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Biomimetic solution-based coatings for functional applications

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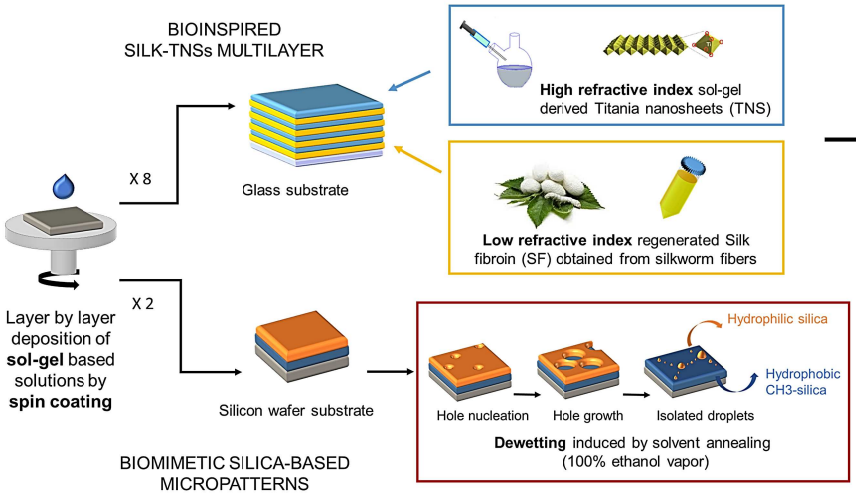
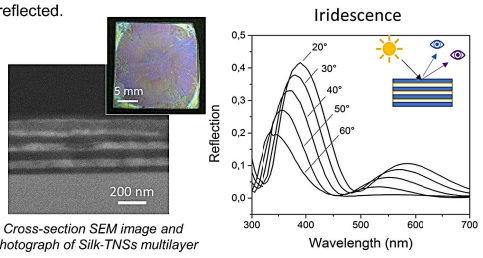
Introduction

Nature is a great source of inspiration for scientists and engineers to design and fabricate functional devices. Many animals and plants present a structural coloration, which is caused by the interaction of light with periodic structure, used for example in camouflage or to transmit information. Several natural surfaces show superwettability properties that allow self-cleaning abilities and water harvesting. Here, we show two examples of biomimetic coatings inspired by the cuticle of the *Hoplia cerulea* beetle and *Stenocara* beetle. The coatings were fabricated by employing a simple and cheap approach based on layer-by-layer deposition of sol-gel solutions by spin coating.

Fabrication and materials characterization

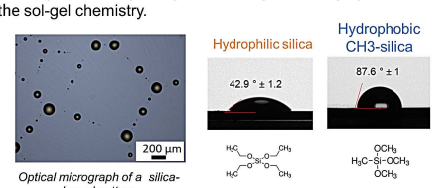


Multilayer refletor: optical structure consisting of alternating layer of a low and a high refractive index material that shows a characteristic color when light is reflected.



Cross-section SEM image and photograph of Silk-TNSs multilayer

Contrast wetting pattern: coating that switches its wetting state locally from hydrophilic (top islands) to hydrophobic (bottom layer) obtained by controlling the sol-gel chemistry.

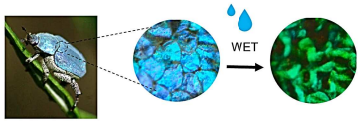


Optical micrograph of a silica-based pattern

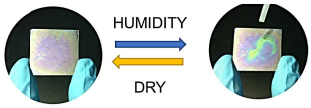
Functional applications

BIOINSPIRED SILK-TNSs MULTILAYER

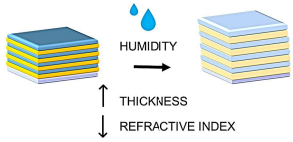
The cuticle of the male of the *hoplia coerulea* beetle shows a blue-violet color derived from a multilayer structure. This color turns to green when it is wet.

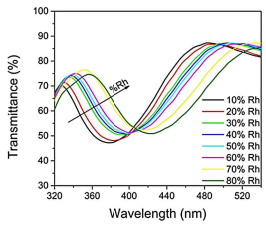


Thanks to the **hygroscopic behavior of both SF and TNSs**, we designed a multilayer structure able to act with a **stimuli-responsive behavior** in presence of humid air. As for the beetle, the fabricated **multilayer** turns its color from blue-violet to green.



The mechanism is **reversible** and its due to variation of both refractive index and thickness of the layers. This functional optical device can be used **as humidity sensor**.

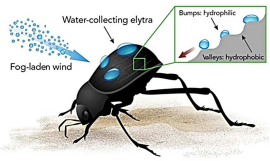




Variation in the optical transmittance of multilayer with humidity. This variation corresponds to a visible color change.

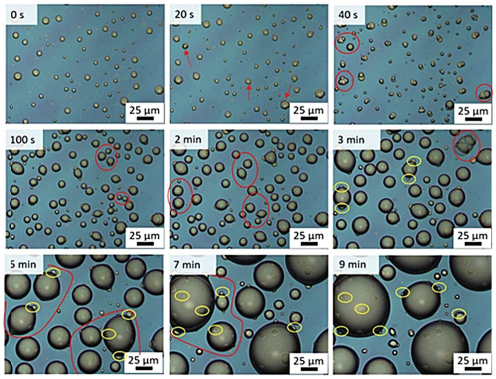
BIOMIMETIC SILICA-BASED MICROPATTERNS

The exoskeleton of some Namib desert beetles contains hydrophilic 'bumps' on hydrophobic waxy background. Thanks to this structure they can collect drinking water from fog on their backs.



The **silica-patterned surfaces** retained low **critical volume for water droplet detachment**, close to that of the natural surface.(8 µl at 45°). Water droplets nucleate preferentially on hydrophilic domains and grow rapidly over the closest hydrophilic silica bumps.

WATER CONDENSATION (50%RH, ΔT 15°C)



Optical micrographs showing condensation of water droplets on a micropattern.

Conclusions

Two different coatings inspired to beetles have been developed by combing sol-gel synthesis and a layer-by-layer deposition by spin coating. A **Silk-TNSs multilayer film** was designed to show a reversible color-change behavior that can be used to sense environmental humidity. **Micropatterns** with topological and wettability contrast were fabricated by a dewetting of silica-based sol-gel bilayers. These hydrophilic/hydrophobic surfaces showed water capture behaviors,

References

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