Direct determination of the refractive index of the multilayered cuticle of a jewel beetle

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It is well known that the metal-like strong reflection observed in the elytra of some kinds of beetles is produced by multilayer thin-film interference. For the quantitative analyses of the structural colors in these elytra, it is necessary to know the accurate values of the refractive indices of the materials that comprise the multilayer structure. However, index determination is not an easy task: The elytron surface is not flat but curved and usually contains many irregular bumps which cause scattering loss. These structural characteristics prevent us from directly applying conventional optical techniques for index determination, such as ellipsometry, since these techniques assume a perfectly specular surface.

Recently, Noyes et al. reported the index values, 1.55+0.14i and 1.68+0.03i, for the two types of materials that constitute the multilayer system of a buprestid beetle, *Chrysochroa raja* [1]. They measured angle- and polarization-dependent reflectance spectrum, and simultaneously analyzed those spectra to determine the index values and thickness of the layers. Although this approach should work in principle, a fitting procedure with many adjustable parameters generally result in several parameter sets that reproduce similar spectra. In particular, it is difficult to distinguish the effect of roughness of the layer surfaces and the optical absorption merely from the reflectance spectrum.

In this paper, we report a new experimental procedure that can directly determine the refractive indices of individual layers in the natural multilayer systems. This procedure involves semi-frontal thin sectioning of the sample and subsequent optical examinations using a microspectrophotometer. The individual layers have the thickness of about only 100 nm. However, they appear as broader stripes in the semi-frontal section, of which width is more than 1 μm. Thus, optical examination of the individual layers is possible using a microspectrophotometer.

We demonstrate that the new procedure allows us to determine the complex refractive index and its wavelength dependence for one kind of jewel beetle, *Chrysochroa fulgidissima*. It is found that the real part of the refractive index values are in good agreement with the values reported by Noyes et al., when they are compared at the wavelength of 550 nm. However, our results show that the magnitude of the imaginary part is larger for the high-index layer than the lower-index layer, which is different from the previous study.

References

1. J. A. Noyes, P. Vukusic and I. R. Hooper, Opt. Express **15**, 4351 (2007).