All-dielectric Cylindrical Homogenized Metasurface for Enhanced Directional Scattering

Rasmus E. Jacobsen and Samel Arslanagić
Department of Space Research and Technology, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark, rajac@dtu.dk, saar@dtu.dk

Metasurfaces (MSs) are flat functional structures enabling advanced wave manipulations such as perfect absorption, cloaking, and lasing, to mention a few [1-3]. At optical frequencies, all-dielectric MSs are more favored over the metallic kinds coming from to their low loss. MSs consist of periodic unit cells which are often arranged in rectangular planes. However, MSs can also take up cylindrical and spherical forms. In recent years, it has been shown that cylindrical MSs can be used for scattering suppression and enhancement [4]. These scattering properties are achieved from the resonances excited in the cavities that the MSs form. Although the underlying theory for cylindrical MSs applies across the electromagnetic spectrum, its primary utilization has been at microwave frequencies. This preference is due to the treatment of the MSs as homogenized surface impedances as well as the lack of analytical models for all-dielectric versions of these.

The purpose of the present work is to investigate all-dielectric cylindrical MSs for enhanced directional scattering, which can be realized for operation at optical frequencies. Similar configurations have previously been investigated, but with focus on minimizing the total scattering for cloaking applications. We employ an analytical approach to derive expressions for the required surface impedance to maximize scattering in single and double MS configurations. To realize these surfaces, we employ a 1-D model for an array of dielectric cylinders. The analytical results are compared with full wave simulations showing excellent agreement. Various examples exhibiting extraordinary directional scattering properties will be presented, see Fig. 1.

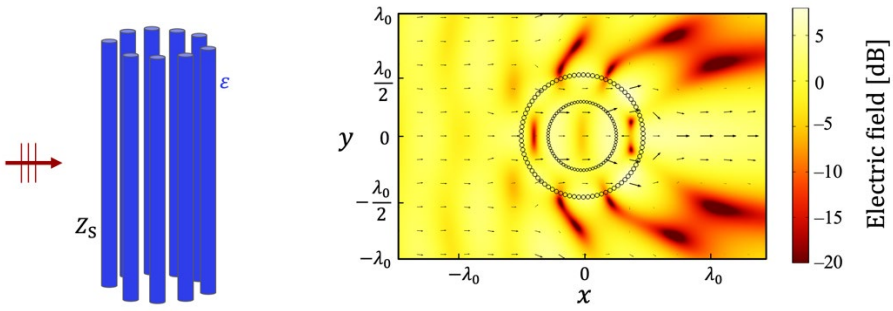

Figure 1. (Left) Sketch of the configuration. (Right) Electric field intensity of a cylindrical double MS.

References

[1] D.C. Zografopoulos, and O. Tsilipakos, "Recent advances in strongly resonant and gradient all-dielectric metasurfaces," *Advanced Materials*, **4**, 1, November 2023, pp. 11–34. doi: 10.1039/D2MA00910B.

[2] R. E. Jacobsen, S. Arslanagić, and A. V. Lavrinenko, "Water-based devices for advanced control of electromagnetic waves," *Applied Physics Reviews* **8**, 4, December 2021, p. 041304, doi: 10.1063/5.0061648.

[3] S. Zahra, L. Ma, W. Wang, J. Li, D. Chen, Y. Liu, Y. Zhou, N. Li, Y. Huang, and G. Wen, "Electromagnetic Metasurfaces and Reconfigurable Metasurfaces: A Review," *Frontiers in Physics*, **8**, January 2021, p. 593411, doi: 10.3389/fphy.2020.593411.

[4] R. E. Jacobsen, A. V. Lavrinenko, and S. Arslanagić, "Reconfigurable dielectric resonators with imbedded impedance surfaces - From enhanced and directional to suppressed scattering," *Applied Physics Letters* **122**, 8, February 2023, 81701, doi: 10.1063/5.0139695.