Tuning structural coloration of concave microstructures through evanescent wave absorption and variation of light collimation

K. Hirsch, N. E. Sturniolo, C. H. Meredith, M. S. Rayes, C. Rider, L. D. Zarzar

Structural coloration produced by multipath total internal reflection (TIR) interference at concave interfaces has recently attracted interest due to ease of fabrication on the microscale and generation of complex geometries to induce unique color shifts. Here, we manipulate the iridescent coloration produced by multipath TIR through evanescent wave absorption of chemical dyes and varied light collimation. Discovering novel ways to tune the coloration is shown here to customize the iridescence, allow for wider viewing angles, and broaden the types of geometries that can showcase this coloration for applications in areas such as anti-counterfeiting, sensors, and displays. To customize the iridescent coloration, a chemical dye is thermally evaporated onto the concave microstructures where the evanescent wave is absorbed causing a selective removal of visible wavelengths of light. Factors such as the type of dye used, and the amount of dye thermally evaporated onto the microstructures is investigated. To reach wider viewing angles and access a broader range of geometries, we alter the light path as it enters and exits the concave microstructure by incorporating refraction at curved interfaces therefore causing non-collimated light to undergo multipath TIR interference. Refraction at curved interfaces is first investigated using a ray-tracing program called Zemax which is then compared to Janus droplets experimentally fabricated through a microfluidic chip. This work shows two novel approaches to tuning the structural coloration generated by multipath TIR interference to further our understanding of the mechanism and how to better improve upon the functionality of the material.