Figure 1.** Configuration and transmittance.

## References

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