A Mueller Matrix Spectroscopic Ellipsometry Study of Scarab Beetles of the Chrysina Genus

L. Fernández del Río¹, H. Arwin¹, J. Landin¹, R. Magnusson¹, K. Järrendahl¹

¹Department of Physics, Chemistry and Biology, Linköping University, Sweden

Date: 25 Nov 2011

Program topic: MMCP
Presentation type: Poster
Contact author: Kenneth Järrendahl, email: kejar@ifm.liu.se, Tel.: +46 13 28 2112

The attractive shiny metallic colour of jewel scarabs is originating from the structure of the exoskeleton. For some directions and wavelengths of the incident light this structure will also cause the reflected light to have a large ellipticity (near-circular polarization). This is due to that the exoskeleton is a helicoidal structure, formed by layers of chitin molecules. The reflected light is most commonly left-handed polarized but right-handed polarization is also observed. In this work six species of Scarab beetles from the Chrysina genus are investigated. The complete Mueller-matrix is measured with a dual rotating compensator ellipsometer (RC2, J.A.Woollam Co., Inc.). The results are presented as contour plots where we represent different parameters as a function of incidence angle $\phi \in [25; 75]^{\circ}$ and wavelength $\lambda \in [240; 1000]$ nm of the incident beam. Parameters of particular interest are the $m_{41}$ element of the Mueller-matrix, which is related to the circular polarization behaviour, the degree of polarization, the ellipticity and the absolute value of the azimuth angle. From ocular observations through left- and right-circularly polarizing filters all specimens showed clear polarization effects in terms of colour changes. However, the Mueller matrix ellipsometry measurements showed two general types of polarization behaviour depending on the studied species. Chrysina macropus and Chrysina peruviana had a smaller range of $m_{41}$ values around zero. Much larger $m_{41}$ variations were observed for Chrysina argenteola, Chrysina chrysargyrea and Chrysina resplendens. Chrysina gloriosa had both types of polarization behaviour depending on if the measurements where made on the green or golden parts of this striped beetle. Comparisons among samples of beetles from the same species were conducted. For instance, different specimens of Chrysina resplendens show rather large differences in the polarization response whereas specimens of Chrysina chrysargyrea showed very similar polarization behaviour. All studied specimens did in some sense reflect both right- and left-handed polarized light. In many cases very high ellipticities (near-circular polarization states) were observed. Models of structures generating the observed polarization effects as well as biological aspects will also be discussed.

Figure 257: Three pictures of C. chrysargyrea from left to right taken with a left-circular polarizer, no filters and with a right-circular polarizer in front of the camera. Two contour plots of $m_{41}$ for C. chrysargyrea showing a large region with left-handed near-circular polarization and C. resplendens showing a large region with right-handed near-circular polarization.