Open Internship in the ESA Advanced Concepts Team in 2016
on

Bio-switchable reflective exoskeletons

Topic description

The Panamanian golden tortoise beetle (Charidotella egregia) has developed the ability to rapidly change the surface reflectivity of its exoskeleton [1,2]. In its nominal (relaxed) state, the beetle's shell appears golden metallic with a high surface reflectivity. If disturbed, the beetle will shift to a red signal colour in under two minutes. This reversible colour changing mechanism is enabled via nano-sized channels embedded into the exoskeleton. Through these channels, the beetle can control fluid levels in different layers of its shell. Increasing the fluid pressure expands each layer, which become smooth and reflective (like a Bragg mirror). When evacuated, this `optical stack' collapses and becomes transparent, revealing the red pigment layer below. Future technologies exploiting this mechanism could potentially result in numerous applications: spacecraft thermal control, smart windows, corrective vision lenses, switchable MEMS for laser optics (in medical and bio-engineering), antiglare mirrors, and protective eyewear.

Candidate's tasks

The successful candidate will investigate this concept by implementing an equivalent electro-mechanical or piezo-mechanical system model (using e.g. OpenSim or COMSOL). In detail, the successful candidate will perform the following tasks:

- Reverse engineering: Translate the underlying bio-optical and bio-mechanical processes into a material model considering, for example, structural coloration due to multilayer interference, diffraction, thin film interference, and scattering effects;
- Analyse the suitability of nano-scale materials such as, for example, multi-layer composite materials, MEMS, carbon-nanotubes and biomorphic materials [3], regarding their potential of replicating the concept synthetically;
- Study the concept feasibility on a systems level for space applications and compare with existing technologies such as, for example, electrochromic devices or thermochromics paints.

The ideal candidate

Mandatory

- B.Sc. in Material Science or Bio-Engineering
- Background in biomechanical systems modelling

Desirable

- Experience in bionics and biomimicry

References

[1] Vigneron, J. P., et al. (2007). "Switchable reflector in the Panamanian tortoise beetle Charidotella egregia (Chrysomelidae: Cassidinae)." Physical Review E 76(3): 031907; DOI: http://dx.doi.org/10.1103/PhysRevE.76.031907.

[2] Caveney, S. (1971). "Cuticle Reflectivity and Optical Activity in Scarab Beetles: The Role of Uric Acid", Proc. R. Soc. Lond. B 1971 178 205-225; DOI: http://dx.doi.org/10.1098/rspb.1971.0062.

[3] Fan, T. X., Chow, S. K., Zhang, D. (2009) Biomorphic mineralization: From biology to materials, Progress in Materials Science, Volume 54, Issue 5, Pages 542-659; DOI: http://dx.doi.org/10.1016/j.pmatsci.2009.02.001