Irridescence, Inclination & Circular Dichroism in Gyroid Photonic Crystals

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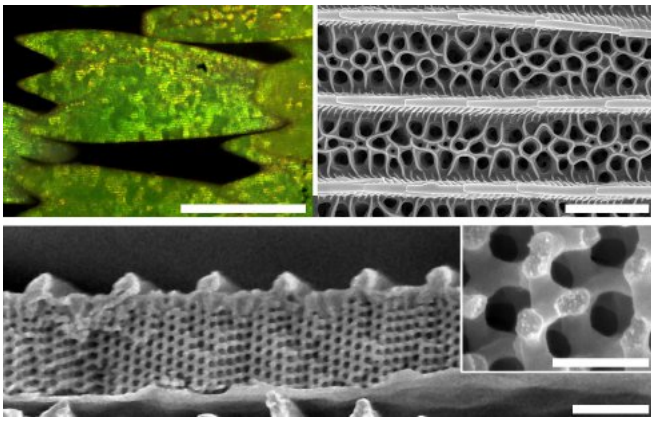

The wing-scale structure of Teinopalpus imperialis exhibiting the Gyroid photonic crystal (adapted from Saba, Wilts et al, 2014)

This talk addresses the single gyroid photonic structure, realised as a porous chitin material in the wing-scales of various green butterflies. Specifically, we will address the question of directionality of the photonic response of this material which has cubic symmetry, both for circularly polarised light and for unpolarised light, discussing the results of a recent analysis of reflectance spectra along the [100], [110] and [111] directions of the cubic crystal (Saba, Wilts et al; 2014). This analysis demonstrates in particular a complexity with the reflection in direction of the [111] which, in contrast to previous claims in the literature, does not show even a partial band gap (Saba & Schröder-Turk, 2015). These results will be compared to typical observations of crystallite orientation (inclination) within the poly-crystalline arrangement of the single gyroid in the wing-scale chitin structures. We will further discuss circular dichroism, i.e. effects related to circular polarisation. The gyroid's structural chirality, manifest in the three- and four-fold screw axes of its symmetry group $I4_132$, suggests the possibility of circular polarisation effects. Specifically for the length scale of the butterfly wing-scales, circular dichroism has been predicted to occur in the near-UV spectrum, and this prediction confirmed for nanofabricated replicas. However, reflections off biological specimens fail to show any circular dichroism signal (Saba, Wilts et al, 2014). We will discuss this finding specifically in the light of the direction dependence of the reflection spectrum, using band structure analysis.

References

M. Saba and G.E. Schröder-Turk, “Block modes and evanescent modes of photonic crystals: weak form solutions based on accurate interface triangulation”, Crystals 5(1), 14-44 (2015)

M. Saba, B.D. Wilts, J. Hielscher and G.E. Schröder-Turk, “Absence of circular polarization in reflections of butterfly wing scales with chiral Gyroid structure”, Materials Today: Proceedings 1, 193-208 (2014)