Extending material-based actuators towards meter-scale applications

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Abstract

Nastic (non-directional) and tropistic (directional) phenomena can be observed in nature: e.g. the opening and closing of the pinecone scales and the growth of sunflowers, respectively. The underlying physico-chemical principles can be integrated into material-based actuators (MBA) leading to the basis for autonomous response to changes in environmental conditions (temperature, relative humidity, etc.). So far, their application potential is essentially addressed at the centimeter scale. An extension to the meter scale is indeed hindered by a number of obstacles that remain to be tackled, mainly: disproportionate response time and insufficient load bearing capability.

In this work, MBA based on the bilayer principle are considered: actuation is achieved by the mechanical combination between a responsive "active" layer, whose expansion/contraction is constrained by a less responsive "passive" layer, resulting in the curvature of the assembly. The strategy lies in optimizing the actuator in terms of displacement and load bearing capabilities, notably by taking advantage of the increase of the second moment of area of the assembly. This approach intends to improve the mechanical response without having to increase the thickness, which would drastically increase the response time.

Accordingly, 180 μm-thick MBA samples comprised of a common paper sheet thermo-laminated with a commercially available adhesive PET sheet were placed in an environmental chamber and subjected to relative humidity cycles ranging between 5 % to 90 %. Water absorption and desorption by the MBA was monitored by weighing the sample with a rate of 2 acquisitions/min. The evolution of the curvature of the MBA was captured in-situ using a 3D laser scanner generating a point cloud of the sample surface exposed to the light beam. Using these measurements, the water content and the second moment of area of the MBA were calculated as a function of the surrounding air relative humidity. These results are discussed in terms of both response time and load bearing, raising perspectives for the upscaling of such MBA.

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