Butterfly wings inspiring next-gen technological innovations

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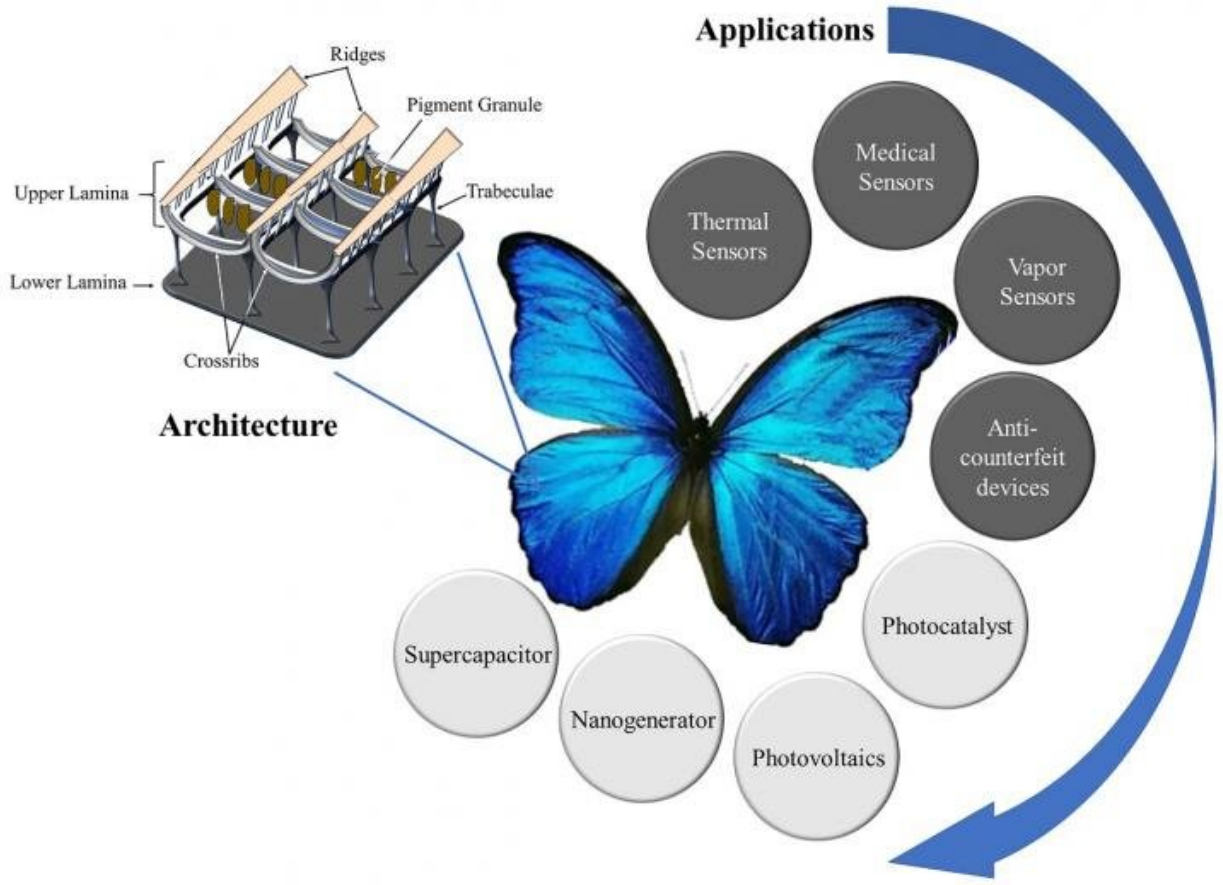

Scheme of butterfly wing architectures and associated applications. Credit: Science China Press

The catastrophic effects of global environmental degradation, health

deterioration and diminishing energy resources are demanding remedy measures aimed at environmental conservation, health interventions and harnessing of the abundant and renewable energy resources. Consequently, sensors and renewable energy harnessing systems have emerged as worthwhile solutions to the existent challenges. However, conventional sensors and renewable energy harnessing systems have presented diminished efficiency and performance to be improved. Therefore, current research trends are focusing on improving the efficiency and performance of these systems.

For centuries, nature has availed an unlimited cache of evolved biological species with improved energy harnessing capabilities and heightened responses to external stimuli, including temperature, pH, humidity and chemical molecules. Specifically, butterfly wings have gained research and aesthetic popularity for their vivid coloring, architectures of unique micro/nanostructures, sensitivity and effective responses to stimuli.

While insect enthusiasts marvel at the beautiful wing coloration and patterning, researchers have determined that the vivid coloration and wing properties result from the structures and pigments found in the wing scales. The huge variety of beautifully colored wings has led researchers to classify the various unique wing scale architectures. Equally, researchers have made attempts to mimic the wing properties in fabrication of various manmade functional materials and systems, such as sensors and energy harnessing applications.

In the overview published in *National Science Review*, researchers in the State Key Laboratory of Metal Matrix Composites at Shanghai Jiao Tong University, Shanghai, China present the recent research progress in sensor and energy applications inspired by butterfly wings. In their review, Zhang W. and co-workers highlight the genesis of wing scale development and the subsequent formation of wing scale architectures.

They describe the general appearance of the wing scale architectures as having three distinct regions namely, the highly convoluted upper lamina, flat and featureless lower lamina and pillar-like connection of the two layers called trabeculae. In addition, the authors discuss the most recent wing structure classification based on variations in specialized regions of the architectures. These wing scale architecture variations influence wing coloration among other properties, including porosity, surface area and responses to stimuli.

Recently, researchers have worked on a variety of sensor and energy systems with the aim of mimicking the properties of natural species into manmade functional systems. This published review has focused on the progress achieved in recent research towards the fabrication of sensor and energy systems inspired by butterfly wings. By employing the different properties of butterfly wings, researchers have successfully fabricated thermal, medical and vapor sensors, anti-counterfeit security devices, photocatalysts, photovoltaic systems, triboelectric nanogenerators and energy storage systems. Comparatively, these featured systems have demonstrated competitive efficiency and performance to similar systems inspired by other natural species.

Unfortunately, more research is still necessary to achieve optimal replication of natural properties onto manmade functional systems. As a result, authors suggest that the application scope should extend to photothermal imaging and therapy in cancer treatment and management. The good performance recorded by medical sensors for health monitoring and photothermal capabilities of butterfly wing inspired materials will generate sufficient mechanism for the detection, imaging, therapy and monitoring of terminal diseases. Similarly, photothermal materials inspired by butterfly wings can gain interest in the emerging stealth technologies research for modern-day warfare and scientific research technologies, such as rockets.

Lastly, butterfly wings have exhibited numerous and diverse properties that enable them effectively respond to external stimuli. Research should envision tapping onto these characteristics in the fabrication of functional systems with multiple responses and high efficiencies. This should be a real break-through in attaining next generation applications that optimize the properties of natural species and meet the global energy shortages, environmental degradation and deteriorating health conditions.

More information: Maurice I Osotsi et al, Butterfly wing architectures inspire sensor and energy applications, *National Science Review* (2020). DOI: 10.1093/nsr/nwaa107

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