TUNEABLE STRUCTURAL COLORS FROM TiO_2 MIE RESONATOR ARRAYS IN GLASS

Mikko Kjellberg[1], Aijth Ravishankar[1], Srinivasan Anand[1]
[1] KTH

Kjellberg M., Ravishankar A.P., Anand S.

Department of Applied Physics, School of engineering sciences, KTH Royal Institute of Technology, Stockholm, Sweden

Abstract

Structural colors originating from the interaction of light with a periodic arrangement of dielectric nanostructures (Mie resonators) have a promising future for vibrant, tunable reflective colors without using conventional pigments or dyes [1], [2], [3]. Such structures have a wide range of applications in displays, sensors, printed colors, and colored photovoltaics [4], [5].

The focus of this work is on the design, fabrication, and optical characterization of TiO_2 Mie resonators on glass substrates for structural color applications, including the effects of embedding medium refractive index and the geometrical shape of the resonators. Fabricated nanoarrays consisting of 200 nm high TiO_2 nanodisks arranged in square and hexagonal arrays with periods ranging from 300 nm to 500 nm, and radius ranging from 100 nm to 145 nm, are investigated together with electromagnetic design and simulations. The fabricated arrays show vivid colors, from blue to red, with associated reflectance peaks (color) of up to 80% with FWHM values of ~50 nm.

Employing multipolar decomposition of the scattered fields of the resonators, single and in arrays, together with reflectance (measured and simulated) we show that besides the resonator material and geometry, the structural colors can be tuned by the embedding medium refractive index and that the sidewall slopes play a major role in determining the (reflected) spectral features due to detuning of the supported Mie modes.

The results provide a comprehensive understanding of the optical characteristics of dielectric Mie resonator arrays for structural coloration, important for advancements in reflective color technologies.

[1] Y. Shen, V. Rinnerbauer, I. Wang, V. Stelmakh, J. D. Joannopoulos, and M. Soljačić, “Structural Colors from Fano Resonances,” ACS Photonics, vol. 2, no. 1, pp. 27–32, Jan. 2015, doi: 10.1021/ph500400w.

[2] J. Jang et al., “Full and gradient structural colouration by lattice amplified gallium nitride Mie-resonators,” Nanoscale, vol. 12, no. 41, pp. 21392–21400, Oct. 2020, doi: 10.1039/D0NR05624C.

[3] S. Sun et al., “All-Dielectric Full-Color Printing with TiO2 Metasurfaces,” ACS Nano, vol. 11, no. 5, pp. 4445–4452, May 2017, doi: 10.1021/acsnano.7b00415.

[4] T. Lee, J. Jang, H. Jeong, and J. Rho, “Plasmonic- and dielectric-based structural coloring: from fundamentals to practical applications,” Nano Convergence, vol. 5, no. 1, p. 1, Jan. 2018, doi: 10.1186/s40580-017-0133-y.

[5] Z. Xuan, J. Li, Q. Liu, F. Yi, S. Wang, and W. Lu, “Artificial Structural Colors and Applications,” The Innovation, vol. 2, no. 1, p. 100081, Feb. 2021, doi: 10.1016/j.xinn.2021.100081.