Iridescent Coleoptera as templates for fabrication of versatile SiO_2/TiO_2 multilayer mirrors and filters

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In the living world, we find many beautiful examples of natural iridescent colours in the Coleoptera (beetles), i.e. vivid colours of physical origin (optical interferences) which result from specular reflection of the light by thin films [1-2]. Detailed studies involving morphological characterization through scanning/transmission electron microscopy, optical reflectance measurements and numerical modelling not only reveal photonic structures responsible for iridescence but also provide optical engineers with ideas for fabrication of devices such as mirrors or filters [3-4]. In many instances, a single biological material (chitin – a polysaccharide based on glucose and similar to cellulose), in combination with air gaps, is used to produce a multilayer structure, which is located within the exocuticle. Periodic air/chitin multilayers give rise to a relatively narrow reflection band which, in the case of *Hoplia coerulea*, lies in the blue part of the visible spectrum and moves only slightly with the angle of incidence [1] and, in the case of *Chrysochroa vittata*, shifts from red to green as the incidence is changed from normal to grazing [2]. Chirped multilayers, composed of chitin and another constituent, give rise to a broad-band reflection producing gold and silver mirror aspects in *Chrysina resplendens* and *Chrysina optima*, respectively. We derived an analytical formula based on a semi-infinite one-dimensional photonic crystal model, which has turned out to be useful for the design of colour-selecting devices based on multilayer films [3-4]. Applications include biomimetics and optical engineering. In the former, one aims to reproduce the visual aspect of a biological sample by transposing the original multilayer structure into an artificial one using a combination of two materials such as SiO_2 and TiO_2 [3]. Transposition is not as straightforward as one might think, as it is revealed by careful analysis of the influences of layer thickness ratio and refractive index contrast on the spectral richness of the reflector [3]. In the latter, one exploits design ideas from various biological multilayer structures in order to design versatile mirrors or filters [4]. At the conference, we will report on reflectance of SiO_2/TiO_2 multilayer films deposited on glass substrate by dc magnetron sputtering (Figure 1-a). We will show how radically different visual aspects (quantified by chromaticity coordinates, Figure 1-b) can be obtained using the same materials but different bio-inspired multilayer designs.

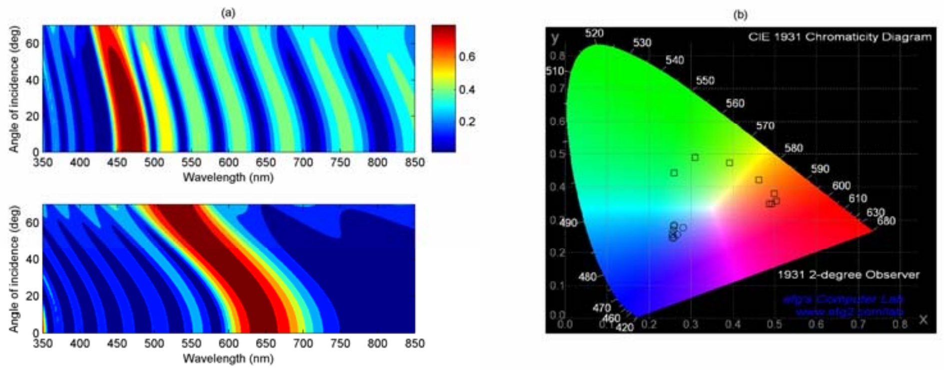

Figure 1. Theoretical reflectance (a) of SiO_2(n=1.5)/TiO_2(n=2.7) multilayer films and corresponding chromaticity coordinates (b) as the angle of incidence is increased from 0° to 70°. Hoplia-type design: 14-periods, d_{SiO2}=8 nm, d_{TiO2}=80 nm (a: top, b: circles); Chrysochroa-type design: 8-periods, d_{SiO2}=200 nm, d_{TiO2}=10 nm (a: bottom, b: squares).

References

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