Temperature-responsive hydrogel films for highly modulable optics

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Thin films of temperature-responsive hydrogel films with controlled chemistry and large range of thickness from a few nanometers to several micrometers, show remarkable functional properties. Under the effect of temperature, hydrogel films swell and collapse by absorbing or expelling water. The effect is fast (less than one second), the transition is abrupt (a few degrees around the transition temperature) and the amplitude of deformation can be very large (400% rate and more). Hydrogel layers also have the advantage of a shapeable architecture: multilayer networks, interpenetrating networks, hybrid networks. These thermo-sensitive hydrogel films are excellent candidates for the development of new optical sensors. We performed an exemple of optical sensor demonstrator with a pNIPAM hydrogel film (which shows LCST properties with phase transition temperature around 32°C) grafted on a solid substrate and covered by a gold layer. As shown by Figure 1, the drop of water is colorless at 40 °C (the hydrogel film is collapsed) and appears blue at 25 °C (the hydrogel is swollen). The color, in agreement with Newton's hue scale, depends on the thickness of the thermo-sensitive hydrogel film. We are also exploiting the multilayer architecture for the fabrication of Bragg dielectric mirrors with high spectroscopic modulation. They are obtained with alternating multilayers of sensitive hydrogels and inorganic gels (Au or TiO₂). On both sides of the transition temperature, the coating is transparent (over the entire spectroscopic range) and reflective (in a targeted range such as visible or thermal infrared for example). These innovative modular Bragg mirrors have a great potential for the development of modulable optical devices. This project can have a real scientific impact in the field of polymer thin films for optics.

Figure 1. Optical demonstrator made with a pNIPAM hydrogel film grafted on silicon substrate and covered by a gold layer. The color of the droplet layer is controlled by the thickness of the temperature-responsive hydrogel films.

Figure 2. Cross-sectional view of pNIPAM/Au multilayers using Scanning Electron Microscopy.

References
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