Structural color of a butterfly - How does multidomain photonic crystal structure produce an uniform color?

Shinya Yoshioka*

Graduate School of Frontier Biosciences, Osaka University,
1-3 Yamadaoka, Suita, Osaka, 565-0871, Japan,
E-mail:syoshi@fbs.osaka-u.ac.jp

It is known that the wing scales of several butterfly species contain photonic crystals that produce brilliant structural colors. The emerald-patched cattleheart butterfly, *Parides sesostris*, is such an example, which has green patches on the black forewings (Fig. 1). However, the photonic crystal inside the wing scale is not observed as a single crystal that spreads over the entire scale, but it is separated into many small domains with different crystal orientations. A photonic crystal generally has band gaps at different frequencies depending on the direction of light propagation. Thus, it is expected that multidomain photonic crystals with different crystal orientations appear in different colors from domain to domain. However, the wing scale is actually observed to be uniformly green under an optical microscope despite the multi-domain structure. To interpret these seemingly contradicting facts, we have carefully investigated the photonic crystal structure of the wing scale; the scale was thin-sectioned in three orthogonal directions and observed by transmission electron microscopy. We discovered that the crystal orientations of different domains are not perfectly random, but there is a preferred crystal orientation that is aligned along the surface normal of the scale. The alignment of the crystal orientations naturally answers the above puzzle regarding the uniform color. It also suggests that there are some mechanisms that control crystal orientation during the developmental process.

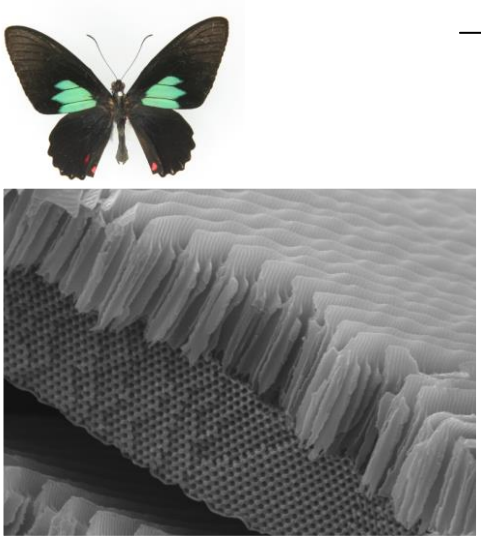

Figure 1. *Parides sesostris*(top) and the cross section of the green wing scale observed by scanning electron microscopy (bottom).

About Corresponding Author:

Dr. Shinya Yoshioka, Assistant Prof.
Graduate School of Frontier Biosciences, Osaka University

E-mail: syoshi@fbs.osaka-u.ac.jp
Telephone: +81 (0)6-6879-4602
Fax: +81 (0)6-6879-4602
Website: http://mph.fbs.osaka-u.ac.jp/~syoshi/
Address: 1-3, Yamadaoka, Suita, Osaka 565-0871, Japan

Education, Academic Backgrownd and Awards
1998 Doctor of Science, Hokkaido University
2000 Assistant Professor, Osaka University
Award: 2004 L'Oréal Art and Science of Color Prize, GOLD PRIZE.

Publications
1) S. Yoshioka, et al., J. R. Soc. Interface, doi: 10.1098/rsif.2013.1029
2) S. Yoshioka, et al., Bioinspiration & Biomimetics, 8, 045001 (2013).
3) S. Yoshioka, et al., J. Phys. Soc. Jpn. 81, 054801(2012).