Material Design and Fabrication of Structural Color using a Biomimetic Approach ~ Mystery of *Morpho* Butterfly's Blue ~

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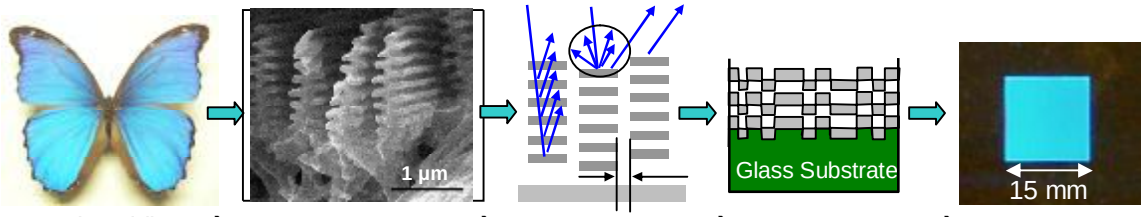
Some of *Morpho* butterflies in South America are well known with their brilliant metallic blue wings. The blue luster is produced from their scale composed of protein without blue pigment. The origin of the color is then not pigment but rather an interference effect based on a microscopic structure. However, the optical characteristics cannot be explained by interference at all, because the wings appear blue from too wide angular range (> ± 40° from the normal) and lack the multi-coloration. This mystery has been tried to explain with a peculiar optical nanostructure [1]. The point was a specific and fine combination of both ordered and disordered nanostructures. The experimental proof of the mystery was achieved by emulating the specific nanostructures, which was realized by extracting the optical principles and using a conventional lithography technique for application purpose [2]. The artificial *Morpho* plate reproduced the basic optical properties of the *Morpho* blue.

The reproduced *Morpho* color was found to serve wide applications, because it can produce a single color with high reflectivity without pigment in wide angular range, which is also impossible to be made by pigment, and resistant to discoloration based on a chemical change over longtime. Furthermore, the pigment-free condition is preferable from ecological viewpoint. However, we must overcome many "death valleys" for wide industrial applications. First, a mass-productive method was developed using nano-imprinting technique [3]. Next, high-speed large area fabrication and duplication were realized by use of laser process and electroforming. The control of optical properties is also in progress in both of angular distribution and coloration. For the precise control, we achieved optical simulation using recent numerical method, which has long been difficult due to randomness in the structure. Also various extended steps are in progress for applications [4].



Morpho Didius **è** Cross-sectional SEM image of the Butterflly's scale **è** extraction of the optical principles **è** simplified design of the structures **è** Reproduced *Morpho*-blue

References

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